A GEOGRAPHIC INFORMATION SYSTEMS TOOL DEVELOPMENT FOR GEOSTATISTICAL ANALYSIS OF ENDANGERED ENDEMIC VASCULAR PLANTS OF TURKEY

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF INFORMATICS
OF
THE MIDDLE EAST TECHNICAL UNIVERSITY

BY

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE
IN
THE DEPARTMENT OF INFORMATION SYSTEMS

MAY 2005

Approval of the Graduate School of Informatics

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ABSTRACT

A GEOGRAPHIC INFORMATION SYSTEMS TOOL DEVELOPMENT FOR GEOSTATISTICAL ANALYSIS OF ENDANGERED ENDEMIC VASCULAR PLANTS OF TURKEY

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May 2005, 135 pages

Modern information systems strive to provide effective use of resources. Supplied with analysis tools, geographical information systems (GIS) can serve its stakeholders with minimal requirements.

In this study, GIS capabilities were employed for Turkish Flora. Data related with the threatened plants that are indigenous to Turkey were gathered from the relevant literature and reshaped into a dataset in which spatial locations were represented in a geographically referenced format. Afterwards, this output was used to investigate the affects of different factors on the distribution patterns of these plants by means of functions of GIS and multivariate analysis. At last, overlay analysis was employed in order to reveal the congruence between official protection reserves, spatial locations of the plants in danger and areas of importance for other elements of wildlife specifically birds.

Outcomes of the study is three-fold. First of all, a simple algorithm was established which can be used in the formation of a unified database of widely distributed floristic data in Turkey. Geographically referenced data and the analysis results produced in the study is another value added for Turkish botanics. From another perspective, effectiveness of GIS in handling different types of non-standard data were scrutinized. Overlay analysis of locations of the plants and the protection reserves constituted the managerial aspect of the study by pointing large gaps in the actual protection coverage and proposing candidate regions for official reserve choices of the future. In essence, GIS was deemed to be an effective tool for parties working on non-standard spatial data.

Keywords: Geographic information systems, Turkey, endangered endemic plants, spatial analysis, gap analysis

ÖZ

TÜRKİYE'DEKİ NESLİ TEHLİKE ALTINDA OLAN ENDEMİK BİTKİLERİN JEOİSTATİSTİKSEL ANALİZİ İÇİN BİR COĞRAFİ BİLGİ SİSTEMİ ARACI GELİŞTİRİLMESİ

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Mayıs 2005, 135 sayfa

Modern bilgi sistemleri daha az gereksinim ile kaynakların daha etkin kullanımını sağlamaya çalışmaktadır. Değişik teknik ve analiz imkanlarıyla donanmış coğrafi bilgi sistemleri (CBS) de asgari gereksinimlerinin karşılığında etkin hizmet verebilmektedir.

Bu çalışmada CBS'nin yetenekleri Türkiye Florası'nın incelenmesinde kullanılmıştır. Ülkeye has ve nesli tehlike altında bulunan bitkilere ait veriler ilgili literatürden elde edilip, coğrafi konumlarının coğrafi refererans sistemlerine uygun olarak temsil edildiği veri kümelerinde yeniden şekillendirilmiştir. Akabinde adıgeçen çıktı sistem bünyesinde bulunan ve sonradan eklenen fonksiyonlar ile çok değişkenli istatistiksel analizler vasıtasıyla, değişik faktörlerin bitkilerin dağılım şablonları üzerindeki etkilerinin incelenmesinde kullanılmıştır. Sonunda tehdit altındaki bitkilerin coğrafi konumlarının, resmi koruma alanlarının ve kuşlar özelinde diğer canlılar için öneme sahip alanların konumlarıyla ne kadar çakıştığını ortaya çıkarmak için çakıştırma analizi kullanılmıştır.

Çalışmanın çıktıları üç boyutta incelenebilir. Öncelikle, değişkenlik gösteren floristik verilerden oluşturulmuş bütünleşik bir veritabanında kullanılabilecek basit bir algoritma geliştirilmiştir. Türk botanik araştırmalarına yapılan başka bir katkı da, coğrafi referans sistemine gore biçimlendirilmiş bitki lokalitelerinden oluşturulmuş bir veri seti ve çalışma sonucu ortaya çıkan analizlerin çıktılarıdır. Başka bir açıdan da CBS'nin standart dışı bir çok veri tipini idare yeteneği gözden geçirilmiştir. Bitkilerin coğrafi konumlarının koruma alanlarının sınırılarıyla çakıştırılmasının halihazırdaki koruma kapsamındaki boşlukları ve gelecekte ilan edilecek koruma alanlarına aday bölgeleri işaret edişi çalışmanın yönetimsel boyutta kullanılabilirliğini ortaya koymaktadır. Esas olarak CBS'nin standart dışı mekansal veri üzerinde çalışanlar için oldukça etkin bir araç olduğu ortaya konmuştur.

Anahtar Kelimeler: Coğrafi bilgi sistemleri, Türkiye, nesli tehlike altındaki endemik bitkiler, mekansal analiz , boşluk analizi

To all Irises, Fritillaries, Bellflowers and Phragmites of Anatolia, who made this geography special

ACKNOWLEDGEMENTS

As an interdisciplinary one this work has enjoyed a prolonged gestation period. Dr. Zuhal Akyürek was the ultimate motivator throughout the interval and my words would be inadequate to describe her assistance. Dr. Nazife Baykal allocated her truly scarce time to my never-ending questions. Dr. Yasemin Yardımcı and Dr. Erkan Mumcuoğlu did not grudge any help from me and my study. Without any hesitations Dr. M. Lütfi Süzen agreed to help us and made great contributions, the grid he introduced being the foremost of all.

My unique mentor in terms of botany was Dr. Mecit Vural. Mentioning his help on the flora would be classical, rather I would like to thank him just because of the passion for plants he passed to me. Having said that, my thanks goes to Güven as he arranged my first meeting with Dr. Vural and helped me with his extensive knowledge on current issues in atlases, protected areas, AFE and so forth. He is also behind the Doğa Derneği based conservation-crazy gang who delineated all borders of the IBAs and KBAs. In this context, I should thank to Engin Gem for his GIS related assistance and Nuri for his invaluable help during the study. Yıldo and Hillary Welch, too, were more than helpful with the GAP Project related issues. I also want to express my gratitudes to the staff of Department of Botany at Gazi University, particularly Dr. Hayri Duman and Dr. Zeki Aytaç who helped me locate some of the plants. Dr. Tuna Ekim's articles were the most favourite ones of the study, that's why I owe a thank to him. I am sorry for other botany related people whose names did not appear here and thank them all.

A good birder is always a good helper: I am grateful to Dr. Can Bilgin for the suggestions and references he cited. I also thank both Nigar Şen and Fatih Nar for their software. Last but not the least, I would like to thank Ayça for being a hard time initiator and Emre and Gül for their statistical guidance.

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ABBREVIATIONS

AFE	Atlas Florae Europaeae
ALTMEAN	Mean Altitude
ALTSTD	Standard Deviation of Altitude
AP	Aerial photography
ASPECTM	Mean Aspect
AVH	Australia's Virtual Herbarium
CORINE	Coordinated Information on the European Environment
CR	Critical
DEM	Digital Elevation Model
EN	Endangered
ESRI	Environmental Systems Research Institute
GCM	Republic of Turkey General Command of Mapping
GIS	Geographical Information System
IBA	Important Bird Area
IDW	Inverse Distance Weighted (IDW) Interpolation
IS	Information System
IUCN	International Union for Conservation of Nature and Natural Resources
MGRS	Military Grid Reference System
MOIMEAN	Mean wetness index
MOISTD	Standard Deviation of Wetness Index
MS	Microsoft
NALTCHG	Number of Altitudinal Changes per Cell
NISO	National Information Standards Organization
PLANT	Number of Endangered Endemic Plants per Grid Cell
PLANTTR	Logarithmically Transformed Number of Endangered Endemic Plants per grid cell
PERM#	Long Term Average of Total Monthly Precipitation for Month #

RS Remote Sensing

SLOPEM Mean Slope

SLOPESTD Standard Deviation of Slope

SMW General Directorate of State Meteorological Works

SRTM30 SRTM 30-Arc Seconds Global Elevation DEM

TAM# Long term mean of average monthly temperature for month #

TMN# Long term mean of minimum monthly temperature for month #

TMX# Long term mean of maximum monthly temperature for month #

TUBIVES Turkish Plants Data Service

USGS U.S. Geological Survey

UTM Universal Transverse Mercator

WGS84 World Geodetic System 1984

CHAPTER 1

INTRODUCTION

Relentless advances in semiconductor technology is among the most influential factors affecting the life of the society in the post-industrial era. Addressed by Moore's Law, strength of microchips have been doubled every 18 months during the last 40 years and this phenomenon is expected to last for another decade (Moore, 1965). In accordance with this, computers have proven their worth in almost every field of human endeavor from modeling and simulating complex scientific problems to forecasting the weather. Today, semiconductor based computers perform tasks better than the way they could be done manually and/or have no other alternatives in the situations when there is not any other practical way to accomplish the objective.

Parallel to the developments in its crucial component, information systems have had more opportunity to serve their stakeholders. Higher capacity combined with lower response times gave rise to the challenges with more complex situations where the number of the variables is larger and the relationships are less typical. Hence, nearly every aspect of the society can be considered inside the problem set of the information systems at the moment.

Use of geographical information systems (GIS) is a good example of applications of modern information systems. In the pursuit of making use of natural resources and strive for efficiency, GIS have been useful tools for the overall well being of the society. In wide variety of issues such as modeling the energy infrastructure of the urban regions and planning the dam projects, this type of information systems became vital initiators of development.

Although it is generally taken as synonymous with wealth, development is not without its problems. Basically, humanitarian development takes place in the form of increasing the pressure on the nature. Boom in population and human needs pushed the use of natural resources and caused various types of environmental problems. Consequently, modern society faced problems of obtaining basic needs of clean air, water and living areas. Additionally, economic operations are badly affected; water shortages for agriculture, decreasing and more expensive raw materials for the production are few of the examples that can be cited here. Last but not the least, biodiversity, richness of wild life, suffered dramatically. Hundreds of different species of living organisms have gone extinct in the previous century.

Today, the future of the earth, its inhabitants and the human development are questioned, scrutinized and evaluated from the same perspective; sustainable development. The term implies, use of resources by allowing them to endure. Seeking for clean energy sources and applying ecologically sound agricultural practices are among the examples of this transformation. With the capacity of working simultaneously on different facets of the reality in the form of layers, GIS act as effective platforms for in depth analysis of these examples.

In this study, GIS was utilized in analyzing the distribution of endangered endemic vascular plants of Turkey. Distribution of the most threatened plants of Anatolia, a significant part of the richest plant collection of this part of the world, was transferred to a widely used format. This step was followed by the exploratory techniques as an attempt to gain insights into the point patterns in general distribution. In that context, visualization, estimation and investigation of the plant densities were handled by the built-in procedures and coded modules namely K & L functions, nearest neighbor distance and kernel based density estimation analyses. Investigation of the effects of different factors on the general distribution by means of a multivariate analysis came after these steps with the help of GIS. Following that, protection schemes and the locations of the plants were superimposed and the general picture of the protection challenges were exhibited. The last part of the manuscript was allocated to the discussions on the subject and future study possibilities.

Scientific questions underlying this study are;

- Can a geographical information system be utilized in the non-standard domain of plant data?
- Is there a meaningful distribution pattern behind the high endemicity ratio of Turkish flora?
- How much protection coverage is provided by the natural protection areas for the threatened plants?

Justification of the study is based on the novelties it offers. As will be presented in the upcoming chapters, the dataset built for the study was compiled upon a nonstandard collection of various sources. Today's needs of clarifying the status of these plants, some of which were only gathered from unknown localities by foreign researches more than one century ago, makes it an obligation to create a consistent dataset. Not only would this be beneficial for field researches to come, but also be required for the studies for understanding the basics of the interesting distribution of Turkish flora which were generally explained by the empirical observations of the experts. This part was scrutinized quantitatively as part of the analysis section of the work. State based attempts on the protection of all these very rare species were also evaluated by means of an overlay analysis, which aimed to reveal the fit between protection areas and the endangered plant locations. All in all, the study on the subject appears to be very helpful for the related parties including state institutions, botanical researchers and conservation oriented societies, who strive to accumulate the current knowledge on biological resources in order to conduct in-depth analysis, facilitate economic contribution and establish protection coverage for these plants.

General organization of the thesis is as follows,

Chapter 2 reviews the literature on GIS, Anatolian Flora, intertwined applications and the future prospects in Turkey.

Chapter 3 introduces the data and the production processes used.

Chapter 4 describes the analyses conducted in the study.

Chapter 5 discusses the outcomes of the study and provides an example of another GIS use by comparing the protection coverage provided by the nature protection areas with the gaps.

Chapter 6 provides the brief comparison of the aims and results of the study.

CHAPTER 2

LITERATURE REVIEW

Many researchers have contributed to the definition and description of the uses of information systems (IS). According to Laudon and Laudon (1998), information systems are sets of interrelated components that collect, process, store and distribute information to support decision making and control in an organization, with the aim of helping the administrators analyze problems, visualize complex subjects and create new products. Authors mention input, processing and output as three basic activities of an IS. Maguire (1991) identified two types of IS on the basis of tasks performed; transaction processing systems, in which the emphasis is on recording and manipulating the occurrence of operations and decision support systems in which the emphasis is placed on manipulation, analysis and modeling for supporting decision making process. Among the general attributes of the IS, utility gain in information retrieval, regulation and management of access to the information; uninterrupted support and maintenance of the information, technology, education; and boost of staff and users were cited.

Behind the prolificacy of this interest and variety, lies an interesting fact: "many disciplines see information systems as their territory" (O'Donovan and Roode, 2002). With reference to the benchmarks published for higher education, authors pointed out that from general business and management to librarianship and information management, 21 of issued statements for disciplines require skills in information and computer technologies.

2.1 Definitions of GIS

Ongoing interest and developments in IS and arise of new needs helped other special areas and/or disciplines come into existence. Geographical information systems (GIS) is an example of this trend. First use of this term goes back to 60's (Tomlinson, 1990). It was used to name the Land Inventory System of the Canadian Forestry Department which was designed to produce maps, map land capability for forestry and classify the lands. The amount and the size of data and the consistent referencing needs led to a search for a computerized system which will tackle the workforce requirements. Consequently, the Canadian Geographic Information System was developed and put in service in 1971 completely. Though, the initial focus was developing a set of spatial data handling and analysis tool that could be used with geographical databases for repeated problem solving, launch of the first commercial GIS software applications took less than twenty years (Heywood, Cornelius and Carver, 2002).

Differentiation in definitions and the discussions on the domain of GIS show a similarity with the ones related with IS. Definition of GIS, as an example, has been discussed widely in the literature (Grimshaw, 1996). Commonly referenced description of Burrough (1986) is "a powerful set of tools for collecting, storing retrieving at will, transforming and displaying spatial data from the real world". For Smith, Menon, Starr and Estes (1987), GIS is a "database system in which most of the data are spatially indexed and upon which a set of procedures operated in order to answer queries about spatial entities in the database". UK Department of Environment's definition (as cited in Maguire, 1991) points a system that captures, stores, checks, manipulates, analyzes and displays data with the provision that they are spatially referenced to the Earth. On the other hand, Aronoff (1989) draws the boundaries with this statement: "…any manual or computer based set of procedures use to store and manipulate geographically referenced data". A wider view was proposed by Carter (as cited in Maguire, 1991) who integrated organizational structure perspective: "an institutional entity, reflecting an organizational structure that integrates technology with a database, expertise and continuing financial support over time".

According to Maguire (1991), defining GIS is difficult given the abundance of different ways of defining and classifying objects and subjects. He associated the diversity of the field with the existence of many different methods. Functionality based classification is one of the examples he gave. The other reason underlying the differential difficulties is the academic debate concerning the central focus of the current GIS activity.

Cowen (1990) classified four major approaches behind the variation in the definitions and separations from other types of information systems: Department of Environment's definition is a process-oriented approach which focuses on GIS' capabilities of information handling with the use of several integrated subsystems. Burrough's (1986) definition falls into the toolbox approach which deals with the generic aspects of GIS. Definitions that stress the interaction between the database and the other tools are members of the database approach and the definition of Smith et al. (1987) is an example of this. The last approach of application divides the systems on the basis of problems that addressed.

Even though there is good number of different definitions, "geographic information systems are seen by many as special cases of information systems in general" (Maguire, 1991). According to De Man (1990), "GIS are a specialized type of information system, typically dealing with spatial data". Cowen (1989) associated GIS with a decision support system that works with spatially referenced data. For De Meyere (as cited in Grimshaw, 1996), GIS are no different than other information systems in the grounds that geographic data is not a sufficient factor for warranting separate treatment. Given their need for input, aim for analyzing and manipulating and focus for output for easing decision making, both of the entities share many in common. On the other hand, Maguire's (1991) view that refers GIS as a subset of IS can be seen as a middle way between the proponents of granting full autonomy and the perspectives which ignore the specific aspect of the domain. Latter approach was also criticized by Grimshaw (1996), who claimed that GIS deserves special attention owing to its ability to combine the tasks of integrating, handling and mapping geographic and non-geographic data simultaneously.

2.2 Use of Distributed Databases and GIS in Environmental and Floristic Studies

Following its introduction, GIS found wide variety of application areas in analyzing, modeling and utilizing humanitarian activities related with geography of the world. From oil pipeline route selection to asset management applications, GIS are used every day in the world for routine operations and have affirmed the projections of Maguire (1991). Even so, the motivation behind its development, the pursuit of efficient use of natural resources, has been maintained which enabled natural resource planning and nature conservation to preserve their preferential status in GIS use.

Initial uses of GIS in the environmental domain were related with the collection and description of the environmental data. With the assist of remote sensing (RS) and aerial photography (AP) technologies, accumulation and the classification of these data dramatically increased. Projects of the United States Geological Survey through its National Mapping Program, which targeted the completion of national inventories of the US, were among the earliest national attempts of gathering, analyzing and presenting information digitally on natural resources for the benefit of federal and state agencies, commercial companies and individual citizens (Starr and Anderson, 1991).

Just as important, studies on bringing the information together gained pace. The underlying factor was the fact that, despite there were significant amounts of data about the nature and its inhabitants, the collectors and collections were so dispersed that effective use was virtually impossible. New biodiversity databases were planned which would connect the different nodes each of which was located in different places; had based on different methodologies, taxonomical considerations; and were only available in different languages. One example was Coordinated Information on the European Environment (CORINE), which endeavored to bring all the sources of European data under one structure. This multinational environmental monitoring and assessment tool was set up in 1985 with the aim of compiling the information on the state of the environment, coordinating the compilation of data and the organization of information within the member states and ensuring that information is consistent and that data are compatible (Commission of European Communities, 1995). The project was found to be successful and the European Environment Agency was set up afterwards (Mounsey, 1991). Today, the agency focuses on "measurable improvement in Europe's environment through the provision of timely, targeted, relevant and reliable information to policy making agents and the public" (URL 2.1) and offers free reports and datasets for desktop computers via its website. Figure 2.1 presents landscape layer of 30 European countries downloaded from the CORINE Land Cover Database (URL 2.2).

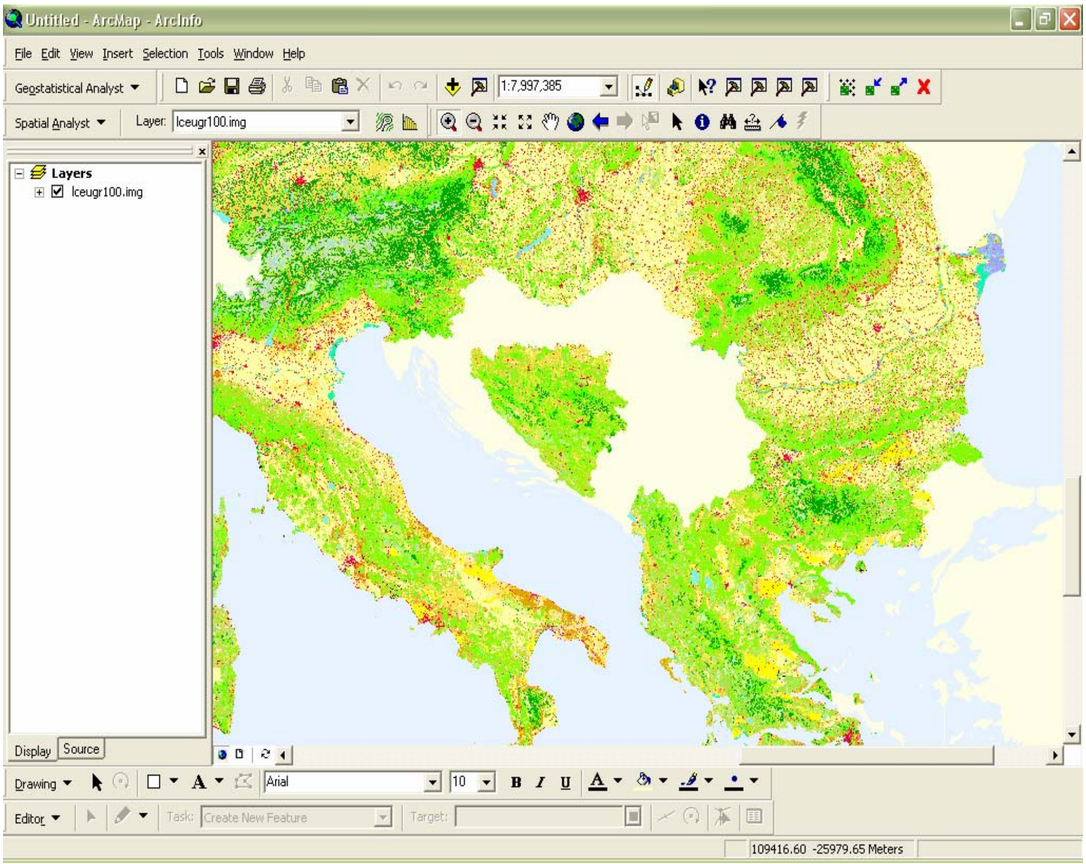

Figure 2.1 CLC 2000 dataset from CORINE Land Cover Database

According to Bisby (2000), colossal developments in related information systems in the Internet are exciting but also chaotic in the sense that wealth of new sources are shadowed by the difficulty of finding the relevant information. He suggested that main goal of the associated parties should be to develop systems that permit interoperability and synthesis across arrays of local systems and embed them in wider scales. Edwards, Lane and Nielsen (2000) with the same motives, pointed out the imbalance between tropical and developed countries concerning the richness of biological resources versus associated scientific information and expressed the need of bringing information to the decision makers and scientists when and where it is needed.

Attempts to gather relevant environmental information and synchronizing these activities with data collection practices gave way to a proliferation of independent databases operated by nongovernmental organizations and universities. Initial motivation of keeping record of available data and facilitating ways of gathering new information exposed itself in form of databases from which relevant information is queried for the associated parties. With the massive development of the Internet, databases were made available to broader audiences. At last, mapping and analyzing capabilities GIS offer led way to visually represented warehouses where basic data retrieval operations were accompanied by visual query capabilities. Flora Base of Australia is among the most widely referenced examples (URL 2.3). The website aims to deliver the latest authoritative information about the Western Australian flora in an accessible and interactive manner. Thematic presentation of information, browsing and searching functions enabled users of the database, which contains botanical information on all the region's plant families as well as the largest database of botanical literature, to explore their own interest. Result of a random query is shown in Figure 2.2.

A more complex application is developed in the same country. Australia's Virtual Herbarium (AVH) is an on-line botanical information system accessible via the Internet (URL 2.4). It provides immediate access to the data associated with scientific plant specimens in each Australian herbarium. Term "herbarium" refers to an organization where a collection of dried botanical specimens systematically arranged for reference resides (Oxford Reference Online., 2004). The AVH can be accessed via the website of the participators and a gateway at these hosts links to the databases of all the other herbaria, unifying the aggregated data into a nationwide view of the botanical information. Different geographic and environmental overlays namely roads, states, localities, latitude & longitude grids, terrain, temperature, rainfall, waterways, regions and subdivisions can be added in order to increase the detail. Figure 2.3 presents a query result.

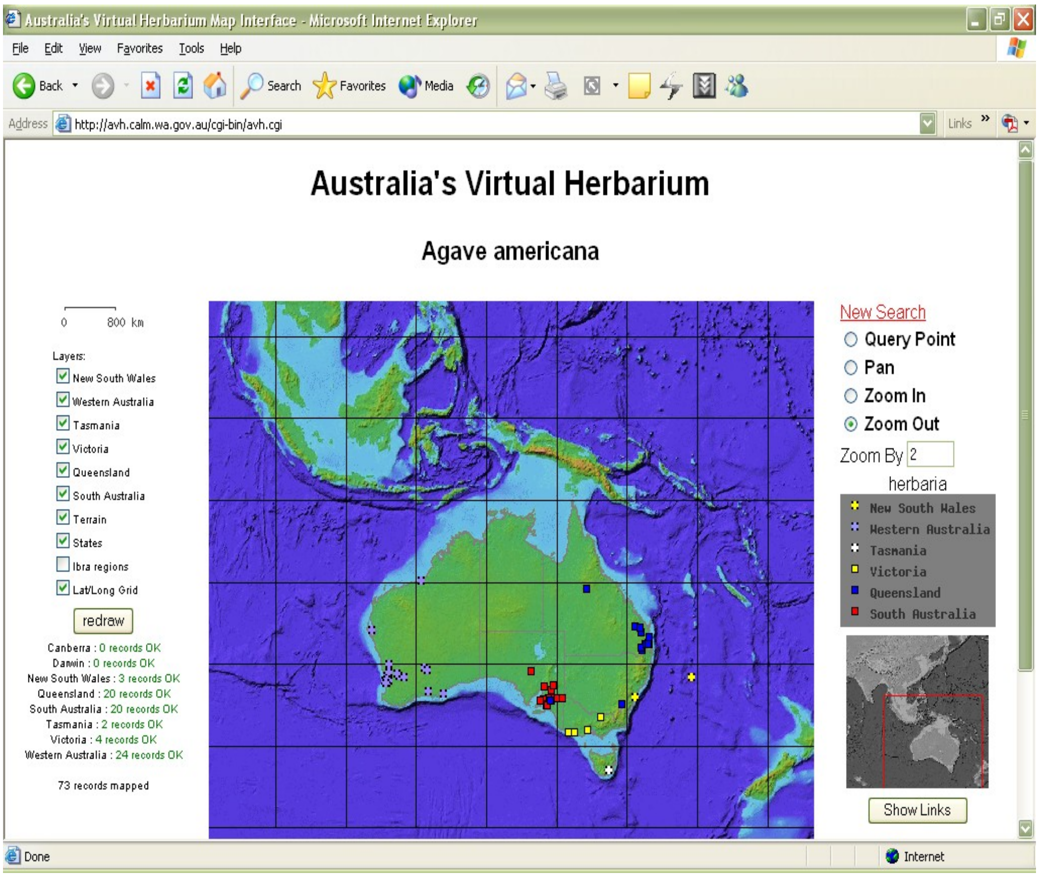

Figure 2.2 A sample result from a FloraBase query

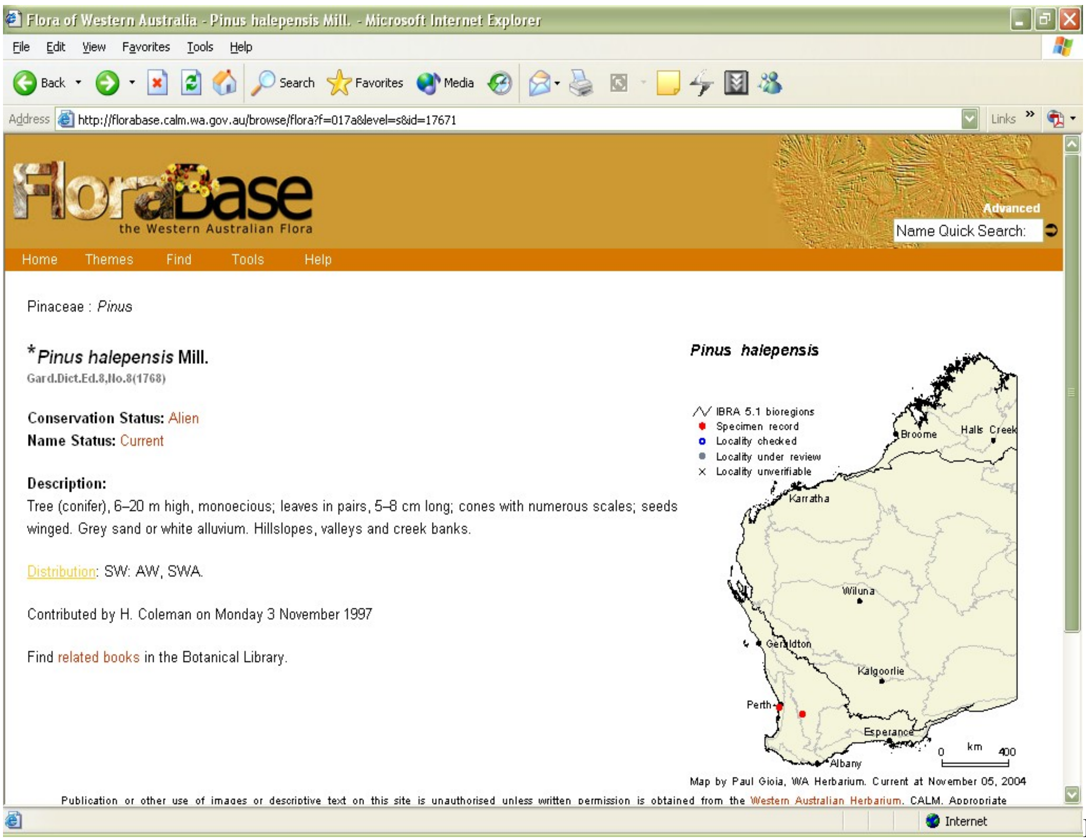

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Figure 2.3 Australia's Virtual Herbarium

The Euro+Med Project which was financed by European Union aims to provide an on-line database and information system for the vascular plants of Europe and the Mediterranean region (URL 2.6). A database was developed at The University of Reading, comprised names and associated data from different resources for this project. The database will be used by specialists from over 50 countries and territories within the region for taxonomical and conservation studies.

Use of distributed networks and computer technology in distribution mapping has also been recently depicted. Atlas Florae Europaeae (AFE), which was launched in 1965, was a collaborative project for gathering information on distribution of vascular plants in Europe (URL 2.7). The principal aim of the AFE was to offer complementary maps for species and subspecies for plants in Europe including Thrace. As of 2004, 14 volumes have been published and added on a database which allows data retrieval via a free software which is exhibited in Figure 2.4, though this effort constitutes circa 20% of the overall collection.

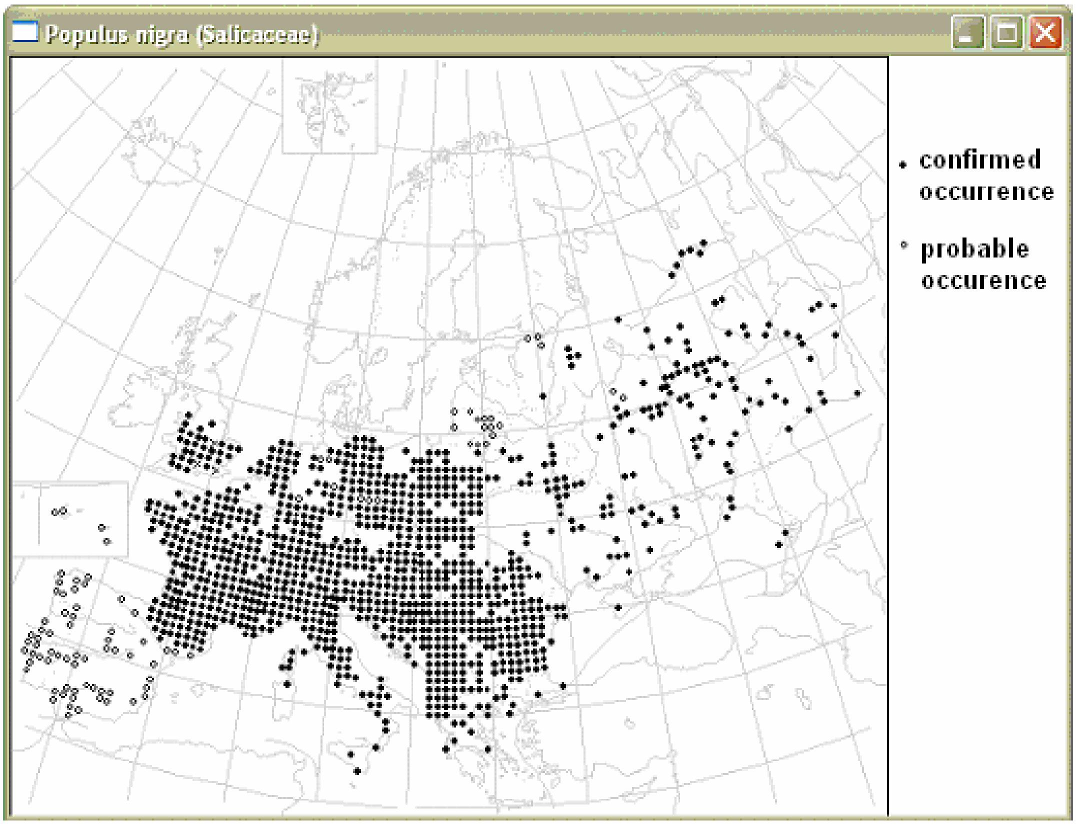


Figure 2.4 Atlas Florae Europae Database Retrieval Tool (URL 2.7)

Given the abundance of independent data sources throughout world, attempts to link and retrieve electronic data from geographically distributed collections to increase their effective use in research, conservation, and education has emerged recently (Stein & Wieczorek, 2004). ANSI / NISO Z39.50 standard which defines a client/server based service and protocol for informational retrieval was developed which represented an advance over traditional central data warehouse concept by facilitating information retrieval directly from loosely coupled institutions. (National Information Standards Organization, 2002). One of the significant projects on this standard is Species Analyst, which serves more than 120 natural history collection databases throughout the world (URL 2.8). These collections allow simultaneous query through the Species Analyst, with the combined information returned to the user in one of a variety of formats including tabular format in Microsoft Excel files and shape file format compatible with GIS Applications. Figure 2.5 shows the world distribution of the fish species “Cyclotohone pallida” retrieved by a query which attained the relevant data from the member collections and merged them in a shape file compatible with ArcGIS application (ESRI, 2002a).

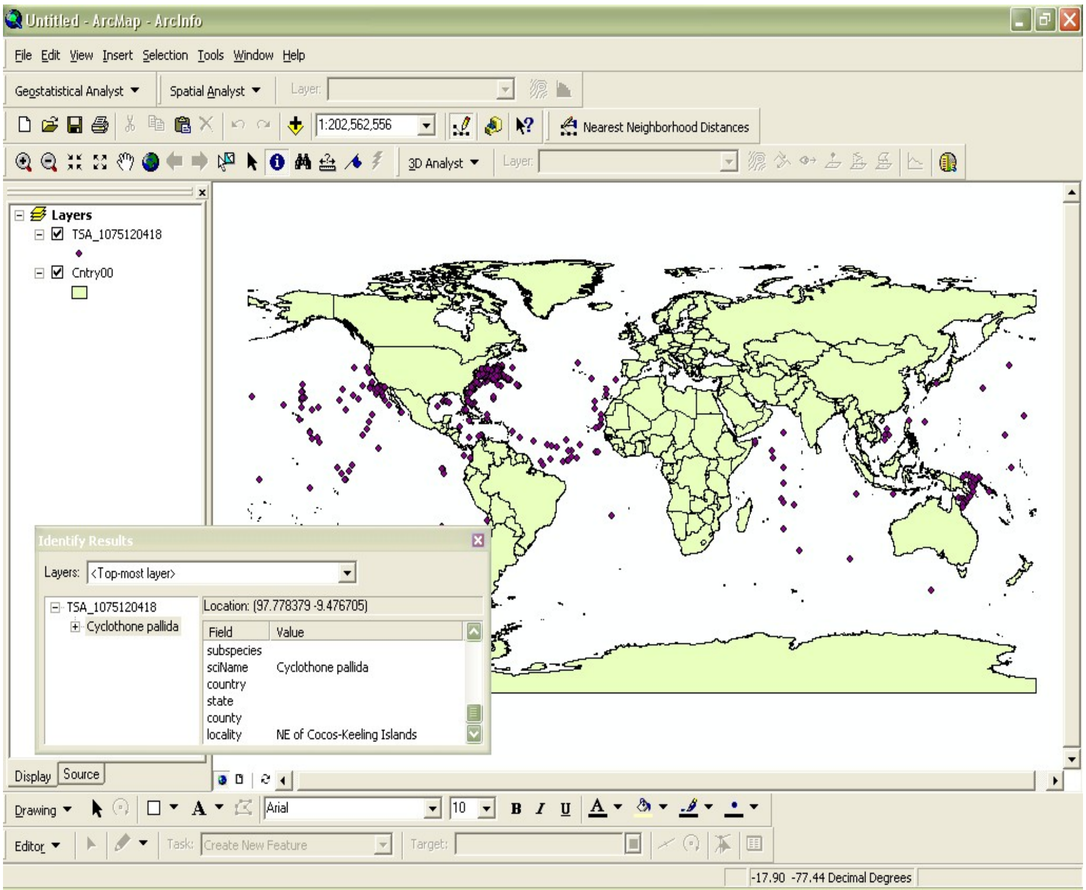


Figure 2.5 GIS compatible Spatial Analyst query result

The advantages that modern information systems and distributed networks offer are not limited to the enhancements in speed and availability of data extraction and visual representation. Beyond these facets, GIS supplied with different layers such as remotely sensed data are increasingly being used for analysis and modeling of environmental events. Despite the findings of Joao and Fonseca (1996), who claimed GIS use was restricted to presentation of data and results in most of the cases and real power of manipulation of data and analysis were generally neglected, current research in environmental domain and GIS are tightly connected (as cited by Wadsworth and Treweek, 1999).

