



## *Introduction*

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## INTRODUCTION

Change is a natural phenomenon. Organisms always tend to mend ways with the environment they are living in. Plants being stationary are continuously subjected to vagaries of nature. Modern anthropogenic activities almost completely altered natural patterns. It is no exaggeration to say that pristine natural habitats are difficult to find. The human dimension is forcing plants to go for quicker changes and the slower ones are pushed towards extinction. Continuation of all these without any change will be a disaster for mankind as well. Hence it is important to look at various patterns happening, to find out processes holding to their virginity, processes that are on the brink of break down, etc. This ecological knowledge can lead us to sustainability ensuring the continuity of human race along with other organisms. Herbaceous vegetation is one of the susceptible ones subjected to the impact of anthropogenic activity. As they are cyclical in existence any minor change will have an impact. They are equally adaptable with better phenotypic plasticity. It is easier to monitor the changes *vis-à-vis* variations in local environment. Equally important is to develop an information base for herbaceous vegetation with reference to their description, identification, phenology, population size, etc. for wider dissemination of knowledge. All over the world, various groups are working in similar lines. Sizable amount of information is available. Here is a brief sketch of available information with appropriate subheads.

## **Bioinformatics**

Over the past few decades, major advances in the field of biology, coupled with advances in computer technologies, have led to an explosive growth in the biological information generated by the scientific community. This deluge of information has, in turn, led to an absolute requirement for computerized databases to store, organize and index the data, and for specialized tools to view and analyze the data ([www.bioinformatics.weizmann.ac.il](http://www.bioinformatics.weizmann.ac.il)).

**Bioinformatics** or biological information technology is the most powerful and fast developing sector in the information technology. It is essentially a fusion of various facets of biological sciences (functional, structural and technological) with mathematics, computer and information technology. Bioinformatics can be defined as the area/branch of information technology that deals with all aspects of biological systems- 'data mining' with the aim of conservation, sustainable utilization that converts bio-resources into economic wealth. It thus involves information pertaining to biological resources, inventory documentation, acquisition, processing, storage, distribution, analysis and interpretation, that combines the tools and techniques of mathematics, computer science and biology with the aim of understanding the biological significance of variety of data (Kumar, 2001). The ultimate goal of the field is to enable the discovery of new biological insights as well as to create a global perspective from which unifying principles in biology can be discerned. This includes databases and structural information as well as methods to access, search, visualize and retrieve the information. Bioinformatics is being practiced world wide because of its great relevance in accessing and understanding developments in modern biology. Bioinformatics has become important to find ways and means in achieving various goals in accessing and using accumulated informations (Ouzounis, 2000). The accumulated valuable data resources can be accessed and there is immediate communication with national and international research groups all over the world at affordable costs. These utilities have made bioinformatics so relevant that the field is gaining enormous importance world wide (Tripathi, 2000).

There are three important sub-disciplines within bioinformatics involving computational biology

- the development of new algorithms and statistics to assess relationships among members of large data sets;
- the analysis and interpretation of various types of data and
- the development and implementation of tools that enable efficient access and management of different types of information.

One of the simpler tasks used in bioinformatics is the creation and maintenance of databases of biological information (Tripathi, 2000)

Protein analysis, cell metabolism, biodiversity, biotechnology, downstream processing in chemical engineering, genetic engineering, vaccine design, diagnostic kits, etc., are other important areas in which bioinformatics constitutes an integral component (Kumar, 2001).

### **Development of Bioinformatics**

Practically, the development of bioinformatics started with the networking of computers and accumulation of data. This discipline is still young and may be traced back to the 1970's (Fuchs, 2000). The discipline developed further during mid-1980s, when use of computers became very popular for data storage and access by users, locally or remotely. It was this period when tools to store, manage and access the information through computers were developed. With the accumulation of new data, new techniques were developed for the proper utilization of databases developing bioinformatics During 1990's, with the introduction of 'World wide web', the developmental work in bioinformatics got a shot in the arm with vast connectivity and accessibility to databases in a user friendly way. The success of internet came about with the advent of various networking tools and servers from mid 1990 onwards, which could make possible the very existence of "World wide web" (Tripathi, 2000). The advent of bioinformatics has revolutionize biological technology The success of biosciences would depend upon the databases (Wada, 2000). Bioinformatics has come to an age within past few years to become a "bonafied discipline" (Tripathi, 2000).

### **Division of Bioinformatics**

Bioinformatics is a multi disciplinary subject. Though only about a decade old, it has become very important for the growth of biosciences, biotechnology, and the economic prosperity of nations. Three well-identified subdivisions of Bioinformatics are:

- a) Molecular Bioinformatics,
- b) Cellular and sub-cellular Bioinformatics, and
- c) Organismic and community Bioinformatics

Out of these three, most Bioinformatics scientist and workers practice molecular Bioinformatics. The other two areas are more recent and are at different stages of development. In the next 5-10 years, cellular and sub-cellular Bioinformatics that will include metabolic pathways, epigenetic, and neuro Bioinformatics on one hand and Bioinformatics of Species diversity, behavior, evolution and the effect of pollutants on higher as well lower species, on the other will occupy the main stage (Kumar, 2001).

### **Importance of bioinformatics**

The rationale for applying computational approaches to facilitate the understanding of various biological processes include:

- A more global perspective in experimental design
- The ability to capitalize on the emerging technology in better characterized organisms
- Easy access to the information
- A method for extracting only that information needed to answer a specific biological question.
- Data can be stored safely, with security and reliably (Tripathi, 2000).

