Discussion

DISCUSSION

Increased human population demanding development in various spheres has resulted directly or indirectly in sudden and often far reaching disturbances in natural ecosystems. Humans have started to realize the tremendous impact their activities have on other species with which they share the resource of earth. Numbers of species are diminishing locally, regionally and finally leading to the global extinction. Extinction is a natural phenomenon. Anthropogenic activities and fragmentation of habitat are making species more vulnerable to extinction. Human pressures are larger in urban systems bringing huge variations in the local flora and fauna. In coherence with global climate, regional weather conditions are getting changed augmenting the magnitude of problems faced by the local biota. Plants clearly have sophisticated methods of determining the environment they experience. Herbaceous plants are sensitive and respond quickly to the anthropogenic pressures. Their short period of life span facilitated to monitor the variations occurring during their life cycles. This ability has important consequences for evolution of morphology, physiology and life history. Natural environment can generate powerful selection pressures, enough to drive evolution forward at a great pace if the variation is present. 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 phenotypic plasticity in most of species which allows individual, and therefore species, to cope with wide range of climatic conditions and pressures during their life times. Data available for the variations in the densities of vegetation because of anthropogenic pressures is very sketchy. It is more limiting for herbaceous vegetation as its monitoring is difficult. This makes it difficult to compare phenotypic variations of herbaceous vegetation across different time scales. Phenotypic plasticity is one of the first responses to be shown by plants as a reaction to anthropogenic activities. In this study availability of published records of vegetal cover of previous decades for herbaceous Baroda and its surroundings facilitated to look for evolutionary variations however small they could be.

The major objective of the present study was to develop a digital database of existing herbaceous flora of Baroda and environs. The database is presented in an electronic format. The results from the sampling study site and the comparative vegetation studies of present and previous years for Baroda and Savli region are discussed under separate subheadings along with pertinent citations. While inter-relating the data, some of the inferences are repeated, as the omission could not convey the message effectively.

Digital database

Bioinformatics or biological information technology is one of the most powerful and fast developing sectors in information technology. It is essentially a fusion of various facets of biological science and information technology. The rapid stride being made in the sphere of Information technology has already radically altered the course of civilization and has the potential to further course of correction in 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.

Importance of electronic data:

1. Data can be managed easily
2. Data can be simulated as needed
3. Data can be stored safely, with security and reliability
4. Data is easily retrieved

Electronic data along with the details of existing status of individual plant in a particular region, etc. congregated at one place can be made useful for various fields of biology like conservation biology, botany, medicine, zoology, etc. A digital database on herbaceous vegetation of Baroda and environs has been developed here which gives detailed information regarding the morphology, taxonomy, existing status, major associates and phenology of a plant. The online available databases of plants compiled by various national and international institutes provides substantial information on the geographic distribution, regional and vernacular names, citations in worldwide flora, etc. of plants but the primary data is seen lacking. Hence considering the lacunas, the present database for the region of Baroda and environs is prepared. The database consists information of 465 wild annual plant species belonging to 74 families. The information about the description of the plant contains actual field measurements of the plant and the existing density status in the region. The phenological data takes care of the periodic life cycle stages occurring in the plant. Data regarding the associated plant species includes the field observations. Hence, based on the collected information in the surveyed localities of the study area, a digital database in HTML format (for herbaceous vegetation of Baroda and its environs) is prepared which includes detailed taxonomic & ecological information, medicinal uses if any, and high resolution digital photographs of almost every specimens, which makes the identification an easy process. Special features of the species are also digitally highlighted. This provides useful information (data and images) without requiring users to physically visit each habitat. Moreover the primary data and high resolution photographs of the specimens can also help in future studies looking for the variations (local and regional) coming up in the plant species due to changing conditions and pressures.

General vegetation growth pattern

Natural communities often contain vegetation of diverse composition. Plant resource requirements, namely water, nutrients and light are similar for all species (Uriate and Reeve, 2003). Species composition reflects a combination of environment and historical events at a site; hence, changes in species composition can provide a sensitive measure of ecologically relevant changes in the environment (Philippi *et al.*, 1998). The area under study (Baroda & Savli) displays a remarkable diversity of herbaceous composition, although it is a part of thickly populated and highly industrialized region, especially the region of Baroda. Most of the land has either been brought under the plough or used for the construction of roads, factories and residential areas with the result that natural vegetation has become conspicuous by its absence and is present only in the form of few relict communities in the remote corners of the area. In such biotically disturbed area, the weed flora of the cultivated fields, waste land, ravine region, hedge flora occupy position of prime importance and form the most conspicuous aspect of vegetation. The area of Savli is an agricultural ecosystem and hence biotically less disturbed compared to the region of Baroda. Area is either plain or ravinous. The plains are mostly under cultivation and hence the hedge flora, weed flora and flora of waste land form a prominent part of vegetation pattern. Good variety of vegetation is also supported in various habitats like ravines, river & pond banks, etc. Greater amount of anthropogenic activities and habitat fragmentation prevails in the region of Baroda compared to that of Savli With more and more of land utilization, an absolute change in the existing vegetation pattern amongst the areas is clearly depicted. Carey *et al.* (1995) and Retuerto & Carballeira (2004) recognized that at local level, the presence of plants depends on their response to microclimate. Of the total number of species in a community as a whole, relatively small percentages are usually abundant and a large percentage is having small importance values. The pattern of few common species with large number of individuals associated with many species with moderate individuals is the characteristic structure of community everywhere. The quantative species abundance relationship vary everywhere (Odum, 1996; Gaston, 1996,1999). This rule (Raunkiaer, 1934) has been named the "*Law of infrequency*" (Palmer, 1995 and Herben, 2000). Model of community assembly by Hubbell (2001) highlights that all individuals of all species are ecological equivalents, and an increase in one species always imply a matching decrease in abundance of the remaining species Because plants are immobile, they interact only with their immediate neighbors Interaction here refers to any kind of effect, both positive and negative, that one plant individual may exert on another; however, the majority of interactions are due to resource competition for nutrients (by roots) and for light (by above ground organs) Plant species richness typically increases after a patch is created, but later declines due to dominance by competitive superior species (Wright *et al.*, 2003 and Vivian-Smith, 1997). As a consequence, in plant communities there may be individuals of very different sizes (both in numbers and size); interactions range then depends on the size of individuals that interact (Pacala & Silander, 1985 and Stoll & Weiner, 2000).