Parallel to these developments, studies related with biodiversity, which represents diversity at all levels of biological organization from community to the gene and which is asserted to be one of the most important knowledge domains vital to a wide range of scientific, educational, commercial, and government activities, also began employing GIS (Frankel, Brown and Burdon, 1995; Schnase, Cushing, Frame, Frondorf, Landis, Maier and Silberschatz, 2003). Indeed, Wadsworth and Treweek (1999) argued that use of GIS pioneered new areas of research and analysis in ecology as a whole. Authors underlined ability to study and manage natural resources in larger areas, easiness of integrating with other resource inventories and power of conceptualizing problems and hypothesis as the underlying factors.

Zhou, Narumalani, Waltman, Waltman and Palecki (2003) developed a quantitative multivariate regionalization model with the help of GIS for delineating ecoregions, which are large sets of similar ecosystems from a groups of biophysical parameters derived from several datasets such as remotely sensed data. The iterative algorithm generated a map of eco regions of Nebraska. Authors found their study applicable in determining and managing the boundaries of ecoregions and ecotones, which are natural limits of eco-regions, owing to its quantitative, integrative, flexible and temporal structure.

In their study, Iverson and Prasad (1998) built a model for estimating poorly known parts of the Illinois by making use of GIS together with the statewide species database. GIS was responsible from the data conversion and analysis. Resulting regression model was claimed to be usable where sampling was heterogeneous.

In order to estimate plant species diversity in agricultural regions, Luoto, Toivonen and Heikkinen (2001) used GIS which enabled the derivation of environmental variables from satellite images and digital elevation models. Accordingly, GIS was defined as a cost-efficient tool that can be employed to analyze wide areas on broad scales.

In the study of Bayliss, Helyar, Lee and Thompson (2003), GIS was used for assessing the most viable grassland areas in England. Areas with the highest conservation value, which was calculated by the incorporation of different criteria including biotic and abiotic factors, were identified as the priority sites for conservation management practices.

An empirical model for estimating the potential distribution of a rare Wyoming plant was developed by Fertig (1999). GIS was used for deriving environmental variables relevant to the species and the intersection methods that were able to reflect the presence and absence of data. Outcomes of the model indicate the power of GIS based correlational methods in developing distribution maps and identifying potential areas of potential habitat for rare species.

Store and Jokimäki (2003) developed a method which produced georeferenced ecological information about the requirements of different life forms with the help of GIS. GIS use was three-fold; production of the data needed in the models proposed, acting as a platform to execute the proposed models and presenting the results of the analysis.

Salem (2003) used GIS in measuring the contribution of Egyptian protection reserves to the biologic diversity. Spatial analysis of endangered plant species was conducted by overlaying the layers of location data and the protected area data. Consequently, protection coverage of the plant areas was determined. In the end unprotected areas with considerable diversity were proposed.

2.3 Situation in Turkey

In Turkey, floristic studies which employed information systems have been limited. Indeed, botanical research itself cannot be described as an established discipline for the country until recently (Ekim, 2001). First attempts to reveal the Anatolian floristic biodiversity took place between 16th and 17th centuries thanks to the efforts of foreign investigators including Belon, de Busbecq, Dernschwam and Tournefort (Baytop, 2003). Subsequent decades saw the flow of foreign botanists from Europe to the peninsula which became a prolific area for discovering new species. The work of these researchers was effectively consolidated by Boissier (1867-1888) with the first flora of the region, Flora Orientalis (Frodin, 2001). As a successful model, this set represented a foundation of the botanical research and writing around the region. However, preparation of the first national local floristic study in Turkish, Ankara Florası (Kosswig, 1929), took relatively longer and awaited the educational reform of the modern republic. Even this and studies alike were short of presenting the country's richness and initiating national awareness. Nevertheless, the real progress on the subject was noted following the publication of Flora of Turkey and the East Aegean Islands (Davis, 1965-1982), which was based on the incorporation of existing literature and the new data collected from distant areas, about which no or little information had been gathered before. Methods employed in the associated surveys and accounts of plant descriptions in the study was rapidly accepted and widely used by Turkish academicians who played active roles in this project by attending the surveys and/or joining the preparation of the references and published the 11th volume as a supplement to the main series (Güner, Özhatay, Ekim and Başer, 2000; Ekim, 2001). A grid system based on two degrees of latitude and longitude as the primary division for the citation of specimens were used in the reference which results in country being divided into twenty nine squares. This grid system was easy to use and memorize but too coarse to delimit the geographical patterns and provide sensitive distribution information.

Accumulation of the aforementioned data encompassing the last four centuries revealed the richness of Anatolia in terms of the number of plants species inhabiting it. Although it is virtually impossible to give exact figures due to ongoing taxonomical changes and new discoveries, circa 9000 plant taxa including species, subspecies and varieties were found to inhabit Turkey (Güner et al., 2000; Ekim and Güner, 2000; Özhatay, Kültür and Aksoy, 1999). Endemism rate, which accounts for the plants that cannot be found outside a country, is approximately 30%, a very high figure for a non-tropic country situated in middle zone (Ekim, 1998). This world class variety shows itself marginally in specific groups of plants such as the ones confined to serpentine rocks for which Turkey is one of the four richest countries in the world (Harrison, Viers and Quinn, 2000). Table 2.1 represents a glimpse of botanical richness of the country in comparison with some selected countries.

Table 2.1 Number of plants for selected countries (UNEP, URL 2.9).

Country	Number of Plant Species
Turkey	ca.9000
Brazil	56 215
Russian Federation (CIS)	22 281
USA	19 473
India	16 000
Australia	15 638
Iran	8 000
Spain	5 050
Canada	3 270
United Kingdom	1 623

Increase in national interest had added considerable contribution to the current knowledge on Turkish flora; however a national database that fully provides distributional information about each species does not exist. According to Babaç (2003), attempts on building a national database to keep data on biological diversity in Turkey started about two decades ago with a computer database that delineates the distribution of some particular plants around Malatya. Since then several databases were developed by the initiatives of state institutions such as Scientific and Technical Research Council of Turkey (TUBİTAK) and State Planning Organization (DPT). These databases were able to cover only portions of the flora, as in the case of the Central Database of Turkish Herbaria which consisted of Herbarium records. The most comprehensive database system was Turkish Plants Data Service (TUBIVES) and it was made avaliable over the Internet via ULAKBIM (URL 2.10). This database had included all records mentioned in Flora of Turkey and the Eastern Aegean, however it provided little geographical detail except the name of the city where the plant was located and the grid system used in Flora of Turkey and the East Aegean Islands (Davis, 1965-1982). Furthermore, like its predecessors the system had no built-in spatial analysis capability. Another problem was associated with the addition of the already collected but not included data. There is still considerable amount of data which was obtained from field surveys, has not been published, hence kept in nonstandard manual storage systems, particularly field notebooks in paper (Mecit Vural, E-mail., May 26, 2004). Existing systems' datasets were not flexible enough to import these data. Recently proposed Biodiversity Database, as part of the Biodiversity and Natural Resources Management Monitoring project which is being executed by Ministry of Environment and Forest and co-funded by the World Bank aims to overcome this matter (Türkiye Cumhuriyeti Çevre ve Orman Bakanlığı, 2004). The project is still underway and outcomes were yet to be publicized.

Just like the unified storage systems, history of studies involving GIS based analysis and modeling has been relatively new. One of the first projects was conducted by Ministries of Agriculture, Forest and Environment with the support of World Bank (Dedeoğlu, 2004). Protecting genetic diversity of several agricultural and industrial plants such as wheat, barley, cedar and fir at selected regions such as Ceylanpınar Plain and Bolkar Mountains was the motivation behind the project. Another project entitled as Investigation of Genetic Diversity Protection in Turkey focused on the preservation of the local variants of agricultural plants at selected cities. GIS was used in the formation and analysis of socio-economic and geographic layers.

Patterns of species richness, endemism and rarity in Turkey was examined by Turak (2000) who used data of breeding birds, butterflies and a group of vascular plants (Verbascum genus). In the analysis grid squares defined by latitude and longitude of one degree difference along the borders of Turkey were utilized. A computerized database was prepared in order to store the distribution data and GIS applications were employed in visualizing the species richness and endemism for each group.

One of the latest studies combining GIS and biodiversity was conducted by Doğan (2003). A regression model was developed to estimate plant richness of Nallıhan. Throughout the study, GIS was utilized in data production and analysis as well as the control of the proposed model.

CHAPTER 3

DATA PRODUCTION

Data related issues are depicted in the following chapter. Types of data, production of the data used in the investigation of endemic plant distribution patterns and the structures of the dataset were described in order.

3.1 Data Types

Types of data employed in the study had different characteristics based on the source and the aims of their use. Section 3.1 is devoted to the description of data types employed.

3.1.1 Main Data

Geocoded locations of the plants were the main data of the study. Positions of plant records were represented in latitude and longitude geographical reference system in decimal format with two decimal digits. As a result of this, value range of the formed dataset was bounded by the global position of the country represented by the geographical coordinate system; latitudes from 25° 40' to 44° 49' East and longitudes from 35° 49' to 42° 05' North.

Following the determination of all locations, a grid layer was needed for mapping purposes. The one used in European continental plant distribution study, Atlas Florae Europae, was selected with this motivation. That grid system was a modification of the Universal Transverse Mercator (UTM) coordinates and the Military Grid Reference System (MGRS), and based on the World Geodetic System 1984

(WGS84) datum (URL 2.7). Each cell was bounded by 50 km UTM lines or also by the boundaries of the MGRS zones; thus areas covered by the boxes were not equal. A box was treated as an independent grid cell if the width of the southern edge was over 33.3 km, joined with the similar adjacent box if the width of the southern edge was between 16.7 and 33.3 km or joined to the adjacent 50 x 50 km slice if the base width was less than 16.7 km. The grid layer is shown in Figure 3.1.

Actually, main motivation of using a grid system was not only related with mapping. In order to make inferences based on quantitative data, literally, looking for the affects of different factors on the distribution of endangered endemics, a measurement unit was needed on which the necessary analysis could be executed. This minimum mapping unit was the individual boxes of the grid. Despite being a standardized and widely used one for mapping purposes, inconsistency of AFE's system concerning the box sizes could be problematic for the statistical analysis. Hence use of another grid system was proposed for the analysis part. Turkish 1/100K Index Grid System, another UTM based mapping schema was selected with this aim. It was consisted of half-degree lines of latitude and longitude, thus the boxes were more homogenous in terms of their sizes (Türkiye Cumhuriyeti Milli Savunma Bakanlığı Harita Genel Komutanlığı, 1992). Additionally, near the borders of the country, non-Turkish parts of the boxes were left away. Figure 3.2 presents the grid system.

The grid prepared the basis for the analysis part. Following the assignment of coordinates to the plants, number of different plants inside each of every box was calculated by ArcGIS application (ESRI, 2002a). These values were then divided to the respective area in order to prevent the richness sheltered by small boxes to be underestimated. However, small boxes covering less than 400 square kilometers were not taken into consideration. As a result, 358 boxes out of 391 were investigated in the analysis.

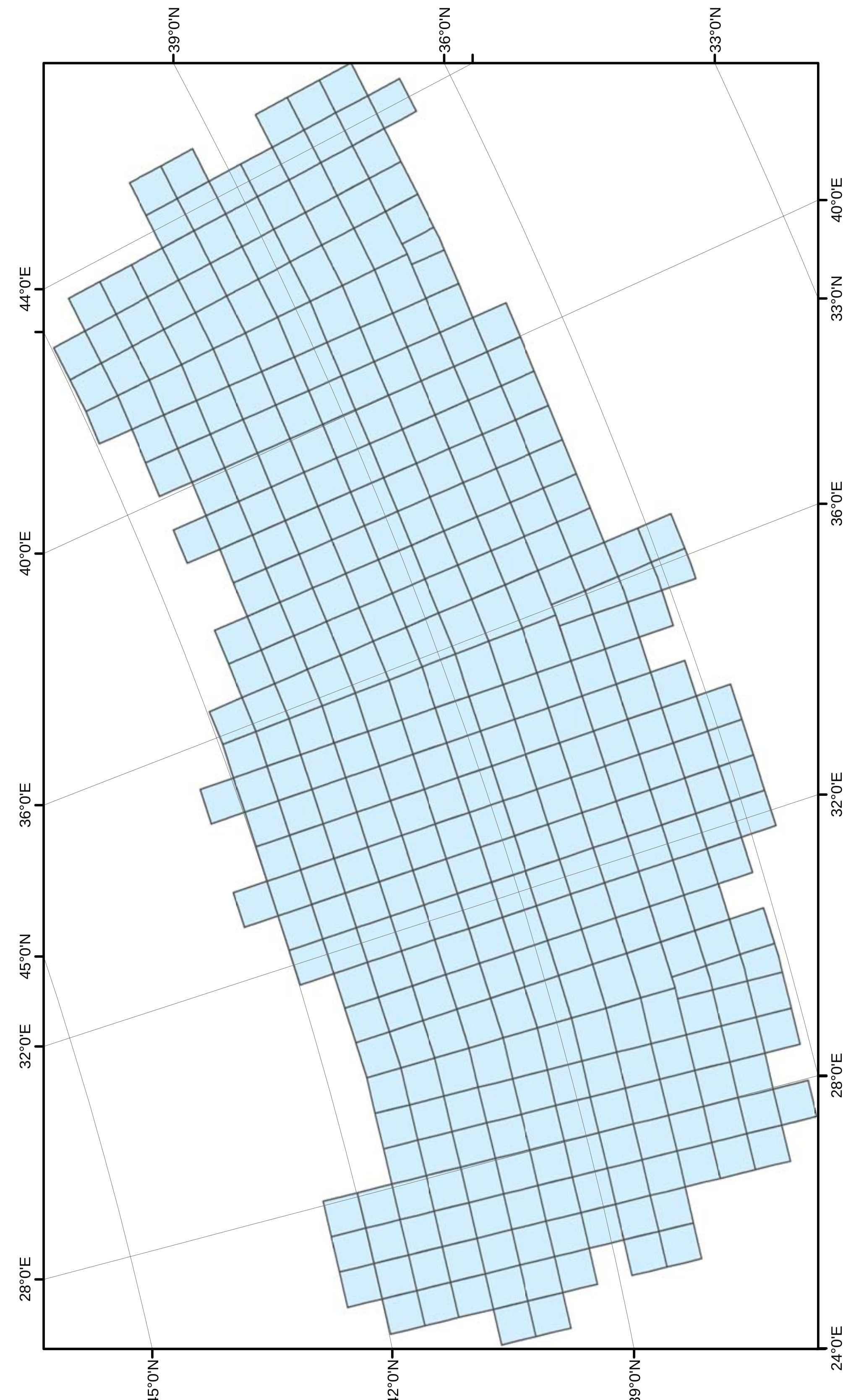


Figure 3.1 Atlas Florae Europae Grid System

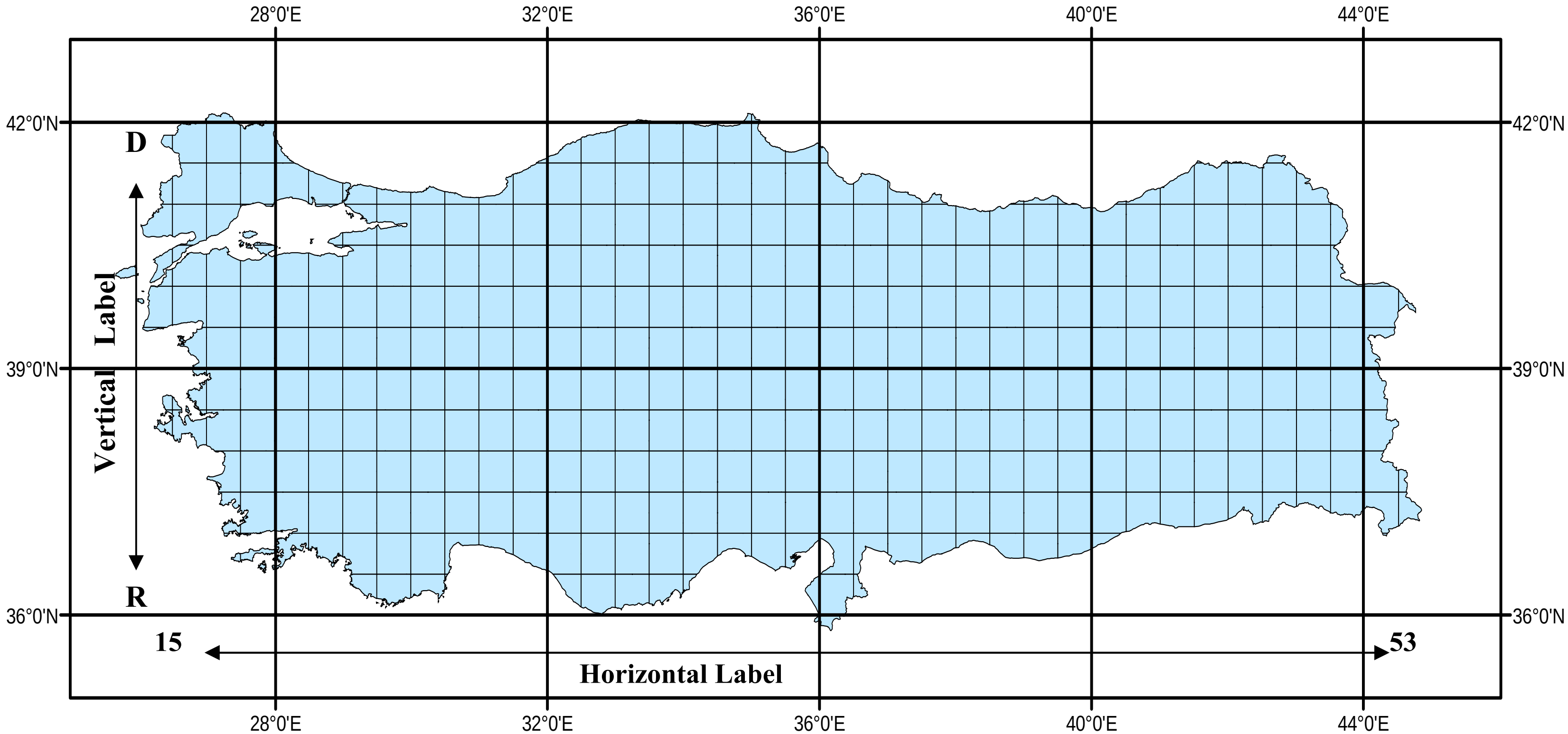


Figure 3.2 Turkish 1/100K Index Grid System

3.1.2 Imported Auxiliary Data

This section is devoted to all types of data that was used in the determination of plant locations. These include GIS compatible files and raw data containing information about geography of the country.

3.1.2.1 Country Files

Geographical and administrative units of Turkey were included in the study as layers of GIS. All villages, lakes, river and road networks and the boundaries of the cities were added to the ArcGIS application (ESRI, 2002a) in shape file format. These data was produced by İŞLEM-GIS Corporation which takes on digitization and marketing of original paper maps for computer use with the permission of General Command of Mapping (GCM) which is the authority for preparing and supervising the distribution of maps in Turkey. The files were obtained from GGIT department and the Nature Society. Table 3.1 lists the structure of all layers whereas Figure 3.3 represents the screenshot.

Table 3.1 Structure of Layers

Layer Name	Data	Attributes	Geometry Type	Coordinate System
Road Network (Karayolları)	Road network	ID Type State_Code European_Code Explanation	Polyline	Geographic Coordinate System based on European Datum 1950.
River Network (Nehirler)	River network	ID Type Name	Polyline	Geographic Coordinate System based on European Datum 1950.
Lakes (Göl)	Lakes	ID Type Name	Polygon	Geographic Coordinate System based on European Datum 1950.
Village Centers (Köy merkezleri)	Villages	ID Name City Town Settlement_Code Type_Code	Point	Geographic Coordinate System based on European Datum 1950.
Cities (Iller)	City boundaries	ID Name City_Traffic_Code Settlement_Code	Polygon	Geographic Coordinate System based on European Datum 1950.

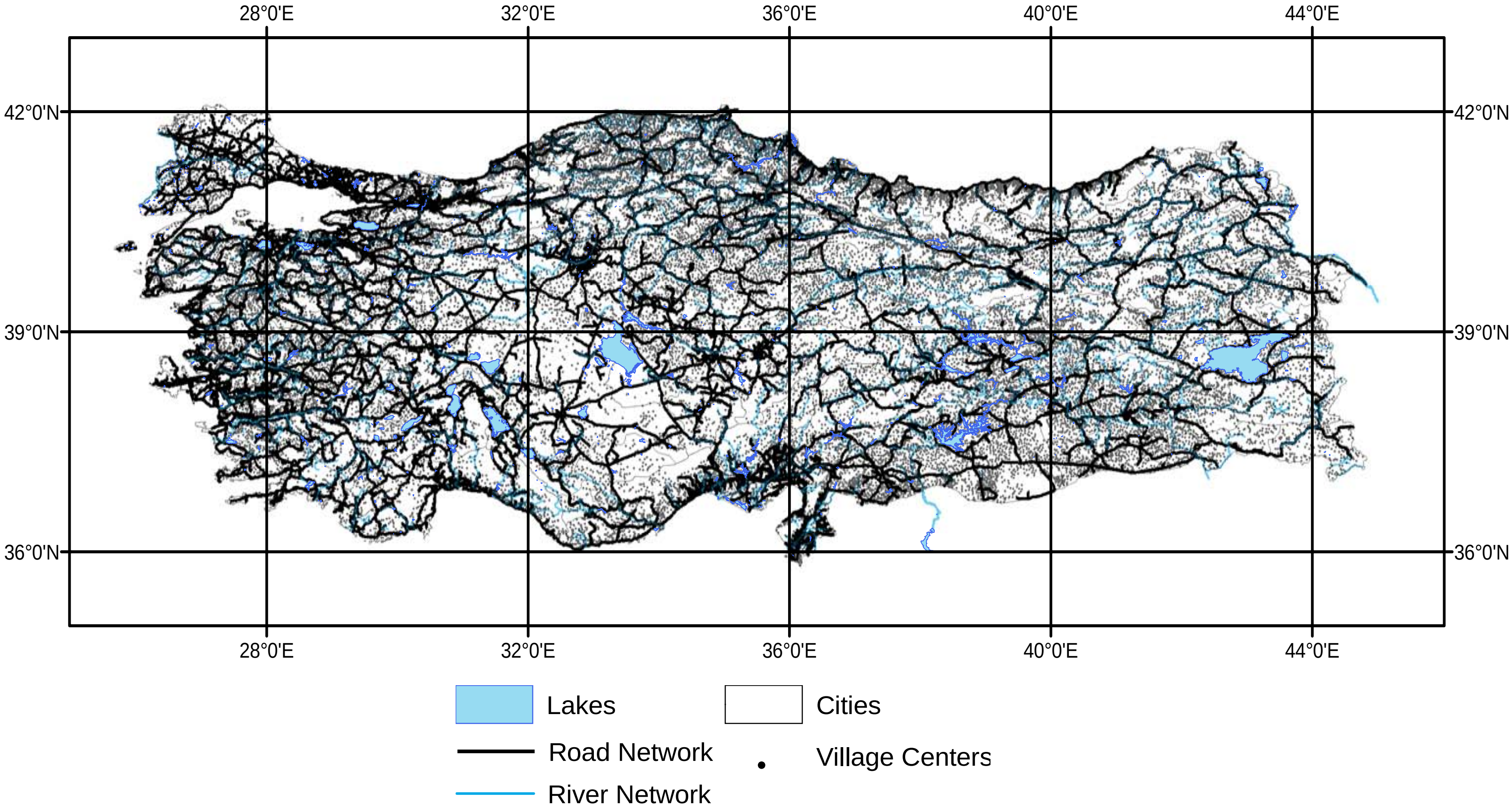


Figure 3.3 Country Layers of Turkey

3.1.2.2 Digital Elevation Model

Digital Elevation Model (DEM) is a digital model of altitude retrieved from a set of height values (Heywood et al., 2002). In any geographical analysis, a DEM can be of great use given its capacity to represent elevations or Z values of the entities as well as the locations in horizontal and vertical dimension. Parallel to the developments in satellite imagery DEM provides accurate results for large areas like Turkey. In the study, SRTM30 dataset was utilized as the elevation representation tool for establishing species locations and analyzing altitude related relations (Figure 3.4). SRTM30 is a near-global DEM combining existing datasets and the new data from the Shuttle Radar Topography Mission, flown in February, 2000 (URL 3.1). American National Imagery and Mapping Agency (NIMA), space agencies of USA (NASA), Germany (DLR) and Italy (ASI) participated in the preparation of the dataset using radar interferometry. Geodetic reference for SRTM30 data is the WGS84 EGM96 geoid, the grid resolution is 30-arc seconds and the distance betweeen two grid cells is 928m at the equator.

Factors related with elevation which may have effect on the distribution of endangered endemics such as mean altitude and variation of altitude were all derived by the DEM. After overlaying the grid layer with the DEM raster, mean altitude, standard deviation of altitude and number of altitudinal changes for each box were populated one by one by with the help of Spatial Analyst (ESRI, 2002b).

3.1.2.3 Geographical Atlases

Geographical paper atlases and maps were employed intensively in locating the plant records when associated GIS layers did not provide the needed information. The most widely used paper map was Türkiye Coğrafi Atlası (2004) with 1:400 000 scale. For species accounts containing foreign names of the locations, The Times Atlas of the World (1967) with scale of 1: 2 000 000 was utilized. As for references to the certain mountains, map plates and descriptions provided by Smith (1994) were also helpful.

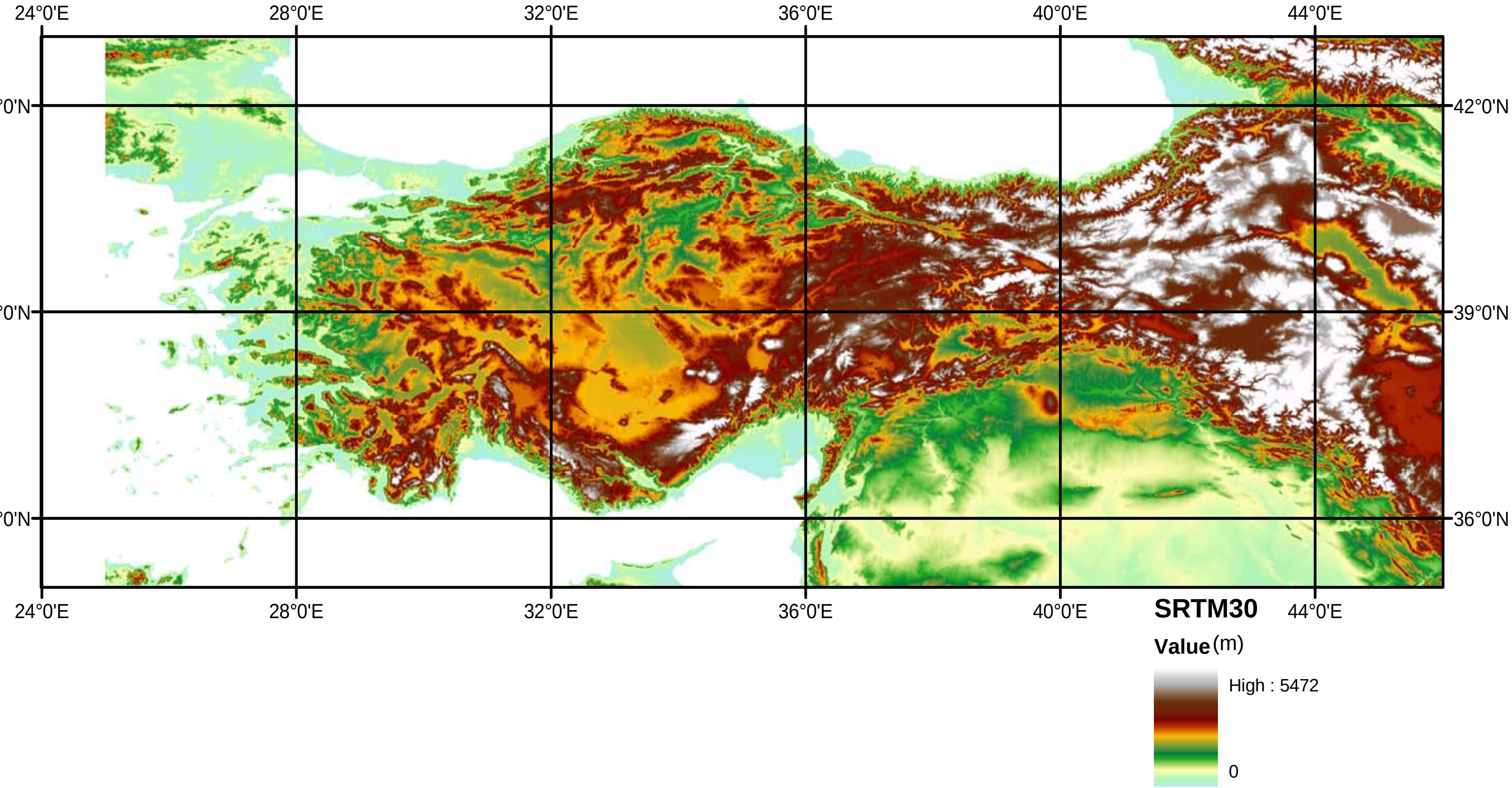


Figure 3. 4 SRTM30 DEM of Turkey

3.1.2.4 Academic Resources Related with Botany

In Flora of Turkey, there were no standard of recounting the addresses of observations. For the same area, may exist as much descriptions as the number of authors. In order to gain insights into the vaguely mentioned locations, reports of trips that took place in the same area or that focused on relocating the species; and accounts for other species reported from the same locality were examined with the aim of obtaining extra information. Available issues of Turkish Journal of Botany and Karaca Arboretum Magazine were the main references of this category.

3.1.2.5 Internet Resources

Locations of most of the plants included in the red list were determined with the use of aforementioned references. However a small portion of the accounts were referring to geographical areas that could not be located with traditional resources. In these cases, Internet resources were proved to be very helpful. The single most important web resource was the gazetteer of Traveljournals.net (URL 3.2) which had a rich collection of location information for important Turkish geographical entities including rivers, mountains, villages and towns. Information supplied was represented in Latitude Longitude reference system in decimal degrees and required no further conversion. For some local names and locations, especially plateaus, official web pages of the governor or unofficial websites devoted to the associated area were investigated in order to capture every relevant detail. At last, for a handful of accounts involving ancient locations, historical maps of Anatolia exhibited in David Rumsey Map Collection web site (URL 3.3) were investigated.

3.1.3 Produced Auxiliary Data

Produced auxiliary data represents different types of data which were formed and used in the analysis part of the study. Basically, factors that have an effect on the distribution of plants and that required a conversion for analysis is appraised in this heading.

3.1.3.1 Climatic Factors

Climatic factors shape the distribution of plants (Davis, 1971; Ekim and Güner, 1986; Frankel et al., 1995). In order to express the relationship, monthly records of precipitation and temperature for 251 big climate stations of Turkey were procured from State Meteorological Works (SMW) (Figure 3.5). Data obtained from the institution was in tables of monthly precipitation in hectograms and minimum, average and maximum temperatures in Celsius degrees for 1970 – 2004 period. Monthly averages of these values were calculated following the removal of stations covering less than 20 years. Furthermore, in order to cope with the obstacles non-continuous Celsius scale would create and form a smoother dataset, figures were reorganized under a different scale between 0 and 100, based on their percentile in the range. Subsequently, monthly precipitation and temperature averages for each station were obtained. Nevertheless, establishment of the stations were not enough for the analyses due to the fact that, they could only provide point records. In order to obtain a continuous distribution of climatic factors, Inverse Distance Weighted (IDW) Interpolation method was used. This technique estimates cell values by averaging the values of sample data points in the vicinity, where closer points have more influence in the calculation (ESRI, 2002b). As an example, interpolated distribution of January precipitation is shown in Figure 3.6. In next step, estimated values were superimposed to the grid boxes by the Spatial Analyst extension of the GIS application and descriptive statistics such as mean, maximum, standard deviation for each of the climatic factor related with each box were obtained. These variables were long term monthly averages of precipitation, average, minimum and maximum temperatures for each month and stored for the analysis section.

3.1.3.2 Topographical Factors

Slope, aspect and soil moisture may have an effect on plant inhabitance at a particular point. In order to quantify the respective factor, DEM of Turkey was utilized by 3D Analyst extension of ArcGIS (ESRI, 2002a). DEM’s coordinate system was based on latitudinal and longitudinal units but in order to make raster calculations for building slope and moisture layers, a system using metric units was needed. Hence, DEM was projected to the Lambert conic projection with European

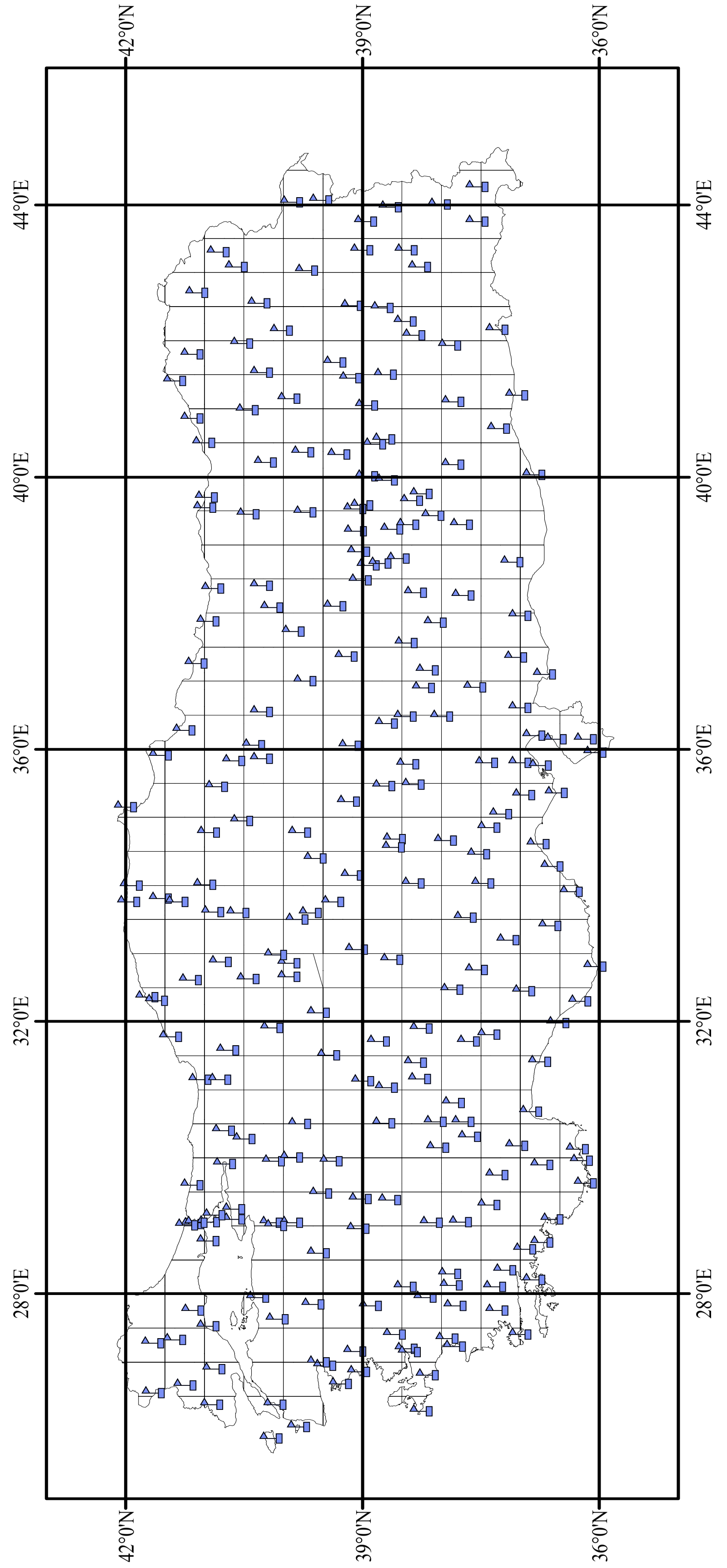


Figure 3.5 The locations of big climate stations used in the study

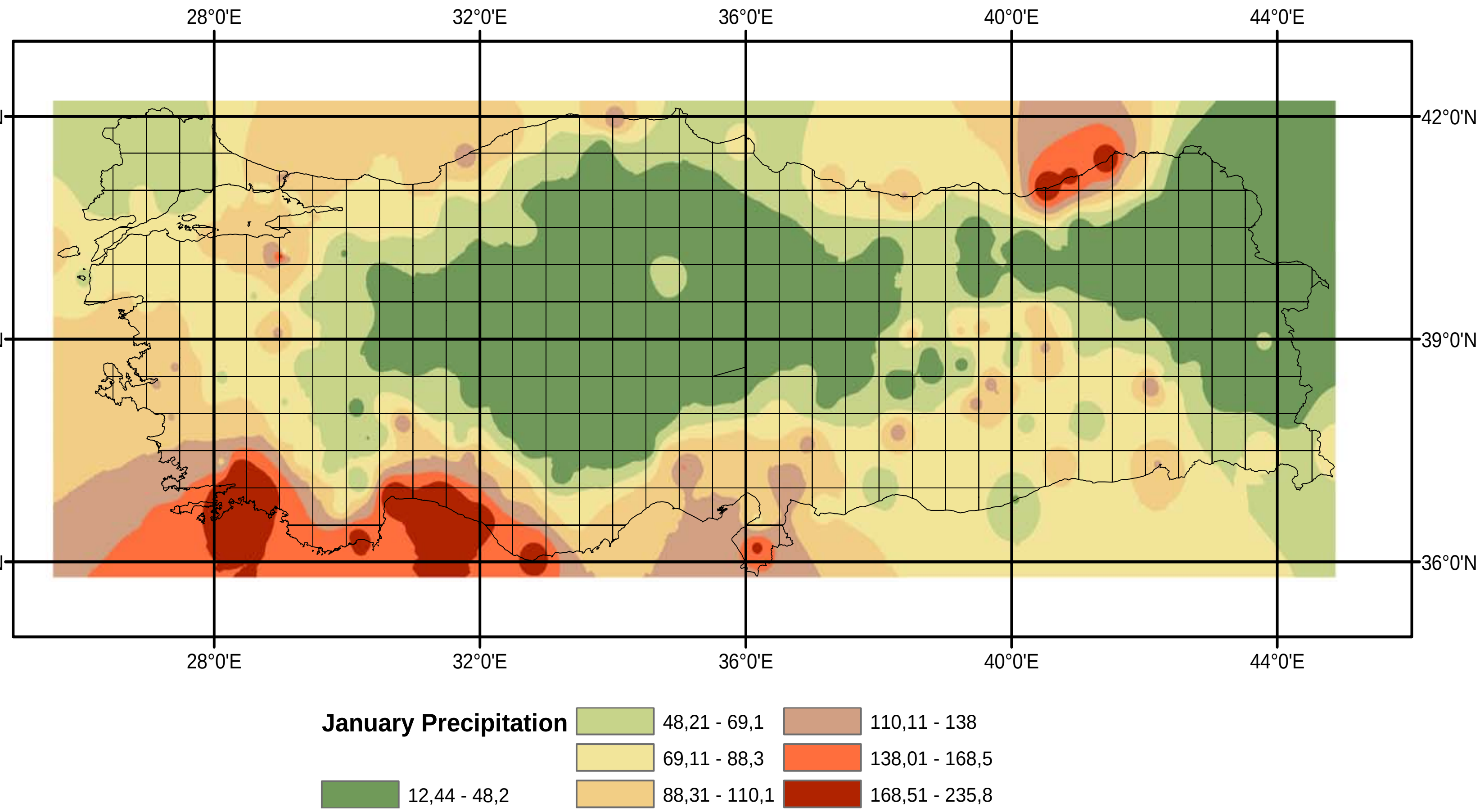


Figure 3.6 IDW Interpolation Results for January Precipitation (in millimeters)

1950 datum. Following this step, aspect and slope layers were derived from the same extension. Respective layers are shown in Figure 3.7 and 3.8 respectively.