Today the information technology has become the most useful tool for documentation of information on different aspects. With the development of many user-friendly software packages, faster chip sets, larger storage devices, etc., there has been amazing progress made in this field that has led the world

to come much closer and easily accessible today for any desired information pertaining to biological diversity (Thakur *et al.*, 2003 and Rawat *et al.*, 2003). In terms of floral biodiversity, India has rich flora of about 45,000 species ranging from algae, fungi, mosses, ferns, lichens and conifers to flowering plants. Flowering plants make about 17,500 species in the form of trees, shrubs and herbs (Walter & Gillett, 1998 and Kehimkar, 2000). Amongst the three, herbaceous group comprises of a large number of species, few of which remain imperceptible because of its inconspicuous looks and small size. Natural vegetation adds aesthetic value to any locality. More importantly, flowering plants could be monitored as indicators of health of habitat, according to their presence or absence. In this way, some sensitive species could also serve as an important tool in environmental monitoring. The remarkable evolutionary success of angiosperms is such that this division deserves special attention. Major information on the subject is in the form of printed books, journals or on the labels of millions of specimens in various herbarium collections. The major endeavor needed in this field lies in building up an easy methodology which helps in quick and correct identification of these less noticed plants and along with that edifice a devise which stores the inventory of the existing flora of the country at one place that can be easily accessible to every one interested. One of the easiest and convenient methodologies of identification is through the field photographs of individual plants. The rapid stride being made in the sphere of Information technology has already radically altered the course of informatics and has the potential to further course correction in a desirable direction. Information technology offers an efficient and feasible technique to handle the task of maintaining exhaustive information in an electronic format. Easy accessibility makes it convenient to use. Building a database is vital for any organization. The photographic database has its own importance and can be widely used in various fields. Of the databases developed and made available on the web, very few mention about tropical vegetation. Information available is scanty and at times pictorial forms are not available making it a bit difficult to confirm the identity of plant.

## **Diversity – A general review**

Diversity of organisms - or Biological Diversity - is the term given to the variety of life on Earth and the natural pattern it forms. The biodiversity we see today is the fruit of billions of years of evolution, shaped by natural processes and, presently by the influence of humans. It forms the web of life of which we are an integral part and upon which we so fully depend. Biodiversity is essential for human survival and economic well being and for the ecosystem function and stability (Singh, 2002). This diversity is often understood in terms of the wide variety of plants, animals and microorganisms. Yet another aspect of biodiversity is the variety of ecosystems such as those that occur in deserts, forests, wetlands, mountains, lakes, rivers, and agricultural landscapes. In each ecosystem, living creatures, including humans, form a community, interacting with one another and with the air, water, and soil around them. It is the combination of life forms and their interactions with each other and with the rest of the environment, that has made Earth a uniquely habitable place for humans (CBD, 2004)) Biodiversity provides a large number of goods and services that sustain our lives. The rich tapestry of life on our planet is the outcome of over 3.5 billion years of evolutionary history. It has been shaped by forces such as changes in the planet's crust, ice ages, fire, and interaction among species, etc. Now, it is increasingly being altered by humans. From the dawn of agriculture, some 10,000 years ago, through the Industrial Revolution of the past three centuries, we have reshaped our landscapes on an ever-larger and lasting scale. We have moved from hacking down trees with stone tools to literally moving mountains to mine the Earth's resources. Old ways of harvesting are being replaced by more intensive technologies, often without controls to prevent over-harvesting. By consuming ever more of nature's resources, we have gained more abundant food and better shelter, sanitation, and health care, but these gains are often accompanied by increasing environmental degradation that may be followed by declines in local economies and the societies they supported (CBD, 2004).

### **Value of biodiversity**

Biological resources are the pillars upon which we build civilizations. Nature's products support such diverse industries as agriculture, cosmetics, pharmaceuticals, pulp and paper, horticulture, construction and waste treatment. The loss of biodiversity threatens our food supplies, opportunities for recreation and tourism, and sources of wood, medicines and energy, etc. It also interferes with essential ecological functions. Our need for pieces of nature we once ignored is often important and unpredictable. Time after time we have rushed back to nature's cupboard for cures to illnesses or for infusions of tough genes from wild plants to save our crops from pest outbreaks. What's more, the vast array of interactions among the various components of biodiversity makes the planet habitable for all species, including humans. Our personal health, and the health of our economy and human society, depends on the continuous supply of various ecological services that would be extremely costly or impossible to replace. These natural services are so varied as to be almost infinite (CBD, 2004)

### **Threats to Biodiversity**

Biodiversity losses around the world continue to mount despite considerable efforts to protect species and wild lands. According to the latest FAO report (FAO, 2000), the annual rate of deforestation in the world during 1990-2000 was 9.4 million ha, and a report issued by the IUCN (Walter & Gillett, 1998) indicates that one out of every eight plant species is endangered or threatened with extinction (Bawa *et al.*, 2002). Human activities are endangering other species around the globe. Extinction is part of the evolutionary process, but today's rate of extinction is much greater than the scale at which species disappear due to evolution alone. Species are now vanishing faster than at any other time in Earth's history (Suzuki, 2004). Declines in number of species, have drawn world attention to the problem of species at risk. Species have been disappearing at 50-100 times the natural rate, and this is predicted to rise dramatically. Based on current trends, an estimated 34,000 plant and 5,200 animal species are facing extinction. While the loss of individual species catches our attention, it is the fragmentation, degradation, and outright loss of forests, wetlands, and other ecosystems that