Similar pattern in the community structure was also detected in the present study, where of the total number of species in a community as a whole, a relative small percentage are usually abundant and a large number of plants are having moderate and low importance values. The species are usually in high numbers during their seedling stage. The intra and inter species competition amongst the species in the community resulted in lowering down the number of species until their establishment stage. The outcome of the interaction is determined by several factors: (i) size and distance of neighboring plants, and (ii) their species identity. In a community however, the maximum size is constrained by external factors (such as predictable periodical disturbance or very low productivity of the environments). After attaining the establishment stage, stability in terms of frequency and density is observed for a particular duration. Flower & fruit setting followed by seed maturation and dispersal stage puts an end to the life cycle of the herbaceous plant.

Sampling sites variations in vegetation structure and composition

The sampling sites in the sub areas of Baroda and Savli were selected on the levels of anthropogenic activities and their disturbance intensities to monitor the changes coming up in the vegetation growth pattern and composition due to above-mentioned pressures. High percentage of anthropogenic activities and disturbance levels were observed at sites of Nandesari and IPCL, moderate levels at Laxmi Vilas Palace and relatively lower levels of disturbance and anthropogenic activities were observed at Timbi, Mevli and Goral sites. This has revealed a direct impact of anthropogenic activities on the vegetation cover and composition available at each site

Site at Nandesari was surrounded by various small and large-scale chemical industries involved in the manufacture of various hazardous chemicals In addition to the above sources of pollution, the National Highway No 8, which passes through the industrial area with heavy vehicular traffic, effects the vegetation growing in the area Moreover a high amount of grazing pressure was observed in the site area. The landscape was highly fragmented and barriers for species dispersal were laid by the residential areas of bharvad community. Vegetation at site IPCL was effected by the pressures from the near by chemical industries and the grazing pressures prevailing at the site Moreover, the herbaceous vegetation was seen growing under the canopy of large trees, which has shown restriction in the vegetation diversity growing in the area. The site at Laxmi Vilas Palace was subjected to the pressures of vegetation clearance by the private authorities of the palace at higher rates which has effected the vegetation growing at the site Impact of anthropogenic activities and disturbances were observed minimal in sites, Timbi, Mevli and Goral. These sites were located away from the urbanized and industrial areas and hence the wild vegetation growth was under minimum pressures of any industrial or vehicular pollution. Activities of grazing, fuel wood collection were noted at a number of localities, but as the wild open area was spread in wider range, their overall impact was insignificant Moreover, the sites at Mevli and Goral were situated in the locality, which is an agricultural ecosystem (Savli region). The total area utilized for urbanization and industrialization is almost at low rate. Mainly the area comprises of small and scattered villages each occupied by few hundred human population and are delimited by immense proportion of land utilized in agricultural activities and ample proportion of land is in wild state in form of ravines and unutilized land. Hence, by and large the anthropogenic and disturbance stresses experienced by the wild herbaceous vegetation were comparatively less to those experienced by the vegetation at the sites of Baroda region.

a) variation in species richness

A variation in the species richness recorded in the sample study was noted amongst each site sampled. The lowest number was recorded at IPCL and highest at Goral

A reduction of plants in number and species diversity at the sites Nandesari and IPCL in this study is attributed to the pressures experienced by plants. The sites experienced high levels of grazing and trampling pressures. Other pressures experienced were of the major chemical industries and the high vehicular pollution. Similar pressures at the other sites were at low level When species differ in their capacity to establish under different abiotic conditions, patches with internal heterogeneity in such conditions are likely to have higher species richness than patches with little heterogeneity (Wilson, 2000; Gurney & Lawton, 1996 and Pacala & Rees, 1998) Disturbed sites have reduced species richness across a range of species functional groups (Rao *et al.,* 1990 and Daniels *et al.,* 1995). Similar observations were also made in the findings of (Armesto & Pickett, 1985; Huston, 1994; Grime, 1998 and Shackleton, 2000). Observations of this study are in conformity with these findings.

b) variation in number of dominant species

Variation was also noted in the species which dominated the specific community A correlation can be drawn between the number of dominants and total species richness in the community. The sites at Nandesari and IPCL possessed less dominant species compared to other sites It was observed that richer the community with species, more dominant members were noted. This was observed for the sites at Timbi, Laxmi Vilas Palace, Mevli and Goral. This is supported by the findings of Michelangeli (2000) who found a positive correlation between patch size and species richness. High numbers of dominant species were reported in the patch with higher species richness. A higher floral diversity can be an indicator of higher habitat diversity, and as Rosenzweig (1995) recalled it, "The greater the habitat variety, the greater the species diversity". The landscape surrounded by heavily industrialized and human influenced activities, contains many species of plants with low density (Kelly & Larson, 1997 and Haig *et al.*, 2000). Similar observations were made at Nandesari and IPCL sites where high number of species with low importance value existed

c) variation in morphological features

Variations in morphological features of good number of herbaceous plants growing in disturbed sites were found compared to those found in undisturbed conditions. The plants located at sites Laxmi Vilas Palace, Mevli and goral (relatively undisturbed sites) were taller and leaf/leaflet size were bigger then those documented at sites at Nandesari and IPCL (disturbed sites) A longer duration of vegetative period was observed for plants growing at undisturbed sites. In this longer duration of vegetative period, the plants attained more height and subsequently high percentage of branching was observed The higher percentage of branching in the plants directly reflected to allocate higher reproductive out put. The grazing pressure was noted high in the sites of Nandesari and IPCL compared to the other sites sampled. Variations observed in the morphological features can be attributed to the prevailing disturbances and high grazing pressures at the disturbed localities. Practices of grazing and trampling may change the habitat fitness for many species (Pandey & Shukla, 1999). Ericsson & Wennström (1997) and Gustafsson, (2004) reported that grazing involves browsing and trampling, which both cause leaf losses that can lower reproductive output and can cause long term effect on decrease in biomass. Similar conclusions can be made for the herbaceous plants observed at Nandesari and IPCL sites, where due to high grazing pressures the plants exhibited smaller size of leaf and leaflets compared to relatively undisturbed sites at Laxmi Vilas Palace, Mevli and Goral. Bazzaz (1991) has reviewed that plants alter in their resource environments through modifications of their modular structure. Plant expresses morphological changes that enable a plant to grow in the areas with scarce resources and stress conditions. Sultan (1987, 2000) and Schlichting & Pigliucci (1995) also reported that in plants, decreased biomass and developmental rates reflects the limitations of resources and the presence of stress. Donohue (1998) reported variations in the number of branches and in the overall size of plants observed in disturbed and undisturbed environments. Plants growing in favorable sites were larger and had more branches that hold more numerous fruits.

The foliage of vegetation growing at Nandesari region showed thick texture. Also vegetation at Nandesari showed symptoms of chlorosis which is the impact of industrial pollution This supports the findings of Bussotti *et al.* (1995) and Fredericksen *et al.* (1995) who reported an increase in leaf thickness in the polluted area and variation in leaf thickness accounts for differential sensitivity to atmospheric pollution. All these support the result and conclusion of this study.