In order to describe soil moisture, topographic wetness index T_i was employed (Beven, Lamb, Quinn, Romanowich and Freer, 1995). T_i is “a function of the upstream contributing area and the slope of the landscape” (Store and Kangas, 2001). This index is the representation of the spatial distribution of soil moisture or the relative depth of water table and is a function of flow accumulation and the slope of the landscape. Increases in the catchment area and/or declines in gradient inflate the topographic index accordingly. Using the raster calculator of ArcGIS (ESRI, 2002a) and applying Equation 3.1 where a_i is the area draining and tan β is the average outflow gradient, topographic index of the STRM30 which is shown in Figure 3.9 was derived. As part of the process, large water bodies were disregarded in order to prevent erroneous results.

$$T_i = \ln \frac{\sum a_i}{\tan \beta} \qquad \textbf{(3.1)}$$

In the last step, produced layers were superimposed to the grid layer. Following the overlay operation, mean aspect, slope, topographic index and standard deviations for each grid cell were determined by Spatial Analyst (ESRI, 2002b) and transferred to the data file where previous statistics were also stored.

3.2 Production of Main Data

As previously depicted, main point of interest and core unit of analysis in the study was the geographical locations of Turkey’s endangered endemic vascular plants. 172 Critically Endangered (CR) and 759 Endangered (EN) species were selected based on the criteria proposed by International Union for Conservation of Nature and Natural Resources (IUCN). These classifications were formed by the assessment of the species extinction risks using the available data on population size and geograpical distribution reductions (IUCN, 2001). If a plant is to be declared as (CR) or (EN), there should be a severe reduction in the population size and global range of the species with rates of up to 90% and 70% over last 10 years or 3 generations, respectively. List of the threatened plants were gathered from red data book of

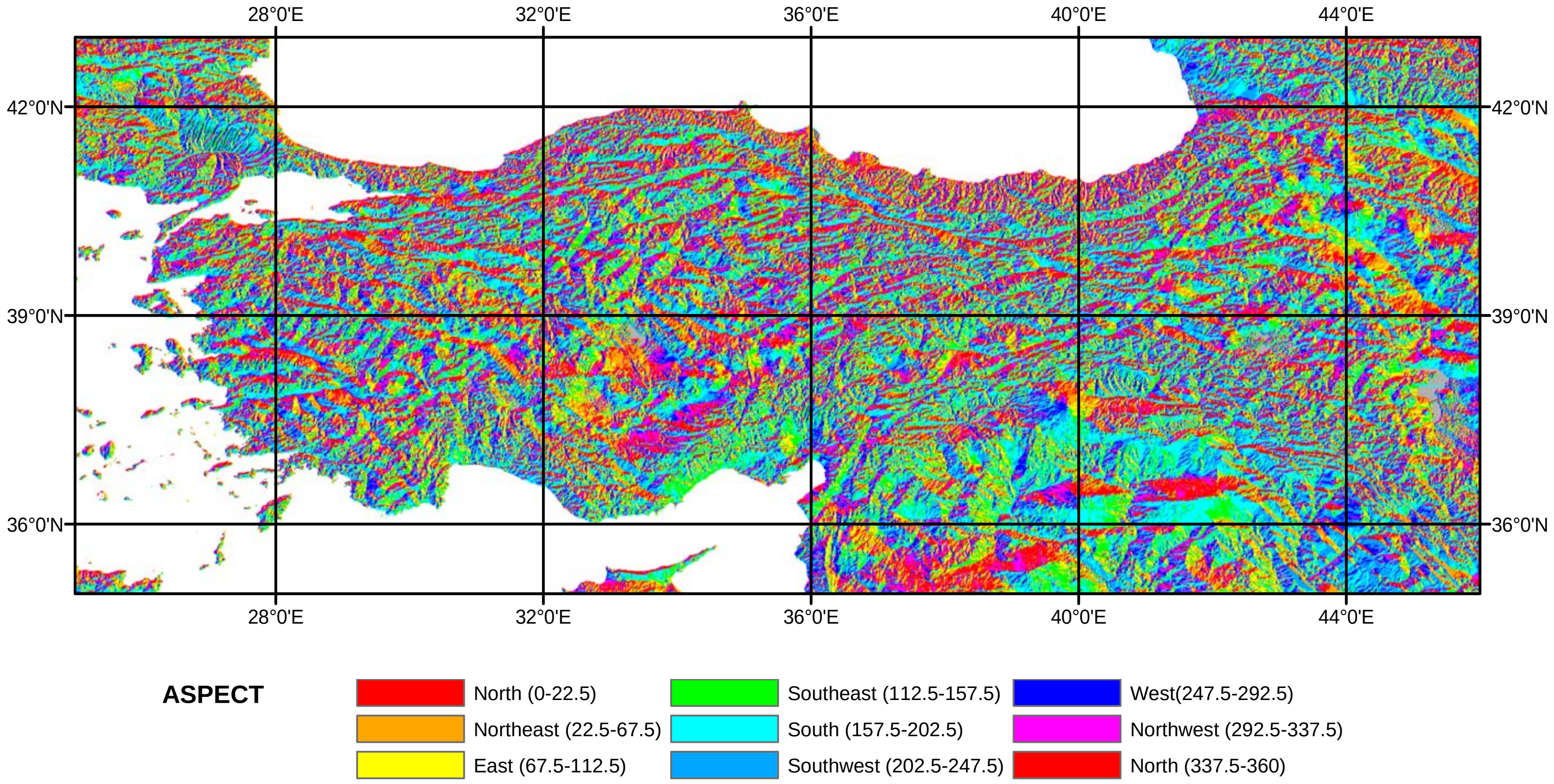


Figure 3.7 Produced aspect raster of Turkey (in degrees)

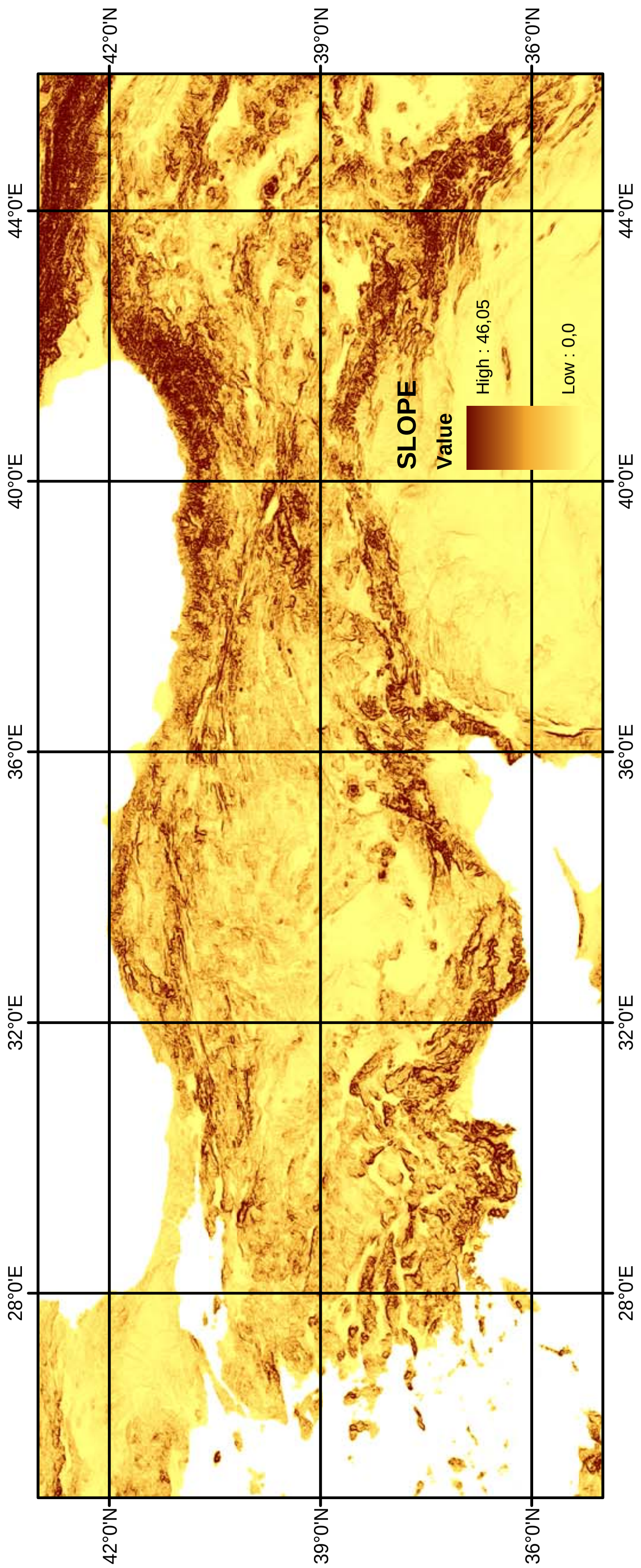


Figure 3. 8 Produced slope raster of Turkey (in degrees)

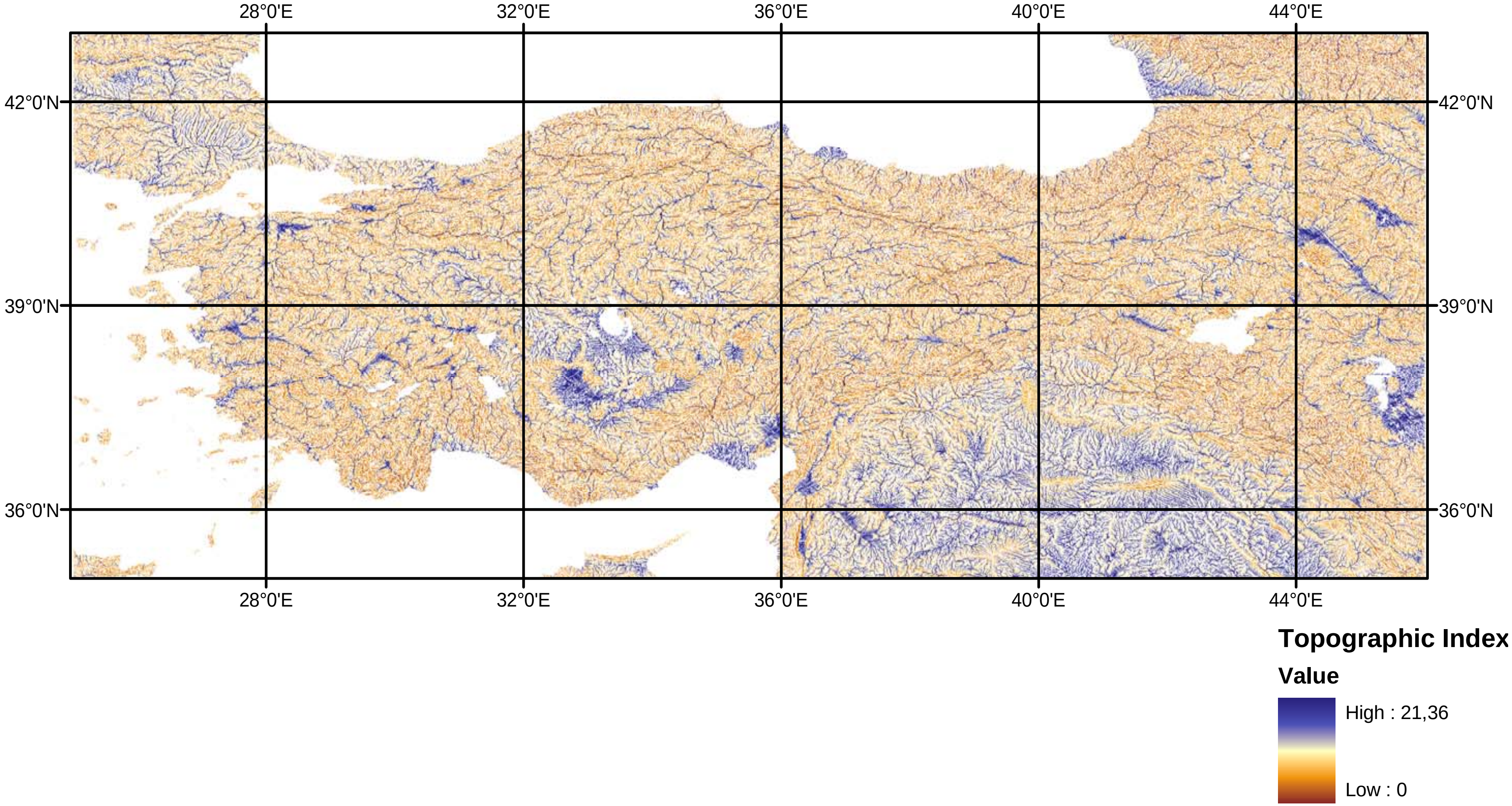


Figure 3. 9 Produced topographic index raster of Turkey

Turkish plants in which the associated classifications have been made (Ekim, Koyuncu, Vural, Duman, Aytaç and Adıgüzel, 2000).

As for the second step, account of each plant from Flora of Turkey and Aegean Islands and its supplements were investigated and all appropriate information related with the analysis was transferred to the dataset which is going to be introduced in section 3.3 (Davis, 1967-1982; Davis, Mill and Tan, 1988; Güner et al., 2000). Appendix A exhibits some examples of the plant accounts provided in the literature.

The most relevant information related with the study in the resources were the descriptions of the observation locations for each plant taxon. These information generally included altitude, observation place and the physical, geological and botanical properties of the location. However, due to the fact that observations of the plants came from various sources spanning a time period of more than 200 years, some parts of the data were far from effectively adaptable to the study.

The single most important factor behind the difficulty was the imperfect description of the locations. During the study it was comprehended that some records contained quite vague statements concerning the observation place, which alone reduced the chance of determining the exact place of the plant. Level of the vagueness differed from account to account and the most commonly used phrases were the ones including “between”, “near” and “above”. This type of defects was more serious for the records encompassing large areas, for which chance of attaining an accurate location was relatively low. In the process of transferring the data from the source book, descriptions covering very large areas were eliminated. For the remaining observations, some were associated with the patterns of DEM with the altitude information provided, some were assigned to the nearest administrative region and the others were assigned to the midpoints between the nodes. Observations citing only the name of a large area such as a mountain or a lake were subjectively evaluated based on the place of the summit or middle point of the area.

Second type of the problem was related with the language of the description data. Although the majority of the records were in English or Turkish, some of them were in other languages including French, German and Latin and worse than that, some of the areas were transferred into the literature the way they were pronounced in the mother tongue of the observer.

Another source of the confusion was the age of the records. Some historical records mentioned areas with their historical names in Armenian, Kurdish, Latin, Arabic and Greek, which created obstacles in locating process.

Last but not the least, not every account was fully described. Numerous accounts did not include at least some part of the data.

3.2.1 Production Algorithm

The algorithm, which is mentioned in this section, strived to transform the plant locations obtained from the descriptions of the sources to the created file. At the first step, data was categorized based on the accuracy. Afterwards, necessary way of transformation was selected in accordance with the cluster. In essence, the aim was to facilitate standard data conversion which was a necessity for integrating the data coming from different sources.

The process commenced with the evaluation of the quality of existing data. Given the purpose of transferring the data in hand to the dataset with the smallest amount of error, first of all most accurate data was copied into the dataset. Locations addressed with any units of a geographical coordinate system were converted into the latitude and longitude format in decimal degrees, ranked "0" in data quality and became ready for the analysis part. However, number of records evaluated in this group was very small and the majority of the accounts required other means of evaluation.

The most intense part of the process was related with the descriptions providing vague or incomplete information about the locations. The most accurate and precise results were obtained from the statements that addressed the distance of the observation from a particular centre of population. With the assumption that "all of the botanical field work were done on the courses of roads", layers of motorways, towns and villages were utilized. Distances were measured with the tools provided by the ArcGIS software and in return the locations were established (ESRI, 2002a).

Like the former description type, these data was considered to be highly accurate and ranked “0” in data quality.

For some plants distance from an administrative unit was not provided in the references. In this type of accounts, which gave reference to the road between two population centers, every information regarding the habitat and the altitude of the observation were investigated and if found, attempts to use these information were made in order to reduce the candidate spots. DEM of Turkey was proved to be very useful by providing approximate elevation information for every point in Turkey. In other cases, observation location was assigned to the middle point of the road in accordance with the motorways layer. Rank of this category of data was “2”, indicating the subjective evaluation. However, all of these held true for close nodes. If the distance proved to be large enough to cover more than two grid boxes, the description was not taken into consideration and ranked “1”.

Vague statements were not limited to the ones involving in-between relation. Some of the descriptions were supplied with reference to geographical entities that caused some degree of uncertainty due to the large areas they cover. In the case of references to mountains, additional notes related with the habitat and the altitude were investigated if available. Though this kind of information was not scarce, areas like mountains were large enough to cover regions that could fit to the description. Hence, for some of the mountains summit points were taken as the plant location. Rank of these data was “2”. Records mentioning streams and lakes were also evaluated with the same notion, but the assigned points were the midpoints of the lake shores and the middle points of the streams.

References to the administrative units of populations were approximately in the way they were applied to the large areas. Observations that addressed near or above a particular center was associated with the center, if no other information was applicable. Parallel to the way of classification, the rank was also “2”.

Up to this point, difficulties in locating the geographical entities were considered. Either the town and village layers or the maps were utilized in locating a particular unit. However, in some descriptions ancient names or the names in other languages, which do not exist in modern sources, were stressed. This type of information necessitated a literature search in which different kinds of media were used. Websites of the city governors, maps that cover ancient maps or historical names and location journals were examined in this notion and the records that became free from uncertainty were evaluated based on previously discussed methods. Nonetheless, if the literature search was not helpful and there was not any additional information in the description concerning the location, the records were not classified and ranked as "1".

As a consequence of applying the respective rules, plant data was classified as rank-1s that refer to unclassified descriptions, rank-2s that involve subjective judgment and rank-0s that were deemed to be accurately transferable. Following that, expert knowledge and publications that might have provided additional information about the unclassified and subjectively evaluated descriptions were employed. The geographical locations of the plants which were determined by the faculty of botanical department at Gazi University were transferred to the dataset immediately and the data was classified as "3". Data provided by published journals of Turkish Journal of Botany, Karaca Arboretum Magazine, GAP Biodiversity Research Project (Welch, 2004) and Important Plant Areas of Turkey (Özhatay, Byfield and Atay, 2003), a reference which was published by World Wild Fund Turkey, a nature protection society, were also added to the respective accounts and the geographical address of the associated plants were determined based on the previously discussed rules. Still, there were some plants whose locations could not be determined. These plants which had a rank of 1 were not included in analysis part of the study. Out of 931 plants, 14 Critical and 56 Endangered taxa could not be located and were not taken into account.

3.3 The Dataset

A dataset that could handle the plant information was needed following the determination of the plant locations. This section describes the structure of the entity and the methods of integrating this set to GIS.

3.3.1 Structure of the Dataset

The data file used in the study strived to integrate spatial and aspatial data those are necessary for mapping and analyzing purposes by providing a medium of storage that can allow data input, manipulation and retrieval. Each of every plant acted as an entity in the dataset and each of these entities had attributes that represented the necessary properties of interest. Every entity had a key attribute, whose value identified the entity uniquely. No entity was allowed to share the same values for the key attributes, given that other kind of practices would be a violation of the uniqueness constraint on the database entities (Elmasri & Navathe, 2000). The attributes of the entities and their domains are described in Table 3.2.

Table 3.2 Structure of the dataset

Attribute	Data Type	Logical Definition
Order_Number	Integer	Set of numbers associated with the list order of the species
Source_Volume	Character string	Volume number of Flora of Turkey and / or the name of the source used for designating the geographical location
Scientific_Name	Character string	Set of characters that represents the name of the plant species
Appropriate_Location	Character string	Set of characters that describes the location of the plant species
City	Character string	Set of characters that describes the city associated with the *Appropriate Location*
IUCN_Threat_Category	Character string	Set of characters for the representation of IUCN Threat Categories applied to the plant. CR: Critical, EN: Endangered
Longitude	Real number with 2 decimal places	Real number for representing the longitudinal value of the plant location in Eastern zone
Latitude	Real number with 2 decimal places	Real number for representing the latitudinal value of the plant location in Northern Hemisphere
Altitude	Character string	Stand alone or interval values of the plant location
Habitat_Notes	Character string	Set of characters for describing the habitat of the plant location

Table 3.2 Structure of the dataset (cont.)

Attribute	Data Type	Logical Definition
Data_Status	Integer	Values for describing the nature of data. 0 : Accurately described location 1 : Undefined location 2 : Location information which involved subjective interpretation of the author 3 : Location information which involved expert interpretation.
Notes	Character string	Set of characters for mentioning additional data.

Combination of *Scientific_Name* and *Location* acted as a composite key which uniquely identified the plants. The schema diagram was shown in Table 3.3.

Table 3.3 Data schema for the dataset

Order_Number	Volume_Number	<u>Scientific_Name</u>	<u>Location</u>
City	IUCN_Threat _Category	Longitude	Latitude
Altitude	Habitat	Data_Status	Notes

3.3.2 Integration of the Dataset into GIS

After the development of the dataset that could store spatial and aspatial data, this collection should be incorporated to the GIS application so that proposed analysis could be rendered. In order to do that, data in hand was stored in an Excel 2002 (Microsoft, 2002b) file with XLS extension. The underlying factor behind this selection was that this format had been a widely used one and was compatible with the most of the important GIS applications. Furthermore, MS Excel itself has supported wide variety of formats and it could effectively convert the format into various other formats. Given the large number of possible future additions to the database, another candidate for the format, MS Access was eliminated on the grounds that it requires much greater amount of disk space. DBF IV format was also eliminated given its insufficient character support that ignores Turkish characters and restrictions on field sizes.

As for the connection of the database file, an Excel ODBC connection from the Windows XP operation system was established. “An ODBC user data source stores information about how to connect to a particular data provider on individual computers” (Microsoft, 2002a). This connection was introduced to the ArcGIS via ArcCatalog utility and added as a table to GIS (ESRI, 2002a). From the table, XY point data was retrieved from the Latitude and Longitude fields and every row in the database file had been added to GIS. Results of the operation and an example query identifying the plants inside a particular grid cell (L26) are shown in Figures 3.10, 3.11 and 3.12.

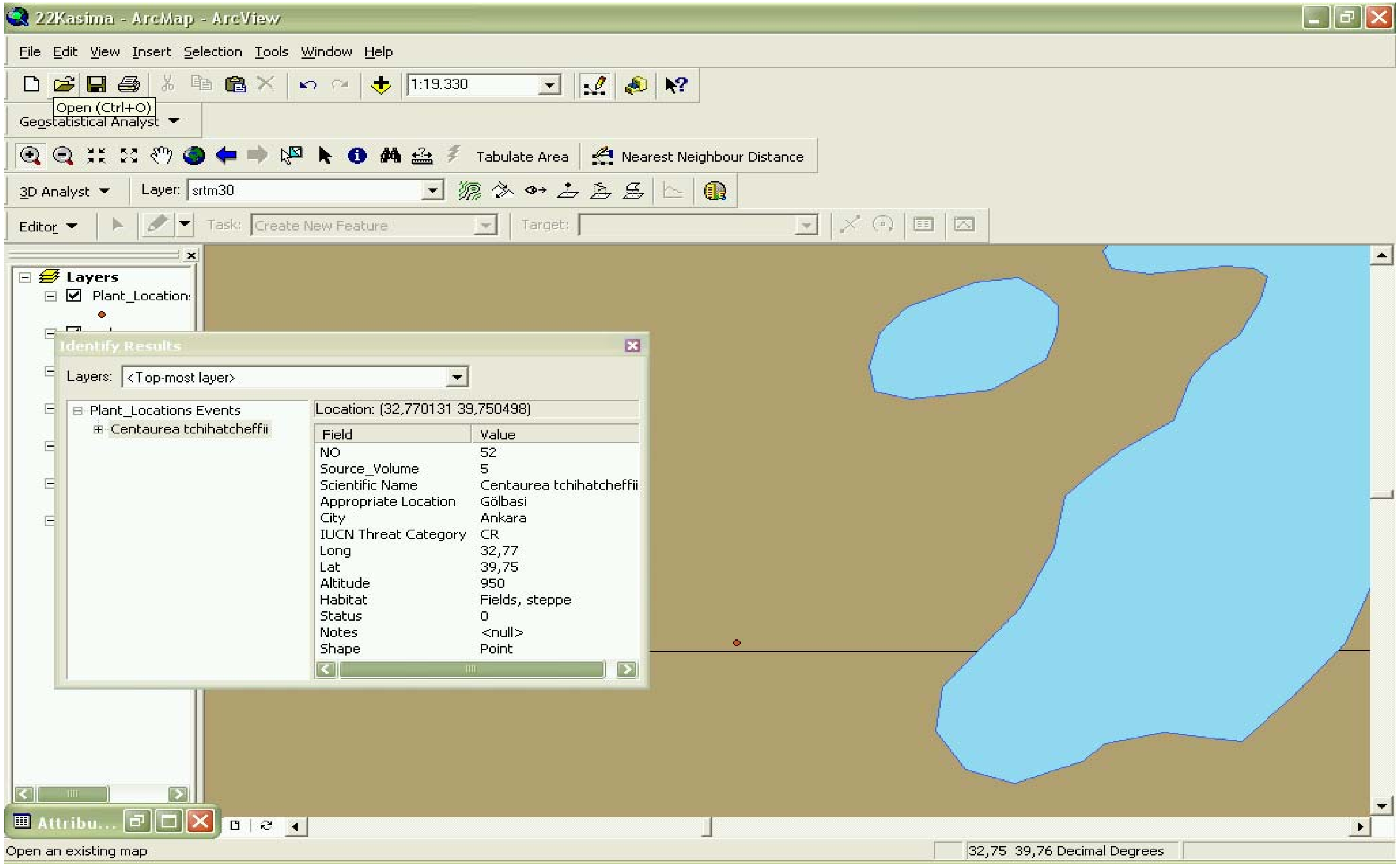


Figure 3. 10 Representation of database in ArcGIS (ESRI, 2002a)

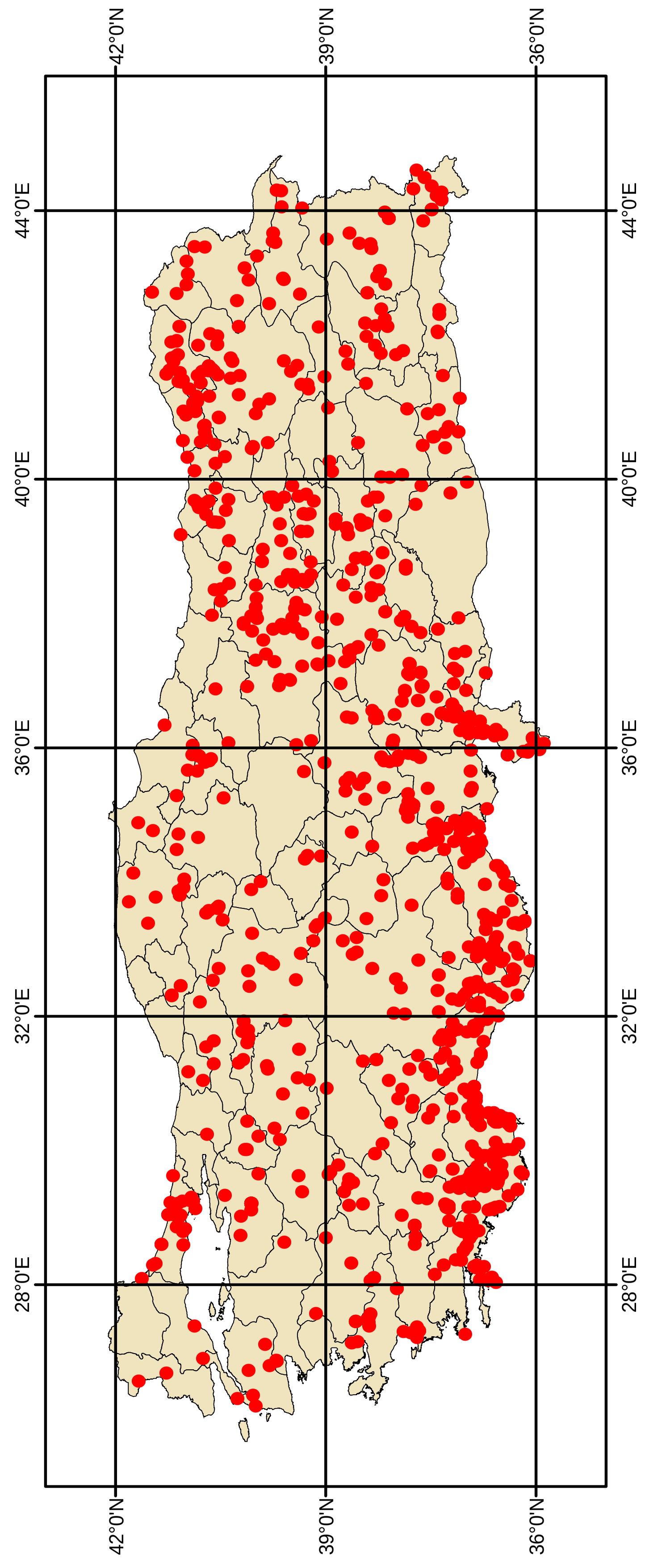


Figure 3. 11 Distribution of threatened endemics across Turkey

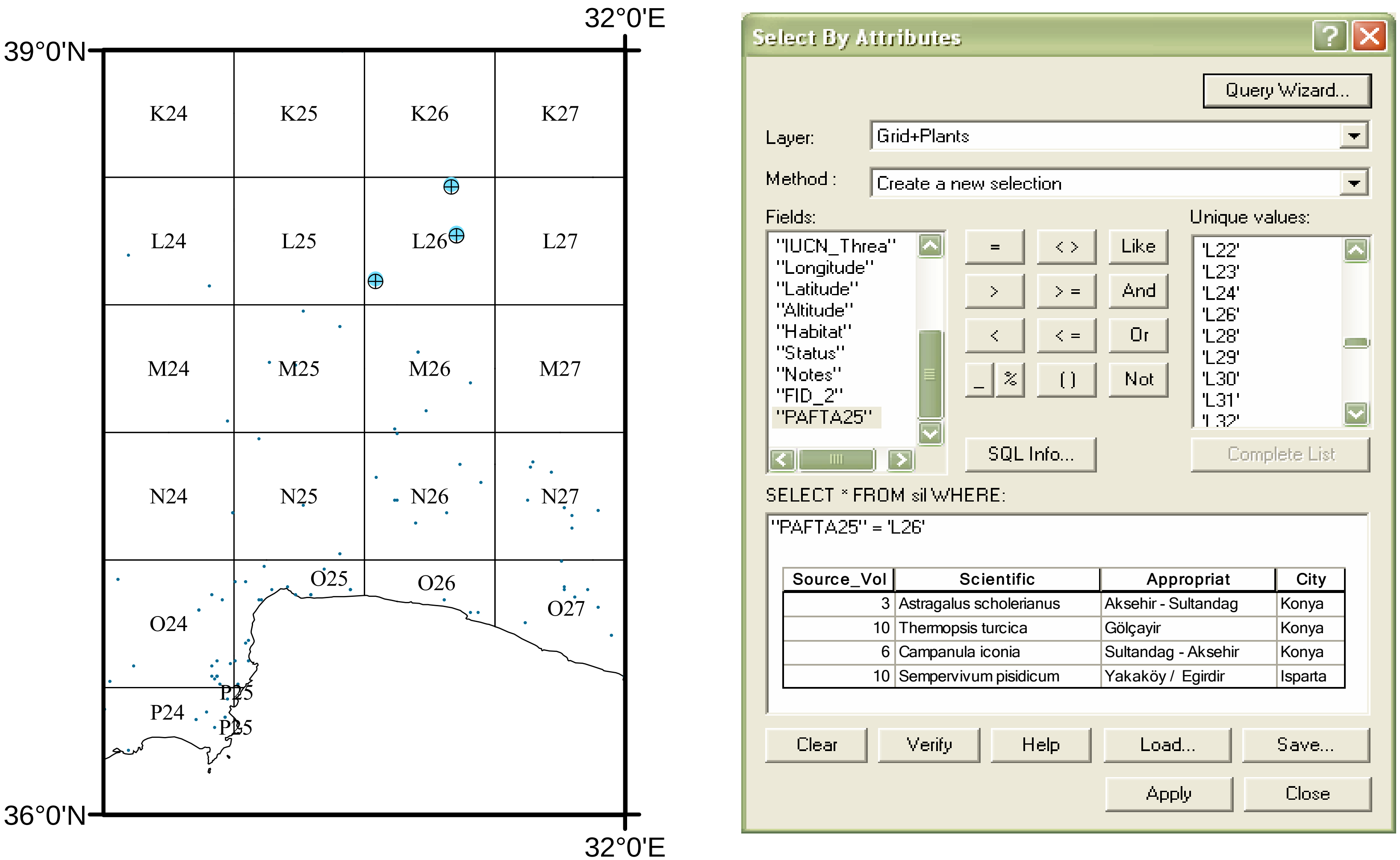


Figure 3. 12 Results of an example SQL query on joined layer Grid + Plant

CHAPTER 4

DATA ANALYSIS

This chapter is devoted to the analysis part of the study. Initial section describes techniques used in exploring data whereas remaining part is allocated to the data reduction and modeling.

4.1 Exploring Data

Exploring data is the first step in analyzing the data. By examination of the data on hand, researcher finds the opportunity to derive summary statistics and/or plots, use them in investigating the patterns the dataset has, suggest possible models by modifying hypotheses made before, putting forward new hypotheses and evaluate the appropriateness of the techniques to be utilized.

In this study density calculation, nearest neighborhood distance analysis, K and L function analyses were performed for investigating and assessing the distribution of Turkish endemics in danger.

4.1.1 Density Calculation

Density estimation lets point values spread out over a surface. The magnitude at each location is distributed throughout a landscape which creates a map of density values for each point on the surface (ESRI, 2002b). In the study, Spatial Analyst extension of ArcGIS application (ESRI, 2002a) was utilized. The Density module of this extension calculates density of a point dataset by using two variables, namely search radius and output cell size and two methods, namely kernel and simple (Figure 4.1).