poses the gravest threat to biological diversity. Global atmospheric changes, such as ozone depletion and climate change, adds up to the stress. Global warming is already changing habitats and the distribution of species. Scientists warn that even a one-degree increase in the average global temperature, if it comes rapidly, will push many species over the brink (CBD, 2004). The loss of biodiversity often reduces the productivity of ecosystems, thereby shrinking nature's basket of goods and services, from which we constantly draw resources necessary for livelihood. It destabilizes ecosystems, and weakens their ability to deal with natural disasters such as floods, droughts, and hurricanes, and human-caused stresses, such as pollution and climate change. Already, we are spending huge sums in response to floods and storm damage exacerbated by deforestation; such damages are expected to increase due to global warming. The reduction in biodiversity also hurts us in other ways. Our cultural identity is deeply rooted in our biological environment. Plants and animals are symbols of our world, preserved in flags, sculptures, and other images that define us and our societies. We draw inspiration just from looking at nature's beauty and power. While loss of species has always occurred as a natural phenomenon, the pace of extinction has accelerated dramatically as a result of human activity. Ecosystems are being fragmented or eliminated, and innumerable species are in decline or already extinct. These extinctions are irreversible and, given our dependence on food crops, medicines and other biological resources, pose a threat to our own well-being. Political and scientific concerns have been raised as we are experiencing an increase in species extinction rates caused by anthropogenic activities (Ehrlich & Wilson, 1991). Many kinds of environmental changes influence or determine processes that can both augment and erode diversity (Sheil, 1999). In India, habitat destruction, over exploitation, pollution and species introduction are identified as major causes of biodiversity loss (UNEP, 2001). The disturbances created by these factors determine vegetation dynamics at the local and regional scales, these disturbances have been considered as an important factor in structuring the communities (Burslem & Whitmore, 1999 and Hubbell *et al.*, 1999).

## **Evolution**

According to Darwin, evolution is descent with modification. It is the change in a population of organisms of the same species over time, a change from simple to complex life form (Slick, 2004). Natural selection is how evolution occurs (Smith, 2000). In "The Origin of Species" Charles Darwin theorized that natural selection was the mechanism that explained the process of evolution. The natural selection theory explains that life exists in its present form as a result of evolution, rather than a random series of inexplicable miracles. He introduced the concept of species changing and adapting slowly over time, and surmised that those adaptive change most often occurred via the mechanism of natural selection. The concepts contained in the terms "Natural Selection" and/or "Survival of the Fittest" are, either separately or as a whole, a valid scientific explanation for evolution. Darwin's observations showed that many distinctively diverse organisms of plants and animals were related through some yet to be discovered explanation. He described Natural Selection as the "preservation of favorable individual differences and variations, and the destruction of those which are injurious or the Survival of the Fittest" ([www.fifi.essortment.com](http://www.fifi.essortment.com)) An additional element of Darwin's theory encompasses the variance in the physical and habitual traits of each species. Darwin asserted that a species must not only adapt, but must also be capable of passing on those adapted characteristics to its offspring in order for a species to cope with the ever changing environments and circumstances it is subjected to (Kazlev, 2002)

## **Short term Evolution**

How fast can organisms evolve and what conditions are conducive to adaptive evolution? A traditional Darwinian perspective is that evolution by natural selection is a slow process that can, with time; result in adaptation and substantial change (Reznick & Ghalambor, 2001). Darwin (1859) based this perception on the abundant evidence that evolution had happened and that organisms have the capacity to evolve under artificial selection, yet the process of evolution by natural selection had not been directly observed. Darwin attributed the difference between the capacity to evolve and the slower apparent rate of evolution to the weaker forces of natural selection compared to

artificial selection. His expectations for the rate of evolution were derived primarily from the fossil record, which sustained the view that evolution could be very slow, yet result in substantial change. Most of the early observations of evolution by natural selection (e.g., industrial melanism, insecticide resistance, heavy metal tolerance) were attributable to anthropogenic influences, which were believed to exert stronger than natural coefficients of selection (Reznick & Ghalambor, 2001). Recent reviews suggest that natural biological populations are capable of sustained rates of evolution many orders of magnitude higher than those observed in the fossil records (Reznick *et al.*, 1997, Thompson, 1998 and Hendry & Kinnison, 1999). These results suggest that sustained evolutionary change and its underlying processes occur fast enough to make them amenable to empirical investigation. For example, high rates of evolution make it more feasible to evaluate the sustained rate of change (Lynch & Lande, 1993 and Burger & Lynch, 1995) or the association between natural selection and speciation (Schluter, 1998), and hence to evaluate the possible relationship between micro- and macroevolution. According to Bradshaw & McNeilly (1991) changes in natural environment can generate powerful selection pressures enough to drive evolution forward at a great pace. Short term evolution is found in species or populations which have become exposed to new environments and are experiencing selection pressures to which they have not previously been subjected. In these situations, it happens that only a certain amount of evolution takes place in relation to the selective factor, and then stops, and that this evolution only takes place in some species.

Reznick & Ghalambor (2001) focused on contemporary studies of microevolution documenting changes in morphological, life history, behavioral, and physiological characters. 47 studies of rapid evolution in response to both anthropogenic and natural changes in the environment were documented. Thirty-six of these studies document a genetic basis to the phenotypic change, while the remaining 11 only report phenotypic change in response to selection which were not on genetic basis. The characters that evolved can be placed into five general categories. morphology, physiology, life history, phenology, and behavior. Morphological traits that exhibited rapid evolution included changes in size. Physiological characters included salinity tolerance in plants, heavy metal tolerance in plants and animals (Antonovics *et al.*, 1971, Klerks &

Weis, 1987 and MacNair, 1987), insecticide resistance (Rosenheim *et al.*, 1996), and thermal tolerance (Holland *et al.*, 1974 and Hendry *et al.*, 1998). The timing or phenology of different traits was found to evolve in a number of plant and animal species. For example, introduced populations of *Solidago* in Europe have evolved clinal (a continuous variation in physiological adaptation) differences in flowering time that parallel environmental gradients (Weber & Schmid, 1998). Similarly, a number of insects have evolved differences in the duration of development, time at emergence (Carroll *et al.*, 1998; Byrne & Nichols, 1999 and Groman & Pellmyr, 2000).