Variation in color of floral parts was also observed. Flowers of wild herbaceous plants at Nandesari and IPCL showed paler coloration. This can be the impact laid by industrial and high automobile pollutants Further studies are necessary to confirm this assumption.

d) variation in reproductive and life cycle duration

Variation in the initiation of reproductive period in herbaceous plants was observed in the disturbed and relatively less disturbed sites The initiation of reproductive period in the sites at Nandesari & IPCL (disturbed sites) was seen 1 to 2 week prior to that at Laxmi Vilas Palace, Mevli and Goral. In addition, variation in the period of emergence of few late monsoon emergents was observed amongst these sites. In disturbed sites those plants emerged one week prior to that observed in the less disturbed localities. Even shrinkage of overall life cycle duration was observed for few plants growing in the disturbed localities. Shrinkage of 15-20 days in the life cycle was observed for the plants growing at the disturbed sites.

Early blooming and early emergence of few plant species at Nandesari and IPCL region is due to the prevailing pressures at the sites. The plants by this behavior, tries to utilize the available resources and mature flowers and fruits earlier before coming across nutrient deficiency and future pressures which directly resulted in curtailing of life cycle duration. Whereas the plants growing at Laxmi Vilas Palace, Mevli and Goral, as the pressures were at low scale, prolonged their vegetative growth period before flower and fruit maturation and hence the plant at these localities exhibited more amount of biomass and longer duration in life cycle. Sultan (2000) shown that plants are plastic for a remarkable array of ecologically important traits, ranging from diverse aspects of morphology and physiology to anatomy, developmental and reproductive timing, breeding system, and offspring developmental patterns Galloway (1995) documented plasticity in the reproductive timing due to anthropogenic pressures in several herbaceous species *Mimulus* plants flower early in unfavorable conditions, whereas plants growing in favorable conditions delay flowering to allocate more biomass to vegetative growth (Pigliucci, 1997). Similar observations of early blooming were made by Post & Stenseth (1999) in 13 species growing in 137 disturbed localities of North Atlantic Experiments conducted on timing and abundance of flowering on *Androsace septentrionalis* L. (Primulaceae) by Ionouye *et al.* (2003) in disturbed and undisturbed plots showed variation in abundance of flowering and the timing of reproductive period. According to Mahall and Callaway (1996), Donohue *et al.* (2000), Gehlhausen *et al.* (2000) and Godefroid & Koedam (2003) plants can specialize and evolve adaptations to particular competitive environments. Phenotypic expression of such adaptations hinges on resource availability and degree of overlap in competitors resource requirement. Donohue *et al.* (2000) and Donohue (2003) also reported that by flowering earlier, plants are able to have mature fruits before they experience conditions of stress. All these support the results and conclusions of this study. The results of present study contradicts with the conclusions of Klinkhamer (1996) who found that *Carlina vulgaris* grew faster and flowered earlier in undisturbed habitat than did plants in disturbed habitat

Diversity indices

The results obtained by calculating diversity indices for all the sampled sites, highlights presence of more diversity and evenness in community structure at the sites Goral, Mevli, Timbi and Laxmi Vilas Palace, whereas presence of comparatively less diverse community at sites IPCL and Nandesari. Cluster analysis implies better dispersal of the plants because of habitat connectivity within the patches of the community at Timbi, Mevli and Goral and moderate amount of dispersal within the community at sites Nandesari, IPCL and Laxmi Vilas Palace which is due to hindrance in the movement (dispersion) of plant species within the community because of habitat fragmentation and higher disturbance levels. Similar type of diversity indices have being worked by good number workers to determine high diversity and evenness in various types communities (Salami, 1998; Pandey & Shukla, 1999; Kutiel *et al.*, 2000; Bhuju & Ohsawa, 2001; Kitazawa & Ohsawa, 2002; Sagar *et al.*, 2003; Wilson *et al.*, 2003).

Variation in phenotypic plasticity

The vegetation pattern in terms of species composition amongst the region of Baroda and Savli showed high percentage of similarity. A range of differences in terms of the density status, growth pattern, phenology, etc. were seen The reproductive phase of many plants of Baroda region started early by 1-2 weeks compared to that of Savli The longevity of reproductive phase and life cycle duration of the herbaceous vegetation was high in the plants growing in Savli region. Gradation was seen in the recorded variations. Some of the areas in Savli showed similarity with the vegetation of Baroda. These areas were closer to Baroda region. Variation was also noted in the morphological characters and branching pattern in the plants of both regions. The plants documented in the Savli region showed an increase of 10-28% in foliage length, an increase of 5-45% in plant height compared to the plants collected from the urban areas of Baroda region. The plants from Savli region had profuse secondary branches that eventually resulted in higher amount of reproductive out put compared to the plants of Baroda region An increase of 7-18% of secondary branches was noted for the plants of Savli region and an increase of 10-45% of increase in reproductive output was noted from the plants collected from Savli region compared to those collected from urban areas of Baroda region. Similar results were found in the studies of Pinard *et al.* (2000) and Talamo & Caziani (2003) who concluded that on busy urban areas, plant species richness, species composition, density and basal area, are different to those in adjacent forests. According to Meyers & Bull (2002), plants modify their growth and morphology according to habitat conditions experienced. From the variations obtained in the current data it can be said that populations sometimes confront the fluctuations through phenotypic variation either: (1) within single individuals; (2) among individuals in the population at one time; or (3) in future generations When environmental and habitat conditions change rapidly and over shorter time scales than a lifetime, individuals that can show transformations in behavior, physiology and morphology might incur a selective advantage (Padilla & Adolph, 1996) Phenotypic plasticity is the potential for an organism to produce a range of different, relatively fit phenotypes in multiple environments (Scheiner *et al.*, 1991; Robinson & Wilson, 1996, De Witt *et al.*, 1998; Kingsolver *et al*, 2002 and Piersma & Drent, 2003). Phenotypic plasticity is an important mechanism by which organisms can adapt to variable environmental conditions, and plasticity has been documented in all major groups of organisms (Via, 1995 and Agrawal, 2001). It was observed that in natural habitats, plants often grow across spatially heterogeneous environments characterized by reciprocal patchiness of light intensity and soil nutrient availability based on the land use type and prevailing pressures. Therefore, growing within different microhabitats, vary in their performance (in terms of, e.g. biomass, dry weight, reproductive allocation, etc.). Accordingly, their pattern of biomass allocation, traits of morphology (e.g. those of height, leaf size, etc.) would be changed in an adaptive way in which capture of either of the different resources from patches where the resource is abundant is enhanced. There are many studies documenting substantial phenotypic changes especially with regard to sizes in relation to resource availability (Piersma & Lindstrom, 1997) Also according to Klinkhamer & De Jong (1993) and Sletvold (2002) reproductive output always increases with plant size. These reasons can be attributed for the higher reproduction output for the plants growing in Savli region than Baroda region because of increase in size of the plant In seasonal environments, different activities related to reproduction and survival are usually separated in time within individuals, and tend to occur at predictable times of the year accompanied by changes in mature adult phenotype. According to Padilla & Adolph (1996) the capacity for rapid phenotypic changes will have obvious fitness payoffs. With habitat fragmentation, species experience reduced habitat scales, facilitating selection for adaptation to local conditions. Subdivided populations subjected to heterogenous environmental conditions (often due to anthropogenic influences) commonly exhibit rapid evolution (Reznick & Ghalamber, 2001). The growing number of examples of rapid evolution (Able & Belthoff, 1998 and Abrams, 1996) indicates that many species respond quickly to new selective pressures, and most of the selective pressures associated with human activity will be extremely strong (Palumbi, 2001) The ubiquity of heterogeneity in natural habitats makes it likely that plasticity must have evolved enabling plants to cope with, and perhaps even to benefit from, heterogeneous nutrient conditions (Wijesinghe & Hutchings, 1999 and He *et al.*, 2004). Hierarchical selection may occur at different organization levels of modular plants, the same environmental pressure modifies some traits but not others at the level, or may affect plasticity at one level but not another (Donohue *et al.,* 2000 and Sultan & Spencer, 2002). Plasticity, which can be an important adaptation to variable environments, can be subject to natural selection (Sultan & Spencer, 2002). The fitness advantages of plastic responses have been demonstrated in rhizomatous plants (Humphrey & Pyke, 1997 and Alpert, 1999). Variations seen in the plasticity of few of the characters like vegetative and reproductive periods, branch and flower size, etc observed in this study are in support of the above citations.