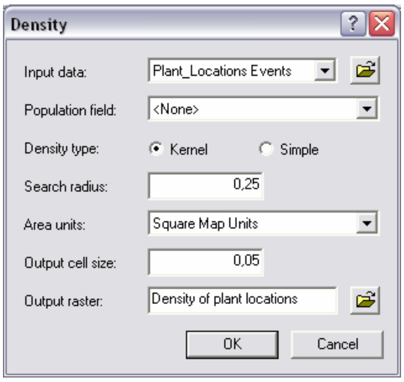


Figure 4.1 Density Module of Spatial Analyst

Simple and kernel methods utilized in the module, took their roots from the literature on spatial density estimation. In simple density calculation, points or lines that fall within the search area are summed up and then divided by the search area size to get each grid cell's density value. This is a quadrat method example, which strives to summarize the pattern in locations of events over divided sub regions or quadrats. A different approach, Kernel, is also available. The idea behind the development of original Kernel estimation was to obtain a smooth estimate of a univariate or multivariate probability density from an observed sample of observation (Bailey & Gatrell, 1995). It is based on the basics of estimation of a bivariate probability density. If s represents a general location in some region R, $s_1, s_2 \ldots, s_n$ are the locations of the n observed events, k() is a chosen bivariate probability density function known as kernel which is symmetric about the origin, λ is the bandwidth which is the radius of a disc centered on s within which points s_i will be accumulated in $\lambda_\tau(s)$ and $\delta_\tau(s)$ is the edge correction factor which represents the volume under the scaled kernel centered on s inside R, then the intensity at s, λ(s), is estimated by the Equation 4.1.

$$\text{Estimated } (\lambda_\tau(s)) = 1 / \delta_\tau(s) \sum_{i=1}^{n} \frac{1}{\tau^2} k\left(\frac{s - s_i}{\tau}\right) \qquad \textbf{(4.1)}$$

In Kernel estimation, researcher uses a floating function that visits each point on a circular part of the grid (Figure 4.2). The width of the circular area is determined by bandwidth τ, which functions like a radius of a circle that scans all of the observations inside the scanned region. The larger the bandwidth, the flatter the estimation of the density and obscured the local features. On the other hand, very small bandwidths will lead to local peaks with no connectivity between other events. In the module, bandwidth is controlled by the search radius variable. The other variable of the module, output cell size, determines the grid size of output raster. This variable can be manipulated for changing the resolution. Larger values will make way to lower quality estimations whereas a very small cell size will inflate the needed calculation time.

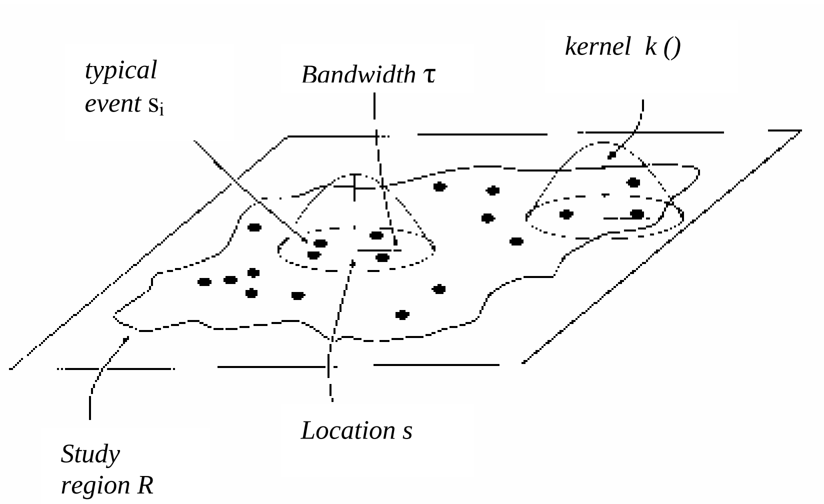


Figure 4.2 Kernel estimation of a point pattern (Reprinted from Bailey & Gatrell, 1995)

For this study, different cell size and search radius values were tried in order to create an overview of the pattern of plant locations. The density maps obtained in kernel method were represented in Figure 4.3. In accordance with the mission of exploring techniques, density maps created in the study were deemed to represent different facets of the information gathered from the dataset rather than entailing a conclusion. Thus the analysis itself and the variable values shown should be taken as a sensitivity analysis.

In the analysis, first variable, search radius, took values from 0.1 to 0.5. Unit of the figures was decimal degrees, as being the unit employed in the data production process. Hence, search radius of 0.1 is equal to one tenth of a decimal degree or a distance between 8.25 and 11.1 kilometers in Turkey (CE 413 Class Lecture, November, 17, 2003)[1]. Second variable was output cell size, which adjusted the

[1] The conversion is associated with the deviations in distances between two latitudinal lines crossing Turkey. Distance accounted by 1 latitude degree is calculated as cosine (degree of latitude) * 111 km and in northern part of the country this equation takes its minimum value of circa 82.5. On the same longitude though, distance between two nodes 1 decimal degree apart is ca.111 km.

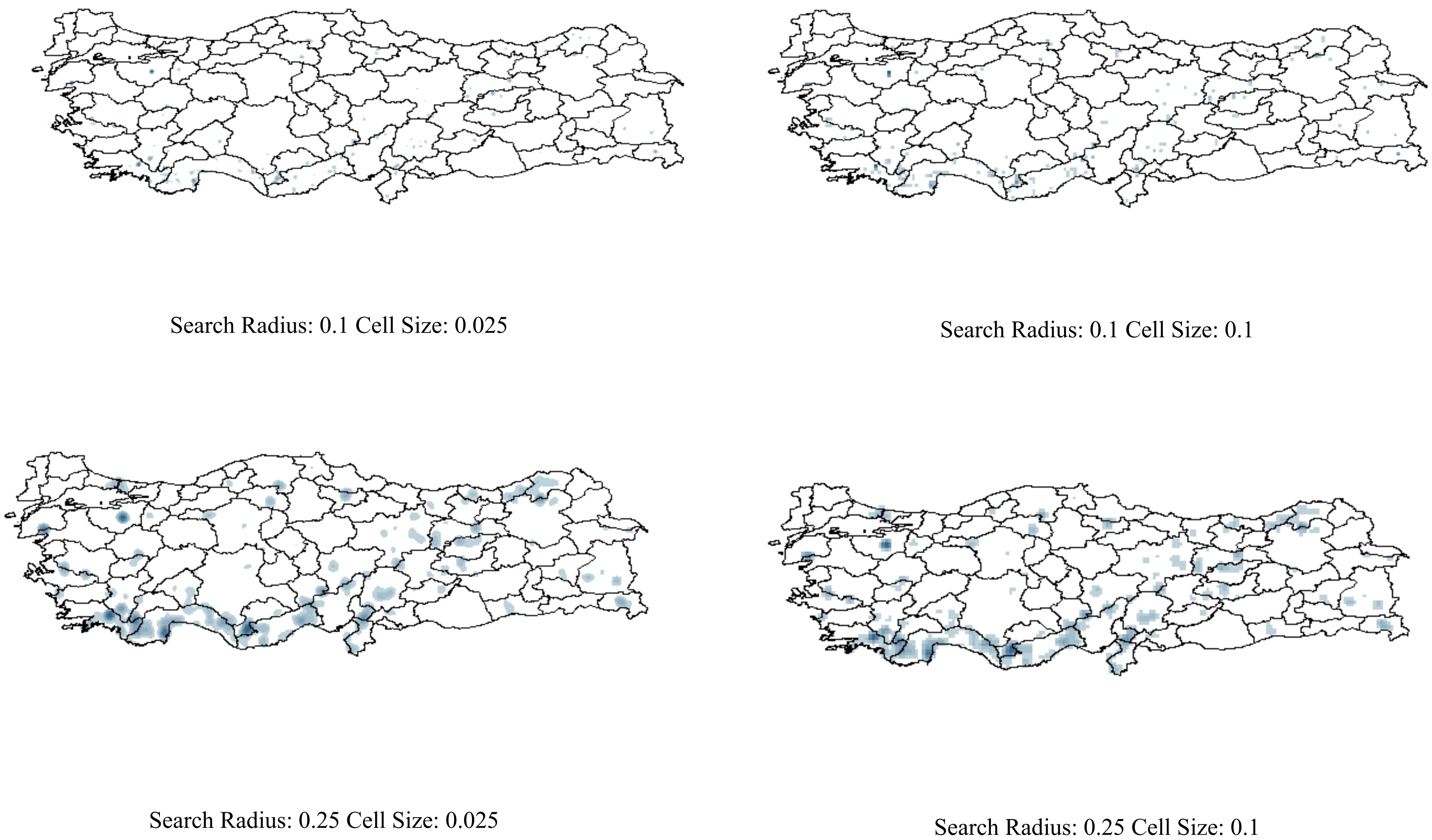


Figure 4.3 Density calculations with Kernel method for plant locations (in units of decimal degrees)

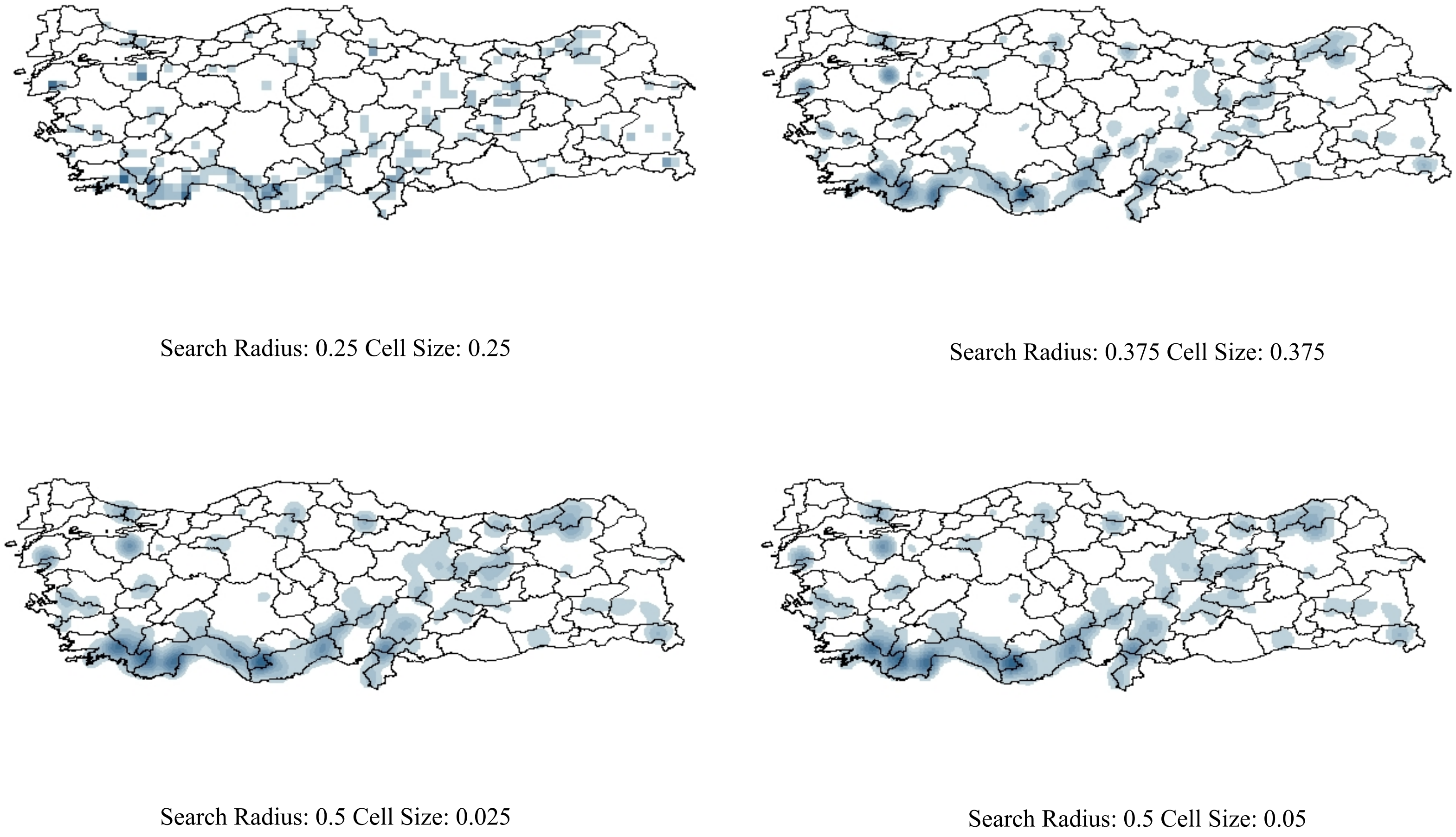


Figure 4.3 Density calculations with Kernel method for plant locations (in units of decimal degrees) (cont.)

the resolution of the map. This variable took values from the range between 0.025 and 0.1. Trivially, these values were mere examples of the continuum of usable figures and selection was based on subjective selection of the researcher.

The effect of different search radii and bandwidth values on the distribution map can be explored from the Figure 4.3. As search radius increases from 0.1 to 0.5, distribution gets smoother, flatter and an unrealistic pattern appears where large areas were shaded. However, smaller figures may also create problems especially when they form spiky distributions. First row of the figure was a good example of this phenomenon where very small search radius was responsible from the separated point patterns on the maps.

Output cell size is related with resolution and estimations based on large figures are prone to less sensitive results. Due to smaller number of cells, number of available cells that can take different values are put under restraint and the solution matrix became incapable of representing minimum required detail. In contrast, very small cell sizes can improve the resolution but the calculation time needed to perform the analysis is inflated due to logarithmic increase in the cells to be considered.

In this analysis, intermediate values for output cell size and search radius gave most effective results for the distribution map. With a cell size of 0.025 degrees and search radius of 0.25 degrees, distribution patterns of endangered endemic plants were represented in Figure 4.4. Given the difficulty of designating a extremely precise coordinate pair for the plants with the data available, this scale could sufficiently describe the major hot spots by forming virtual buffers around the close localities and stressing the importance of discrete areas such as Uludağ and Kaz Mountains.

An immediate comment on the analysis may be related with the shape of the shaded areas. As can be seen from Figure 4.4, density of the points situated on the southern, eastern and northeastern part of the country is higher, whereas there are small number of distinct spots on the west. At this point, one finding of botanical researchers should be mentioned. According to Davis (1971), there is an artificial oblique belt running from the vicinity of Gümüşhane to Anti-Taurus where it

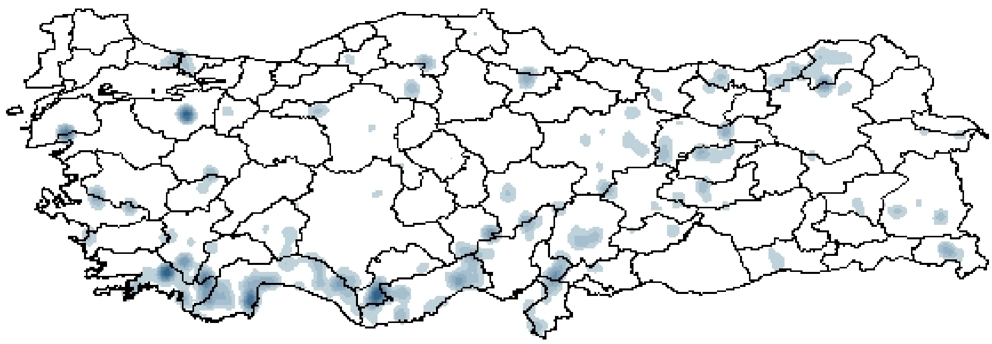


Figure 4.4 Density of Turkish Endangered Endemics. Kernel Method, output cell size 0.025, τ = 0.25

bifurcates to a prong to Antakya and another to Adana. Named as "Anatolian Diagonal", this line was found to be a major floral break which acted as a distributional limit and/or corridor for many plant species. The analysis indicated the parallelism with the existing knowledge by drawing artificial boundaries of the diagonal and exposing other rich regions to the discussion.

4.1.2 Nearest Neighbour Distances

In exploring the spatial distribution of events, particularly the locations of the plants throughout the country, former methods gave a basic idea about the general appearance of the intensity. From a visual point of view, screenshots obtained pointed out the hotspots of endangered endemic plants. On the other hand, in order to gain insights into the geospatial determinants of the plant records, relationship between individual locations should be investigated in a more quantitative manner. Therefore, nearest neighbor distances were investigated. Distance between 2 events was used to examine the degree of spatial dependence in the overall point pattern. Equation 4.2 represents the $\hat{G}$ (w) function, which is an estimation of empirical cumulative probability distribution

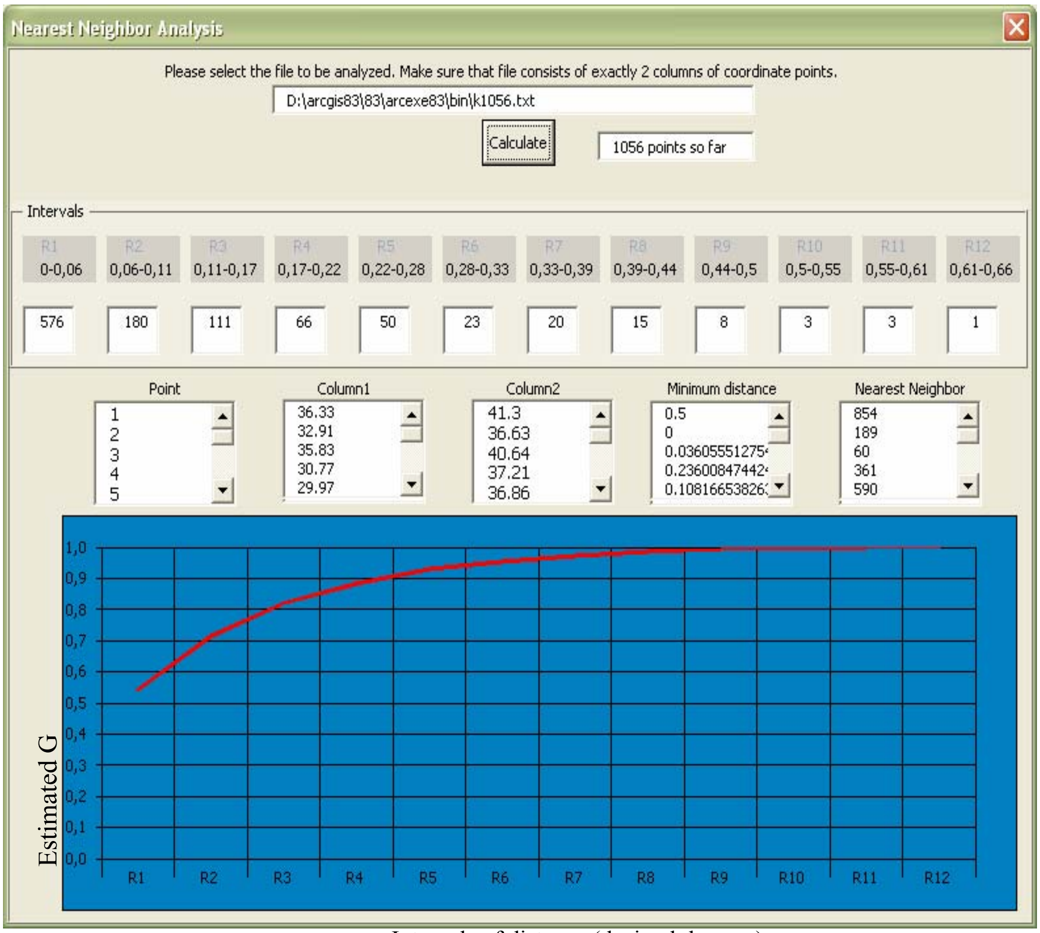
$$\hat{\mathbf{G}}(\mathbf{w}) = \frac{\#(\mathbf{w_i} \leq \mathbf{w})}{\mathbf{n}} \quad \mathbf{(4.2)}$$

where **n** is the number of records and **w** is the distance in degrees of latitude/longitude (Bailey & Gatrell, 1995).

Due to lack of this function in ArcGIS (ESRI, 2002a), a program which also forms a graphic of the nearest neighbour distribution function was written in Microsoft Visual Basic and added as a macro on to the main application. The code is available in Appendix C.

The module retrieves event locations from a text based data file in which exactly two columns exist. For each point, distance with each of every other point is calculated and the least apart point and the smallest distance are determined. Result is represented in two matrices, one of which pointing the nearest neighbor observation and the second one the distance. In order to set the graph, equal intervals are formed by dividing the difference between the minimum and the maximum of nearest neighbor distances by an arbitrary value of 12. For each interval, number of nearest neighbor distances smaller than the interval's upper bound is found and this value is divided by the number of points. After all a representative graph of the distribution function is output. Screenshot for the whole plant data is shown in Figure 4.5.

According to the outcome of the module, the largest distance between any observation and its nearest neighbor is 0.6618 decimal degrees which covers a distance between 54.6 and 73.46 km in Turkey whereas the smallest value is because of the same point occurrences (CE 413 Class Lecture, November, 17, 2003). From the graph, it can be seen that distribution function climbs steeply in the early part of its range. Out of 1056, 576 events (54%) have their nearest neighbours inside the range of 0 - 0.06 degrees (0 to 6.6 km) and only 50 (4.7%) of all are more than 0.33 degree (at least 27.2 km) apart from their nearest neighbours. This clearly indicates a clustering based on inter – event attractions, as opposed to a regular distribution pattern. In other terms, environs of most endangered endemic plant locations support more than one species and small number of places host high number of plants. Another explanation may be the existence of a corridor like distribution in which solitary species are replaced by their affiliates in small distances. Having added these, it can be proposed that Turkish plants had adapted to few environments that possess distinctive characteristics throughout their evolution. That can led to a hypothesis proposing the abundance of factors affecting the distribution of Turkish endemics.



Intervals of distance (decimal degrees)

Figure 4.5 Nearest Neigbour Analysis module

4.1.3 K Function

The third analysis tool of the study was the K function. It is a useful tool in examining larger scales of pattern. In contrast to the Nearest Neighbour Distance method, it takes all of the events into consideration, therefore offers a better picture of spatial dependence over a wider scale. The definition of the K function is given in Table 4.1.

Table 4.1 The K function

K(h) = Expected number of events within distance *h* from an arbitrary event / λ where λ is mean number of events per unit area (Bailey & Gatrell, 1995).

Given that all points are available in the dataset, if all point to point distances were calculated, definite figures rather than expected values would be used. In order to find the empirical values of K(h), another Visual Basic routine was written and added on to ArcGIS application as a macro (ESRI, 2002a). The code is available in Appendix D.

When run, the routine requests the data file from which the event locations will be gathered. Data file should consist of two fields for latitudinal and longitudinal position of the point. For each of every point, distances with the other points are measured. The smallest and the highest distances for whole dataset are recorded and the difference between these two values are divided by 24 (just an arbitrary value) in order to form the intervals. Once they are formed, each point's distance with every other point is compared with these intervals. For each interval, number of events within the boundaries is determined. This procedure is repeated for all members of the dataset. In conclusion one matrix of [n x n] dimension is created and each P_{ab} – P_{xy} distance is compared with interval boundaries. Following this step, value for each of the interval is substituted for Table 4.1 and respective K (h) values are determined. The result of the execution of the written module with already derived plant locations is shown in Figure 4.6, which is an exploratory device in interpreting the distribution of plants from the perspective of geospatial interdependence. First impression suggests a degree of "piling up" in immediate h values up to 4.64 decimal degrees and decreasing rate of increment for succeeding h values afterwards. Nevertheless, in order to measure the clustering, we should compare our K(h) estimates with number of events that should be expected in the case of a random distribution. Random occurrences of the events connotes that an event at any point in the area concerned is independent of other events and equally likely over the whole region (Bailey and Gatrell, 1995). Hence for a random process, expected number of events within a distance of h of a randomly chosen event would be $\pi\lambda h^2$ where λ is the mean number of events per unit area and K(h) takes the form of Equation 4.3.

$$K(h) = \lambda \Pi h^2 / \lambda = \Pi h^2 \qquad \textbf{(4.3)}$$

If our estimated value were larger than Πh^2, this would point a higher-than-random density in the particular distance range of h; in a more geospatial way of defining, a clustering. A negative result would on the other hand indicate a regular distribution.

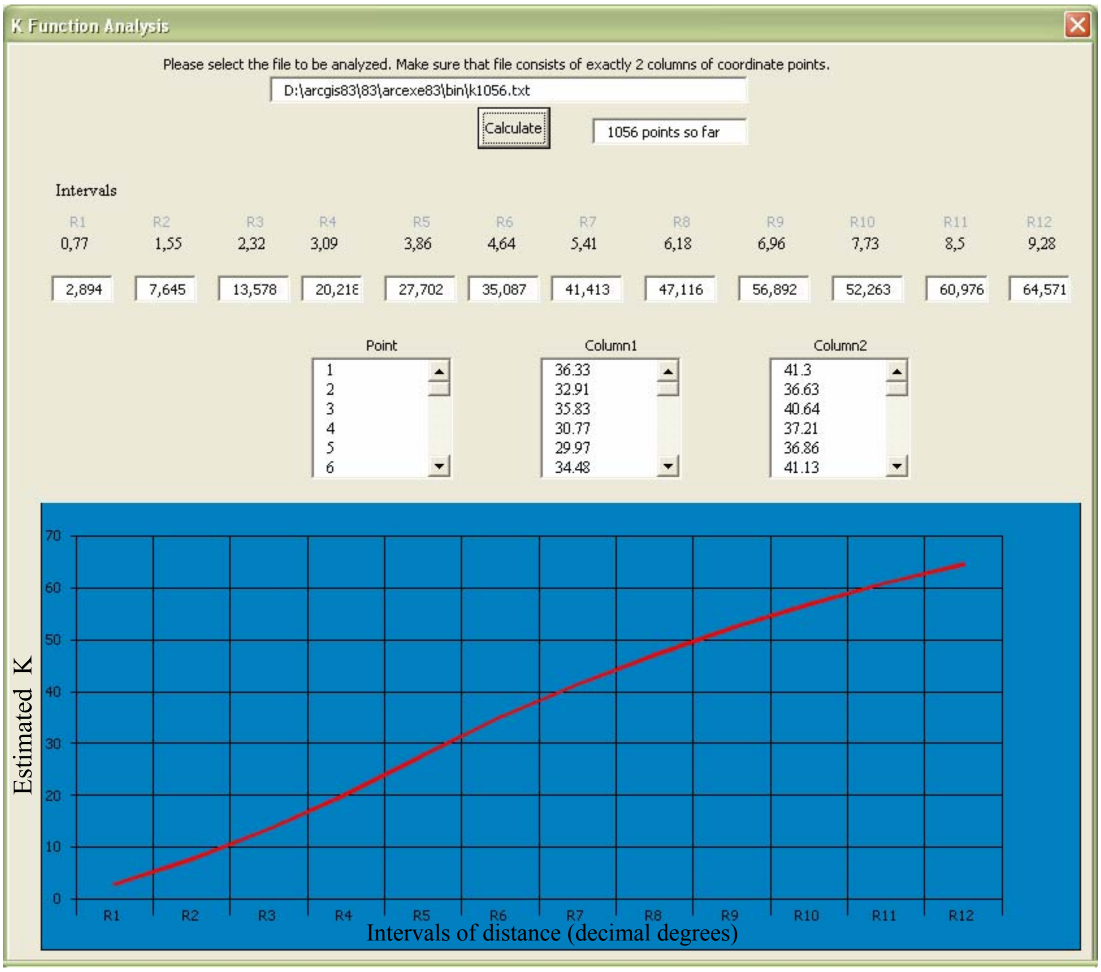


Figure 4.6 The K function module

In order to represent this relationship, the L function was used. Evidently, the L function is only an extended version of the K function, as shown in Equation 4.4.

$$L_{expected}(h) = \sqrt{\frac{K_{expected}(h)}{\Pi}} - h \qquad \textbf{(4.4)}$$

Another MS Visual Basic program was written and added on ArcGIS (ESRI, 2002a) for the L function, which is available in Appendix E. This module retrieves the data file in the way, previously mentioned modules do. However, given the fact that the function is more effective in explaining the spatial dependences between points in short distances, interval sizes are divided by two and h values larger than (h_{max} / 2) were not taken into account (Bailey and Gatrell, 1995). Another discrepancy is in type of the graph function which was changed in favor of 2D Bar for better visual representation. The L function with plant data applied is shown in Figure 4.7.

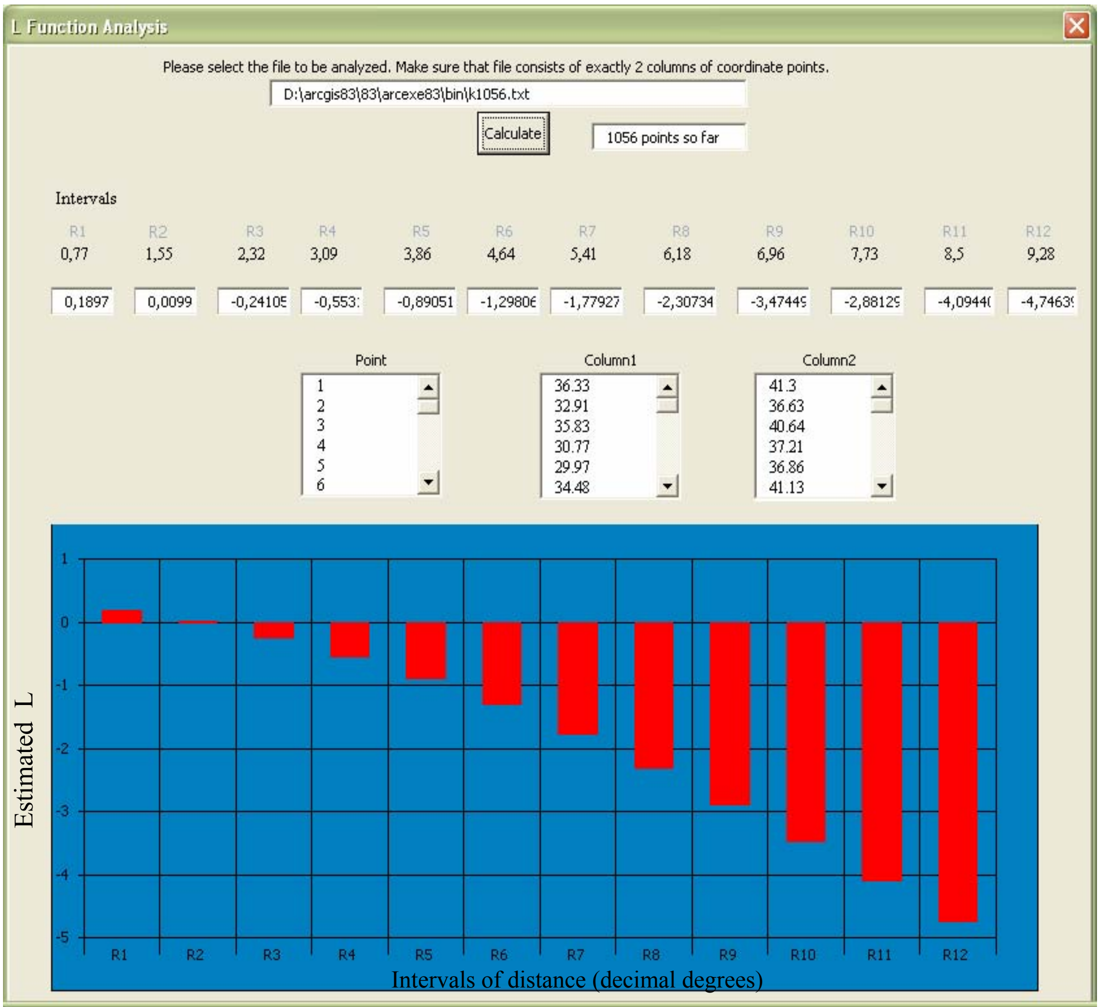


Figure 4.7 The L function module

According to the results, up to the distances of 1.55 decimal degrees (at most 172 km (CE 413 Class Lecture, November, 17, 2003)), points are distributed in clusters. In contrast, in larger distances the distribution turns out to be more regular. These results are not contradicting with the previous outcomes and support the view that a significant part of Turkish endangered endemics are situated in proximate regions.

4.2 Data Reduction

Before moving on the data reduction or analysis phases, investigation of variable normality must be assured. This assurance can be done by checking two components of normality, skewness and kurtosis (Tabachnick & Fidell, 2001). While skewness measures the symmetry, kurtosis is related with the peakedness of the distribution. A normal distribution has a skewness statistic of 0. As the value increases, distribution deviates from normality. From a different perspective nonnormal kurtosis leads to underestimation of the variance of a variable. However, large samples consisting more than 200 cases are immune to this problem. Given that the study combined 358 cases, kurtosis was out of scope. Though conducting transformation for highly skewed variables might be useful for the study, residual analysis is selected for investigating the existence of normality violations, due to the facts that it is quite impractical to test each of every variable and transformation deteriorates the interpretation of the factors. Moreover, temperature related variables were already transformed beforehand into a scale for the sake of analysis. Nevertheless, in order to remove possible outliers and eliminate abnormal distribution, the dependent variable, number of endangered endemic plants per grid cell (PLANT) is logarithmically transformed. Skewness statistics for the variable before and after the transformation (PLANTTR) are presented in Table 4.2. Skewness of the new variable is small enough to be an indicator of normality.

Table 4.2 Descriptive statistics for the dependent variable

	Minimum	Maximum	Mean	Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
PLANT	.00	208.395	14.224	23.844	3.756	.129
PLANTTR	.00	2.32	.789	.6162	.047	.129

Prior to the establishment a model that gives clues about the relationship between dependent and independent variables, it is necessary to eliminate variables which do not contribute significantly. General aim should be minimizing the number of factors to be included in the expression and making most of them so that smallest number of independent variables account for the greatest amount of variation. All statistical tests and measurements mentioned from this point on are conducted by statistical application SPSS 10, which is an effective tool with wide variety of available procedures (SPSS, 1999).

For the study 64 relevant variables have been determined. These are meteorological variables of long term mean of average monthly temperatures (TAM#), long term mean of maximum monthly temperatures (TMX#), long term mean of minimum monthly temperatures (TMN#), long term averages of total monthly precipitation (PERM#) and topographical variables of mean slope (SLOPEM), standard deviation of slope (SLOPESTD), mean aspect (ASPECTM), mean wetness index (MOIMEAN), standard deviation of wetness index (MOISTD), mean altitude

(ALTMEAN), standard deviation of altitude (ALTSTD) and number of altitudinal changes per cell (NALTCHG). With so many factors most of which were derived from other variables, likelihood of high correlations is quite high. Although every variable may have a contribution of its own to the overall model, use of highly correlated variables would be an undesirable situation for the analysis, due to the fact that not only the number of variables needed would inflate, but also interpreting the analysis results would be harder.

Correlations between the variables are determined with Pearson's Correlation Coefficient. This measure is a very widely used measure of linear association between two variables. Result of the measurement gives a value between -1 to +1, where larger absolute coefficients indicate stronger relationships (SPSS, 1999).

Results of the bivariate correlation measurements are represented in Table 4.3, 4.4, 4.5 and 4.6. From Table 4.3, it can be concluded that long term means of average temperature for months are correlated with each other. In order to capture enough information regarding the seasonal temperature differences and temporal changes around different regions of Turkey, months with the highest correlation with dependent variable, logarithmically transformed plant counts per grid cell are selected as representatives of the seasonal variables (Table 4.4). Given that long term means for maximum, minimum and average temperatures are highly correlated with each other (Table 4.5), no variable except TA12, TA4, TA8 and TA10 is needed for the model. All in all, target of this selection process is to prevent analysis to be inflated with large number of variables but at the same time would not let the differences in the seasonal temperature patterns ignored with the motivation of eliminating all highly correlated variables. In the same notion, variables dealing with the precipitation averages are checked for the correlations with endemic threatened plant richness from Table 4.6 and PER1M, PER3M, PER8M and PER11M are set aside for the incoming processes.

Table 4.3 The bivariate correlation measured with Pearson's Correlation Coefficient for long term mean of average monthly temperature data

	TA1M	TA2M	TA3M	TA4M	TA5M	TA6M	TA7M	TA8M	TA9M	TA10M	TA11M	TA12M
TA1M	1,000	,997	,970	,906	,852	,763	,590	,614	,733	,893	,976	,998
TA2M	,997	1,000	,984	,927	,873	,781	,612	,633	,750	,901	,973	,992
TA3M	,970	,984	1,000	,975	,934	,851	,709	,728	,828	,940	,968	,966
TA4M	,906	,927	,975	1,000	,981	,922	,817	,834	,910	,968	,942	,909
TA5M	,852	,873	,934	,981	1,000	,977	,902	,911	,956	,968	,908	,857
TA6M	,763	,781	,851	,922	,977	1,000	,967	,968	,976	,938	,843	,772
TA7M	,590	,612	,709	,817	,902	,967	1,000	,996	,964	,857	,705	,606
TA8M	,614	,633	,728	,834	,911	,968	,996	1,000	,979	,882	,734	,632
TA9M	,733	,750	,828	,910	,956	,976	,964	,979	1,000	,955	,841	,751
TA10M	,893	,901	,940	,968	,968	,938	,857	,882	,955	1,000	,961	,906
TA11M	,976	,973	,968	,942	,908	,843	,705	,734	,841	,961	1,000	,985
TA12M	,998	,992	,966	,909	,857	,772	,606	,632	,751	,906	,985	1,000
ABBREVIATIONS: TA#M: Long term mean of average monthly temperatures												

Table 4.4 Correlations between climatic and topographical variables and logarithmically transformed endangered endemic plant numbers (PLANTTR) measured by Pearson's Correlation Coefficient

	PLANTTR
TA1M	0,156
TA2M	0,154
TA3M	0,178
TA4M	0,189
TA5M	0,165
TA6M	0,141
TA7M	0,151
TA8M	0,176
TA9M	0,210
TA10M	0,215
TA11M	0,194
TA12M	0,163
PRE1M	0,354
PRE2M	0,314
PRE3M	0,218
PRE4M	0,011

Table 4.4 Correlations between climatic and topographical variables and logarithmically transformed endangered endemic plant numbers (PLANTTR) measured by Pearson's Correlation Coefficient (cont.)