If these data are taken at face value, then it highlights that high rates of adaptive evolution is observable within the lifetime of an investigator and orders of magnitude faster than inferences based on the fossil record (Reznick & Ghalambor, 2001). Likely, that environmental change will not necessarily elicit genetic change, as target populations may adapt through phenotypic plasticity. The key is to evaluate when rapid adaptive evolution is possible and to consider whether the small amount of data available yields any clues

### **Phenotypic plasticity**

When populations of organisms spread over a large area, groups can be under different environmental conditions and reproductively isolated. For plants, their time of flowering, bud break and leaf fall, and their temperature tolerance is adapted to the local environment ([www.hcs.ohio-state.edu](http://www.hcs.ohio-state.edu)). When plants colonize a new environment, with little existing vegetation they have an opportunity to develop a variety of forms to fill different ecological niches. This leads to phenotypic plasticity ([www.biomed.brown.edu](http://www.biomed.brown.edu)). **Phenotypic plasticity** is the ability of individuals to alter its physiology, morphology and /or behavior in response to a change in the environmental conditions and the potential for an organism to produce a range of different, relatively fit phenotypes in multiple environments (Bradshaw, 1965; Schlichting, 1986, Sultan, 1987; Schlichting & Pigliucci, 1998 and Pigliucci, 2001). According to Dorn *et al.* (2000) and Relyea (2002) plasticity in plants is favorable if the environment is variable. A given plant genotype can experience different

environmental conditions as a result of variation in the abiotic environment, variation in the presence or identity of neighbors, disturbance, herbivory, parasitism, mutualistic relationship, or variation in consumer pressure (Sultan, 1987, 2000 and Baldwin, 1999). Many studies have shown that plant species produce a broad range of phenotypes in response to variation in the abiotic environmental conditions (Silvertown & Gordon, 1989; Sultan, 1993 a, b, & c and Pigliucci, 2001). Variation in trait expression induced by these or other environmental factors then affect interactions among plants. In context of evolution, phenotypic plasticity demonstrates the two meanings of adaptation: the plastic response is itself an example of physiological adaptation and it is widely held that the ability to be plastic is adaptive in the sense of increase fitness. It is recognized that plasticity has many ecological benefits (DeWitt *et al.*, 1998 and Meyers & Bull, 2002) Although originating in the field of evolutionary biology, phenotypic plasticity is a truly interdisciplinary topic, lying at the intersection between most of today's important biological disciplines, from evolution to molecular biology and, ecology Phenotypic plasticity occurs in many traits ranging from morphology through developmental biology to physiology and behavior, and can be found in all classes of organisms. Nearly every biological discipline deals with some aspects of phenotypic plasticity (Tollrian, 2002). When environment within a species range differs, it may be unlikely that any single phenotype will confer high fitness in all situations. In such a case, change in phenotype that depends on environment can provide an increase in environment tolerance. Phenotypic plasticity is thus one solution to the problem of adaptation to heterogeneous environments. Because of the importance of heterogeneous environments in the ecology and evolution of most of the species, phenotypic plasticity has been of great interest to ecologist and evolutionary biologists for many years (Via *et al* , 1995).

### **Taxonomy: An Expedient**

At present, more and more research is stressing the need to document natural assemblages as a basis for the conservation and sustainability of natural systems. In this context, taxonomy should represent the core reference system and knowledge base for any discussion of biodiversity: the framework within which biodiversity is recognized and species diversity characterization occurs (Bisby, 1995) Systematic conservation evaluation depends on the basic information about the number of taxa present in a given area, their distribution and their taxonomic relationships. The existence of reliable taxonomic and systematic survey data is of fundamental importance, together with well maintained collections and catalogues (Palmer *et al.*, 2002, and Giangrande, 2003) Taxonomic expertise is restricted to a few, often, elderly workers, with no younger taxonomists being trained to take their place. As a consequence, many species remain un-described or unattended for (Boero, 2001).