Vegetation structure and anthropogenic activity amongst the regions of Baroda and Savli

The vegetation pattern in terms of species composition amongst the region of Baroda and Savli showed both commonness as well as variations. Commonness in terms of herbaceous species diversity was observed between the two regions. A range of differences in terms of the density status was observed Total percentage of plants occurring with high density was more in Savli region compared to Baroda region where as percentage of plants occurring with moderate and low density was high in Baroda region compared to Savli region. Baroda region is an industrialized urban system with diverse anthropogenic activities. A high percentage of variation in existing human population was also noted amongst the two regions. Baroda regions possess 85% high percentage of human population compared to Savli region and hence high percentage of land utilized for residential purposes. This has altered land use/land cover pattern resulting in the deeper fragmentation of the habitat. Hence, the area available for natural vegetation has been reduced. Road widening in various areas of Baroda has resulted in leveling up the road side ditches where good number of wet land communities were seen growing during monsoon. This has led in lowering down the density of habitat specific plants in the Baroda region. In Savli region, such activities are observed at a minimum scale. The wild land and various habitats like wetlands, agricultural fields, ravines, etc. available in the Savli region are four to five folds higher than what was observed for Baroda region According to Holt *et al.* (1995) the current state of any plant community represents a sum of processes, including initial conditions, wide ranging events, and spatially localized dynamics Species composition at a site provides a strong signal of environmental factor of interests; it may be of direct ecological interests and may be a feasible measurements Because environmental factors differentially affect species and species composition can provide information about environmental factors (Philippi *et al.*, 1998). According to Hoffmann (1998) each plant species is bound to specific site conditions. If the site conditions change (e.g intensity of land use, climate), plant species will respond with altered abundances and hence alter the distribution patterns in a landscape. Many plants are therefore known to be good indicators of site conditions and possibly can serve as indicators of changing environmental conditions. Savli region is agrarian while Baroda region is an industrialized urban system. Hence, levels of anthropogenic activities were noticed less in Savli region compared to Baroda region. Activities such as road widening and conversion of wild lands and agricultural fields into residential lines in Baroda region are responsible for lowering the density of a good number of plants occupying different habitats in the region which was noticed at minimum scale in Savli region These activities were found mainly responsible factor for the restricted distribution of good number of species found in Baroda region compared to that of Savli region. According to Polasky *et al.* (2000) conversion and fragmentation of natural land cover by humans is cited as one of the main factors leading to the overall decline of biological diversity and the extinction of many plant and animal species. Loss of habitat through land use practices has been recognized as the major threat to diversity (Wilcove *et al.,* 1998 and Rouget *et al.,* 2003). According to Blomqvist *et al.* (2003) small-scale landscape elements, such as ditch banks, field margins, hedgerows and road verges are an important remaining source of biodiversity in many landscapes. Similar conclusions were given by Ripple *et al.* (1991), Reed *et al.* (1996), Tinker *et al.* (1998) and Saunders *et al.* (2002) in their studies. The division of the landscape by linear elements such as roads, power line corridors and other rights-of-way contributes to this loss of habitat. Landscapes bisected by these elements would be expected to have more and smaller habitat patches, decreased connectivity between patches, decreased complexity of patch shape, and higher proportions of edge habitat (i e habitat that is modified from the interior conditions expected for that land-cover type) Small landscape elements are believed to function as natural corridors between habitat patches in fragmented landscapes (Fritz & Merriam, 1993 and Corbit *et al.*, 1999). Ditches, hedgerows and other small landscape elements do function as important habitat refuges for the survival of many plant species (Corbit *et al.,* 1999; Honnay *et al*, 1999 and Endels *et al.,* 2002). Ecological impacts of roads may include: (1) direct removal of habitat (Geneletti, 2003), (2) fragmentation of remaining habitat into smaller, isolated remnants (Findlay & Houlahan, 1997), (3) imposition of edge effects of multiple types (on structure, function and composition) and different depths (Meffe & Carrol, 1997); (4) enhanced dispersal of particular species (Trombulak & Frissell, 2000) or introduction of exotics (Forman & Debliger, 2000) with concomitant alterations of community composition (Angold, 1997); (5) disruption of dispersal of organisms (i.e. a barrier function) and concomitant isolation of populations (Meffe & Carroll, 1997) and (6) chronic disturbance from human activity and vehicular traffic (Reijnen *et al.*, 1996). The small-predicted effect of fragmentation on the extinction threshold is supported by simulation studies and empirical studies, which found that the effects of habitat loss far outweigh the effects of habitat pattern (fragmentation) on population density and survival. (Fahrig *et al.,* 1995; Andren, 1997; Bascompte & Sole, 1996; Eriksson & Kiviniemi, 1999; With & King, 1999 and Fahrig, 2001) The observations and conclusions of present findings support the findings mentioned above.