	PLANTTR
PRE5M	-0,111
PRE6M	-0,112
PRE7M	-0,072
PRE8M	-0,051
PRE9M	-0,010
PRE10M	0,106
PRE11M	0,253
PRE12M	0,331
SLOPEM	0,152
SLOPESTD	0,137
ALTSTD	0,096

ABBREVIATIONS: **TA#M**: Long term mean of average temperatures for month #, **PRE#M**: Long term average of total precipitation for month #, **SLOPEM**: Mean Slope, **SLOPESTD**: Standard Deviation of Slope, **ALTSTD**: Standard Deviation for Altitude

Table 4.5 Bivariate correlations between long term monthly means of average, maximum and minimum temperatures for January and July measured with Pearson's Correlation Coefficient

	TA1M	**TMN1M**	**TMX1M**	**TA7M**	**TMN7M**	**TMX7M**
TA1M	1,000	,984	,973	,590	,802	,415
TMN1M	,984	1,000	,933	,642	,864	,431
TMX1M	,973	,933	1,000	,458	,691	,310
TA7M	,590	,642	,458	1,000	,874	,887
TMN7M	,802	,864	,691	,874	1,000	,609
TMX7M	,415	,431	,310	,887	,609	1,000

ABBREVIATIONS: **TA#M**: Long term mean of average temperatures for month #, **TMX#M**: Long term mean of maximum temperatures for month #, **TMN#M**: Long term mean of minimum temperatures for month #

Table 4.6 Bivariate correlations between long term averages for total monthly precipitation measured with Pearson's Correlation Coefficient

	PRE1M	PRE2M	PRE3M	PRE4M	PRE5M	PRE6M	PRE7M	PRE8M	PRE9M	PRE10M	PRE11M	PRE12M
PRE1M	1,000	,925	,738	,079	-,459	-,282	-,056	,058	,154	,430	,877	,992
PRE2M	,925	1,000	,924	,385	-,287	-,363	-,152	-,043	,061	,390	,860	,917
PRE3M	,738	,924	1,000	,654	-,062	-,360	-,188	-,080	,021	,364	,747	,734
PRE4M	,079	,385	,654	1,000	,585	-,067	-,124	-,075	-,022	,215	,237	,081
PRE5M	-,459	-,287	-,062	,585	1,000	,628	,445	,373	,334	,298	-,167	-,439
PRE6M	-,282	-,363	-,360	-,067	,628	1,000	,933	,878	,819	,620	,024	-,233
PRE7M	-,056	-,152	-,188	-,124	,445	,933	1,000	,967	,905	,744	,237	,000
PRE8M	,058	-,043	-,080	-,075	,373	,878	,967	1,000	,955	,836	,346	,116
PRE9M	,154	,061	,021	-,022	,334	,819	,905	,955	1,000	,903	,469	,211
PRE10M	,430	,390	,364	,215	,298	,620	,744	,836	,903	1,000	,728	,479
PRE11M	,877	,860	,747	,237	-,167	,024	,237	,346	,469	,728	1,000	,907
PRE12M	,992	,917	,734	,081	-,439	-,233	,000	,116	,211	,479	,907	1,000
ABBREVIATIONS: **PRE#M**: Long term mean of total monthly precipitation												

Correlations between topographical variables are presented in Table 4.7. Between SLOPEM, SLOPESTD and ALTSTD exist great amount of correlations and just one of them may account for most of the variance all of them explain. With reference to Table 4.4 SLOPEM is selected, given that it has the strongest correlation with dependent variable. In addition to this variable, MOIMEAN, MOISTD, NALTCHG, ALTMEAN, ASPECTM are selected.

Table 4.7 Bivariate correlations between topographical variables measured with Pearson's Correlation Coefficient

	SLOPEM	SLOPESTD	MOIMEAN	MOISTD	ALTMEAN	ALTSTD	NALTCHG	ASPECTM
SLOPEM	1,000	,898	-,667	-,163	,438	,845	,547	,079
SLOPESTD	,898	1,000	-,570	-,046	,404	,867	,555	,091
MOIMEAN	-,667	-,570	1,000	,504	-,293	-,494	-,322	-,299
MOISTD	-,163	-,046	,504	1,000	-,099	-,025	-,032	-,126
ALTMEAN	,438	,404	-,293	-,099	1,000	,444	,310	-,036
ALTSTD	,845	,867	-,494	-,025	,444	1,000	,630	,065
NALTCHG	,547	,555	-,322	-,032	,310	,630	1,000	,009
ASPECTM	,079	,091	-,299	-,126	-,036	,065	,009	1,000

ABBREVIATIONS: **SLOPEM**: Mean Slope; **SLOPESTD**: Standard Deviation of Slope; **MOIMEAN**: Mean Wetness Index; **MOISTD**: Standard Deviation of Wetness Index; **ALTMEAN**: Mean Altitude; **ALTSTD**: Standard Deviation of Altitude; **NALTCHG**: Normalized Number of Altitude Change; **ASPECTM**: Mean Aspect

Following the first step of variable removals, factor analysis is utilized for removing redundant variables from the dataset. Supplied with different extraction methods, factor analysis is a useful procedure for preparing a clean dataset with minimal redundancy. As the extraction method, principal component analysis was employed. This method attempts to find linear combinations of variables which are called components. Components explain most of the variance observed in a much larger set of factors and with few numbers of them, a significant part of the variance can be accounted for.

There are 2 statistical tests that check the validity of conducting factor analysis on the variables. First one is Bartlett's Test of Sphericity, which tests the null hypothesis that the correlation matrix is an identity matrix. If the null hypothesis can be rejected, use of multivariate analysis is of use since the dependent variables are correlated (SPSS, 1999). On the other hand, Kaiser – Meyer – Olkin (KMO) test which measures the sampling adequacy, outputs a statistic which expresses the proportion of variance in the variables which is common variance. The larger the statistic, the larger the variance that is caused by the variables. Most widely used threshold is 0.5 and larger figures indicate suitability of the structure to a factor analysis.

In the initial step, each of every candidate variables that was picked up after the correlational inspection is included in the factor analysis. Most widely used rotation method of Varimax rotation and extraction method of principal component are employed with a limit of 300 iterations. Given the results of sampling adequacy measurement and sphericity tests (Table 4.8), factor analysis may be useful for the dataset. Output of KMO Measure, 0.703, is larger than 0.5 and high enough to spur a factor analysis. Furthermore Bartlett's Test result indicated a significant relationship among the variables.

Table 4.8 KMO and Bartlett's test in the initial step

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**0.703**
Bartlett's Test of Sphericity	Approx. Chi-Square	6340.422
	Df	120
	Sig.	**0.000**

After these, next step of the factor analysis is conducted. In this part, anti-image correlation matrix is explored. Anti-image correlation matrix includes the negative partial correlations between variables and can point the unexplained variances variables can account for. On the anti image correlation matrix, values smaller than 0.5 are indications of unrelated factors that are not included in the prominent components that covers the greatest portion of the variance. According to the Table 4.9, PER8M is removed from the model.

In the second stage, all variables but PER8M are all included in the factor analysis. Usefulness of the analysis can be deduced by comparing the first results of KMO and Bartlett's tests with the ones associated with the smaller dataset (Table 4.10).

Given that measure of sampling adequacy increased, first removal may be deemed beneficial for the model. Checking the anti-image correlation matrix shown in Table 4.11 reveals that on the diagonal each value is greater than 0.5 and no more factor removal is required at this stage. Thus, remaining variables might be used in

Table 4. 9 The anti-image correlation matrix for initial stage

	PLANTTR	PRE1M	PER3M	PER8M	PER11M	TA4M	TA8M	TA10M	TA12M	SLOPEM	MOIMEAN	MOISTD	ALTMEAN	ALTSTD	NALTCHG	ASPECTM
PLANTTR	**,609**	-,284		4,682E-03	3,254E-02	1,340E-02	,177	-,196	,233	-4,825E-02	-5,632E-02	-3,476E-02	-,155	-2,449E-02	,170	-1,972E-02
PRE1M	-,284	**,788**	-4,812E-02	,441	-,655	-,216	,146	-6,277E-02	7,688E-02	-,174	2,542E-02	-3,716E-03	,330	9,167E-02	-7,866E-02	1,544E-02
PER3M	9,898E-02	-4,812E-02	**,706**	,265	-,568	,306	-,190	-,397	,421	,149	2,415E-02	8,980E-02	,173	-7,761E-02	1,023E-03	-1,045E-02
PER8M	4,682E-03	,441	,265	**,353**	-,604	-1,723E-02	,295	-,236	,221	-,114	-4,714E-02	9,125E-02	,419	-3,019E-02	-6,607E-02	4,498E-02
PER11M	3,254E-02	-,655	-,568	-,604	**,608**	,235	-9,979E-02	,205	-,503	3,595E-03	9,411E-03	-1,141E-02	-,402	2,932E-02	8,526E-02	4,618E-02
TA4M	1,340E-02	-,216	,306	-1,723E-02	,235	**,838**	-,215	-,465	-,309	6,846E-02	2,132E-03	9,973E-02	-,202	-5,883E-02	,195	3,515E-02
TA8M	,177	,146	-,190	,295	-9,979E-02	-,215	**,748**	-,620	,595	-5,344E-02	-8,076E-02	-9,650E-02	-,123	7,886E-03	5,393E-02	-6,711E-02
TA10M	-,196	-6,277E-02	-,397	-,236	,205	-,465	-,620	**,746**	-,608	-1,962E-02	3,174E-02	1,415E-03	,127	4,476E-03	-,171	4,619E-02
TA12M	,233	7,688E-02	,421	,221	-,503	-,309	,595	-,608	**,703**	2,345E-02	-3,738E-02	-3,757E-02	,127	2,094E-02	-1,092E-02	-7,276E-02
SLOPEM	-4,825E-02	-,174	,149	-,114	3,595E-03	6,846E-02	-5,344E-02	-1,962E-02	2,345E-02	**,685**	,462	-8,132E-02	-,151	-,693	-7,938E-03	9,371E-02
MOIMEAN	-5,632E-02	2,542E-02	2,415E-02	-4,714E-02	9,411E-03	2,132E-03	-8,076E-02	3,174E-02	-3,738E-02	,462	**,694**	-,488	2,701E-02	-6,238E-02	-1,332E-03	,321
MOISTD	-3,476E-02	-3,716E-03	8,980E-02	9,125E-02	-1,141E-02	9,973E-02	-9,650E-02	1,415E-03	-3,757E-02	-8,132E-02	-,488	**,565**	,128	-,124	-1,276E-02	-2,229E-02
ALTMEAN	-,155	,330	,173	,419	-,402	-,202	-,123	,127	,127	-,151	2,701E-02	,128	**,553**	-6,295E-02	-,163	,130
ALTSTD	-2,449E-02	9,167E-02	-7,761E-02	-3,019E-02	2,932E-02	-5,883E-02	7,886E-03	4,476E-03	2,094E-02	-,693	-6,238E-02	-,124	-6,295E-02	**,709**	-,348	-4,511E-02
NALTCHG	,170	-7,866E-02	1,023E-03	-6,607E-02	8,526E-02	,195	5,393E-02	-,171	-1,092E-02	-7,938E-03	-1,332E-03	-1,276E-02	-,163	-,348	**,780**	1,567E-02
ASPECTM	-1,972E-02	1,544E-02	-1,045E-02	4,498E-02	4,618E-02	3,515E-02	-6,711E-02	4,619E-02	-7,276E-02	9,371E-02	,321	-2,229E-02	,130	-4,511E-02	1,567E-02	**,559**

ABBREVIATIONS: **PRE#M**: Long term mean of total monthly precipitation, **TA#M**: Long term mean of average monthly temperature, **SLOPEM**: Mean slope, **MOIMEAN**: Mean wetness index **MOISTD**: Standard deviation of wetness index, **ALTMEAN**: Mean altitude, **ALTSTD**: Standard deviation of altitude, **NALTCHG**: Number of altitude changes, **ASPECTM**: Mean aspect

Table 4.10 KMO and Bartlett's test for the second step

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**0.743**
Bartlett's Test of Sphericity	Approx. Chi-Square	5937,230
	Df	105
	Sig.	**0.000**

the analysis for investigating the existence of a meaningful model that can explain distribution of endangered endemic plants throughout the country partially or wholly.

4.3 Model Building

One of the aims of this study was understanding basics behind the distribution patterns of endangered endemic vascular plants in Turkey quantitatively by means of GIS tools. In order to achieve this, a model which could formulate the relationships for comprehending the distribution patterns of endangered endemics was needed following the removal of unfitting variables. Multiple regression was utilized for establishing a linear equation for predicting the dependent variable, endemic endangered plant richness per area, with the help of independent variables remained after the data reduction phase of the study. Regression analysis is a statistical technique that makes it possible to assess the relationship between one dependent variable and several independent variables (Tabachnick and Fidell, 2001). In this connection, several independent factors are combined to predict a value on a dependent factor for each subject in the dataset. The result of regression is an equation that represents the best prediction of the dependent variable from several continuous independent variables. The form is shown in Equation 4.5, where Y ‘ is the predicted value on dependent variable, A is the intercept, Xs are independent variables and B_k s are coefficients assigned to the independent variables during regression.

$$Y' = A + B_1X_1+B_2X_2 + \dots + B_nX_n \qquad \textbf{(4.5)}$$

In this study, Y ‘ is logarithmically transformed form of number of endangered endemic plants per cell and X_n are measured values of factors for the cells. With this model, determining the effects of each factor on the number of threatened endemics

Table 4.11 The anti-image correlation matrix for reduced number of variables

	PLANTTR	PRE1M	PER3M	PER11M	TA4M	TA8M	TA10M	TA12M	SLOPEM	MOIM	MOISTD	ALTMEAN	ALTSTD	NALTCHG	ASPECTM
PLANTTR	**,579**	-,318	,101	4,439E-02	1,348E-02	,183	-,201	,238	-4,803E-02	-5,616E-02	-3,533E-02	-,173	-2,436E-02	,171	-1,995E-02
PRE1M	-,318	**,861**	-,191	-,543	-,232	1,837E-02	4,756E-02	-2,364E-02	-,139	5,154E-02	-4,918E-02	,179	,117	-5,529E-02	-4,907E-03
PER3M	,101	-,191	**,727**	-,530	,322	-,292	-,356	,385	,188	3,805E-02	6,832E-02	7,110E-02	-7,222E-02	1,928E-02	-2,324E-02
PER11M	4,439E-02	-,543	-,530	**,717**	,282	,103	8,031E-02	-,475	-8,262E-02	-2,398E-02	5,513E-02	-,205	1,390E-02	5,701E-02	9,217E-02
TA4M	1,348E-02	-,232	,322	,282	**,822**	-,220	-,482	-,313	6,694E-02	1,322E-03	,102	-,214	-5,938E-02	,194	3,596E-02
TA8M	,183	1,837E-02	-,292	,103	-,220	**,744**	-,593	,568	-2,084E-02	-7,004E-02	-,130	-,285	1,758E-02	7,700E-02	-8,420E-02
TA10M	-,201	4,756E-02	-,356	8,031E-02	-,482	-,593	**,759**	-,586	-4,828E-02	2,122E-02	2,375E-02	,257	-2,740E-03	-,193	5,853E-02
TA12M	,238	-2,364E-02	,385	-,475	-,313	,568	-,586	**,730**	5,027E-02	-2,766E-02	-5,948E-02	3,856E-02	2,833E-02	3,801E-03	-8,490E-02
SLOPEM	-4,803E-02	-,139	,188	-8,262E-02	6,694E-02	-2,084E-02	-4,828E-02	5,027E-02	**,683**	,460	-7,167E-02	-,114	-,701	-1,562E-02	9,959E-02
MOIMEAN	-5,616E-02	5,154E-02	3,805E-02	-2,398E-02	1,322E-03	-7,004E-02	2,122E-02	-2,766E-02	,460	**,692**	-,487	5,160E-02	-6,390E-02	-4,462E-03	,324
MOISTD	-3,533E-02	-4,918E-02	6,832E-02	5,513E-02	,102	-,130	2,375E-02	-5,948E-02	-7,167E-02	-,487	**,556**	9,971E-02	-,122	-6,771E-03	-2,653E-02
ALTMEAN	-,173	,179	7,110E-02	-,205	-,214	-,285	,257	3,856E-02	-,114	5,160E-02	9,971E-02	**,670**	-5,542E-02	-,149	,122
ALTSTD	-2,436E-02	,117	-7,222E-02	1,390E-02	-5,938E-02	1,758E-02	-2,740E-03	2,833E-02	-,701	-6,390E-02	-,122	-5,542E-02	**,704**	-,351	-4,382E-02
NALTCHG	,171	-5,529E-02	1,928E-02	5,701E-02	,194	7,700E-02	-,193	3,801E-03	-1,562E-02	-4,462E-03	-6,771E-03	-,149	-,351	**,781**	1,870E-02
ASPECTM	-1,995E-02	-4,907E-03	-2,324E-02	9,217E-02	3,596E-02	-8,420E-02	5,853E-02	-8,490E-02	9,959E-02	,324	-2,653E-02	,122	-4,382E-02	1,870E-02	**,538**

ABBREVIATIONS: **PRE#M**: Long term mean of total monthly precipitation, **TA#M**: Long term mean of average monthly temperature, **SLOPEM**: Mean slope, **MOIMEAN**: Mean wetness index **MOISTD**: Standard deviation of wetness index, **ALTMEAN**: Mean altitude, **ALTSTD**: Standard deviation of altitude, **NALTCHG**: Number of altitude changes, **ASPECTM**: Mean aspect per cell is targeted. All in all, the model may be useful for understanding the dynamics of endangered endemic distribution and in more general terms factors affecting the distribution of the narrow endemics, endemic plants whose distribution ranges are extremely small at global scale.

In order to see the marginal contribution made by classes of variables beside their individual contributions, variables may be input to the regression in different sets sequentially while conducting the linear regression analysis. So, variables of the study which were thought to be interrelated with each other were divided into three sets; variables dealing with precipitation (Set1), topography (Set2) and temperature (Set3). In SPSS, these sets are input in 3 blocks as independent variables whereas PLANTTR is added as the dependent variable.

Initial results of the sequential linear regression are shown in Table 4.12. First part represents the model summary, which is a report of relationship between dependent variable and the model. At this point, R, the multiple correlation coefficient and its square, which is called the coefficient of determination deserve special attention. These statistics indicate how strong the equation can estimate the dependent variable using the values of independent variables. This is calculated by comparing the model predicted values with the observed ones. If the differences are small, R and R square get larger and indicate a better fit. Thus, larger coefficients are indication of stronger models.

Table 4.12 Summary of the first stage of multiple regression

Model Summary				
Model	**R**	**R Square**	**Adjusted R Square**	**Standard Error of the Estimate**
1	,376	,141	,134	,5743
2	,449	,201	,181	,5585
3	,521	,272	,244	,5364

ANOVA						
		Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
1	**Regression**	19,124	3	6,375	19,331	,000
	Residual	116,408	353	,330		
	Total	135,532	356			
2	**Regression**	27,304	9	3,034	9,727	,000
	Residual	108,229	347	,312		
	Total	135,532	356			
3	**Regression**	36,855	13	2,835	9,855	,000
	Residual	98,677	343	,288		
	Total	135,532	356			

Table 4.12 Summary of the first stage of multiple regression (cont.)

Coefficients						
		Unstandardized Coefficients		**Standardized Coefficients**	**t**	**Sig.**
		B	Std. Error	Beta		
1	**(Constant)**	,441	,097		4,541	,000
	PRE1M	1,106E-02	,002	,593	5,556	,000
	PRE3M	-1,351E-03	,002	-,045	-,583	,560
	PRE11M	-5,057E-03	,002	-,234	-2,157	,032
2	**(Constant)**	-,144	,477		-,301	,764
	PRE1M	1,181E-02	,002	,633	6,014	,000
	PRE3M	-1,133E-03	,002	-,038	-,489	,625
	PRE11M	-5,225E-03	,002	-,241	-2,240	,026
	SLOPEMEAN	4,737E-02	,020	,193	2,423	,016
	NALTCHG	-3,890E-05	,000	-,186	-3,198	,002
	MOIMEAN	3,089E-02	,053	,047	,581	,562
	MOISTD	5,849E-02	,092	,037	,636	,525
	ALTMEAN	1,719E-04	,000	,170	3,011	,003
	ASPECTM	2,078E-05	,001	,001	,014	,989
3	**(Constant)**	,407	1,114		,365	,715
	PRE1M	1,710E-02	,003	,917	6,306	,000
	PRE3M	-7,844E-03	,004	-,260	-1,841	,066
	PRE11M	-3,323E-03	,003	-,154	-,965	,335
	SLOPEMEAN	3,244E-02	,019	,132	1,702	,090
	NALTCHG	-3,920E-05	,000	-,187	-3,253	,001
	MOIMEAN	5,587E-02	,052	,085	1,083	,280
	MOISTD	6,871E-02	,089	,044	,768	,443
	ALTMEAN	2,086E-04	,000	,207	3,396	,001
	ASPECTM	6,514E-04	,001	,024	,466	,641
	TA4M	-1,936E-02	,057	-,103	-,343	**,732**
	TA8M	-,119	,034	-,716	-3,530	,000
	TA10M	,251	,065	1,594	3,889	,000
	TA12M	-,136	,030	-1,175	-4,547	,000

For the model, these values turned out to be 0.521 and 0.272. Another inference which can be drawn from the table is the contributions of individual variable sets to the model. First set consisting precipitation related variables accounts for the largest portion of the variance with a marginal R^2 contribution of 0.141 to the model. Set 2, which includes topographical variables makes a smaller marginal contribution (0.06) to the model. Although Set 3's contribution to the model (0.071) is significant and larger than the one introduced by Set 2, Set 1 appears to include the most important variables for the model.

ANOVA domain of the table gives the result of statistical significance of the model with the sets involved. All three models were found significant and eligible for use.

Coefficients part of Table 4.12 outputs the significance of each variable and the coefficients. Using this part, overall equation may be revealed. However, before designating the equation, significance of each variable should be examined from the significance figures. Insignificant variables may be eliminated so that a more robust model could be formed. In that sense, several variables are found to be useless in the model. The most insignificant of these, TA4M, is the first to be removed from the analysis. Since the removal needed another regression pass, all variables except TA4M are utilized in the new analysis. This procedure is repeated up to the point where no insignificant variable remained inside the proposed model. Consequently, ASPECTM, MOISTD, PRE11M, MOIMEAN and SLOPEM are removed from the model. In the end coefficients of correlation and determination are diminished marginally, but variables with insignificant individual contributions are eliminated, too (Table 4.13). Moreover, significance values of F statistic (0.0) presented in ANOVA section are well below the thresholds and proves that variance explained by the model is not related with chance.

Table 4.13 Summary of the final stage of the multiple regression

Model Summary						
Model	**R**	**R Square**	**Adj. R Square**	**Std. Error of the Estimate**		
1	,360	,130	,125	,5772		
2	,416	,173	,163	,5644		
3	,510	,260	,245	,5362		
ANOVA						
		Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
1	**Regression**	17,589	2	8,795	26,396	,000
	Residual	117,943	354	,333		
2	**Regression**	23,417	4	5,854	18,380	,000
	Residual	112,116	352	,319		
3	**Regression**	35,200	7	5,029	17,492	,000
	Residual	100,332	349	,287		
		Unstandardized Coefficients		**Standardized Coefficients**	**t**	**Sig.**
		B	**Std. Error**	**Beta**		
1	**(Constant)**	,410	,097		4,251	,000
	PRE1M	7.93000	,001	,425	5,785	,000
	PRE3M	-2.88800	,002	-,096	-1,304	,193
2	**(Constant)**	,239	,112		2,129	,034
	PRE1M	9.18800	,001	,493	6,692	,000
	PRE3M	-3.69200	,002	-,122	-1,693	,091
	NALTCHG	-0.02400	,000	-,115	-2,228	,027
	ALTMEAN	0.22070	,000	,219	4,174	,000

Table 4.13 Summary of the final stage of the multiple regression (cont.)

3	**(Constant)**	,170	,675		,253	,801
	PRE1M	16.13000	,002	,865	7,601	,000
	PRE3M	-11.13000	,003	-,369	-3,913	,000
	NALTCHG	-0.03038	,000	-,145	-2,929	,004
	ALTMEAN	0.20010	,000	,198	3,704	,000
	TA8M	-,109	,032	-,655	-3,442	,001
	TA10M	,250	,054	1,588	4,678	,000
	TA12M	-,154	,025	-1,323	-6,128	,000

Last part of the analysis is related with the residuals. Residual is difference between an observed value of dependent variable and the value predicted by the model. Normality of the residuals warrants the linear relation between variables and appropriateness of the model for data. Normality is checked from the histogram and P-P Plot of the model in Figures 4.8 and 4.9. It is concluded that histogram is quite close to the normal curve and does not violate the normality assumption that residuals should follow normal distribution. From the perspective of P-P Plot, normality assumption is also not violated given that P-P residuals in Figure 4.9 follow the 45-degree line.

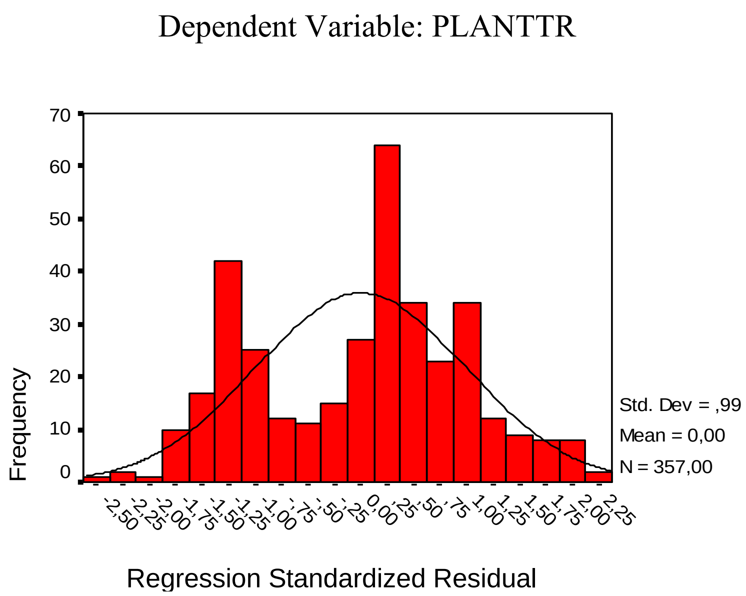


Figure 4.8 Histogram for the model

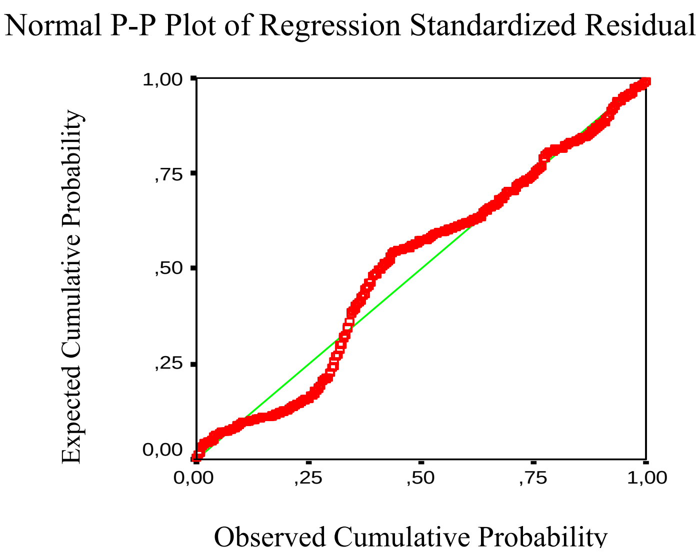


Figure 4.9 Normal P-P plot of residuals for the model

Overall model established after the subsequent regression trials is summarized in Table 4.14.

Table 4.14 Estimated model

PLANTTR = 0.17 + 16.13 * PRE1M - 11.13 * PRE3M - 0.03038 * NALTCHG + 0.2001 * ALTMEAN - 0.109 * TA8M + 0.25 * TA10M - 0.12 * TA12M

CHAPTER 5

DISCUSSION

This chapter is devoted to the discussion of the study. Initial part is about the utilized data. In the subsequent sections, production procedures are put under spot whereas the last part includes evaluation of the analyses and an example use of the study outputs.

5.1 Assessment of Imported Data

Use of appropriate data and effective use of data are among the main considerations in a study regardless of the domain. Bounded with the availability of data and the medium to handle it, the research strived to make most of the available elements. Subsequent sections summarized the weaknesses and strengths of them.

Virtually every study, investigating any kind of interaction among entities with reference to the Earth partially or as a whole, has to outsource some degree of relevant information from outside parties, due to the fact that it would be either infeasible or impossible for researcher to gather associated data on his own. Thereby, all geographic and topographic layers employed in the study were either imported directly or by-products of the imported ones.

The study made use of different layers of geographic information on which data production and analysis were conducted. Country files which provided data concerning Turkish administrative units such as villages, towns and their borders, geographic elements such as lakes, rivers and entities like motorways created the first layer in the data hierarchy. For a study covering a huge area of ca. 800, 000 square kilometers, scale and quality of data were quite satisfactory.

Topographical information gathered and manipulated in the study was solely based on digital elevation map, SRTM30. This dataset was the most accurate and valid global digital topographic database and appeared to be the most suitable dataset at national level (Girgin, 2003). As mentioned at previous sections, this input was used directly in terms of locating possible plant distributions and indirectly as the basis for remaining topographical layers such as aspect and slope. Because of being free of charge and publicly available contrary to the national products prepared by GCM, it was a perfect solution for the study. However even this dataset is not without its disadvantages. Despite being more accurate compared its predecessors, SRTM30 is a dataset making use of radar interferometry, therefore a great approximation of Earth surface. There are locations where SRTM data are missing, especially around high mountainous areas, though inclusion of former data degraded the importance of this problem. Additionally, shortcomings SRTM30 were inherited by the derived topographical layers. However, given the large scale of the study, DEM data source was useful and shall be for similar research, until a more accurate version replaces it.

Climatic data requirements were satisfied by State Meteorological Works (SMW). This institution is virtually the only authority for preparing and disseminating meteorological information. Given the wide coverage area its stations provided, SMW was deemed to be the most appropriate provider for the study. Nevertheless, there were some problematic issues. First of all, data was gathered from major stations but these stations are not normally distributed. For example number and density of stations around İstanbul is incomparable with the ones of Eastern Anatolia. In addition to that, some of the stations were learned to be out of order for certain periods of time without producing data. Thus, statistics calculated for some of the stations span shorter periods. Furthermore, values obtained by the stations are directly related with their location and except Uludağ, meteorological data on remote locations, especially around mountainous areas, do not exist. Interpolation technique used in the study, Inverse Distance Weighting, was not a complete solution as well in the absence of data in question. This was clearly a drawback for the study, given the abundance of plants distributed in higher elevations. Unfortunately, there was not any solution to the problem, given the difficulty of obtaining meteorological data from respective areas. As an additional but minor problem, data retrieved from SMW were in a tabular format which was quite hard to classify and manipulate. Prospective researchers should be aware of this problem. All in all, meteorological data utilized was the most accurate and valid data any Turkish research could make use of, but compared to theoretical needs of the study, it was far from perfect.

Two grid systems were used throughout the research. For mapping purposes, grid system of Atlas Florae Europae project was employed. In the analysis part though, a system developed for Turkey was used in the grounds that cell areas were well-proportioned and could facilitate statistics generation. Compared to their substitutes such as the one used in existing literature on botanical research, aforementioned grid systems were more standardized in the sense that they were used by wider audiences and could be used easily by other disciplines without any conversion, more structured due to being geographically well referenced and more appropriate for making inferences and deriving statistics owing to the size of the grid cells. Half degree to half degree cells were large enough to cope with the uncertainty associated with the plant locations but small enough to form coherent geographical units sharing many in common and appropriate for investigating the effects of factor variations on plant distributions along spatial corridors. In conclusion, grid systems selected in the study confirmed to the needs and were effective in general.

Retrieval of plant data needed for determination of locations was directly related with the availability of the relevant literature. Given the vague nature of limited data related with historical records, some species in the dataset were ignored and not included in the analysis section. Ironically, some recent study on the newly defined or rediscovered species were also unavailable because either they have not been published yet or were not reachable for the executives of the study.

5.2 Assessment of Produced Data

Outsourced data was not the sole type of input the study required. Some of the data was produced as part of the study. These include the coordinates assigned to the plants, topographical factors of moisture, slope, aspect and continuous functions of precipitation and temperature.

One of the most significant outputs of the study was the geographically referenced locations of endangered endemic vascular plants. Given the degree of uncertainty relevant literature possessed, expecting a comprehensive and completely certain formation would be unrealistic. In this connection, formed dataset certainly includes information shaped by subjective cognition. This was especially the case for the cases with the data status of 2 on which predefined assumptions were applied. In addition to that, even some of the most objective assignments utilized some sort of auxiliary layers such as country files and DEM. Individual shortcomings of these entities may distract the overall accuracy and preciseness of the dataset; however, as stated previously, employed data is highly accurate and these distractions are of limited scale.

All kinds of topographical data used in the study was produced by the combination of SRTM30, relative formulae and GIS applications. Mathematical equations used in the production process were taken from the relevant literature and assessing the effectiveness of them is out of scope this study. However, remaining tangible resources may be evaluated. ArcGIS provided all procedures for the production phase, through raster calculator function which facilitate the creation of new sets of data. Other element of the production was the DEM resource which was assessed in the previous section. Trivially, strengths and the drawbacks of the main data were reflected in the by-products. As an example, slope and aspect values obtained might include marginal amount of errors especially around mountainous areas due to the weaknesses SRTM30 have (M. Lütfi Süzen, pers. comm., January 10, 2005). However, given the scale of the study and the improbableness of obtaining perfectly accurate data at national scale, the overall quality of the produced data could be regarded acceptable.

Climatic factors procured from the associated institution consisted of monthly totals of daily observations recorded in stations throughout the country. In order to make inferences about the correlations between these factors and the plant distributions though, either there must be as many stations as the plants themselves or some sort of approximation should be conducted. In this context Inverse Distance Weighting provided continuous values for associated factors along the country using the existing station network. However, distribution of the stations involved was far from normal; in result values estimated by the IDW turned out to be open to errors. The reason lies in the fact that IDW estimates cell values by averaging the values of sample data points in the vicinity and the closer a point is to the center of the cell being estimated, the more influence or weight it has in the averaging process. In essence, this method assumes that the variable being mapped decreases in influence with distance from its sampled location which in geographic terms valid. However, in the case of Turkey, where data accuracy is positively related with the coverage of SMW, applications are prone to be imperfect. A minor reflection of this problem may be explored from Figure 5.1, where IDW based estimation of annual precipitation along southwestern part of the country was represented. This geographical section is an area of large plains and compared to other regions climatic variations inside are rather small. However, large distances between neighboring stations led to discrepancies in the results of interpolation along the empty parts of the region. These problems may be realized by comparing two neighboring stations Şanlıurfa and Ceylanpınar, both of which were defined to be more arid than the empty area between them. Indeed, this empty area should be very similar to the both climatically, due to the scarcity of any geographical boundary that could create variations around. Thus, the difference in the estimated precipitation values was related with the interpolation method itself. This method needs 12 contributory for the estimation of a particular point. Around locations where station coverage was poor, relatively farther stations were used. Although being effective in providing smoother distributions in the areas where the stations were regularly situated which was the case for most of the country, the technique fell victim to the erroneous results around the borders where number of stations was relatively small. Nevertheless, this error was kept in minimal due to the fact that most of the boxs in the extreme parts of the country were small and were not included in the analysis. Therefore it can be concluded that interpolation techniques used in the production of the data was effective in general.

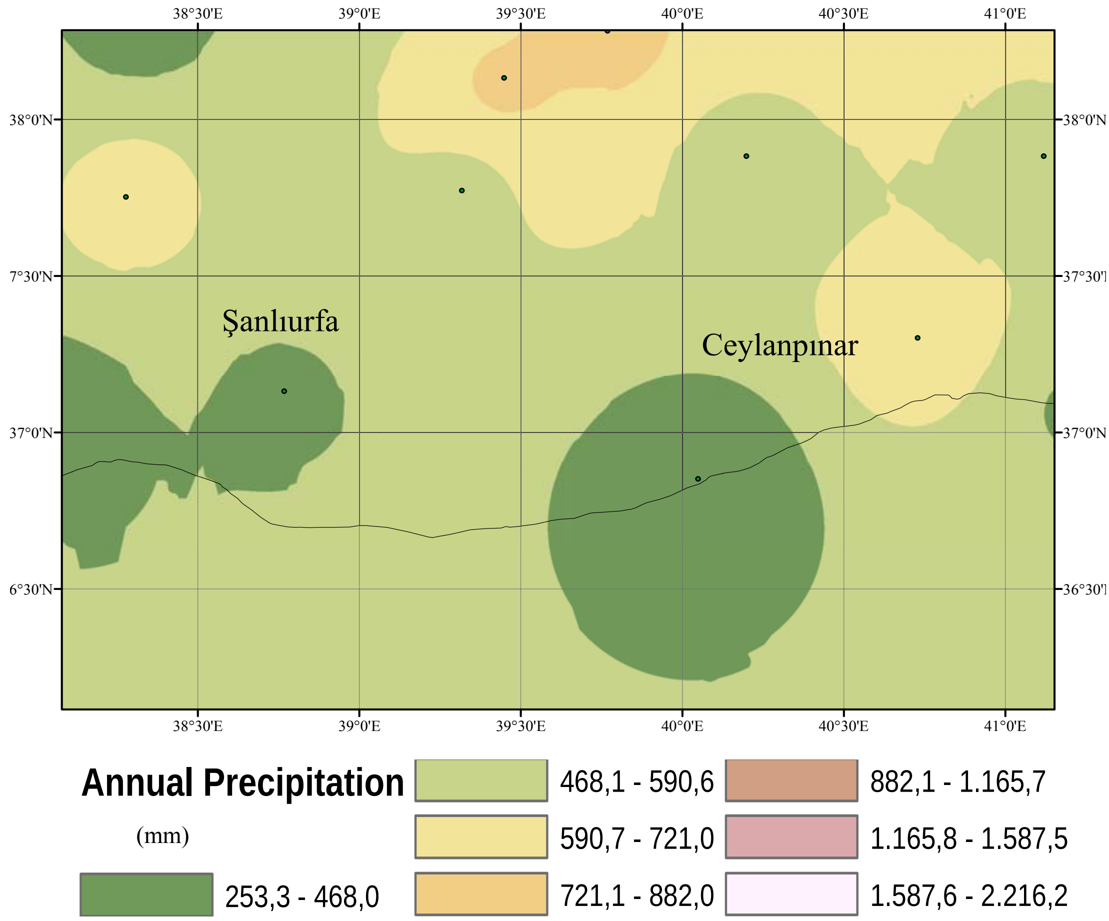


Figure 5.1 Precipitation distribution along Southwest Anatolia interpolated with IDW

5.3 Assessment of the Analyses

Two types of analysis were conducted in the study. The first one, exploratory research, was made available by the use of existing GIS procedures and the coded libraries which was added to the application. By providing the basic information about the distribution patterns, these efforts contributed to knowledge base. In the first step, Kernel method was applied to the data on distribution of threatened endemics. Owing to the fact that species referenced in the study comprises more than 25% of all Turkish endemics, this set is an effective sample of the larger population and inferences can hold true for all endemics in general. In the end a visual representation of the distribution was provided and the results fit to the previous findings.