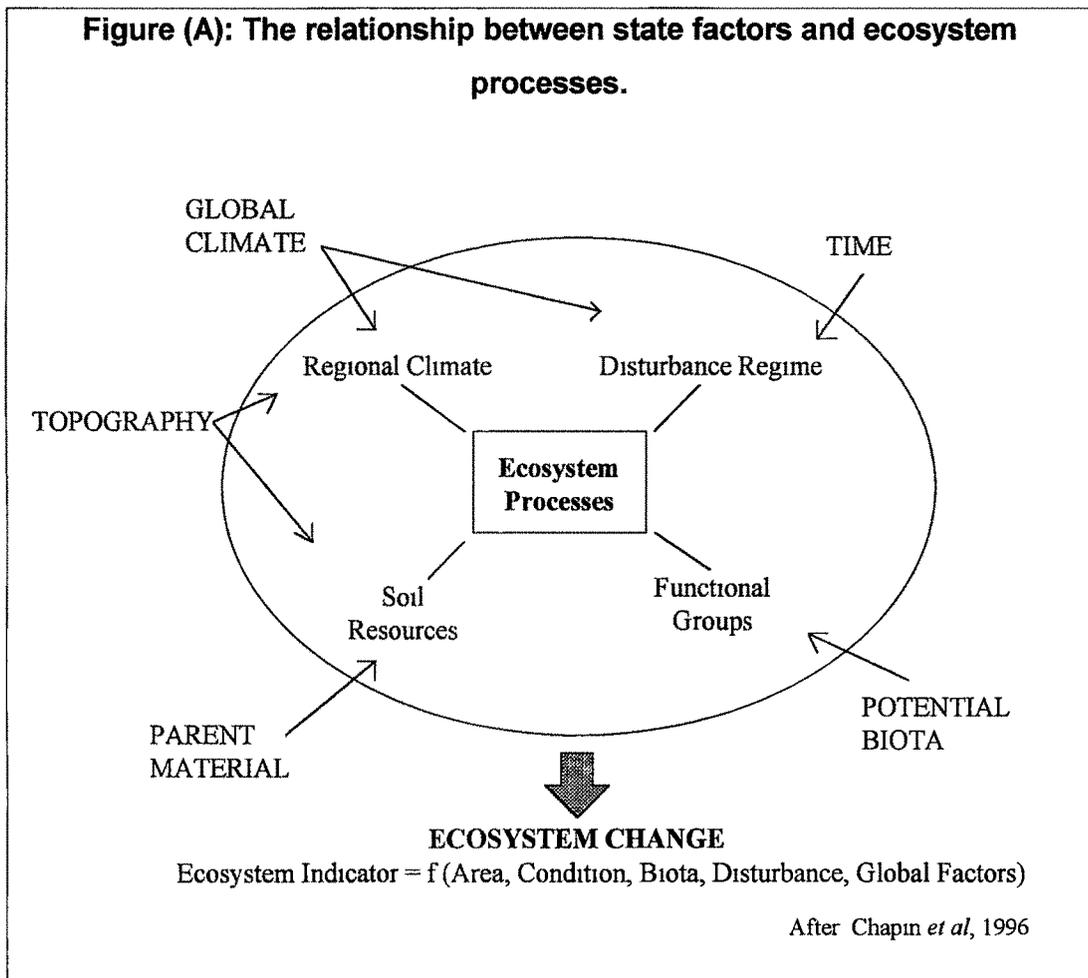
Society has a growing need for credible taxonomic information in order to allow to conserve, manage, understand, and enjoy the natural world At the same time, support for taxonomy and collections is failing to keep pace Existing taxonomic practices have served us well for centuries but are clearly inadequate for challenges at hand. The taxonomic community must rally around a common vision, critically evaluate its needs, set an ambitious research agenda, embrace emerging technologies, and univocally communicate its aspirations (Winston, 2000). Molecular data have revolutionized phylogenetics but not diminished the importance of traditional work. Morphology links living and fossil species, is the object of natural selection, inspire the search for causal explanations and democratize science. Visual morphological knowledge is ideally suited to internet communication. Some naively see information technology challenge as liberating data from cabinets. The reality is that for all but a few taxa, much data is outdated or unreliable. Many specimens represent un-described or misidentified species (Winston, 2000). Rapid access to bad data is unacceptable; the challenge is not merely to speed data access but to expedite taxonomic research One can envision virtual monograph, revisions, floras and faunas that are living dynamic works rather than static documents (Wheeler *et al.*, 2004).

It is time to approach taxonomy as large-scale international science. The goal of discovering, describing, and classifying species of a region assuredly qualifies as a big science. In the face of biodiversity crisis, the need for urgency could not be greater. One can imagine a taxonomic renaissance built on a foundation of cyber infrastructure. Aspiring taxonomists in developing countries have full access to taxonomic literature formerly reserved for a few great libraries. Peer reviewed species descriptions are published electronically and made instantly available (Wheeler *et al.*, 2004). Our generation is the first to fully comprehend the threat of the biodiversity crisis and the last with the opportunity to explore and document species diversity of planet. The grand biological challenge is to create a legacy of knowledge for planet that is soon to be biologically decimated (Wheeler *et al.*, 2004).

#### **Importance of vegetation study**

Vegetation refers to the plants or plant communities covering the land surface of a particular place. Vegetation is consisting of a loose assemblage of species, each species having its own ecology and history. Vegetation exhibits diverse features from region to region. This diversity is the result of evolution and adaptations according to the history, climate, topography and geology of each region, as well as the interactions among vegetation and other organisms, including man. Every plant is a product of the conditions under which it grows and therefore a measure of environment (Devaraj, 1999). Knowledge of vegetation is important to numerous scientific (and other) disciplines, such as biology, ecology, forestry, agronomy, hydrology, meteorology, and even some social sciences. A plant community integrates the effects of its physical environment and therefore serve as an indicator for ecological variability. Plant communities can also be related to scale because they form hierarchies where smaller communities can be grouped to form larger communities. This implies that the environmental factors which differentiate plant communities at different scales, are also related to scale ([www.geography.berkeley.edu](http://www.geography.berkeley.edu)). "Ecological" processes encompass biological interactions which are driven by biotic interactions.

The figure (A) below summarizes the concept



Vegetation has certain characteristics: e.g., succession, density, and coverage. Vegetation is affected by interacting factors, e.g., climate, relief, parent material, time, organisms (including humans), and disturbance (e.g. natural: fire, landslides, floods; anthropogenic: forest cutting and clearing) ([www.geography.berkeley.edu](http://www.geography.berkeley.edu))

On a local scale, soil and hydrological conditions may be very important, and these might seem to give support to the vegetation type approach. On a regional scale, however, macroclimate is more important, and if study sites are selected that control for local microclimatic differences an analysis of plant composition would support the continuum point of view. An important term on a local level is the plant association. The association is seen as a discrete grouping of plants that maintains its identity in time and space. Two species or more may often be found together, and in extreme cases, there may be an

obligate relationship, it is much common that species do not have exactly the same distribution. Species coexist if they are sufficiently different in their niches, the particular resources they exploit, and have corresponding weakness in other areas, so that no one species is able to out compete the others. Species composition of a community essentially reflects which niches are available (Landau, 2003)