Metapopulation structure

A metapopulation is a collection of subpopulation of the same species, each of which occupies a separate patch of a subdivided habitat (Hanski, 1994, 1999). As habitat loss and fragmentation become the dominant force in shaping ecological communities, study of metapopulations provides important insights into how fragmentation of habitat and changes in population size should be managed and conserved (Dobson, 2003).

Listed plants of this study fall in three ranges of metapopulation structure: broad range, moderate range and narrow range. The plants falling in broad range were those inhabiting a wide range of habitats in the study region. It was found that the probability of these plants to continue through generation is high as, if one of the habitat is fragmented or disturbed or destroyed, then the continuity of those plant can persevere through the other range of habitats. The plants falling in the moderate range of metapopulation were those that were distributed in specific habitat across the area but their status in that specific habitat was very high or in other words the plants were dominating in that particular habitat. The probability of these plants to continue is secured in a particular region until the specific habitats are protected. The disturbance or destruction of habitat might result in lowering down the population composition of this particular group of plants. The plants with very narrow range of metapopulation were those which were seen growing in a specific habitat or were distributed in the narrow pocket of a particular region only. The density status of these plants was also seen to be of meager amount. The extinction risk of this group of plants is high as the disturbance, fragmentation or clearance of that particular habitat might result in disappearance of these plants from the region. The metapopulation model proposed by Hastings (2003) points out that for a single species, survival is possible if, per patch, the rate of extinctions due to disturbance is less than the rate of colonization. Extinction threshold is the minimum amount of habitat required for a population of a particular species to persist in a landscape (Hanski *et al.*, 1996). As the amount of habitat in the landscape declines, models predict that the overall mortality rate increases relative to the overall reproduction rate. Simulations (Fahrig, 1987; Hill & Caswell, 1999 and With & King, 1999) predict that habitat loss can increase the extinction threshold such that more habitats are needed for population persistence in more fragmented landscapes. According to Bascompte & Sole (1996) if an organism is constrained strictly to one type of habitat in the landscape, then as habitat is lost and patch populations become smaller, and local (patch) extinction probabilities increases. The same reasons can be attributed for the plants falling in the narrow metapopulation range. Because there is no between patch movement, the overall extinction probability depends simply on the size of the largest patch in the landscape. Species with small ranges (i.e. those present in a small number of regions) are the first to go extinct, because these species are likely to have lower mean population density (Lande, 1993; Mills & Smouse, 1994; Brown *et al.,* 1996 and Fahrig, 2002). According to hypothesis made by Robinson & Quinn (1988) species richness will decline on habitat fragments compared to continuous land, more on small than on large fragments. This can be as population can become small on fragments and risk of extinction is greater for small populations A decline in the richness of habitat specialists will result in decline in the richness of the whole community. Rare species will be more susceptible to extinction than common species because their populations become smaller than those of co-occurring species of higher natural abundance. The more fragmented a habitat already is, the greater is the number of extinctions caused by added destructions Populations of rare plants often exhibit patchy distributions under natural conditions (Wolf, 2001 and Oertli *et al.*, 2002) It was observed that although conditions within isolated habitat patches are suitable for population growth, smaller populations may still suffer extinction risk from stochastic events; common species will become more common, while intermediate species have become rarer. According to Mangel & Tier (1994), Bakker & Berendse (1999), Berendse *et al.* (1999), and Hilderbrand (2003) decline in intermediate species is particularly worrying; since they are likely to become the new threatened species in the future. The more restricted a population's capacity to expand, the greater the risk of local extinction. Low local abundances and small geographical ranges typically increase the risk of extinction that species face According to Gaston (1998), local rarity increases the likelihood that demographic and environmental stochasticity will wipe out populations, and a restricted distribution means that all or most individuals will probably experience adverse conditions simultaneously. According to Tilman *et al.* (1994) extinctions occur generations after fragmentation and represent a debt-a future ecological cost of current habitat destruction. Habitat destruction lowers effective colonization rates of all species. A slight increase in habitat destruction threatens many more species if a large portion of habitat already is destroyed. Rare species are always subjected to stochastical extinction. Dominant species often are considered to be free from extinction threat because they are abundant in the undisturbed fragments that remain after destruction. The results and conclusions of this study are in conformity with the above findings.

Comparison with past data

The current data (2001-2003) of growth pattern and composition of herbaceous vegetation within the regions of Baroda (disturbed ecosystem) and Savli (lesser disturbed ecosystem) was compared with the previous records on floristic work of Baroda and environs which were conducted during the years 1967 & 1980 and for the Savli region in the year 1973. The study area of Baroda is an example of an urban ecosystem where tremendous urbanization and industrialization during last 4 decades have changed the whole environment. High degree of irregularity has been noted in seasonal changes, mean annual rainfall period and a rise in the yearly temperatures as evident from meteorological observations of the observatory of M.S. University. The annual rainfall calculated for the years between 1960's to 1980's was 84 cm where as a decline in annual rainfall for the next two decades was recorded i.e annual rainfall between years 1980's to 2000 was calculated to 74 cm. Maximum heat periods were recorded in the months of April and May during the years 1960 to 1980 In the years between 1980 to 2000, max temperatures were experienced in April, May, June and July In the years 1996, 1999 and 2000, max temperature was also recorded in the month of March (Meteorological Data from M S. University, Baroda). Hence a high variation in temperature and yearly rainfall is experienced in the region since last 4 decades. Herbaceous plants being sensitive respond quickly to the changing conditions and pressures experienced and the reactions are viewed in terms of shifts in density structure and phenological pattern. Rapid industrialization and urbanization has resulted in the shrinkage of overall land available for wild plants to grow. This has resulted in higher competition for space and resources. These impacts have directly affected the overall populations of plant population growing in the region. The situations observed for Savli region are at different grades. The region of Savli is comparatively lesser disturbed ecosystem compared to regions of Baroda. The developmental activities like industrialization and urbanization are observed at a lower scale compared to those observed for Baroda region Hence, the difference between the current vegetal cover and of the past records was moderate. The shifts in density are observed at minimum scale. The plants, which were reported earlier as occurring in very meager density and restricted to one particular locality, failed to get relocated. The shifts in the phenological durations compared to previous records were also observed at lower scale.