As indicated by the outcomes, general distribution of the plants follows a regular distribution along endemicity centers proposed earlier; main concentration is on the line beginning from southwestern Anatolia, follows the range of Taurus up to Adana and Osmaniye where upper sections of the bend follows a northeastern route on the mountains of eastern sections of Inner Anatolia and western parts of Eastern Anatolia. This arc continues up to the northeastern extremity of the country with Kaçkar range and mountains around Artvin. Near Osmaniye, a significant density can be observed in Amanos Mountains, one of the richest endemicity centers of all. Another density of importance begins from the southeastern parts of Lake Van and follows the mountainous topography up to Hakkari. Aforementioned distribution pattern fits the famous Anatolian Diagonal phenomenon (Davis, 1971; Ekim, 1986). In addition to this regular formation, stand-alone spots with large number of threatened endemics were determined. In the western half of the country, mountains support rich collections and act as endemicity centers of the region; Uludağ, Kaz Mountains, Bozdağ range and massifs around Denizli, Uşak and Kütahya are among the examples. Coastal areas are relatively unimportant with İstanbul being the only exception. Indeed, the metropolis is one of the few endemic rich coastal plant areas of the country. In the Black Sea region, mountains again support most of the variety; Küre and Ilgaz mountains and environs of Amasya being the major areas. However, Inner Anatolia support few areas of importance, but this time steppes hosting the crucial spots. Around Beypazarı, Çankırı and Lake Tuz considerable number of endangered endemics were spotted. In the eastern half of the country, majority of the endemic-rich areas are in mountainous areas and inside deep valleys, with few steppe species located between Malatya and Sivas, which is an expansion of Inner Anatolia phenomenon. None of these findings contradict the existing knowledge, but provides a combinatory perspective, future research can make use of.

In addition to the general picture, statistics retrieved from Nearest Neighborhood analysis and functions of K and L were of use. For example, short nearest neighbor distances reveal the fact that, a significant portion of Turkish endemics in danger are situated very near to each, which led to the inference that most of the species are found in small number of dispersed clusters or in corridors where narrow endemics are replaced by new ones in small distances. This might have corroborated the opinions of Davis (1971), which concluded that “the Anatolia flora appears to be in a highly active state of evolution”. Suggestion of clustering were also depicted by the

K and L functions, which revealed the fact that Turkish threatened endemics are either found in small number of very rich areas or areas very near to each other.

In order to reveal and express the relationships between endemic plants' distribution and the relevant factors in a quantitative manner, multivariate analysis of regression was employed. Actually, use of multiple regression for understanding the relationships between different factors has been frequently cited in the literature and research on distribution of life forms with respect to spatial variations is not an exception (e.g. Baquero and Telleria, 2001). The analysis ended up with a model which explains statistically significant but a modest part of the variation on the dependent variable. An interesting outcome of the analysis was that, climatic factors explain more variation on the dependent variable than the topographical factors do, with a wide margin. Variables related with precipitation and temperature turned out to be the most significant ones. Topographical factors were, in contrast, affect the variation marginally, which was astonishing. Indeed, literature cited topographical variation as an important indicator of an endemic-rich area and this was particularly echoed for Turkish flora (Davis, 1971; Ekim 1986; Ekim and Güner, 1986; Ekim and Güner 2000). The only outcome which conformed to the expectations was the significance of altitudinal factors over the other topographical variables. Altitudinal change and average altitude was only significant members of this set. More numerous variables from climatic domain were referenced in the model; winter and spring precipitation and winter, summer and autumn temperatures were found to have significant affects on the number of endemic plants per cell.

It would be safer to avoid making generalizations and deriving sharp inferences out of this model, given the following reasons. First one is related with the cases. In the study, smallest unit of analysis was the individual grid cells. Other than the ones at the extremities of the country, sectors of the grid system covers large areas (ca. 2500 square kilometers). Although this scale was considerable smaller than the ones referenced in the previous studies (Davis, 1965-1982; Turak, 2000); vague nature of data referenced in the literature prevented further reduction. Consequently, small scale variations in the topographical and climatic factors which were thought to be important in endemicity remained marginal in the large area of cells and generally could not be reflected in the cases. Another shortcoming of the model was that, only part of factors could be considered. Harrison et al. (2000) for example determined a list of more than 100 variables in order to investigate the richness of plants inhabited Californian serpentines. Given the high degree of correlations among some of the variables, use of so many factors was not feasible, however some crucial variables such as soil type were certainly needed for creating a complete model. Because of the problems with obtaining detailed soil map and with the qualitative nature of the soil types, this important factor could not be attached to the model. Indeed, basics behind the richness of Turkish endemics still need clarification and further research.

In essence, proposed model was bounded by the limitations on the preciseness and the availability of the inputs. Effect of using relatively few variables must have deteriorated the value of the model and the scale of the study also did so. These problems were reflected in the small values of R^2. Thus, future studies willing to reference to these findings should be careful in interpretation. Coefficients proposed by the model are of no use unless the same grid systems are used and same kind of transformations is examined. In spite of these problems, proposed model may be beneficial in the grounds that, it is the first quantitative research related with Turkish endemics in national scale. Although being very coarse, outcomes of the research can be usable for the upcoming studies, especially for the ones measuring the importance of altitudinal variations in endemicity composition of an area. In a smaller scale, applications of the principles cited can be of greater use and may lead to more valid and precise results.

5.4 Managerial Application of the Study

Outcomes of this study appear to be eligible for contribution to the current knowledge on Turkish flora, however its real value may only be deduced if it can be used in other aspects of life. Indeed, designation of the geographical locations or understanding the basics behind the distributions of the life forms constitutes only the first step toward the aim of efficient use of these resources from the managerial perspective. If the outputs of the study would be of use, they should be both suitable for and compatible to the conservation purposes.

In this section, an application which strives to reveal the current protection status of the threatened plants is presented. In order to fulfill this aim, geographical locations of the individual plants and the protection areas declared by the state were superimposed in GIS environment. Moreover for revealing the congruence between plant locations, protection areas and areas known to be important for other life forms, dataset of Important Bird Areas (IBA) in Turkey (Kılıç and Eken, 2004) were also added to the system. This dataset includes the boundaries of 183 areas determined by the application of international criteria. From a GIS point of view, the analysis being conducted was an overlay technique, which enabled different layer of information to be investigated simultaneously. In addition to that, this analysis might be taken as an simple application of gap analysis, which is "a method for identifying gaps in the network of conservation land and water areas" (Jennings, 2000). By presenting the coverage scheme the protected supply, this method can be used effectively in evaluating the current status of conservation efforts and determining the managerial decisions to be taken in the future.

Initial requirements of the analyis were the borders of the official protection areas, IBAs and the plants' location data, which was retrieved from the outputs of the study. By using a paper map obtained from the Ministry of Environment and Forestry, 37 National Parks (including 2 additional proposed candidates), 35 Nature Protection Reserves and 17 Nature Parks were digitized and in return polygons needed for the operation were prepared. Following that, plant dataset was merged to the polygons that represent the reserves. At last, IBA data was merged onto the previous data. As a result plants inside the protection reserves and IBAs were determined. In order to prevent the errors introduced by the vague records of the plants and shortcomings of the paper map digitization from affecting the analysis, two buffer zones with 5 and 10 km radii were formed for reserves and the analysis was repeated (Figure 5.2). IBA data obtained from Nature Society was precise enough and no buffer zones were introduced.

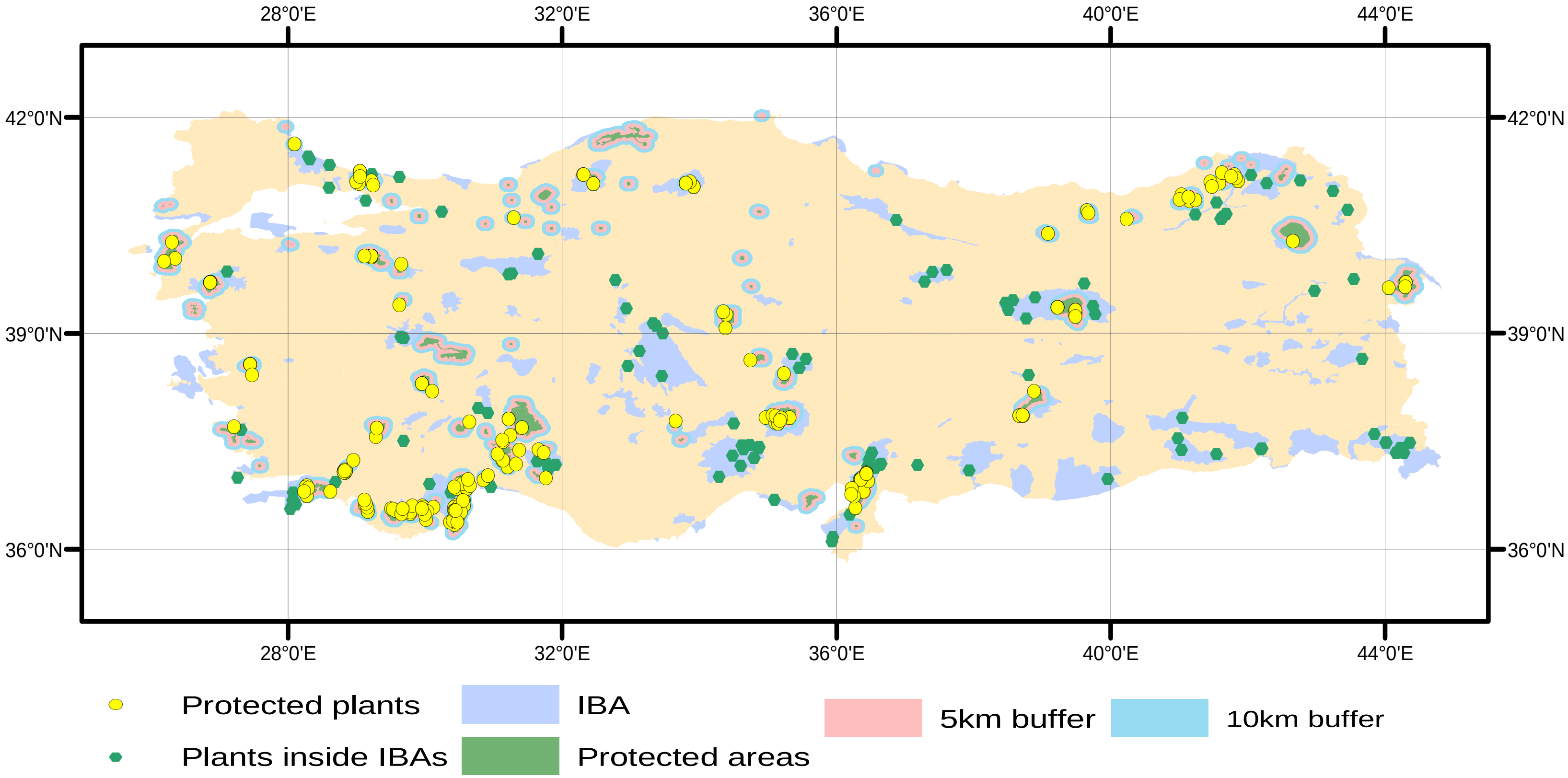


Figure 5. 2 5- 10 km buffer zones for officially protected areas, IBAs and endangered endemic plants inside these areas

According to the results, at least 132 plants were inside the protected areas. Majority of them are located inside the National Parks and only a marginal portion is detected inside the boundaries of Nature Protection Reserves and Nature Parks (Table 5.1). IBAs cover 26.6% of plant populations, indicating a significant amount of congruence. Proposed buffers eventually inflated the list of protected plant populations with an additional 27 inside the first 5 km zone and another 82 inside the second 5 km zone. The analysis showed that less than one fourth of all threatened endemics (241 out of 1056) were inside the protected zones (Figure 5.3) and the real figures should be even lower, due to the possible overshoots intersecting the buffer zones. On the other hand, IBAs coverage is far more consistent with the plants and signals the presence of overlapping areas. Given that only a modest portion of the plants' range is protected by the reserves and national parks dominate the picture, incoming reserves, especially nature protection reserves and nature parks, should be delineated in a way that populations of endangered plants are safeguarded inside the borders. As proved in the study, these will also help other life forms in danger.

Table 5.1 Statistics for official protection areas and IBAs

	National Park & Potential Reserves	%	Nature Protection Reserves	%	Nature Parks	%	IBA	%
Number of plant populations inside	**117**	***88.6***	**6**	***4.6***	**9**	***6.8***	**281**	***26.6***
Number of Reserves	**20**	***54***	**4**	***11.4***	**5**	***29.4***	**67**	***36.6***

In essence, this application ratified the use of GIS and the outputs of the study by demonstrating how nonstandard and widely dispersed information could be brought together and assessed instantaneously inside a GIS environment in a cost effective way.

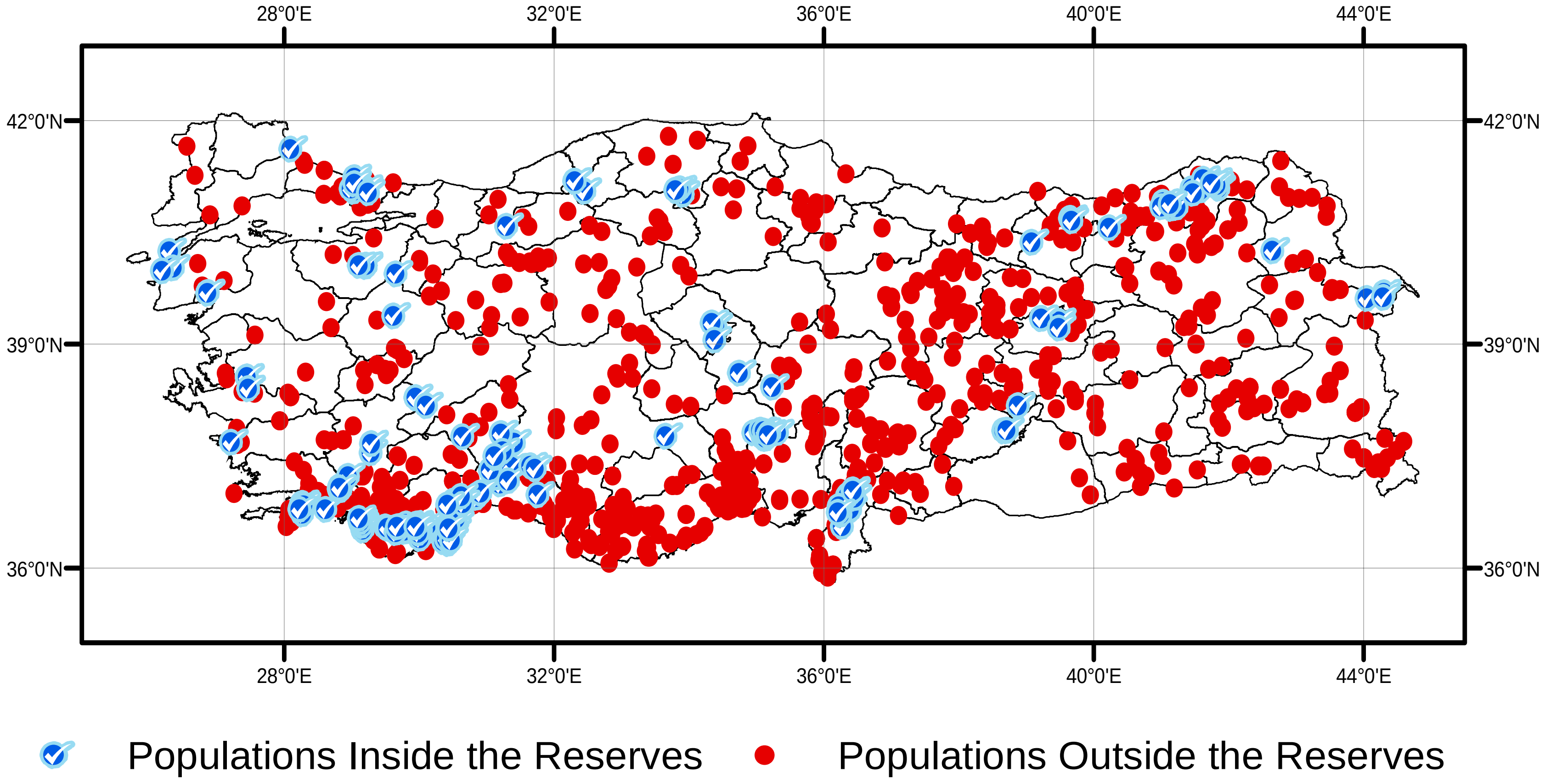


Figure **5.3** Plants inside and outside the boundaries of the reserves

5.5 Interpretation of the Clusters

In section 4.1, plants have been found to be distributed in clusters across the country. While understanding the countrywide distribution of these endemics, an attempt to evaluate this pattern was made by means of non-spatial factors as an extension of traditional datamining techniques. Whether the distibution of the coherent groups that share common non-spatial attributes show parallelism or not was the basic question behind this investigation. This attempt could be beneficial for understanding whether non spatial factors in the literature can be used to understand the distribution or not. For this purpose, K-Means clustering were employed. K-Means is a procedure which strives to identify relatively homogeneous groups of cases based on selected characteristics (SPSS, 1999). In order to test the non-spatial characteristics in the interpretation of geographic distribution, a set of vectors representing individual plants were formed. Each vector described the plant in 3 dimensions; its *life-cycle* which involves annual plants that complete their life cycles in one growing season, bi-annual plants which complete their life cycles in two growing season and perennial plants which have a life cyle of more than two years such as shrubs and trees; *mean altitude* it grows up and the taxonomic *family* it was classified in. Dataset hosted 932 entities in contrast to 1056, due to the absence of related information for the remaining plants. Execution and visualization of the related procedures were made available by IS781 Dataming Tool (Nar and Şen, 2005).

Outcomes are presented in Figure 5.4, 5.5 and 5.6, in which different number of unique symbols represent the clusters. For comparing effects of different figures, procedure was repeated for 2, 6 and 12 clusters. Altitude based clusters were evident in each of the figures, giving clues about the altitude based groupings. Regardless of family or life-cycle, clusters based on altitude appear in the figures. However, clusters based on other factors were found intertwined with each other thus not clearly defined. Hence the example fell short of providing any inferences apart from the fact that altitude itself plays crucial role in the distribution. Nevertheless, it would not be wise to state that number of variables needed to describe the plant distribution pattern is high. In this context, traditional means of datamining appear to be inadequate for explaining the determinants of spatial phenomena fully.

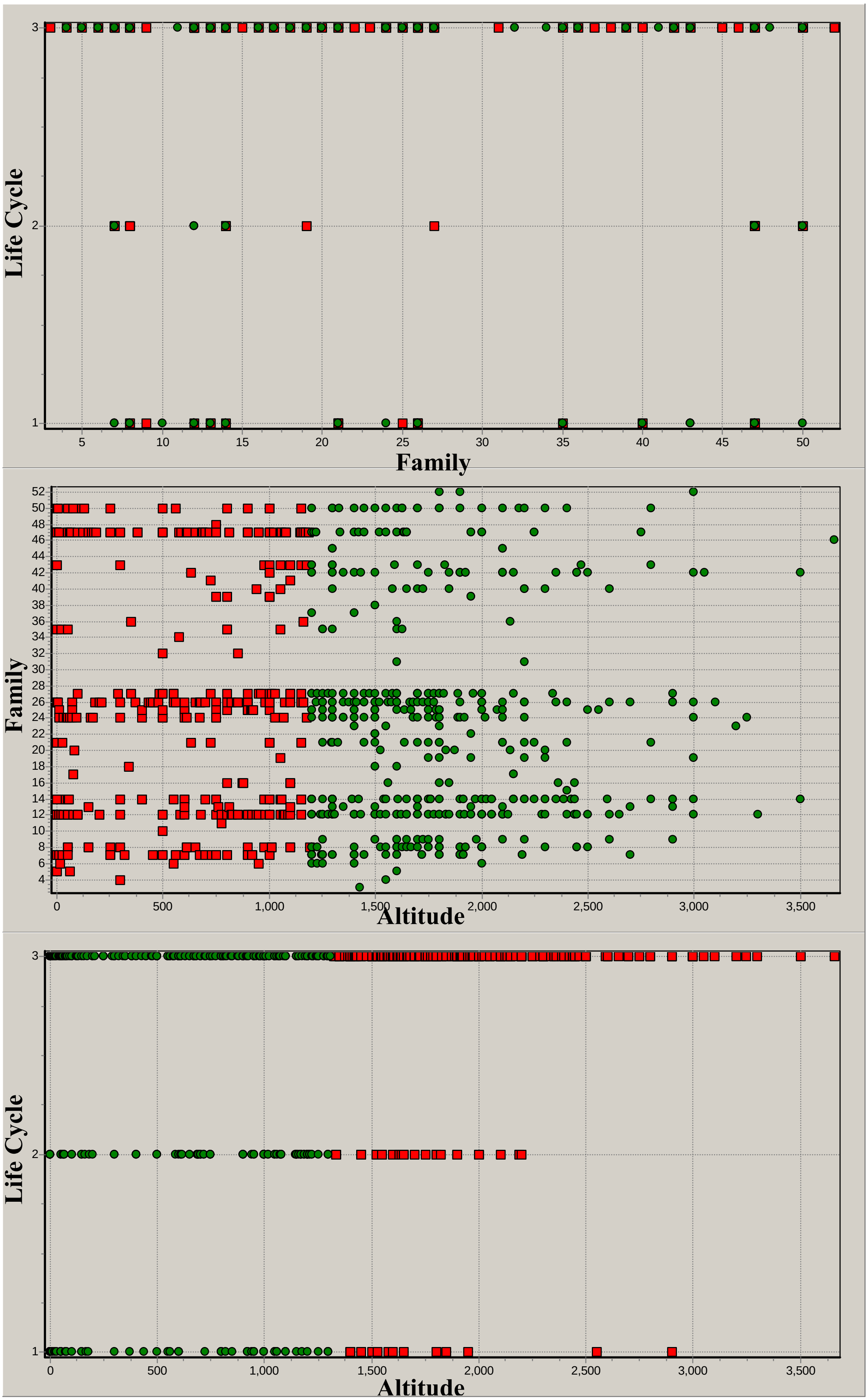


Figure 5.4 Graph of K-Means clustering with 2 clusters

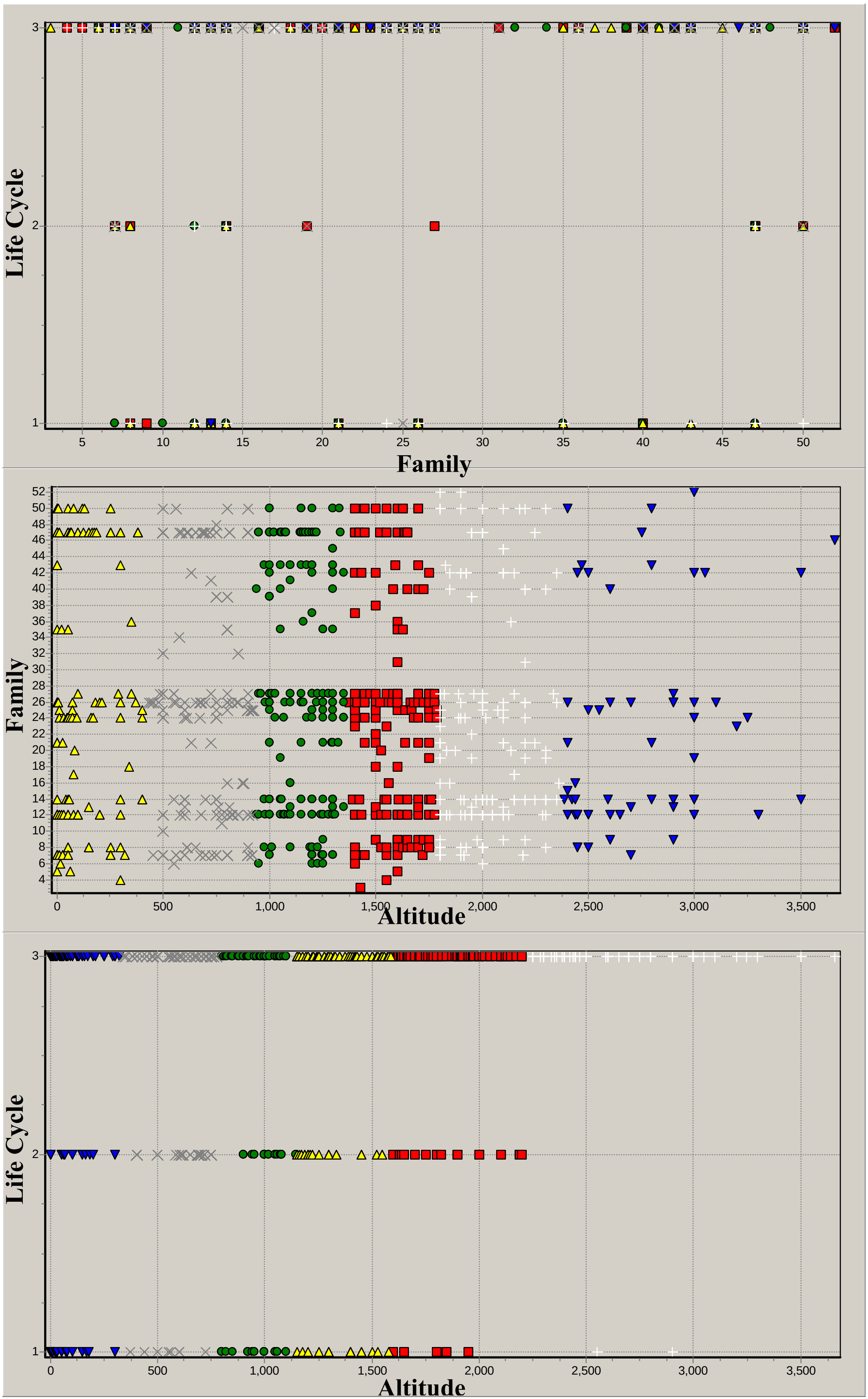


Figure 5.5 Graph of K-Means clustering with 6 clusters

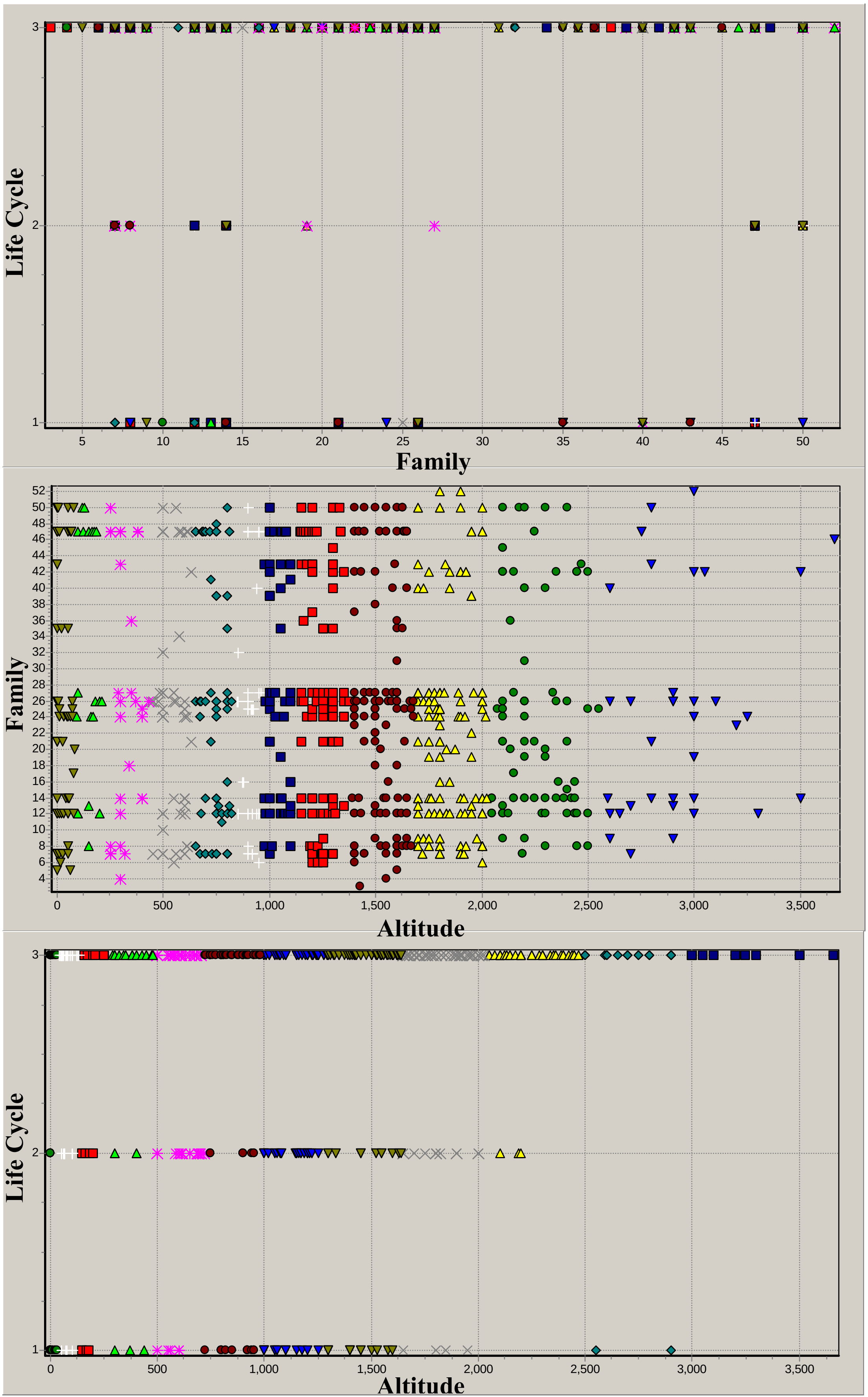


Figure 5.6 Graph of K-Means clustering with 12 clusters

CHAPTER 6

CONCLUSIONS

Intensified humanitarian pressure on earth poses various threats toward the future of the society. There is no need to list all possible outcomes of the current level of exploitation, but one issue is quite clear: if the modern civilization is to utilize the resources of the planet in long term, a more efficient use is compulsory. Use of GIS is one of the tools that can be an effective solution to the problem, given the features it possesses. It enabled retrieval, manipulation, analysis and interpretation of the issues with so few resources that no manual practice can challenge the mechanism. This also holds true for the conservation of environment. With modest resources and many unknowns, current stakeholders require tools that can cope with multidimensional problems inherited in these problems. Ironically, a fruit of civilization, GIS appears to be the one of the most promising tools that can satisfy these requirements.

In this study, capabilities of GIS were used to make contributions to the current knowledge on Turkish endemic plants which are on the eve of extinction. This was a quite good test of GIS capabilities, which was executed in different aspects of the unstructured plant domain. At the first stage, non-standard data in the literature was accumulated with the use of GIS transformed into a coherent structure that can be used by a wider spectrum of related caretakers owing to its geographically referenced base. While forming this structure, different facets of the issue were gathered in layers and processed simultaneously inside very small periods of time. In contrast, with manual methods, hundreds of man-hours would be needed to fulfill the requirement. Besides, quality of the work would hardly be the same. It would not be unrealistic to state that, apart from the limitations dictated by the vagueness of the relevant literature and shortcomings of the imported data, there remains very little space for other factors to degrade the overall quality of the GIS output. Returning to the question forwarded in the early sections of the study and considering the outputs, GIS's capacity to handle non-standard data is deemed to be approved.

Another use of GIS was related with the analyses. Mapping, deriving statistics and providing data for statistical model building were among the services rendered in the study. Even at the extremely large scale the study was executed, distribution related analyses turned out to be feasible and fruitful. Outcomes related with the density strengthen the earlier findings on the narrow endemics and evolution of plants accross Turkey and exhibit the importance of Anatolian Diagonal for many plant taxa. Future studies on these issues combined with GIS and detailed field surveys appear to be promising for botany related disciplines.

Statistical model that was put forward in the study was a novel approach to the current knowledge on Turkish endemics in general. Given the shortage of necessary data and limited reach to the existing data, model could only make use of a modest portion of the factors that should be examined and provided limited but significant quantitative proof on the interaction between altitudinal variation, precipitation, temperature and the richness of a particular area in endangered endemics, which appears to be a surrogate measure for endemic plants as a whole. Nevertheless, results of the model should be evaluated carefully and further modifications are recommended.

Last stage of the study reflects a managerial aspect on the use of GIS with regards to environmental protection. All major types of protection schemes were employed in GIS and areas that are covered by these state warranties were superimposed to the distribution of plants that urgently need protection. In the end, a picture of protection scheme was captured where the inadequate coverage was signaled. Many more reserves should be declared in the regions where endangered plant density is high. In the future eastern half of the Mediteranean between Ermenek and Bolkar range; western parts of Eastern Anatolia including environs of Sivas and Malatya; and the higher sections of the southern parts of Eastern Anatolia should be included in the protected area inventory. In decision making process for future proposals, outputs of the study may be used in delineating or modifying the limits of these zones. Congruence between IBAs and plants is also noteworthy in the sense that gaps in protection network seem to be equally destructive for both and with few reserves, many different elements of biodiversity can be safeguarded. In the end, use of the overlay analysis is deemed to be very beneficial for the state officials in the position of delineating the reserves, conservation oriented parties in the search of ways to determine the priorities and researchers who are looking for consistent mediums for combining different facets of data on a common ground.

Information systems in general help its users by enabling effective and efficient exchange of different types of information in a cost effective manner. In this regard, GIS can be defined as a very useful tool that can provide crucial assistance to all kinds of conservation effort. This study is expected to be an example of that.