### **Various disturbances and their impact on plant communities**

Disturbance is a very common and wide spread phenomenon in nature and may be defined as a discrete event along time that modifies ecosystems, community and population structure, changing the substrate, the physical environment and availability of resources in plant populations (White and picket, 1985) It can be considered as a basic process responsible for many other processes, such as fragmentation, migration, local and regional extinction etc. Disturbance and fragmentation are two related processes with strong relationships and it is difficult to distinguish the role and rate of the interactions. It is driven by many factors and interacts with other processes acting in a more restricted context, such as fragmentation (Li & Reynolds, 1994 and Anon, 2001). Human induced disturbance differs from natural ones especially in extension, severity and frequency. Disturbance process is transformed into a stress process, which reduces the overall plant diversity at a site (Moloney & Levin, 1996). Disturbances strongly affect ecological systems and are often responsible for the maintenance of dynamic stability and the persistence of plant communities. Disturbances occur across a wide range of spatial and temporal scales, and on all levels of ecological organization. Additionally, humans often strive to alter disturbance regimes ([www.uni-bielefeld.de](http://www.uni-bielefeld.de)). The assessment of disturbance impact and the development of models with predictive capabilities require an operational method to describe disturbances, to understand disturbance dynamics, and to identify the significance of disturbance regime in various ecosystems. Recognition of relationships between dimensions of disturbance events and dimensions of system response is the key for detection pattern resemblance of various disturbances on proportionate scales (Jentsch, 2000)

Various disturbances responsible to alter the vegetation composition in a region are:

- a) Climate change
- b) Urbanization
- c) Habitat fragmentation and anthropogenic activities

#### **a) Climate change**

Most field biologists are convinced that they are already seeing important biological impacts of climate change pertaining to morphology, phenology, etc. in vegetation (Smith *et al.*, 1999; Easterling *et al.*, 2000; Penuelas & Flella, 2001; Pounds, 2001; Walther *et al.*, 2002 and Thomas *et al.*, 2004). Ecological processes are influenced by prevailing climatic conditions (Saether, 1997). Recently, increasing attention has been given to large scale patterns of climate variability with marked ecological impact on inter-annual and longer time scales and have been shown to affect terrestrial vegetation both directly and indirectly (Stenseth *et al.*, 2002). The Earth's climate has warmed by approximately 0.6 °C over the past 100 years with two main periods of warming, between 1910 and 1945 and from 1976 onwards. The rate of warming during the latter period has been approximately double that of the first and, thus, greater than at any other time during the last 1,000 years. Organisms, populations and ecological communities do not, however, respond to approximated global averages. Rather, regional changes, which are spatially heterogeneous are more relevant in the context of ecological response to climatic change. Changes in the precipitation regime have also been neither spatially nor temporally uniform (Walther *et al.*, 2002). There is now ample evidence that these recent climatic changes have affected a broad range of organisms with diverse geographical distributions (Hughes, 2000; Wuethrich, 2000; McCarty, 2001; Ottersen *et al.*, 2001 and Walther *et al.*, 2001). Phenology—the timing of seasonal activities in plants—is perhaps the simplest process in which to track changes in the ecology of species in response to climate change (Parmesan 1996; Dukes & Mooney, 1999; Brown *et al.*, 1997 and McGowan *et al.*, 1998). In Europe, for example, leaf color changes show a progressive delay of 0.3–1.6 days per decade, whereas the length of the growing season has increased in some areas by up to 3.6 days per decade

over the past 50 years (Menzel & Fabrian, 1999). This extension of the growing season accords with the lengthening of  $12 \pm 4$  days derived from satellite data (Myneni *et al.*, 1997) as well as with an advance in the seasonal cycle by 7 days (Keeling *et al.*, 1996). An analysis of 50 years of data on 13 plant species in 137 localities revealed responses to the North Atlantic Oscillation in 71% of the total, with early-blooming and herbaceous species showing greater responses to winter warming than late-blooming and woody plants (Post & Stenseth, 1999). Applications of historical data are crucial for monitoring changes that have occurred in the vegetation structure (Swetnam *et al.*, 1999). Interpretation of the influence of climate on vegetation, as revealed in the historical record, can improve application of historical variability to current contexts (Millar & Woolfenden, 1999).

## **b) Urbanization**

Exploding cities is the familiar metaphor of the current form of urbanization. Cities and towns, growing in population and spreading into the surrounding countryside, spawning suburbs and swallowing up farms and villages, are the idioms of modern urban growth (Qadeer, 2000, 2004). According to Jellinek *et al.* (2004) the expansion of urban areas and adjacent farming land into natural landscapes modifies habitats and produces small isolated pockets of native vegetation. This fragmentation of the natural habitat subdivides communities, reduces population sizes and increases vulnerability to extinction. In the absence of major changes in policy and human behavior, effects on the environment will continue to alter biodiversity. Land use change is expected to be of particular importance in the tropics. An important reason for concern about the changes in abundance and diversity of organism is that species differ substantially in their effects on ecosystem processes (Chapin, 2003). Urbanization of the globe is accelerating, with potentially large impact on vegetation in cities and surrounding areas. Plants in urban ecosystem are exposed to many pressures, pollutants and higher temperatures than plants in rural areas and each factor has a detrimental influence on plant growth (Gregg *et al.*, 2003). Impact of urbanization on climate and plant species can be

estimated by comparing observations in cities with those in surrounding rural areas (Kalnay & Cai, 2003). Urban ecosystems differ from natural or rural ones in many obvious ways. Human activities, such as building, traffic, or industrial production affect the quality of air, water, and soil, which influence ecosystems in many ways. Plants can be destroyed, their production reduced. The results of these events are altered population dynamics, species composition, and altered energy and matter fluxes in urban ecosystems. Cities can be seen as organisms or as large ecosystems, especially with regard to energy and matter fluxes. Structurally and functionally they form complexes of interconnected habitats. Urban ecosystems and the composition of urban plant communities are greatly dependent on human activities which cause impacts on them. The extent of these impacts varies in time and space. Typically, cities show a mosaic of habitats with increasing degrees of human impact along a gradient from the outskirts to city centers. To understand present urban biota and their ecosystems it is necessary to see them as a result of historic development (Sukopp, 2004)