According to Soule (1991), Ehrlich & Wilson (1991), Raven & Wilson (1992) and Sinclair *et al.* (1995) humans have caused numerous species extinctions primarily through the conversion of natural habitat into land dominated by agriculture and other anthropogenic activities. Comparing the current data of Baroda region with past records it shows that the graph of species with common occurrence has shown a decline whereas high numbers of commonly occurring species in previous records have experienced a decline in density. Majority of species, which were reported to occur in very small ranges in earlier records, were found to undergo local extinction. These were species, which were restricted to a particular region with very low number in their population patch and habitat destruction in that particular locality is found responsible for the local extinction of those species. Moreover, changes in reproductive period of herbaceous plants were noted for various years of study. Two major changes were observed, one was change in the timing and the second one an alteration in the duration of reproductive period By and large, the duration was curtailed

The main reasons attributed to these changes are

1) anthropogenic pressures

2) fragmentation of land

3) variations in meteorological parameters

The impact seen on the plants are

1) decline in density

2) change in metapopulation

3) alteration phenotypic plasticity

Climatic changes

Impact on climatic changes on the overall growth pattern and the phenological changes is reported in many studies (Jeffree & Jeffree, 1994; Philippi *et al.*, 1998; Silvertown, 1998; Brown, 2003 & Khanduri *et al*, 2003). Root *et al.* (2003) reported that four types of change in species' traits due to climatic fluctuations are possible: first, the density of species may change at given locations, and the ranges of species may shift, second, because many natural history traits of species are triggered by temperature-related cues, changes could occur in the timing of events (phenology), such as migration or flowering, third changes in morphology, and fourth, genetic frequencies may shift The impact of long term variations in temperature and rainfall in Baroda region was observed on the phenological pattern of herbaceous plants The reproductive period is seen preponed for a good number of plants currently as compared to those of previous records Moreover shrinkage in the overall duration of reproductive period is noted for herbaceous layer compared to the previous records. Similar impact of climate changes on vegetation structure were made by Parmesan & Yohe (2003), Root *et al.* (2003) and Thomas *et al.* (2004) in their studies where they have shown numerous shifts in the distributions, abundances and phenology of plant species compared to past 30 years of records. According to reports of IPCC (2001), over the past 100 years, the climate of earth has warmed by approximately to 0.6^0C with two main periods of warming between 1910 and 1945 and from 1976 onwards. The rate of warming during the period 1976 onwards has been approximately doubled when compared with the period between 1910 and 1945, which is greater than at any other time during the last 1000 years. National Aeronautics and Space Administration (NASA), USA indicated that the year 2002 goes down in the record books as the second warmest year on record since recording keeping of global temperatures begin in 1867

Flowering plants are the first indicator of climate change. According to Menzel & Fabrian (1999) changes in phenology from year to year may be a sensitive and easily observable indicator of changing biosphere. Brown (2003) reports that rising temperatures are causing plants to burst into bloom weeks earlier. Abu-Asab *et al.* (2001) reported advances in first flowering in 89 species in Washington DC, showing a significant advance of 4.5 days over a 30-year period. Menzel & Estrella (2001) reported that, flowering in numerous plant species occurred 3-4 days earlier per decade over the past 50 years, and in North America these activities occurring 1.2-2 days per decade earlier over the last 63 years. The classical neodarwinian view of adaptation maintains that populations tend to evolve characteristics that make them well suited to the particular conditions experienced over a long period of time and at a small spatial scale (Pigliucci, 1996). Recent research has revealed that evolution often occurs on contemporary time scales, often within decades (Bone & Farres, 2001 and Stockwell *et al.*, 2003) Monocarpic plants, which flower once and then die, are ideal systems for testing evolutionary ideas because the cost of reproduction is easily quantified and the timing of flowering is a key determinant of fitness (Metcalf *et al.*, 2003). Similar conclusions can be drawn from the present study where herbaceous plants have shown shifts in the phenological conditions compared to those recorded in 1967 As depicted from the meteorological data, high fluctuations in the yearly rainfall and temperature recorded since past 4 decades could be a major reason for variations Change in species composition occurs for many reasons, one of which is a response to a change in the underlying environment Plant species composition naturally changes at temporal scales from seasonal phenology and year to year fluctuations. Plants alter their phenotypes as they experience variations in local environment conditions. This has resulted in shifting the flowering period or reproductive period 10-15 days early compared to past records and the same is observed for continuously for three years of study tenure. Moreover the climatic fluctuations and pressures also have resulted in shrinkage of life cycle duration for a good number of herbaceous plants compared to past records especially for Baroda region. Few plant species have also shown an increase in the total reproductive period. These plant species are seen maintaining high density as compared to the previous records. By these shifts, plants are able to adapt with the prevailing environmental conditions in the manner to get best benefit from the available resources and end the life cycle before they experience stress conditions (abiotic) and also from their superior competitors.

Impact of disturbances, anthropogenic pressures and land fragmentation

Compared to the past records, the current inventory of herbaceous plants from Baroda and Savli region reveled a decline in the density status of good number of herbaceous plant species. Fair number of plant species occurring in high densities during 1967 and 1980 are now showing decline in their density structure. The plants which occurred previously in low density status are in the verge of local extension. The reasons can be attributed to changing landuse pattern and increasing anthropogenic pressures. Large proportion of land which was available in the form of agricultural fields and open wild lands where plants previously flourished, are now being rehabilitated to industrial and residential areas. This has led to deeper fragmentation of land area which was previously continuous The development of industrialization, high standard of living and increasing human population in the area has led to escalating in the city boundary which has resulted in removal of wild habitats and rehabilitating it for residential and commercial purposes. Similar type of impact is observed at low scale in Savli region because compared to the regions of Baroda, the development, industrialization and commercialization are at very low scale. Hence compared to past records for Savli region, much fluctuations in the density structure of herbaceous plants was not observed in the current inventory. According to the available data, anthropogenic habitat conversions are currently at their historical maximum (Tilman *et al*, 2001 and Seabloom *et al.,* 2002). If this process of habitat conversion expands further into biologically rich lands that are currently only threatened, then rates of extinction will rapidly increase. Destruction of habitat in a landscape results in loss of populations of organisms that depend on that habitat. Different species disappear at different points on the habitat loss gradient (Gibbs 1998, 2001; Eriksson & Kiviniemi, 1999 and Davis, 2003). Similar effects of land fragmentation on plant species (Fahrig & Merriam, 1994; Schumaker, 1996; Fahrig, 1997; Harrison & Taylor, 1997; Vitousek *et al.*, 1997; Bender *et al.*, 1998; Forys *et al.,* 1998; Fritts & Roodda, 1998; Debinski & Holt ,2000; Davies *et al.,* 2001 Scheffer *et al.,* 2001; Sawchik *et al.,* 2002 and Ashley *et al.*, 2003) and anthropogenic pressures (Hendry & Kinnison, 1999, Bone & Farres, 2001; Kinnison & Hendry, 2001; Reznick & Ghalambor, 2001; Wood, 2001; Endels *et al.,* 2002 Garbutt & Sparks, 2002 and Severns, 2003) are being analyzed by good number of workers. It can be said that fragmentation reduces habitat area and adds to the length of exposed edge that is facing surrounding landscape and ecological consequences of fragmentation results in direct effects of habitat loss and indirect effects of reduced inter-patch dispersal. Habitat patches that survive the process of fragmentation become increasingly isolated from one another and this can cause species decline in excess of predictions based strictly on reductions in habitat area. Anthropogenic pressures result in reduction of populations of species which are unable to cope up with the changing conditions and at times leads to local extinction of species which are continuing with low density. It may also alter the microclimate, interfere with population and community dynamics and as a consequence may reduce the number of species present as well as number of organisms within a species (Foster & Gaines, 1991, Saunders *et al.,* 1991, Lamberson *et al.,* 1992, 1994; Pulliam *et al.,* 1992 and Haig *et al.*, 2000). At within patch scale, fragmentation can increase the risk of local extinction The term "microevolution" is generally used to refer to changes that take place due to prevailing disturbances within species and populations within the approximate lifespan of a human being (Dobzhansky, 1941 and Hendry & Kinnison, 1999) Measurable microevolutionary change on plant species due to prevailing pressures has often been observable over periods of years or even months (Gingerich, 1993 and Hendry & Kinnison, 1999). Contemporary evolution is associated with the same factors that are driving the current extinction crises: habitat loss and degradation, over harvesting and exotic species (Hendry & Kinnison, 1999) Similar conclusions can be made from present study where due to prevailing pressures and fragmentations, shifts in density status, phenology, etc. in plant species is observed compared to previous records and this shift is stabilized as observed from the three years of study tenure. 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 in future is likely to bring more alterations in similar manner.