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APPENDICES

APPENDIX A: Examples from the Plant Accounts in the Literature

Plant Taxon	Information Provided	Source
Alkanna haussknechtii	In callibus apricis regionisis inferioris montis Logman et in vinetis "Kyrasdere" ad Amasia; dry slopes, vineyards, 400-600 m.	Flora of Turkey, Vol.5
Cephalaria scoparia	Versant septentrional du Bey Dağ d'El Malı au sud_est de l'Avlan gölü; alt.c 2300m.	Flora of Turkey, Vol.10
Heptaptera cilicica	Village de Tchaousli, pres de Mersina (Cilicia); hills below 500 m.	Flora of Turkey, Vol.4
Heracleum sphondylium subsp.artvinense	Şavval Tepe above Murgul; rocky igneous slopes in gully, 2800 m	Flora of Turkey, Vol.4
Thymus pectinatus var. pallasicus	Auf Gips (am Halys(Kızılırmak) am Salzsee von pallas (Tuzla G.) zwischen Kaiserie (Kayseri) und Sivas, c. 1300 m; open steppe on gypsaceous or calcerous slopes, 1100-2160 m	Flora of Turkey, Vol.7

APPENDIX B: List of Endangered Endemic Vascular Plants

Scientific Name	Appropriate Location	Longitude	Latitude	Altitude	Habitat	Status
Acantholimon caryophyllaceum subsp. parviflorum	Boyabat	34,76	41,47	350	Bare eroded hills	2
Acantholimon confertiflorum	Bozkır	32,25	37,20	1100-1220	Chalky hills	2
Acer undulatum	Fethiye- Akbel Yayla	29,16	36,52	1350-1500		2
Achillea armenorum	Süleymanlı	36,83	37,87	2700-3000	Alpine rocks, 2700-3000m	0
Achillea fraasii var. troiana	Kaz Mountains	26,86	39,70	1500		2
Achillea monocephala	Pozantı - Yenianassa (Yenikonacık)	34,85	37,41		Ruins	2
Achillea multifida	Uludağ	29,21	40,07	1700-2550	Abies forest, alpine slopes	2
Acinos trodii subsp. grandiflorus	Mount Çal	29,16	36,88	1420-2150	Rocky slopes, open Pinus nigra woodland near tree-line, on limestone	3
Acinos trodii subsp. grandiflorus	Olukbaşı	29,14	37,25	1650-1850	Rocky slopes, open Pinus nigra woodland near tree-line, on limestone	2
Acinos trodii var. vardaranus	Mount Sandras	28,80	37,06	1800	Rocky slopes on serpentine	3
Aethionema demirizii	Fındıkpınarı	34,37	36,93		On edges of limestone cliffs	0
Aethionema karamanicus	Küçükkoraş	33,82	37,12	1300		0
Aethionema lepidioides	Darende - Kavak	37,45	38,64	1050-1550	Stony slopes	2
Aethionema lepidioides	Gürün	37,28	39,73	1060	Stony slopes	0
Aethionema lepidioides	Tecer - Gürün 36.km	37,23	39,11	1520-1560	Stony slopes	0
Aethionema lycium	Mount Çalbalı	30,37	36,80	2000-2100	Rock crevices	3
Aethionema papillosum	Mount Berit	36,85	37,00	2590	Scrub among rocks	2
Aethionema sintenisii	6km Southeast of Gümüşhane	39,53	40,43	1000	Stony slopes	0
Aethionema speciosum subsp. compactum	Sandras Mountain	28,83	37,06	1970	Stony flats (snowbeds) near tree line, on serpentine	3
Agropyron deweyi	32 miles east of Van	43,66	38,66	630	Rocky slopes	0
Ajuga davisiana	West facing slopes of Mount Köse	37,96	40,07	1800	Open Astragalus-Verbascum steppe	2
Ajuga relicta	Mount Ahır	37,11	37,65	1800		2
Ajuga vestita	Mardin - Diyarbakır 19.km	40,63	37,45	900-1200	Sloping and vertical limestone rocks facing S&W	0
Ajuga vestita	Diyarbakır - Ergani	40,03	38,21	900-1200	Sloping and vertical limestone rocks facing S&W	3
Ajuga xylorrhiza	Çermik- Çüngüş 2.km	39,45	38,15	900	Vertical rock crevices	0
Alchemilla ancerensis	Ballıköy (Anzer)	40,51	40,59	2150	Meadows	0
Alchemilla bursensis	Tahtaköprü	29,65	39,96	1200-1400	Bogs under fagus	2
Alchemilla cimilensis	Başköy	40,79	40,73	2100	Meadows	2
Alchemilla ciminensis	Keşiş Mountains	39,73	39,76	2450	By streams	2
Alchemilla elevitensis	Elevit Yayla	41,00	40,86	2100	Rocky stream banks	0
Alchemilla erzincanensis	Keşiş Mountains	39,73	39,76	2450	By streams	2
Alchemilla hemsinica	Yukarı Kavron	41,13	40,89	2500	Banks	0

Alchemilla ikizdereensis	Dereköy	40,61	40,71	1000	Stream banks, meadows and slopes	0
Alchemilla kackarensis	Yukarı Kavron	41,13	40,89	2350	Stream banks, Nardus stricta meadows	0
Alchemilla orduensis	Yavuz Wood / Çambaşı	37,97	40,63	2100		2
Alchemilla trabzonica	Zigana Pass	39,36	40,61	1750	Stream banks	0
Alkanna areolata var. sublaevis	Mount Spil	27,45	38,57	100-1500	Rocky slopes, limestone scree, steppe, garigue, coniferous forest	2
Alkanna dumanii	Kuruseki	32,91	36,63	1200-1300	Quercus coccifera wood	0
Alkanna haussknechtii	East of Mount Karaman	35,83	40,64	400-600	Open forests, vineyards	0
Alkanna hispida	Ermenek - Mut 30.km	33,15	36,58	1720	Limestone rocks, ruins, Juniperus and Pinus forest, Quercus scrub, wheat fields	0
Alkanna hispida	Gülnar - Ermenek 61.km	32,96	36,58	1230-1270	Limestone rocks, ruins, Juniperus and Pinus forest, Quercus scrub, wheat fields	0
Alkanna hispida	Mut - Mount Eğri 16.km	33,51	36,74	800	Limestone rocks, ruins, Juniperus and Pinus forest, Quercus scrub, wheat fields	0
Alkanna macrophylla	Perge	30,85	36,96	0	Maritime rocks and ruins	0
Alkanna macrophylla	Konyaalti Boulevard	30,61	36,84	25	Maritime rocks and ruins	0
Alkanna milliana	3 km East of Mut	33,46	36,66	450	Crevices of limestone rocks	0
Alkanna mughlae	Asar Tepe / West of of Amos	28,27	36,74	50	Limestone cliffs	0
Alkanna mughlae	İztuzu	28,61	36,80	May.15	Limestone cliffs	0
Alkanna oreodaxa	Akseki-Manavgat 25.km	31,77	36,88	560	Limestone rocks	0
Alkanna pinardii	Lara	30,80	36,86	0	Dry sandy places	0
Alkanna pinardii	Tarsus	34,83	36,82	320	Dry sandy places	2
Alkanna saxicola	Ermenek - Anamur road	32,92	36,62	1200-1290	Limestone rocks	0
Allium baytopiorum	Mount Ağrı	44,30	39,70	1200		2
Allium eldivanense	Bakırlı / Mount Eldivan	33,43	40,47	1800	Stony, rocky dry open places	2
Allium gorumsense	Gürümze	35,81	37,99	1280		0
Allium karamanoglui	Osmaniye - Fevzipaşa	36,45	37,17	800	Dry slopes & scrub	2
Allium kurtzianum	Mount Susuz	27,11	39,87		Mountain slopes on marble	2
Allium nemrutdaghense	Mount Nemrut	38,66	37,86	2150	Montane steppe	2
Allium pseudoalbidum	Susuz - Hasköy	42,89	40,99		Mountainous area	2
Allium stenopetalum	Hasanoğlu / Gürümze	35,81	37,99	1280	Clayey places	2
Allium turcicum	Mount Halkis (Sultana) / Sason	41,42	38,43	1152	Stony slopes under mixed trees	2
Alopecurus adanensis	Adana - Karataş 8.km	35,35	36,92	0	Roadside ditches	0
Alopecurus anatolicus	Sivas - Tatlıca	36,92	39,67	1500	Marshy ground, on Liquidambar forest	0
Alopecurus myosuroides var. latialatus	Adana - Karataş 5.km	35,35	36,94	0	Wet places	2
Alyssum caricum	8km South of Muğla	28,37	37,15	40-300	Serpentine screes and scrub	0
Alyssum caricum	42km South of Muğla	28,56	37,00	40-300	Serpentine screes and scrub	0
Alyssum crenulatum	1 mile south of Yayladağ	36,06	35,89	500-900		0
Alyssum davisianum	Kesik Söğüt - Hamam	29,64	38,96	1400-1900	Rocky igneous slopes	2
Alyssum dubertretii	Belen	36,19	36,50			0
Alyssum niveum	Yakapınar	31,30	40,24		Calcareous steppe	0
Alyssum praecox var. albiflorum	Lake Seyfe	34,39	39,26		Salt Marsh	2
Alyssum trapeziforme	Mount Susuz	35,11	37,41	2000		2
Ampharicarpos exsul	Tahtalı Mountains	30,44	36,54	1800-2000	Limestone crevices	2
Ampharicarpos exsul	Above Eldirek Village	29,55	36,87	1800-2000	Limestone crevices	2
Anacyclus latealatus	18 km after Tefenni before Burdur	29,93	37,39	1100	Fallow fields and steppe	0
Anchusa limbata	Kayadibi	30,77	37,21		Calcareous hills, under Pinus brutia and Cedrus	0

Anchusa limbata	Gümüş	29,97	36,86		Calcareous hills, under Pinus brutia and Cedrus	2
Angelica sylvestris var. stenoptera	Rize - Çayeli	40,57	41,04	50	By streams, damp grassy places, etc.	2
Ankyropetalum arsusianum	Mount Ahır	37,12	37,65			2
Ankyropetalum arsusianum	Arsus	35,89	36,41			0
Ankyropetalum reuteri	Mount Ahır	37,12	37,65			2
Anthemis adonidifolia	Pozantı	34,86	37,42	850		0
Anthemis antitaurica	Saimbeyli - Mount Bozoğlan	36,05	38,05	2000-2100	Rocky slopes	2
Anthemis calcarea var. calcarea	Akdağ / Olur	42,13	40,82	1525	On dry limestone or igneous rocks	2
Anthemis calcarea var. calcarea	Oltu	41,99	40,55	1070-1550	Dry mountain slopes and raciles	2
Anthemis calcarea var. calcarea	Mount Kurt	41,58	41,08	2400	Dry mountain slopes and raciles	2
Anthemis calcerea var. discoidea	7 km North of Tortum	41,50	40,36	1550		0
Anthemis calcerea var. discoidea	Western shore of Lake Tortum	41,63	40,63	1070		2
Anthemis cuneata	Fethiye- Dirmil 51.km / West of Hacı Osman Mountain	29,50	36,78	1000	In Pinus brutia woods on limestone	2
Anthemis davisii	Baykan - Bitlis 13. km	41,87	38,22	1150	Shaly screes in gullies	0
Anthemis dipsacea	Bozdağ	28,10	38,32	1300-1500	Mountain pastures and among dwarf scrub	2
Anthemis dipsacea	Aydın Mountain	27,94	37,99	900-1000	Mountain pastures and among dwarf scrub	2
Anthemis halophila	Mersin	34,63	36,80	0	Sands and sandy soil near seashore	2
Anthemis halophila	İskenderun	36,17	36,59	0	Sands and sandy soil near seashore	2
Anthemis xylopoda	Çıplakdağ near Armutlu	27,56	38,36	1400-1600	Schistase rocks	2
Apera baytopiana	Karaböğürtlen	28,50	37,04		River banks	0
Apera triaristata	Shore of Lake Salda	29,69	37,51	1000	Dry places	3
Apera triaristata	Denizli-Acıpayam 39.km	29,28	37,56	1000	Dry places	3
Arenaria angustifolioides	Geyran Yayla from Ceylan exit	29,60	36,73	1700-2500	Open rocky slopes and scree	2
Arenaria commagenae	Mount Nemrut	38,66	37,86	1950	Stony mountain slopes	3
Arenaria davisii	Mount İspiriz / Başkale	43,88	38,10	3400	Rock crevices	2
Arenaria kotschyana subsp. stenophylla	Akdağ	35,87	40,81	1550-1900	Rocks	2
Arenaria mons-cragus	Akdağ	32,20	36,81	1600	Rocky places	2
Arenaria scariosa	Kovans (Kale)	39,69	40,39	1800	Dry stony slopes	0
Arenaria sipylea	Mount Spil	27,45	38,57		Cliffs	2
Arenaria sivasica	Gökpınar	37,33	38,66	1600	Open rock scree	2
Arenaria speluncarum	Kamışdere / Ermenek	32,95	36,76		Limestone rocks	2
Aristolochia geniculata	Mount Mahras / Mut	33,29	36,72	1200	Rough fieds with limestone blocks	2
Aristolochia geniculata	Summit of Adras Mountain	32,99	36,70	2000	Rough fieds with limestone blocks	2
Aristolochia isaurica	Gökçay Valley / Bozkır-Hadim 54.km	32,30	37,03	1200-1250		0
Aristolochia isaurica	Özyurt	32,87	37,25	1200-1300		0
Aristolochia isaurica	Kazancı	32,85	36,50	900-1000		0
Aristolochia krausei	Limonlu	34,24	36,57	550		0
Aristolochia krausei	Silifke	33,93	36,38			2
Aristolochia rechingeriana	Sinekbeli Pass	29,65	36,49	1400	Calcareous stony fallow ground	0
Aristolochia samsunensis		36,33	41,30	15	Near Samsun wheat fields	2
Armeria trojana	Kaz Mountains	26,86	39,70	1500-1700	Siliceoua (schistose) rocks, stony places	2
Arum elengatum subsp. alpinariae	Kesik Yayla / Seben	31,63	40,60	1600	Juniperus scrub	2
Asparagus coodei	Mount Mahras	33,29	36,72	1200-1300	Limestone rocks, slopes with Quercus coccifera and Juniperus, wheat fields	2
Asparagus coodei	Kuruseki	32,91	36,63	1100	"	2
Asparagus lycaonicus	Lake Bolluk	32,95	38,56	1010	Saline plain near lake	2
Asparagus lycicus	Elmalı	29,92	36,74			0

Asperula bryoides	Oyukludağ	29,57	36,54			2
Asperula cilicica	Maden / Bolkar Mountains	34,62	37,45	1000-1600	Rocky places	0
Asperula pseudochlorantha	Göynük	30,55	36,67	0	Limestone rocks	0
Asperula sintenisii	Kaz Mountains	26,86	39,70	1600-1800		2
Asperula virgata	51 km North of Tortum, eastern shore of Lake Tortum	41,68	40,67	1100	Limestone scree	2
Asphodeline sertachae	Çığlık	32,54	36,34	1820	Steep slopes subalpine meadows open pinus nigfra and abies cilicica forest	2
Asplenium tadei	Northern side of Geyik Mountain	32,15	36,92	2250	North facing limestone cliffs	0
Astragalus akmanii	Karagöl / Mount Ahır	36,92	37,64	1750-1800		3
Astragalus altanii	Pötürge	38,88	38,19	1450	Quercus scrub	2
Astragalus argaeus	Mount Erciyes	35,45	38,53	3000-3200	Alpine regions	2
Astragalus bakirdaghensis	Emli Pass / Çukurbağ	35,10	37,76	1650		2
Astragalus bakirdaghensis	8 km East of Mount Bakır	35,86	38,21	1330		0
Astragalus beypazaricus	Beypazarı-Nallıhan	31,79	40,11	600		0
Astragalus brevidentatus	10 km North of Sereflikoçhisar	33,46	39,01	970	Stony slopes	2
Astragalus cicerellus	Marshy/swampy area west of city	35,35	38,72			2
Astragaus clavatus		40,69	37,30			3
Astragalus columnaris	Acıpayam-Kızılhisar	29,57	38,67	980	Fields	2
Astragalus depressus var. tasheliensis	Near Deleğrik / Çobanlar Yayla	32,52	36,41	1700	Stony places	2
Astragalus distinctissimus	Yarpuz	36,43	37,05	1210-1230	Under pinus etc.	0
Astragalus diyarbekirensis	Diyarbakir - Siverek 12.km	40,06	37,91	600		0
Astragalus ekimii	Dehlizyurdu / Mount Engizek	37,24	37,80	1500-1700	Steppe	2
Astragalus elazigensis	Fırat University Faculty of Science Campus	39,17	38,68	1100		2
Astragalus eliasianus	10 km South of Sarıkamış	42,65	40,27	2200	Open pinus sylvestris forest	0
Astragalus eskishehiricus	Near Abbashalimpaşa	31,05	39,24			3
Astragalus eskishehiricus	1 km South of Hamidiye	30,55	39,33	930		3
Astragalus geobotrys	Çukurören	29,78	38,82	1700-1900		0
Astragalus geobotrys	Uşak - Banaz 10.km	29,49	38,68	950-1000		0
Astragalus goeznensis	Gözne	34,57	37,00	1000-1300	Under Pinus brutia	0
Astragalus gymnalopecias	11 km from Bahçesaray	42,90	38,15	1900	Upland districts	2
Astragalus hartwigii	Western Akdağ Mountains	29,53	36,55	2600-2800	Alpine pasture, rocky limestone slopes	2
Astragalus huber-morathii	21 km North of Gülnar	33,55	36,46	670	Quercus forest, macchie	0
Astragalus huber-morathii	Bozağaç - Ahırini	33,37	36,25	700	Quercus forest, macchie	2
Astragalus isauricus	Above Taşkent	32,49	36,93	1500	Limestone debris	0
Astragalus karasarensis	2 km East of Karasar Pass	38,05	39,30	1550		0
Astragalus karasarensis	Northern side of Lake Tödürge	37,60	39,89	1350		2
Astragalus kastamonuensis	Tosya - Derinöz	34,66	40,82			2
Astragalus kitianus	70 km Northwest of Erzurum	41,75	40,33	2200	Steep rocky places	0
Astragalus lineatus var.bibracteolatus	Kasımkuyu Hill / Mount Engizek	37,25	37,81	2300-2400	Stony places	2
Astragalus nevshehiricus	Nevşehir - Ürgüp 2.km	34,74	38,63	1310	In tree culture	0
Astragalus nigrocalycinus	2 km West of junction / Oltu - Sihsor	42,16	40,65	1450		2
Astragalus panduratus	Tosya	34,04	41,02			2
Astragalus panduratus	Mount İdris	33,23	40,05			2
Astragalus physodes subsp.acikirensis	18 km West of Polatlı	31,93	39,58	840-850	Steppes	0
Astragalus physodes subsp.acikirensis	4 km South of Delice	34,00	39,93	650	Steppes	0
Astragalus robertianus	Southwest of lake Balık	43,54	39,76	2400	Grazed alpine meadow, open steppe	2
Astragalus rosecalycinus	Mut - Karaman 8.km	33,40	36,71	300	Mudstone slopes under Pinus brutia	0
Astragalus rosecalycinus	Around Kazancı	32,85	36,50	850	Mudstone slopes under Pinus brutia	2
Astragalus scabrifolius	Darende-Gürün	37,43	38,67	1330-2000	Artemisia steppe	2

Astragalus scholerianus	Akşehir - Sultandağ	31,35	38,28	1700-1800	Mountain slopes	2
Astragalus simonii	Yeniçubuk	36,10	39,21	1150		0
Astragalus simonii	Gülağaç - Derinkuyu	34,53	38,34	1000		0
Astragalus stenomoides	Mount Erciyes	35,45	38,53	2200-3000	Steppe, scree	2
Astragalus stojani	Midyat	41,03	37,39	900	Mountain	3
Astragalus stridii	Narpız Valley / 6 km Southeast of Demirkazık Village	35,14	37,75	2800-3000	Limestone scree and rock	2
Astragalus syringus	5 km North of Kastamonu	33,77	41,43	900	Calcareous mari	2
Astragalus syringus	Harput	39,27	38,71	900-1600	Calcareous mari	2
Astragalus tatlii	Rizekent - Çıkrıklı	40,97	40,00	2200	Calcerous steppe	2
Astragalus trichostigma	Beypazarı	31,92	40,17			2
Astragalus uhlwormianus	Environs of Havza	35,66	40,97	400-500		2
Astragalus uhlwormianus	Harput	39,26	38,70	400-500		2
Astragalus ulashensis	Sivas - Malatya 27.km	37,00	39,51		Mountaineous districts	0
Astragalus victoriae	Taşpınar	34,03	38,18		Eroded tuff slope	0
Astragalus victoriae	Karapınar	33,65	37,78		Eroded tuff slope	2
Asyneuma babadagensis	Akbel Yayla / Babadağ	29,16	36,52	1670	Vertical rocks	2
Asyneuma davisianum	Gürün - Pınarbaşı 35.km	36,95	38,79	1700	Limestone stony steppe	0
Asyneuma ekimianum subsp. sivasicum	Deliktaş - Kangal	37,21	39,34	1900	Saxatile on limestone rocks	0
Asyneuma ilgazensis	Mount Ilgaz	33,80	41,08	2000	Pinus nigra scree	2
Asyneuma linifolium subsp. glabrum	Gorge near station	30,01	40,15	300	Limestone rocks	0
Asyneuma linifolium subsp. nallihanicum	Nallıhan	31,35	40,18	650	Limestone gorge	2
Asyneuma pulvinatum	Tahtalı Mountains	30,44	36,54	1500-2000	Sloping or vertical crevices in hard limestone rocks and cliffs	2
Asyneuma rigidum subsp. graminifolium	Mount Ilgaz	33,80	41,08	2300	Mountaiın steppe	2
Atriplex tatarica var. constantinopolitana	Büyükada	29,13	40,86		Sandy sea shore	0
Atriplex tatarica var. pseudo-ornata	Aksaray - Sultanhanı	33,79	38,21	950	Salt Steppe	2
Aubrieta olympica	Uludağ	29,21	40,07	2000-2400	Cliffs	2
Barbarea minor var. anfractuosa	Mount Sandras	28,83	37,06	2100-2200	Snowbed meadows and rocky slopes on serpentine	3
Barbarea auriculata var. paludosa	Tercan - Aşkale	40,54	39,83	1800	Moist pastures	2
Barbarea hedgeana	Akdağ / Çivril	29,95	38,30	1900	Dry stony limestone slopes	2
Barbarea integrifolia	Lake Dipsiz / Dörtkonak Yayla	39,36	40,58		Lake Margins	0
Barbarea lutea	Mount Kısır	43,05	40,97	2300	Streamsides	2
Bellardiochloa carica	Mount Girdev	29,62	36,73	2400	Damp alpine pasture, near streams and melting snow	2
Bellevalia anatolica	Near Pertek	39,32	38,86		Dry rocky slopes	0
Bellevalia crassa	Refahiye	38,77	39,91	1400	Steep scree	2
Bellevalia edirnensis	1km from Uzunköprü - İbriktepe Junction	26,68	41,28	250	Cultivated Land, fields, fallow fields, meadows	0
Bellevalia edirnensis	City Center	26,56	41,67	70	Cultivated Land, fields, fallow fields, meadows	0
Bellevalia rixii	Çuh (Güzeldere) Pass	43,97	38,16	2800-3000	Limestone and shaly scree	2
Beta maritima var. grisea	Kocarı Mezra - Çıplak	26,35	40,04	0	On sand near the coast,scattered inland in waste places	2
Beta trojana var. trojana	Truva	26,19	40,00	0	Sea shore	2
Biarum davisii subsp. Marmariensis	Taşlıca / Bozburun	28,11	36,63	0		0
Biarum ditschianum	Esen Stream Valley	29,32	36,39	30-60	Holes or crevices on limestone rocks among garique	2
Biarum eximum	Minaret Han / Tarsus	34,89	36,92	60	Low plains	2
Bolanthus huber-morathii	Kışla	29,20	38,47	1600	Open rock scree	3

Bornmuellera kiyakii	Çamlık	31,64	37,36	1400-1700	Clearing in Pinus nigra forest	0
Bromus macrocladus	Aydın Mountain	27,94	37,99		Grassy hills and meadows	2
Bromus macrocladus	Birgi / Bozdağ	28,06	38,36		Grassy hills and meadows	2
Bromus psammophilus	Tarsus	34,79	36,81	0	Sand dunes	2
Bromus sipyleus	Uludağ	29,21	40,07		Shaded slopes and montane woods	2
Bromus sipyleus	Kaz Mountains	26,86	39,70		Shaded slopes and montane woods	2
Bromus sipyleus	Mount Spil	27,45	38,57		Shaded slopes and montane woods	2
Bunium microcarpum subsp. longiradiatum	Mount Cudi	42,52	37,38	1300	Limestone slopes and oak forest	2
Bupleurum pendikum	Pendik	29,24	40,89	0	Dry grassland near sea level	0
Calamintha caroli-henricana	ca. 30 km North of Çaldıran	44,03	39,34	2400-2700	Limestone boulders near lava rock	0
Campanula akgulii	Karbastı / Hizan	42,38	38,16	1550	Limestone crevices	0
Campanula antalyensis	Beşkonak	31,13	37,23	1200	Conglomerate rocks	2
Campanula bipinnatifida	Babadağ	28,88	37,73	1900	Schistose rocks	2
Campanula blumelii	Medetsiz / Bolkar Mountains	34,64	37,40	1500-1800	Calcareous steep stony slopes	2
Campanula choruhensis	29 km East of Demirkent	41,85	41,11	2500	Shaded rock crevices	0
Campanula choruhensis	Çamlıkaya - Karkamış	41,23	40,66	1800	Shaded rock crevices	2
Campanula damboldtiana	16 km East of Ayaş	32,44	40,09	1190	Marly eroded slopes,stony steppe	0
Campanula damboldtiana	North of Orhaniye / Kazan	32,67	40,11	1200-1250	Marly eroded slopes,stony steppe	0
Campanula ekimiana	Kızılcahamam-Eğerlikuzdere	32,71	40,53	950-1000	Steep rocky slopes	2
Campanula fruticulosa	Mazdaköy- Fethiye	29,66	36,93	1600-2400	Rocks	2
Campanula iconia	Sultandağ - Akşehir	31,35	38,28	1800	Alpine regions	2
Campanula isaurica	Saray Mahallesi /Anamur	32,82	36,08	1800-2200	Calcareous rocks	2
Campanula koyuncui	Babadağ	29,16	36,52	1500-1750	Calcareous rocks	2
Campanula latiloba subsp. rizeensis	Çamlıhemşin	41,01	41,03	250	Steep rocks	0
Campanula latiloba subsp. rizeensis	Köprübaşı - Sürmene 1.km	40,12	40,87		Steep rocks	0
Campanula leucosiphon	Kamışdere / Ermenek	32,95	36,76		Crevices, entrance of caverns, limestone rocks	2
Campanula leucosiphon	Balkusan Stream	33,01	36,65	915-1100	Crevices, entrance of caverns, limestone rocks	2
Campanula lycica	Kepez	30,55	36,91	50	Phrygana, terra rosa	2
Campanula lycica	Kaş	29,65	36,19	50	Phrygana, terra rosa	0
Campanula parmicifolia var. capillata	Ovacık / Munzur Mountains	39,22	39,36	1760-2900	Limestone slopes, rocks, steep igneous screes	2
Campanula parmicifolia var. capillata	Mount Göl	37,71	37,65	1760-2900	Limestone slopes, rocks, steep igneous screes	2
Campanula peshmenii	Eskiköy	38,02	38,15	1800-2200	Limestone rocks	0
Campanula pubicalyx	Hamitseydi Pass / Sarıvadi-Beşkuyu	32,81	36,50	1500-1700	Rocks	0
Campanula pulvinaris	Karababa	36,04	39,42	2200-2700	Rocks	2
Campanula quercetorum	Pülümür - Tunceli 46.km	39,67	39,17	1100	Quercus scrub, limestone gorge	0
Campanula raveyi	Mount Samsun	27,31	37,67	100-200	Stony slopes, sandy places	0
Campanula sivasica	Bolucan	37,98	39,68	1400	Gypsum	0
Campanula sivasica	Karayün	37,30	39,68	1500-1550	Gypsum	0
Campanula sorgerae	16 km North of Konya	32,55	38,00	1200	Steppe	2
Campanula troegerae	Yusufeli - Waterfall	41,68	40,67	610	Rock crevices	2
Campanula yaltrikii	Elmalı - Çığlıkara	29,78	36,51	1900-1950	Calcerous rocks	2
Campanula yildirimlii	Northwest of Ovacık / Munzur	39,22	39,36	2000	Rocky outcrops	2
Campanula yildirimlii	Sandıkbağ	38,46	39,29	900	Rocky outcrops	0
Carduus amanus	Amanos	36,39	36,80			2

Carduus olympicus var. olympicus	Uludağ	29,21	40,07	1900-2200	Rocky slopes and screes, often in Juniperus communis subsp. nana scrub	2
Carex cilicica subsp. muglaica	Mount Girdev	29,62	36,73	2400	By streams of melting snow	2
Carthamus tenuis subsp. tenuis	36 km East of Silifke	34,24	36,55	100		0
Carum rupicola	Yukarıbeycik / Tahtalı Mountains	30,44	36,54	2000-2350	In crevices of shsded vertical limestone rocks with the stems spreading and adpressed to the rock face	2
Centaurea aladagensis	Mount Susuz	35,11	37,41			2
Centaurea amaena	near Kayseri	35,49	38,72	1200	Stony hills	2
Centaurea anthemifolia	Pozantı - Çiftehan	34,85	37,48		Rocky slopes	2
Centaurea aucherana	Salihli	38,50	39,34			0
Centaurea brevifimbriata	Darende-Gürün / 15km north of Darende	37,44	38,64	1280	Fields	0
Centaurea cariensiformis	35 km East of Elbistan to Gürün	37,52	38,25	1650	Field margins	0
Centaurea cariensis subsp. niveotomentosa	Mount Hacıosman	29,54	36,72	900-2300	Open woods (Pinus quercus), stony slopes, rocks	2
Centaurea cheirolepidoises	Zümrüdova	29,81	36,60			0
Centaurea chrysantha	Maden / Bolkar Mountains	34,62	37,45	1000-2190	Rocky slopes	0
Centaurea davisii	Mount Cudi	42,45	37,38	900	Limestone cliffs	2
Centaurea drabifolioides	Arslanyurdu Stream / Şebinkarahisar	38,42	40,33			2
Centaurea hadimensis	Tosmur Yayla / Gevne Valley	32,40	36,65	1500	Rocky places	2
Centaurea halophila	Şereflikoçhisar- Near Lake Tuz	33,32	39,15	920	Salt steppe	0
Centaurea haussknechtii	Mount Sof	37,14	37,13	1070	Limestone	3
Centaurea haussknechtii	Göksun - Kapalak	36,49	38,02		Grassland	2
Centaurea hermannii	Çilingöz	28,29	41,47	100-500	Macchie, Quercus forests	0
Centaurea hermannii	Mount Aydos	29,25	40,94	100-500	"	2
Centaurea iconiensis	Seydişehir-Bozkır 22.km	32,06	37,39	1050		0
Centaurea isaurica	Karaman - Ermenek 64. km	32,95	36,71	1430	Limestone	2
Centaurea isaurica	Near Beyreli	32,42	36,91	1800	Limestone	2
Centaurea kilaea	20 km South of Akçakoca	31,17	40,96	0-20	Sandy beach and dunes	2
Centaurea kilaea	Kasatura	28,09	41,63	0-20	Sandy beach and dunes	2
Centaurea kilaea	Kilyos	29,04	41,25	0-20	Sandy beach and dunes	2
Centaurea leptophylla	Peterek	41,43	40,79	1829		2
Centaurea longifimbriata	Varegoza / Mount Sat	44,22	37,42	1750-1800	Dry meadows	2
Centaurea mykalea	Uluborlu Dam	30,41	38,07	1200	Open areas in forest	2
Centaurea mykalea	Davutlar-Selçuk 7.km	27,28	37,79	30	Roadside	0
Centaurea nivea	Caraja - Dudaş	31,26	39,84			3
Centaurea nivea	Abbashalimpaşa	31,08	39,40			3
Centaurea nydeggeri	5-10 km Southwest of Hamur	28,31	41,43	1650	Water permeable slope	2
Centaurea odyssei	Kaz Mountains	26,86	39,70	1600	Rocky slopes, open areas between pines and above tree line	2
Centaurea pamphylica	East of Manavgat	31,44	36,79			2
Centaurea pamphylica	Aksu Stream	30,91	37,02			2
Centaurea pergamacea	Ankara - Şereflikoçhisar 99.km	33,12	39,18	1090	Fields	0
Centaurea pergamacea	Malya State Farm	34,34	39,30	900-1300	Fields	2
Centaurea pergamacea	Harput	39,26	38,70	900-1300	Fields	2
Centaurea poluninii	Mount İspiriz / Başkale	43,88	38,10	3300	Scree	2
Centaurea pseudokotschyi	Akdağ	32,20	36,81		Rocks	2
Centaurea scopulorum var. gracilior	Environs of Gazipaşa	32,31	36,27	200-300	Limestone Rocks	0
Centaurea scopulorum var. gracilior	Anamur - İncekum	33,40	36,16	200-300	Limestone Rocks	2
Centaurea sericea	Dursunbey	28,63	39,59			0
Centaurea sipylea	Mount Spil	27,45	38,57			2

Centaurea straminicephala	Tortum Falls	41,68	40,67	1000-1150	Calcareous rocks, steppe	0
Centaurea taochia	Oltu	42,00	40,55		Calcareous rocks	2
Centaurea tchihatcheffii	Gölbaşı	32,77	39,75	950	Fields, steppe	0
Centaurea wagenitzii	Bay of Adrasan	30,43	36,34	50	Macchie	2
Centaurea yozgadensis	Küplü	30,01	40,12			0
Centaurea zeybekii	Kurudere - Ovacık / Mount Nif	27,44	38,39	600	Open Pinus brutia forest	2
Cephalaria amana	Sincanköy	36,25	36,73	800		0
Cephalaria anatolica	Lake Tortum	41,63	40,63			2
Cephalaria dirmilensis	Dırmil Pass	29,58	36,96	1560	Pınus nigra subsp. pallasiana forest	0
Cephalaria ekimiana	Tepebaşı	32,71	36,67	1100	Roadside, disturbed ground	0
Cephalaria hakkiarica	Diz Stream / Mount Cilo	44,01	37,49	2440		2
Cephalaria isaurica	Türbelinas / Kargı Stream	32,05	36,65	1100	Slopes	3
Cephalaria peshmenii	Çakırlar / Hisar Çandır/ Mount Çalbalı	30,37	36,80	1800	Calcerous rocky slopes, Cedrus libani forest	2
Cephalaria scoparia	Yaylakuzdere	30,42	36,58	1400-2300	Serpentine, open areas in Cedrus libani forest	0
Cerastium dominici	Göztepe	29,15	36,97	2000	Ophiolitic scree	2
Cerastium pisidicum	Alacayayla / Bozburun	31,05	37,32	1700	Conglomerate slopes	2
Cerasus erzincanica	Eriç - Kemah	38,89	39,51	1200-1500		2
Cerasus incana var. velutina	Mount Ali	35,55	38,66	1400		2
Chaenorhinum cryptarum	Bey Mountains	38,35	38,25	1000	Limestone caves	2
Chaenorhinum huber-morathii	Pertek-Tunceli 40 km from Elazığ	39,40	38,86	1060-1400	Igneous gullies and limestone alebris	0
Chaenorhinum huber-morathii	Mount Çelemelik	39,31	38,49	1060-1400	Igneous gullies and limestone alebris	2
Chaerophyllum aksekiense	Pınarbaşı / Akseki	31,86	36,88	1450	Open Cedrus libani forest	0
Chaerophyllum karsianum	Karakale /Arpaçay	43,46	40,87	2100	High mountain steppe	0
Chaerophyllum posofianum	Alköy / Posof	42,78	41,48	1500-1700	Fields	0
Chamaecytisus gueneri	Ağla - Eskere	28,79	37,05	1450-1700	Open Pinus nigra forest serpentine slopes	3
Chinodoxa luciliae	Bozdağ	28,10	38,32	1600-2000	Open mountainsides	2
Chinodoxa sardensis	Above Armutlu / Mount Mahmut	27,52	38,38	550	Pinus woods, damps north-facing mountain slopes	2
Chinodoxa sardensis	Kemalpaşa - Yukarıkızılca	27,47	38,42	550	Pinus woods, damps north-facing mountain slopes	2
Chrysocamela elliptica	Environs of Beypazarı	31,92	40,17			2
Chrysocamela elliptica	Avşin / 40 km northeast of Kemaliye	38,57	39,47			2
Chrysocamela elliptica	Bereketli	34,50	37,76			2
Chrysocamela noeana	Sivas - Zara	37,39	39,86	1000-1400	Stony slopes	2
Cicer reticulatum	9 km East of Savur near Dereiçi	40,97	37,55		Edge of vineyard	0
Cirsium cassium	Kılıçdağ	35,97	35,95	1000		2
Cirsium davisianum	Mount Dumlu	41,25	40,24	2500-2800		2
Cirsium eliasianum	Lake Çıldır	43,24	40,99	1950	Alpine meadows near lake	2
Cirsium hakkiaricum	Diz Stream / Mount Cilo	44,01	37,49	2438	Rocky slopes	2
Cirsium polycephalum	Büyükçekmece	28,59	41,03	0	Dry places by roadsides, in fields, dry hills, open places	0
Cirsium polycephalum	Kilyos	29,04	41,25	0	Dry places by roadsides, in fields, dry hills, open places	0
Cirsium pubigerum var. paphlogonicum	Kayseridere / Northern side of Ilgaz	33,91	41,03	1500-2000	By streams, rarely in forests	2
Cirsium simplex subsp. satdaghense	Mount Sat	44,16	37,35	2000-2900		2
Clypeola ciliata	Lake Avlan	29,97	36,58	1000		2
Cochleraria amana	15 km Southeast of Osmaniye	36,36	36,99	2000	Ophiolitic Rocks	2

Colchicum davisii	Mount Kartal 45 km before Nurdag Pass	36,63	37,19	1000-1950	Rocky slopes often North facing in sheltered shady situations on limestone	0
Colchicum heldreichii	3 km East of Derbent	32,04	38,03	1600	Grassy meadows and depressions in mountians	0
Colchicum heldreichii	Geyik Mountains	32,16	36,88	2338	Grassy meadows and depressions in mountians	2
Colchicum inundatum	20 -30 km from Gencek to Aydınkent (İbradı)	31,45	37,30	1200-1250	Meadows flat alluvial plains periodically waterlogged	2
Colchicum micaceum	Bozdağ	28,10	38,32	1750-1800	Gritty or rocky mountain slopes often in turf predominantly in sheltered spots uncovered by snow late in the spring on schist	2
Colchicum micaceum	Babadağ	28,88	37,73	1500-1700	Gritty or rocky mountain slopes often in turf predominantly in sheltered spots uncovered by snow late in the spring on schist	2
Colchicum micranthum	Kurtköy	29,30	40,92	480-500	Erica and Arbutus macchie on mountain slopes, Quercus scrub, meadows, woods	0
Colchicum micranthum	Büyükdere	29,04	41,17	480-500	Erica and Arbutus macchie on mountain slopes, Quercus scrub, meadows, woods	2
Colchicum minutum	10 km from Gündoğmuş to Manavgat	31,90	36,81	1000	Deep terra rossa in depressions in sparse Quercus scrub, old fields, dolines; on limestone	0
Colchicum minutum	West of Issos (Dörtyol)	36,22	36,84		Deep terra rossa in depressions in sparse Quercus scrub, old fields, dolines; on limestone	2
Colchicum munzurense	19 km from Tunceli to Ovacik	39,48	39,23	950	Scree boulder beds cliff ledges recently uncovered from snow light oak forests on limestone	0
Colchicum paschei	Mount Nemrut	38,71	37,86	2000	Mountain Steppe on stony and rocky ground	3
Colchicum sanguicolle	Above Ovacık / Babadağ	29,15	36,58	1200-1250	Meadows open slopes edges of cedar forest	2
Colchicum sanguicolle	Göğübeli Pass	29,76	36,84	1750	Meadows open slopes edges of cedar forest	2
Colchicum sanguicolle	Mount Tahtalı	30,43	36,53	1350	Meadows open slopes edges of cedar forest	2
Colutea melanocalyx subsp. melanocalyx	Sar Köyü	30,64	37,77	1250	Woodland and shrub , rocky slopes	2
Colutea melanocalyx subsp. melanocalyx	Solyma	30,45	36,51	1250	Woodland and shrub , rocky slopes	2
Consolida cornuta	West of Ilıca	41,11	39,95	1800-1900	In grain and fallow fields	2
Consolida hellespontica subsp. rosea	Mecidiye / Mahmudiye	30,84	39,61	1000-1100	Field sides	2
Consolida lineolata	41 km Southwest of Mut	33,18	36,56	940	Pinus forest	0
Consolida staminosa	Çaykavak Pass	34,54	37,60	1580	Thorn-cushion steppe on igneous substrate	2
Corydalis caucasica subsp. abantensis	Abant road	31,54	40,71	1000-1500	Scrub	2
Corydalis caucasica subsp. abantensis	Esentepe	32,21	40,80	1000-1500	Scrub	2
Corydalis henrikii	Mount Kartal 45 km before Gaziantep	36,95	37,18	1000-1100	North facing calcareous slopes on limestone	0