### **C) Habitat Fragmentation and anthropogenic activities**

Only in recent decades, have humans started to realize the tremendous impact that their activity has had on other species with which they share planet earth. Human activity has resulted in rapid changes in earth's surface, the composition of its atmosphere, its climate, and diversity of its organisms. Humans have increased the rate of species extinction by two orders of magnitude, mostly because of land use change and habitat destruction (Kruess & Tscharntke, 1994; Cole *et al.*, 1995 and Barker *et al.*, 1996). Currently, the sixth major event of mass species extinctions in the history of life on earth has been recorded. Whereas previous episodes were the result of mega catastrophes such as the hypothesized meteorite impacts, the current mass extinction events results almost exclusively from human activity. The activities include logging of forests, city building and road development which had major effects on the diversity of plants. This present day extinction rate differs considerably between different ecosystems, with highest in terrestrial systems (Sala, 2003). Human activities have caused severe global environmental

problems that are leading to a major population and species extinction crisis in plants and animals. Hundreds of populations and species have become extinct in recent decades and many more, including thousands of populations, are on the verge of extinction (Tilman *et al.*, 1994; Gigord *et al.*, 1999; Mellink *et al.*, 2002 and Chapin, 2003) Fragmentation describes a patchy distribution of suitable habitats, sometimes thought of as "ecological islands," surrounded by a matrix of inhospitable or inadequate habitats of varying permeability. Fragmentation means more than the mere existence of isolated or patchy habitats; it also implies that a more continuous habitat has been subdivided or broken up by some (often anthropogenic) process, with the attendant loss of intervening habitat (Soule, 1991; Ehrlich & Wilson, 1991; Raven & Wilson, 1992; McNeely, 1994; Sinclair *et al.*, 1995; Saunders *et al.* 1991; Andren, 1994 and Debinski & Holt, 2000). Although it occurs naturally through fire (Wright, 1974) and windfall, the most important cause is human's land use pattern for agriculture, forestry and the development of housing (Doherty *et al.*, 2000). Fragmentation results in a loss of original habitat area, a decrease in habitat patch size, and an increase in isolation of the remaining fragments (Andren, 1994 and Davies *et al.*, 2001). These effects make some species (particularly those unable to persist in the new environment created by clearing) more vulnerable to local extinction (and, in the longer term, to global extinction) through stochastic events (Cairns, 1996). This also leads to an increased vulnerability of fragments to invasion by non-native species and results in an increase in new habitat (e.g. monocultures of crops, urban environments) which may cause continual disturbance to habitat at the edge of the fragment (Andren, 1994 and Paton 1994) and leads to a decrease in core habitat along the ecotones well beyond the actual loss of area (Yahner, 1988 and Bhat *et al.*, 2000).

Fragmentation of native habitat is one of the biggest causes of extinctions. A single road bisecting a habitat patch cuts the habitat in half effectively reducing the individual population sizes in half. Different creatures are variably sensitive to fragmentation. Faunal group can access different patches separated by small divisions but plants being immobile, can be seriously affected Conversion of habitat to farmland or commercial use not only divides habitat it

also increases the relative amount of habitat edge. The edge of an area provides a buffer between two different habitat types. As habitat is fragmented not only is the land divided but by the act of division part of the habitat is converted to buffer or edge which may support a different flora and fauna than from the original habitat. Additionally microclimate conditions can be altered by a change in tree structure, creation or erosion channels or road cuts and altered solar flux (Saunders *et al.*, 1991) Habitat fragmentation leads to the disappearance of species, either by their exclusion from the remaining area or by demoting species from 'abundant' to 'rare' and from 'rare' to 'extinct' (Forys & Allen, 1998). Fragmentation may also cause morphological changes in populations, potentially by altering selection regimes. Habitat fragments have often been regarded as 'islands' in a sea of urbanization (Sumner *et al.*, 1999).

### **Metapopulation structure**

Areas of habitat that contain the necessary resources and conditions for a population to persist are called habitat patches or patches. The individuals of species that live in a habitat patch constitute a local population. Because the habitat of any species is usually not distributed homogeneously in nature, a species may occur as a set of local populations, each occupying a patch separated from other patches by areas of unsuitable habitat. A set of local populations occupying an array of habitat patches and connected to one another by movement of individuals among them is called metapopulation, or "population of populations" (Ricklefs & Miller, 1999 and Hanski, 1999). Metapopulation theory is of particular importance to conservation biologists attempting to understand the process of regional extinction- and survival- of species. Although the dynamics and evolution of a single closed population are governed by its life history, populations of many species are not completely isolated and are connected by the movement of individuals. Consequently, the dynamics and evolution of many populations are determined by both the population's life history and the patterns of movement between populations. Regional groups of interconnected populations are called metapopulation. These metapopulation are in turn connected to one another over broader geographic ranges. There is, therefore, a hierarchy of population structure

from local population to metapopulation to broader geographic groups of populations

As local populations within a metapopulation fluctuate in size, they become vulnerable to extinction during periods when their numbers are low. Because the local populations are assumed to be small, local catastrophes and chance fluctuations in numbers of individuals have an important effect on population dynamics. Extinction of local populations is common in some species, and the regional persistence of such species is dependent on the existence of metapopulation. Hence, elimination of much of metapopulation structure of some species can increase the chance of regional extinction of species (Ricklefs & Miller, 1999). The dynamics of metapopulation are affected by extinction and colonization rates and by the relationship of those rates to the spatial arrangement and density of habitat patches. Population persistence is related to population size. Small populations suffer a high risk of extinction than do large populations (Ricklefs & Miller, 1999). The structure of metapopulation varies among species. In some species one population can be particularly stable over time and act as the source of recruits into other less stable populations. In other species, metapopulation may have a shifting source. Any one local population may temporarily be the stable source population that provides recruits to more unstable surrounding populations. As the conditions change, the source population becomes unstable, as and when locally or physical environment deteriorates (Hastings, 2003).