Reasons for few plants to maintain dominant position through decades

Good number of plants which were documented in early records to exist in high densities are still maintaining their high density status. These plants are viz. *Cissampelos pareira, Cocculus villosus, Argemone mexicana, Cleome viscosa, Cleome gynandra, Bergia odorata, Sida acuta, Corchorus aestuans, Cayratia trifolia, Crotalaria medicaginea, Indigofera linnaei, Tephrosia purpurea, Teramnus labialis, Clitoria ternatea, Rhynchosia minima, Cassia tora, Melothria maderaspatana, Trianthema portulacastrum,* etc. along with a wide range of Poaceae and Cyperaceae members.

These plants are seen possessing a good number of below mentioned properties, which seems to be responsible for their maintenance of high-density status through decades

a) **These plants do not have any specificity for a particular habitat.** These plants are seen occupied in variety of habitats like ravines, road side hedges, as weed in agricultural fields, fallow fields, bank of river and ponds, etc. By being flexible in habitat preference, have better phenotypic plasticity and plants are able to adapt themselves in multiple habitats. Hence, this increase their probability of surviving with high density through generations.

b) **The duration of their flower opening.** The flower opening duration in these plants observed is continuous for entire day or for few days together. This facilitates visits of more number of and variety pollinators which aids in high probability of genetic exchange and seed setting.

c) **Longer life cycle duration.** The life cycle duration of these plants observed is of more than 6 months. In this longer life span, plants are able to produce more fruit and seeds which eventually results in maintaining high density.

d) **Size of flower and seeds.** The size of flower and fruits observed in these plants are usually smaller and flowers are usually grown in as inflorescence or the fruits possess seeds of high number and smaller in size. Presence of inflorescence results in attracting more number of pollinators and results in high amount of genetic exchange. High number and smaller size of seeds ensures them with assured levels of continuity by minimizing the adverse effect taking place from predation and wastage, thereby giving rise to high density of plant population in succeeding generations.

e) **Associates.** The plants are seen growing with variety of associates most of them acting as facilitators.

f) Other properties like **climbing nature, rooting at nodes, etc.** makes the plant to overcome the trampling and grazing hazard by continuing the growth through the rooted branches and branchlets.

g) **Plants growing in post monsoon period.** These plants can avoid high level of inter species competition for space and resource because by the time the post-monsoon individuals emerge, the monsoon emergents are at their climax stage.

h) **Members of Graminiae.** Mostly all grass species are found extended through out the entire area inconsequential of disturbed or undisturbed conditions. As the underground parts of the plants are perennial in nature, the plants are able to overcome various pressures of grazing, trampling, etc Moreover the plants also have high reproductive output, and hence can continue with high density through generations.

Fischer and Stocklin (1997) and Holt (1997) demonstrated local extinction risks to be lower for species with longer life cycles and species which commonly occupy diverse array of habitats. According to Blate *et al.* (1998), Kollmann *et al.* (1998) and Moles *et al.* (2003) large seeded species have lower survivorship through post dispersal seed predation than small seeded species. According to Tilman (1994), Bekker *et al.* (1998) and Leishman *et al.* (2000) frequent and severe disturbance may tend to favor species with high colonizing ability and thus long term preference is for plants having numerous small seeds Similar results on herbaceous species are shown in the experiments by (Hau, 1997; Reader, 1997; Hulme, 1998; Moles and Drake, 1999; Kıvıniemi, 2001 and Moles & Westoby, 2003). Species producing smaller seeds have a colonızation advantage relative to larger seeded species. Small-seeded species may also disperse better in time because they live longer in soil seed banks and suffer less seed predatıon (Harper *et al.,* 1970; Rees 1993; Guo *et al.*, 2000 and Levine & Rees, 2002). Petersen *et al.* (2000) ın his study on relationship between ınflorescence size and reproductıve output concluded that higher reproductive yield exısts among plants havıng inflorescence Jennersten (1988), Menges (1991) and Jennersten & Nilsson (1993) in their study highlighted that larger inflorescence size ıs assocıated with higher pollınation activity and hence hıgher seed setting. Experıments done by Auerbach *et al.* (1997) in the disturbed and undısturbed areas predicting the densıty and bıomass of herbaceous species growing in the area found that gramınıoıds were the only growth form to have sıgnıficantly hıgher biomass and densıty both ın disturbed and undisturbed condıtions and gramınioıds are more successful plant species in the dısturbed condıtıons. Observations of this study are ın line with these fındings.

Herbarium comparison

A good number of studies have demonstrated that the local extinction can be studied by comparison of past data with current data (Ouborg , 1993, Bisang &. Urmi, 1994; Leach & Givnish, 1996, Rich & Woodruff, 1996; Fischer & Stocklin, 1997 and McCollin *et al.,* 2000). A similar pattern of herbarium comparison of previous records with current collection was also followed in the present study for the plants that have shown reduction in density compared to earlier records. The study reported that sizable number of plants has show reductions in size and number of flower, fruit & seed, in the size of plant, in branching pattern, finally affecting the size of population. These reasons might have eventually resulted in declining the population by lowering down the reproductive out put and responsible for the density decline of plants in the region. Lande (1995), Lynch *et al.* (1995) and Newman & Pilson (1997) reported that with a decrease in effective population size of plants, the risk of local extinction increases over time through the accumulation of deleterious alleles, and stochastic events According to Menges (1991), Heschel & Paige (1995), Agren (1996), Fischer & Matthies (1997) and Hendrix & Kyhl (2000) plants from small populations produce less fit progeny and have lower vigor. Sheridan & Karowe (2000) reported that multiple consecutive generations of inbreeding in small populations could result in inbreeding depression, a process that weakens the average individual fitness through repeated generations of inbreeding and the overlap of deleterious alleles. Plants show symptoms of inbreeding depression by displaying decreases in survivorship across life-history, seed weight, seed set (Agren, 1996 and Kery *et al.,* 2001), and progeny fitness (Karoly, 1994 and Sheridan & Karowe, 2000). Bruna (1999) reports that flowering probability is low in wild plants growing in disturbed and fragmented landscape. In this study also the plants which have shown reduction in reproductive structures, were found growing in a small size of population. Past records depict that the plants were growing in sizeable populations in the reported localities. The habitat from where the plants were collected were reported to be continuous during the earlier years but now have shown high amount of fragmentation due to developmental activities and are encircled by high levels of disturbance which is the probable reason for the isolation of population of the plants The populations of plants viz. *Merremia tridentata,* *Hibiscus lobatus, Asphodelus tenuifolius, Exacum pedunculatum, Hoppea dichotoma, Cleome simplicifolia, Sutera dissecta, Sida alba, Desmodium gangeticum*, *Biophytum sensitivium, Clitoria biflora*, *Tephrosia strigosa, Sopubia delphinifolia*, and *Indoneesiella echioides* were reported to grow in good population patch in specific localities, which due to urbanization has in recent period undergone fragmentation. The mentioned plants were located in isolated populations in a group of 3 to 4 individuals and at times growing singly separated at a distance from similar companion. Hence variations in the morphological and reproductive features were noted by examining the plants from the past records of herbarium specimens *Merremia tridentata* has shown decline in the flower number and corresponding fruit number. This has been noted by the increase in nodal interval of flower growth compared to the past collections. *Hibiscus lobatus* have shown a decline in the seed out put 34-43% of seeds are showing shriveled texture and reduction in size compared to the past collections *Asphodelus tenuifolius* have shown reduction in flower and fruit size and seed number compared to past collections *Hoppea dichotoma* have shown reduction in the overall height and a high reduction in reproductive out put compared to past collections. *Exacum pedunculatum* have shown reduction in the overall height and a high reduction in reproductive out put. Also a reduction is noted in the size of the flower compared to past collections. *Sutera dissecta* have shown 38-41% of reduction in the reproductive out put and 40-45% reduction in the height and branching pattern compared to past records. *Biophytum sensitivium* have shown a height reduction to 25-30% and 40-45% reduction in reproductive output compared to past records. *Tephrosia strigosa* have shown 30-34% reduction in fruit number compared to past records. *Indonessiella echioides* have shown reduction in spike length and 23-31% reduction in the flower number compared to past records. *Sopubia delphinifolia* have shown reduction in the height and 25-40% reduction in the reproductive output compared to past records. *Cleome simplicifolia* have shown reduction in 25-35% reduction height and reproductive output compared to past records. *Clitoria biflora* have shown reduction in reproductive output compared to past records. *Sida alba* have shown reduction in height and reproductive output compared to past records. *Desmodium gangeticum* have shown reduction in seed number per pod compared to past records Severns (2003) reported effect of long-term disturbance and fragmentation cause population isolation and inbreeding depression in Kincaid's lupine colonies, such as low seed production. Lienert *et al.* (2002) reports that in *Swertia perennis* small site area combined with a high degree of spatial isolation negatively affected populations: density of adult plants, genetic variability and several phenotypic fitness measures were all significantly reduced in isolated plants A combination of stochasticity with these genetic and demographic factors could eventually lead to population extinction.

Habitat fragmentation, which subdivides sites and isolates populations, also induces negative effects of small population size on population viability through generations (Saunders *et al.*, 1991, Jennersten *et al.*, 1992, Ellstrand & Elam, 1993, Young *et al.*, 1996; and Young & Clarke, 2000) The persistence of small, isolated populations is threatened by environmental, demographic and genetic stochasticity (Shaffer, 1987). Negative effects of small population size on plant fitness can further increase extinction risks of small populations (Courchamp *et al.*, 1999 and Stephens & Sutherland, 1999). Lesica & Allendorf, (1995) reported that the existence of locally rare, or peripheral populations, could be due to a number of factors including past stochastic events. The effects of isolation and a typical habitats can result in peripheral populations diverging from central populations both morphologically and genetically, as a result of genetic drift and natural selection. Furthermore, such populations are often isolated and of a smaller size. This may lead to lower levels of gene flow between populations, possible inbreeding and consequent loss of genetic diversity, all of which also combine to increase the rate and level of divergence. As populations with very low levels of variability may be unable to adapt and evolve to changing environmental conditions, including climatic change (Jones *et al.*, 2001), the adaptive capacity of these small populations may be compromised in the long term. Parmesan & Yohe (2003), Root *et al.* (2003) and Thomas *et al.* (2004) assume that each species of plant can persist only under a particular set of climatic conditions. As disturbance and shrinkage of land persists, their ranges often contracts as the area of climatically suitable habitat declines. Few studies have examined how long term climatic changes might be linked to the immediate causes of declines in the plant population (Kiesecker *et al.*, 2001 and Pounds, 2001) From a population genetics perspective, such changes can promote genetic drift in local populations if sizes of local populations are small enough to effectuate drift yet remain large enough to buffer populations against chance extinction (Fore & Guttman, 1996). Such changes can also promote genetic divergence among local populations if habitat fragmentation substantially reduces gene flow among them (Whitlock & Barton, 1997). These outcomes are significant because prolonged isolation can reduce gene exchange and thereby lower population viability, via depression in a variety of fitness components. These reasons can be correlated to the reduction in reproductive output and reduction in overall size of the plants viz. *Merremia tridentata*, *Hibiscus lobatus, Asphodelus tenuifolius, Exacum pedunculatum, Hoppea dichotoma, Cleome simplicifolia, Sutera dissecta, Sida alba, Desmodium gangeticum*, *Biophytum sensitivium, Clitoria biflora*, *Tephrosia strigosa, Sopubia delphinifolia*, and *Indoneesiella echioides,* which are reported in the present findings.