### **Importance of monitoring herbaceous vegetation**

Compared to trees and shrubs which live for a highly variable period, herbaceous plants grow, flower and form fruits completing life cycle in less than a year's period. Species found only in the ground vegetation stratum usually have a shorter lifespan and different survival tactics than those that eventually occupy other strata. Ground vegetation species are finely tuned to their environment. The large numbers of species and individuals will yield a rich data base for analysis of their dynamics in response to environmental changes. Shifts in the concentration of airborne pollutants, increased in UV-B radiation, and the variability of temperature and moisture regimes are among the environmental changes that may impact the species. The plants are sensitive and respond quickly to the anthropogenic pressures. Their short period of life span facilitates to monitor the changes/variations occurring during their life cycles (Pichette & Gillespie, 2001). Long-term monitoring of ground vegetation helps in differentiating between short-term natural cyclic population variation, and vegetation shifts driven by environmental changes and disturbance levels. Faster results on population change are more likely to be achieved from monitoring the ground vegetation stratum than from monitoring other vegetation strata. Phenological observations can also contribute to documenting climate cycles and long term change. Monitoring rare plant species, most of which are herbaceous, is important for determining population stability. It is also within this stratum that the movement of invasive species can most easily be tracked. Because of their relatively short life spans and rapid maturation rates, they are expected to respond more rapidly to environmental change. Full exposure puts ground vegetation species under direct risk from changes in climate, moisture regime, etc. Information, derived from accurate, standard methods documenting the reactions of herbaceous species to such exposure, could provide a useful early warning about the future changes in environmental gradient (Pichette & Gillespie, 2001).

### **Importance of the present study**

The review of literature shows that, plants clearly have sophisticated methods of determining the environment they experience. This ability has important consequences for the evolution of morphology, physiology and life history of plants. Natural environment can generate powerful selection pressures, enough to drive evolution forward at a great pace if the variation is present. There is a range of good evidence that short-term evolution can take place in relation to the climatic fluctuation. Even in normal conditions, most climatic factors are strongly fluctuating. Although, there is usually regularity due to seasons, there is also a strong stochastic element. This has caused the evolution of strong physiological and phenological plasticity in most of species which allows individual, and therefore species, to cope with wide range of climatic conditions during their life time.

Increased human population in the last few decades demanding development in various spheres has resulted directly or indirectly in sudden and often far reaching disturbances in natural ecosystems. Population of scores of species are diminishing or disappearing locally, regionally and finally leading to the global extinction. Extinction *per se* is not a creation of humans or their activities. It is a natural phenomenon. Anthropogenic activities are making species more vulnerable to extinction. Human pressures are larger in urban systems bringing huge variations in the local flora and fauna. The natural ecosystems are gone at least in big cities and their places have been substituted by synthetic or artificial system.

Baroda city and its surroundings (the study area for this study) is an example of an urban ecosystem where tremendous urbanization and industrialization during last 4 decades have changed the whole environment. In coherence with global climate, regional weather conditions are being changed augmenting the magnitude of problems faced by the local biota. The work planned here is an attempt to understand the synergistic effects of all stresses on the quality and quantity of herbaceous vegetation cover at Baroda and its surrounding regions. The available base line information of past 4 decades on the floristic inventory of Baroda and its environs is valuable for a comparative account. Emphasis is given on scrutinizing herbaceous vegetation in the selected study area. Compared to trees and shrubs which live for highly variable period,

herbaceous plants grow, flower and form fruits completing life cycle in less than a year's period. These plants are sensitive and respond quickly to anthropogenic pressures. Their short period of life span facilitates a better monitoring of the changes/variations occurring during their life cycles.

Development of an electronic database of herbaceous vegetation of the study region to be linked later to any of the larger databases for wider dissemination of knowledge is also planned. Vegetation of the study area is of tropical type and has sizeable diversity. Moreover, sizeable number of flora has commonality in occurrence with that of flora of Western Ghats, one of the hot spots of the world. This boosts up the importance of the study. Availability of previous published records of vegetal cover of Baroda and its surrounding facilitates to look for evolutionary variations however small they could be.

**Keeping these as a background, the proposed study was initiated with objectives :**

**Preparing a database for the existing herbaceous vegetation.**

**Looking into the ecological divergences and evolutionary trends of herbaceous plants growing in Baroda and surrounding regions.**

**Approach for achieving the objective**

The present work was initiated with a review of previous work done on the grounds of floristic study of Baroda and its environs available in the form of Ph. D/dissertation works in the Dept of Botany. This is selected as a base line information for comparison. Details of the works are –

- 1) 1967 : A study on the flora and vegetation of Baroda and environs including an account of Cyperaceae of Gujarat - Ph. D. Thesis by Prof. S. D. Sabnis
- 2) 1973 . Studies on the flora and vegetation of Savli taluka - Ph. D. Thesis by Dr. S. N Padate
- 3) 1980: Studies on the residual urban vegetation system at Baroda - Ph D Thesis by Dr. S. N. Patil

The selection criterion of the background information was based on the following criterion.

- Availability of thorough milieu information
- Adequate time gap between earlier and subsequent works which can aid in making significant comparisons
- Variations in the environmental characters and anthropogenic pressures of the regions over a time period

Based on review of these works coupled with a preliminary survey of the study area the field experiments for this work have been designed and executed. Development of a database for this herbaceous vegetation comes from an exhaustive survey of prominent databases available.