Corydalis lydica	Bozdağ	28,10	38,31	1450-1800	Stony slopes	2
Corydalis lydica	Uludağ	29,21	40,07	1400-1800	Stony slopes	2
Cousinia aucheri	Malatya - Elazığ 47.km	38,80	38,43	600-950	Steppe	0
Cousinia birecikensis	Çiftlik	37,93	37,11			0
Cousinia davisiana	Ermenek	32,89	36,64	1400	Chalky slopes	2
Cousinia decolorans	7 km Northwest of Divriği	38,16	39,42	1500	Steppe	0
Cousinia decolorans	Sürek	39,33	39,66	1500	Steppe	0
Cousinia euphratica	50 km East of Malatya	38,83	38,45	680		0
Crambe tataria var. parviflora	Uşak - Salihli 20.km	29,18	38,67	900-1400	Steppic habitats, stony slopes, fallow fields	0
Crenosciadium siifolium	Kesik söğüt / Mount Murat	29,68	38,94	1400-1800	Damp meadows, stream sides in Pinus nigra forest	2
Crenosciadium siifolium	Dedegöl Mountains	31,21	37,81	1400-1800	Damp meadows, stream sides in Pinus nigra forest	2
Crepis aurea subsp. olympica	Uludağ	29,21	40,07	2000		2
Crepis hakkarica	Diz Stream / Mount Cilo	44,01	37,49	2440	Rocky slopes	2
Crocus adanensis	Kurt Castle / Düziçi	36,47	37,26	750-1300	Edge of woods, juniperus&quercus macchie	0
Crocus asumaniae	5 km from Cevizli	31,77	37,20	1250	Sparse quercus woodland	2
Crocus biflorus ssp artvinensis	Tuzlu Hill	41,47	41,04	3000	Open rocky slopes, scrub, alpine turf, sparse coniferus woods	2
Crocus biflorus subsp. wattiorum	Tahtalı Mountains	30,44	36,54	100-500	Crevices of limestone rocks, edge of Pinus woodland	2
Crocus gargaricus subsp. herbertii	Kirazlı Yayla / Uludağ	29,21	40,07	1370-2200	Wet meadows	2
Crocus karduchorum	Hizan - Tatvan 19.km	42,28	38,29	1830-2200		0
Crocus kotschyanus subsp. hakkariensis	Yüksekova-Şemdinli 15.km	44,36	37,49		Short turf, open stony places, sparse scrub	0
Crocus kotschyanus subsp. hakkariensis	Mordağ	44,32	37,75	3250	Short turf, open stony places, sparse scrub	2
Crocus mathewii	Kalkan	29,41	36,27	400-1100	Exposed stony areas	0
Crocus oliverii subsp. istanbulensis	Alemdağ	29,24	41,05	150-170	Dryish scrub&clearings	0
Crocus speciosus ssp xantholaaimos	Dranaz Pass	34,88	41,68	1350	Clearings in Abies and rhododendron woods	0
Crucianella sorgerae	Ovacık	33,42	36,16	300	Rocky clearings in Pinus brutia forest	0
Cyclamen mirabile	Çine - Yatağan	28,15	37,44	500-1000	Quercus macchie, Pinus brutia forest, on metamorphic and granitic rocks	2
Cyclamen mirabile	5 km South of Barla	30,77	37,97	1000	Quercus macchie, Pinus brutia forest, on metamorphic and granitic rocks	0
Cyclamen pseud-ibericum	20 km South of Feke	35,85	37,65	800	Pinus brutia forest, Fagus-Ostrya scrub on limestone, metamorphic or igneous rocks	0
Cyclamen pseud-ibericum	Mount Düldül	36,51	37,35	1000	Pinus brutia forest, Fagus-Ostrya scrub on limestone, metamorphic or igneous rocks	2
Delphinium ilgazense	Mount Ilgaz	33,80	41,08	2200	Rocky limestones slopes	2
Delphinium iris	Ardahan - Kars 6.km	42,76	41,13	1700		0
Delphinium kitianum	Cevizli	32,86	36,50	1300	Igneous and calcerous slopes	0
Delphinium munzianum	Tortum - Oltu 26.km	41,80	40,36	2200	Rocky limestone slopes	0
Delphinium nydeggeri	10 km East of Çamardı	35,06	37,86	1650		0
Dianthus akdaghensis	Camialanı / West Side of Akdağ	29,50	36,56	2200	Rocky limestone slopes	2
Dianthus elegans var.gramineus	Ködürümsü Port / Asar/ 14km South of Fethiye	34,28	37,02	0		2
Dianthus goerkii	6 km Southeast of Demirkazık Village	35,14	37,75	2500-2700	Limestone scree	2

Dianthus ingoldbyi	Anzak	26,30	40,26			2
Dianthus leucopheus var. patens	Narpiz Valley	35,14	37,75	2500	Scree	2
Dianthus robustus	Koşkar Stream - Bingöl Mountains	41,41	39,26	1930		2
Dianthus sessiliflorus	Bingöl Mountains	41,41	39,35			2
Dianthus setisquameus	Akdağ	35,87	40,81	1900	Alpine section	2
Dionysia teucroides	Diz Stream / Mount Cilo	44,01	37,49	1900-2000	Limestone cliffs	2
Dipsacus cephalarioides	20 Miles east of Muş	41,71	38,68		Roadsides	0
Doronicum tobeyi	Karagöl (Karataş Hill)	38,18	40,50	2600	In streams	2
Dorycnium amani	Zorkun	36,35	36,97	1400		0
Draba elegans	Gülek Pass	34,79	37,28	1000-1100	Rock faces and crevices	2
Ebenus pisidica	Gökçeova / Mount Sandras	28,81	37,08	1500-1700	Mountain slopes	2
Ebenus pisidica	Dirmil Pass	29,58	36,96	1560	Mountain slopes	0
Ebenus plumosa var. plumosa	Yaparlar	29,52	38,61	100-850	Dry slopes	2
Ebenus plumosa var. speciosa	5 km South of Ermenek	32,92	36,61	1150-1350	Dry rocky limestone slopes with Quercus shrubs	0
Ebenus reseii var. minor	Geyran Yayla / Bozdağ	29,15	37,28	210	Mountain slope	2
Echinophora lamondiana	1.5 km West of Darende	37,49	38,55	1150	Slopes of eroded hills	0
Echinophora lamondiana	3 km North of Hekimhan	37,91	38,84	1100-1200	Slopes of eroded hills	0
Echinophora lamondiana	Alacahan	37,56	39,11	1550	Slopes of eroded hills	0
Echinops mersinensis	Sarıkavak	34,70	37,08	1000	Roadsides,rocky slopes	0
Echinops mersinensis	Yenice	34,51	36,92	940	Roadsides,rocky slopes	0
Echinops vaginatus	Mount Ahır	36,90	37,63	1200	Rocky slopes	2
Echinops vaginatus	Mount Sof at Görkündag / Besni	37,14	37,13	1070	Rocky slopes	2
Elymus clivorum	Çaylar - Varto 6.km	41,34	39,25	1750	Slopes in steppe	0
Elymus longearistatus subsp. sintenisii	2-3 km West of Maçka	39,64	40,84		Rocky slopes	2
Elymus longearistatus subsp. sintenisii	Mount Kubbe	38,60	38,28	1700	Rocky slopes	2
Elymus nodosus subsp. gypsicolus	Çetinkaya - Kırkgöz	37,69	39,34	1580-1700	Gypsum slopes	2
Elymus nodosus subsp. plathyphyllus	Akçay - Cumaçay 20.km	43,32	39,98	2200	Dry pastures	2
Elymus sosnowskyi	Northwest of Başgedikler railway station / Lake Kuyucuk	43,45	40,73		Dry mountain slopes and raciles	2
Elymus sosnowskyi	Oltu	42,00	40,55		Dry mountain slopes and raciles	2
Eremopea mardinensis	Nusaybin	40,78	37,25	600-850	Limestone gullies, fallow fields	0
Eriolobus trilobatus var. sorgerae	West of Gömbe	29,67	36,56	1200	Field margins	2
Erodium absinthoides subsp. haradjanii	Mount Düldül	36,51	37,35	1500-2100	Mountains	2
Erodium brandianum	Mount Yaralıgöz	34,13	41,75	1900-2000	Subalpine limestone rocks	2
Erodium hakkiaricum	Karadağ	44,49	37,59	2900	Rocky slopes	2
Erodium hendrikii	Yağmurdere	39,86	40,58	1800	Stony slopes	0
Erodium olympicum	Uludağ	29,21	40,07	2300	Limestone rock crevices	2
Erodium sibthorpianum subsp. sibthorpianum	Uludağ	29,21	40,07	2300-2493	Marble screes	2
Erodium somanum	Mount Soma / Pınartepe	27,57	39,14	1000-1100	Rocky north and east facing mountain slopes at tree line	2
Eryngium isauricum	Near Kozağacı	33,02	36,30	1300	Calcerous rocks	0
Erysimum amasianum	Kırklar Mountain	35,25	40,46	400-600	Vineyards	2
Erysimum amasianum	Vicinity of Amasya Castle	35,81	40,67	400-600	Vineyards	2
Erysimum caricum	Babadağ	28,88	37,73	2200-2400	Rocky slopes, 2200-2400 m.	2
Erysimum deflexum	Meryemana Stream / Maçka	39,65	40,70	1380-1400		2
Erysimum degenianum	Halkalı	28,79	41,04	0	Dry places on limestone hills near the sea	0
Erysimum echinellum	Hazarbaba Mountains - Lake Hazar	39,33	38,40	2400-2450	On serpentine rock	2
Erysimum leptocarpum	İspir - İkizdere 12.km	40,91	40,52	1420	Stony slopes	0
Erysimum pallidum	Elmalı	29,89	36,78	1700	Rocky places	2

Erysimum pallidum	Mount Honaz	29,29	37,68	1700	Rocky places	2
Euphorbia isaurica	Kamışdere / Ermenek	32,95	36,76			2
Euphorbia pisidica	Katara Pass / Gökhisar	29,43	37,10	1500-1600	Pasture-land and volcanic rocks in mountain passes	2
Euphorbia pisidica	Dırmil Pass	29,58	36,96	1500-1600	Pasture-land and volcanic rocks in mountain passes	0
Ferula amanicola	Yağlıpınar / Yarpuz	36,43	37,05	1600-1650	In mixed forests	2
Ferula huber-morathii	Hınıs - Pasinler 29.km	41,76	39,60	1800	Stony slopes	0
Ferula huber-morathii	Near Hasangüran	42,26	39,10	1700	Stony slopes	2
Ferula longipedunculata	Mount Işık / Binboğa Mountains	36,55	38,34	1900	Rocky slopes	2
Ferula tenuissima	Yağlıpınar / Yarpuz	36,43	37,05	1600-1650	In mixed forests	2
Ferulago antiochia	Şenköy	36,14	36,05	1200	Rocky slopes	0
Ferulago isaurica	Kozlu Stream / Kargı Stream	31,95	36,70	1000	Pinus nigra forest	2
Ferulago longistylis	Çağlayan	39,73	39,59	1700	Rocky slopes	0
Ferulago sandrasica	Mount Sandras	28,84	37,09	2000	Rocky serpentine slopes	2
Ferulago silaifolia	Uludağ	29,21	40,07	1000	Cliffs, screes, in forest	2
Ferulago silaifolia	25 km West of Bursa	28,73	40,22	0	Cliffs, screes, in forest	0
Festuca decolorata	Uludağ	29,21	40,07		Nardus stricta meadows	2
Festuca ilgazensis	Lesser Ilgaz	33,86	41,10	2100	Limestone rock	2
Festuca pontica	Meryemana	39,67	40,67	1290-1300	Wet crevices	0
Festuca punctoria	Uludağ	29,21	40,07	1700-2500	Rocky meadows and scree on siliceous and calcerous substrata above tree line	2
Festuca rubra subsp. pseudorivularis	Uludağ	29,21	40,07	650-2000	Damp shady places, meadows with Nardus stricta	2
Festuca ustulata	Kaz Mountains	26,86	39,70	1800	Subalpine meadows	2
Flueggea anatolica	Kadıncık I Dam	34,79	37,08	340	Macchie scrub	0
Fritillaria acmopetala subsp. wendelboi	Mountains northeast of Akseki	31,90	37,19	1700	Cedrus forest, rocky places on limestone	2
Fritillaria acmopetala subsp. wendelboi	Ermenek - Karaman 30.km	32,92	36,84	1900-2020	Cedrus forest, rocky places on limestone	3
Fritillaria acmopetala subsp. wendelboi	Kaş Yayla	32,92	36,25	1600	Cedrus forest, rocky places on limestone	0
Fritillaria assyrica subsp. melanenthera	Silifke	33,93	36,38	2-200	Sandy or rocky hills near the sea	0
Fritillaria assyrica subsp. melanenthera	2 km North of Mut	33,42	36,66	290	Sandy or rocky hills near the sea	0
Fritillaria baskilensis	Y.Kuluşağı	38,65	38,63	1300	Rocky hillsides	0
Fritillaria carica subsp. serpenticola	Karaçulha - Altınyayla	29,59	36,96	1700	Serpentine screes with Pinus and Juniperus	2
Fritillaria forbesii	Marmaris - Emecik	28,07	36,80	350	Pinus brutia forest, macchie on serpentine	2
Fritillaria forbesii	Fethiye	29,13	36,63	0-1000	Pinus brutia forest, macchie on serpentine	2
Fritillaria kittaniae	South of Sinekçibeli Pass	29,65	36,49	1500	Limestone rock in Cedrus libani forest	0
Fritillaria sibthorpiana subsp. enginiana	Pankuduz Hill / Mount Sandras	28,81	37,08	1000-1050	Pinus brutia and Platanus orientalis woodland and wood margins on limestone serpentine and shales	2
Fritillaria sibthorpiana subsp. enginiana	Akköprü above Dalaman Stream	28,92	36,92	1100	Pinus brutia and Platanus orientalis woodland and wood margins on limestone serpentine and shales	0
Fritillaria sororum	Tarsus	34,89	36,92	500-950	Quercus scrub Pinus brutia forest on limestone stony places	2
Fumana trisperma	Gürün	37,28	38,73			0
Galanthus koenenianus	Yağmurdere and Araliya / Soğanlı Mountains	36,87	40,58	1550	Mixed woodland on volcanic soil	2
Galanthus peshmenii	Sumahşehri	30,44	36,60	200-400	Maquis north facing rocky limestones	2

Galium aladaghense	1.5 km to Sulupınar	35,31	37,83	2470	Slopes of high mountains	2
Galium baytopianum	Mount Dumluca / Divriği	38,07	39,37			2
Galium galiopsis	Mount Hazarbaba	39,33	38,40	1200-2450	Serpentine scree	2
Galium globuliferum	Muğla - Fethiye 141.km	29,11	36,68	0	Rocky openings, macchie	2
Galium huber-morathii	Gorge of Çarşamba Stream / Bozkır-Konya	32,61	37,39	1000	Limestone rocks	2
Galium isauricum	Akseki	31,76	36,99	1050	Chalky plateaues	0
Galium papilliferum	Keşiş Mountains	39,72	39,78	2700-2900	Alpine igneous (dioritic) scree	2
Galium pterocarpum	Sencan Stream between Gürümze and Süphandere	35,87	37,96	1000-1200	Scrub, among shady metamorphic rocks	2
Galium tolosianum	Arsus	35,89	36,41	600-1350	Porphyritic rocks	0
Galium tortumense	39 km North of Tortum	41,61	40,60	1150-1200	Rocks, scree	0
Galium tubiflorum	Çatak Yayla / Bozdağ	29,16	37,25	1500-1675	Shady limestone rocks	2
Galium zabense	Hakkari - Van 9.km	43,84	37,61	1200	Gravel slopes	0
Gaudiniopsis huber-morathii	Atbükü	30,48	36,45	0-50	Macchie, Pinus Brutia forest	0
Gaudiniopsis sorgerae	17 km East of Eğirdir	30,91	37,91	1250	Pinus nigra subsp. pallasiana forest	2
Genista sandrasica	Mount Sandras	28,82	37,06	1700-1750	Open Pinus nigra forest, on serpentine	3
Geranium cinereum subsp. subcaulescens var. elatius	Mount Hübek	36,69	37,92			2
Geranium cinereum subsp. subcaulescens var. pisidicum	Kurucuova	31,41	37,69	1500-2000	Pinus nigra - Cedrus libani forest, Calcerous alpine pasture	0
Geranium davisianum	Amlakit Yayla	41,03	40,92	2000-2400	Mixed picea-rhododendron forest on igneous rock	2
Geranium eginense	Kemaliye	38,49	39,26		Rocky slopes	2
Geranium platypetalum var. albipetalum	Cehennem Stream / Kaçkar Mountain	41,15	40,84	3000	Stream sides	2
Gladiolus humulis	Mount Nemrut	38,71	37,86	2100	Rocky south-facing slopes	3
Glaucium grandiflorum var. torquatum	Mucur	34,38	39,07		Calcareous hillsides in steppe	0
Globularia davisiana	Kesme Pass	30,51	36,60	60-100	On and below vertical limestone cliffs	2
Globularia davisiana	Çukur Yayla-Tahtalı Mountains	30,42	36,54	1525	On and below vertical limestone cliffs	2
Globularia dumulosa	Ak Mountains	29,57	36,54	1800-2800	Limestone rocks	2
Globularia dumulosa	Above Geyran Yayla / Bozdağ	29,15	37,28	1830-2135	Limestone rocks	2
Globularia dumulosa	Aladiş Yayla / South Of Pirnas / Boncuk Mountains	29,40	36,92	1830-2135		2
Globularia trichosantha subsp. longisepala	Yaylacık Hill	31,32	37,18	1800-1950	Rocky alpine meadows	2
Glycyrrhiza iconica	Konuklar Çiftliği / 27 km west of Sarayönü	32,71	38,34	900		0
Gonocytisus dirmilensis	8 km north of Altınyayla	29,53	37,08	1050-1100	Pinus nigra forest	0
Graellsia davisiana	Kadınpınarı Stream / Mount Engizek	37,08	37,81	2200-2500	Shady cliffs	2
Graellsia davisiana	Above Yalak / Binboğa Mountains	36,49	38,28	2000-2050	Shady cliffs	3
Gypsophila davisii	Gökçeova / Mount Sandras	28,81	37,08	1700	Subalpine pastures	2
Gypsophila germanicopolitana	5 km South of Çankırı	33,60	40,54	700-750	Gypsum slopes	0
Gypsophila graminifolia	Mount İspiriz	43,88	38,10	2700	Serpentine screes	2
Gypsophila hakkiarica	Mount Sat / Yüksekova	44,27	37,35	2900	Dry river bed nr permanent snow	2
Gypsophila leucochleana	Kavak / 1km East of Darende	37,50	38,54	1000-1050	Limestone	0
Gypsophila olympica	Uludağ	29,21	40,07	2000-2500	Limestone hills	2
Gypsophila perfoliata var. araratica	Doğubeyazıt - Iğdır 11.km	44,05	39,63	1500	On dry loam	0
Gypsophila peshmenii	Above Karz Stream	42,53	38,21	1800-2600	Limestone slopes	2

Gypsophila pilulifera	Near lighthouse / Lara	30,80	36,86	25	Pine forest at sea level	0
Haplophyllum megalanthum	Emiralan - Değirmendere	27,13	38,63	400	Open limestone hill slopes near pine woods	2
Hedysarum antitauricum	Karsantı (Aladağ)	35,39	37,55	1100-1200	Mixed Quercus or Pinus forest on serpentine	2
Hedysarum laxum	Dededağ	35,40	38,17			0
Hedysarum pycnostachyum	Malatya - Elazığ 51.km/Baskil	38,83	38,45	680		0
Hedysarum rotundifolium	Harput	39,26	38,70	750	Steppe	0
Hedysarum rotundifolium	Arapkir - Malatya	38,42	38,75	750	Steppe	2
Heldreichia atalayi	Akdağ	37,95	37,88	1300	Open scree slopes	2
Helianthemum germanicopolitanum	Çakmaklıdere Valley	33,63	40,53	750-800		3
Helichrysum artvinense	Ardanuç	42,06	41,13		On dry calcereous soil	0
Helichrysum artvinense	Saşkırat Yayla	41,45	41,10		On dry calcereous soil	2
Helichrysum compactum	Bozdağ	29,20	37,30	1200-1400	Rock ledges	2
Helichrysum compactum	Elmalı Mountain	29,89	36,78	1200-1400		2
Helichrysum heywoodianum	Mount Samsun	27,31	37,67	800-900	Sloping limestone rocks with Inula heterolepis or Pinus brutia	2
Helichrysum peshmenianum	Yazıgül Yayla / Mount Aydos	34,48	37,31	3000	Alpine steppe	2
Helichrysum plicatum subsp. isauricum	Mount Oyuklu	32,88	36,85	1900	Degraded Abies cilicica forest	3
Helichrysum plicatum subsp. isauricum	Derme Hill	30,01	36,41	2100	Degraded Abies cilicica forest	2
Helichrysum plicatum subsp. isauricum	Han Pass near Mount Geyik	32,14	36,81	1600	Degraded Abies cilicica forest	2
Helichrysum sivasicum	Bolucan - Yeşildere	37,83	39,63	1600-1700	Steppe	0
Heliotropeium ferrugineogriseum	Mor Yakup Monastery	41,20	37,09	920		0
Heliotropeium ferrugineogriseum	Dar el-Ahmar (Mor Gabriel) Monastery	41,54	37,33	920		0
Heptaptera cilicica	Adana - Misis 30.km	35,65	36,94	5	Hills	2
Heptaptera cilicica	Tarsus - Gülek 12.km	34,95	36,99	130	Hills	0
Heptaptera cilicica	Çavuşlu	34,91	37,16	0-500	Hills	2
Heptaptera cilicica	Cemilli	34,45	36,82	500	Hills	0
Heracleum marashicum	Süleymanlı - Ilıca	36,85	37,87	900	Mixed Pistacia-Quercus scrub	2
Heracleum sphondylium subsp. artvinense	Şevvaltepe / Murgul	41,56	41,28	2800	Rocky igneous slopes in gully	2
Herniaria amoena	Zorkun Yayla	36,25	37,08	1550	Mountain meadows	0
Herniaria pisidica	Çimenova	31,13	37,49	1500		2
Hesperis aintabica	Kilis	37,11	36,72	700-800		2
Hesperis balansae subsp. balansae	Mount Spil	27,45	38,57			2
Hesperis breviscapa	Keşiş Mountains	39,72	39,78	1760-2800	Screes, rocky places	2
Hesperis breviscapa	Refahiye	38,77	39,91	1760-2800	Screes, rocky places	2
Hesperis breviscapa	Between Pülümür and Tunceli	39,77	39,28	1760	Screes, rocky places	2
Hesperis hedgei	Siverek - Diyarbakır 17 miles	39,62	37,72	1050	Fallow fields on basaltic clay	0
Hesperis kitiana	Patnos-Tutak 21.km	42,75	39,37	1750	Fallow fields	0
Hesperis novakii	Derik	40,46	37,30		Thickets	0
Hesperis pisidica	Mount Eldirek	29,57	36,92	1850-1980	Hills	2
Hesperis pseudoarmena	Akdağ	32,20	36,81		Rocks, in alpine zone	2
Hesperis pseudoarmena	Mount Ali	30,12	36,58		Rocks, in alpine zone	2
Hesperis stellata	Kop Pass	40,48	40,04	2440	Rocky slopes	0
Hesperis trullata	20-30 km Northwest of Gaziantep	37,18	37,18	975	Among non-lime rocks on clay	2
Hieracium barbeyi	Mount Kuşluca / Bahçe	36,65	37,20	1500-1920		2
Hieracium barbeyi	Mount Kışlıcı	36,39	36,80	1500-1920		2
Hieracium diaphanoidiceps	Salalet - Chinzart	41,54	40,83		Woodland margins	2
Hieracium giresunense	Şebinkarahisar - Tamdere	38,44	40,38	1300		0
Hieracium huber-morathii	Beyşehir	32,03	37,87	1280		0
Hieracium macrogonum	Kayseridere / Tosya	33,91	41,03		Corniferous woodland	2
Hieracium nydeggerorum	Karadağ / Olur	41,60	40,77	1700	Forest	2
Hieracium radiatellum	Karaoluk / Yalnızçam	42,27	41,09			2
Hieracium scamandris	Kaz Mountains	26,86	39,70	820	Montane forest	2
Hieracium tamderense	Tamdere	38,36	40,50	1620-1700	Alpine meadows	2
Hieracium tamderense	Keşiş Mountains	39,72	39,78	1620-1700	Alpine meadows	2

Hieracium tmoleum	Bozdağ	28,10	38,32	1300	Mountain steppe	2
Hieracium tuberculatum	Kayseridere / Gavur Dağı	33,91	41,03			2
Hypericum huber-morathii	Korkuteli - Elmalı	30,06	36,92	1200-1250	Limestone rock	2
Hypericum imbricatum	Çamurcu Yayla	32,68	36,30	2100	On rocks	2
Hypericum kazdagensis	Northeast of Sarıkız Hill / Kaz Mountains	26,87	39,71	1500	Scree	2
Hypericum malatyanum	Meletbaşı mezra / Eskiköy / Doğanşehir	38,02	38,15	1900-2000	Limestone rock crevices	0
Hypericum marginatum	Ardanuç	42,05	41,13	760-800	Crevices of limestone rock	2
Hypericum minitum	Abbas / Olukbaşı	29,14	37,25	1650-2100	Crevices of limestone rock	2
Hypericum monadenum	Mount Düldül	36,51	37,35	1000-2000	Rocky places	2
Hypericum peshmenii	Armağan / Başpınar	38,76	39,22	1750	Limestone rock crevices	0
Hypericum pumilio	Mount Deli / Sivas - Divriği	37,77	39,59			2
Hypericum rupestre	Ulaş - Şamlar	34,78	37,00	150	Limestone cliffs	2
Hypericum sorgarea	28 km Northwest of Divriği	37,93	39,48	1500	Marly hills, fallow fields in steppe	0
Hypericum sorgarea	18 km South of Zara	37,76	39,75	1500	Marly hills, fallow fields in steppe	0
Inula sechmenii	Kalkan - Kaputaş	29,42	36,27	50	Large vertical limestone rocks	0
Iris necartifera var. mardinensis	Şenyurt - Tozan Military Point	40,70	37,11	500	Steppe, in terra rosa	2
Iris necartifera var. necartifera	Şenyurt - Tozan Military Point	40,70	37,11	500	Steppe, in terra rosa	2
Iris stenophylla subsp. allisonii	Çaltı / Akseki	31,81	36,85	850-1500	Stony slopes at edge of Pinus woods	0
Isatis arenaria	Terkos	28,60	41,35	50-60	Sand dunes	2
Isatis constricta	Maden	39,67	38,40	1300	Igneous slopes	2
Isatis constricta	Northern side of Lake Hazar	39,39	38,51	1200	Igneous slopes	2
Isatis constricta	Lamas valley/ East of Mara	33,96	36,73	1200-1300	Igneous slopes	2
Isatis constricta	Kazanoğlu / Gürümze	35,81	37,99	1200-1300	Igneous slopes	2
Isatis davisiana	Uluçınar	35,89	36,41	300-500	Igneous scree and Pinus Brutia Forest	2
Isatis ermenekensis	Akpınar Yayla	32,86	36,46	1600-1700	Calcerous rocky slopes and screes	0
Isatis glauca subsp. galatica	Çayırhan	31,67	40,10	550	Roadsides in crops and gardens	2
Isatis huber-morathii	Mount Sapan, 15 km South of Pınarbaşı	36,44	38,63	1590-1620	Serpentine	2
Isatis mardinensis	Kasrik Pass	42,18	37,40	400	Shady limestone cliffs	0
Isatis spatella	Mount Artos	43,10	38,23	2250	Among rocks in limestone gorge	2
Isatis undulata	Bağıştaş	38,46	39,44		Bushy places	2
Johrenia polycias	Kavaklıdere Valley	32,86	39,90	800		2
Kalidopsis wagenitzii	Eskil - Lake Tuz	33,45	38,42	940	Open halophyte vegetation	2
Kitaibelia balansae	Gülek Pass	34,79	37,28			2
Kitaibelia balansae	Akseki - Beyşehir 15.km	31,80	37,17			0
Kundmannia anatolica	Akseki - Manavgat 25.km	31,77	36,89	560	Limestone cliffs	0
Lamium demirizii	Gömbe	29,67	36,55	2200-2500		2
Lamium purpureum var. aznavourii	Beşiktaş	29,03	41,07	30-170	Quercus and abies forest, earthy slopes, gravelly banks, fields and waste places	0
Lamium purpureum var. aznavourii	Rumelihisarı	28,99	41,10	30-170	Quercus and abies forest, earthy slopes, gravelly banks, fields and waste places	0
Lamium sandrasicum	Mount Sandras	28,84	37,09	2200	Serpentine gullies nr. snow line	2
Lamyropsis lycia	Tahtalı Mountains	30,44	36,54	2100	On limestone	2
Lamyropsis lycia	Maşda / Mount Maşda	29,56	36,95	2100	On limestone	2
Lathyrus belinensis	Yazır to Belen, 2 km from Yazır	29,99	36,48	430-450	Rocky limestone hillside and margins of cultivated land	0

Lathyrus belinensis	Kumluca - Kemer 9. km	30,36	36,37	560	Rocky limestone hillside and margins of cultivated land	0
Lathyrus phaselitanus	Tekirova	30,52	36,51	70	Macchie	0
Lathyrus tauricola	20 km North of Akseki	31,77	37,20	800-1300	Open Pinus forest etc.	0
Lathyrus tauricola	Hafızpaşa Pass / Antalya - Bucak	30,50	37,18	800-1300	Open Pinus forest etc.	2
Lathyrus woronowii	Artvin - Savsat 35.km	42,04	41,21	370	Schister screes, rocky slopes	3
Lens tomentosus	22 km north west of Mardin	40,62	37,47		Fields, calcerous bedrock under oaks	0
Lilium carniolicum subsp. ponticum var. artvinense	8 km from Mersivan / Mount Genya	41,82	41,15	1580	Picea-Rhododenrdon forest, dense scrub and woodlands, below tree line	2
Limoniopsis davisii	Mount Artos	43,10	38,23	2135	Limestone crevices	2
Limonium tamaricoides	Karamanoğlu	33,97	37,26			0
Linaria chalepensis var. brevicalyx	Alanya promontory	32,00	36,54	10	Limestone slopes	0
Linaria chalepensis var. brevicalyx	Arapsuyu	30,65	36,88	50	Rocks	2
Linum anisocalyx	Kuzucubelen	34,44	36,85	0-500	Foothills,Pinus brutia forest	0
Linum boissieri	Mount Sandras	28,84	37,09	2200		2
Linum boissieri	Kaz Mountains	26,86	39,70	1700		2
Linum hirsutum subsp. anatolicum var. platyphyllum	Çekirge	29,02	40,21	200	Rocky places	0
Linum hirsutum subsp. oreocarium	Babadağ above Kadiköy	28,88	37,73	2300	Limestone screes	2
Linum mucronatum subsp. gypsicola var. gypsicola	South of Çankırı	33,63	40,53		Marly gypsum hills	2
Linum mucronatum subsp. gypsicola var. papiliferum	17 km south of Altınyayla	29,67	36,90	1100	Steppe	0
Linum pamphylicum	Bucak	30,60	37,47	900	Dry hills, rocky slopes	0
Linum pamphylicum	Çeltikçi	30,48	37,54	900	Dry hills, rocky slopes	0
Linum tauricum subsp. bosphori	Riva	29,22	41,22			0
Lotus malatayicus	Kilizik	38,38	38,35	1000	Vineyards	2
Lupinus anatolicus	Hills southeast of Selçuk between Kuşadası and Efes	27,30	37,89	180		2
Lythrum anatolicum	South of Lake Efteni	31,04	40,75	140	Aquatic marsh	2
Malope anatolica	9 km southwest of Davutlar	27,21	37,70	300	Macchie	0
Malus sylvestris subsp. orientalis var. microphila	Suludere	35,65	40,84	630	Forest remnants	2
Marrubium bourgaei subsp. caricum	Olukbaşı / Gölgeli Mountains	29,14	37,25	1650-2135	Alpine steppe on limestone, scree near summit	3
Marrubium vanense	20 km East of Hasbaşı / Van-Hoşap	43,50	38,36	1920	Ravines	2
Matricaria macrotis	Bodrum, Muşgebbi-Karatoprak	27,26	37,01	50-100	Limestone rocks and igneous sandy slopes in macchie	2
Matthiola longipetala subsp. pumilio	Antalya - Lara	30,74	36,86	50	Sand dunes	2
Micromeria carica	Olukbaşı / Gölgeli Mountains	29,17	37,25	1540-1800	Limestone rocks in Pinus nigra forest	3
Micromeria cilicica	Gözne	34,57	37,00	1200-1300	On rocks	2
Micromeria dolichodonta	Bozağaç	33,38	36,28		Limestone rocks	0
Micromeria fruticosa subsp. giresunica	Tamdere - Yavuzkemal	38,35	40,59	1500	Crevices of granite rocks, near road tunnel	2
Minuartia asiyeae	Gökbel Yaylası	32,34	36,57	1250	Pinus nigra cedrus libani forest, limestone rocks	2
Minuartia corymbolusa var. gypsophilioides	Malatya-Gürün 65.km	37,68	38,35	1400-1480	Rocky slopes	0
Minuartia dianthifolia subsp. kurdica	Mount Artos	43,10	38,23	2590-3000	Stony slopes	2
Minuartia mesogitana subsp. flaccida	Enzislen Rock / Küre Mountains	33,38	41,54		Stony places	2

Minuartia mesogitana subsp. macrocarpa	Kumluköy / Antalya - Serik	30,95	36,88	5	Dunes	0
Morina persica var. decussatifolia	Inside Bar Valley / Tortum	41,54	40,23	2200	Pebbly steppe	2
Morina persica var. decussatifolia	5 km West of Lake Tortum	41,61	40,67	1600	Pebbly steppe	2
Muscari adilii	Beypazarı Sekli Köyü	31,77	40,19	900-1020	Clearings of pinus nigra and oak forests	3
Muscari macbeathianum	West of Yeşilkent (Yalak) towards Tufanbeyli	36,43	38,30	1200	Open areas among Pinus	2
Muscari mirum	20 km Northeast of Çameli	29,45	37,23	1450-1650	Open stony places serpentine rocks	0
Muscari mirum	Dırmil Pass	29,58	36,96	1450	Open stony places serpentine rocks	0
Muscari sandrasicum	Ağla - Fire watchtower/ Mount Sandras	28,81	37,07	1750	Snowbed meadows and rocky slopes on serpentine	3
Nepeta baytopii	Bingöl-Diyarbakır 50.km	40,54	38,54	1200		2
Nepeta conferta	Mount Kuhu	29,78	36,50	1600-2000	Cedrus libani forest	2
Nepeta crinita	Malatya - Pötürge / Mount Kubbe	38,63	38,25	1680	Rocky slopes	2
Nepeta crinita	Erkenek / Akdağ	37,89	37,93	1450	Rocky slopes	0
Nepeta nuda subsp. glandulifera	Beşkuyu-Çamurlu Yayla	32,70	36,33	1900	Rocky slopes	2
Nepeta nuda subsp. glandulifera	Konya - Bozkır 74.km	32,38	37,41	1070	Rocky slopes	2
Oenanthe cyclocarpa	Lake Köyceğiz	28,69	36,95	120	Marshy ground, on Liquidambar forest	3
Omphalodes davisiana	Mount Sultanbaba	39,48	39,32	2700	Open scree slope	0
Onobrychis albiflora	9 km Southwest of Sincan	37,79	39,45	1160	Volcanic slopes	0
Onobrychis bornmuelleri	Göllüalan	35,28	41,13	360 - 500	Dry slopes	2
Onobrychis germanicopolitana	Tatlıçay Stream	33,53	40,71	670	Gypseum hills	2
Onobrychis lasistanica	Cimil	40,79	40,73	2100		0
Onobrychis mutensis	Köselerli	33,42	36,57	200	Stony steppe	0
Onobrychis occulta	Tecer - Gürün 36. km	37,24	39,12	1520	Limestone rocks	0
Onobrychis quadrijuga	Near Böğrüdelik	37,29	38,96	1750	Limestone rocks	2
Onobrychis sivasica	Mount Yıldız	36,91	40,12	2000	East facing slopes, stony steppe, rocky places	2
Onobrychis sivasica	Mount Yama	37,94	39,06	2000	East facing slopes, stony steppe, rocky places	2
Onobrychis stenostachya subsp. krausei	13 km South of Sivas	37,01	39,65	1300-1510	Limestone	2
Ononis adenotricha var. nuda	Beyşehir - Akseki 54.km	31,72	37,34	1300-1450	Pinus nigra forest	0
Onopordum bracteatum var. arachnoideum	Kazancı	32,85	36,50	650-850		0
Onosma arcuatum	Karaurgan - Horasan	42,27	40,24	1500-2100	Rocky igneous slopes, limestone scree, grassy forest clearings	2
Onosma bozokmanii	Büyükdüz Research Forest	32,30	41,20	750	Forests	0
Onosma circinnatum	Fındıklı	41,80	41,20	900	Banks,roadside	0
Onosma davisii	Şırnak - Cizre	42,20	37,41	600	Open Quercus aegilops scrub	2
Onosma helleri	Diyarbakır - Bingöl 25.km	40,02	38,09	730	Fields and woods, basalt slopes	0
Onosma helleri	Pülümür	39,90	39,48	1550	Fields and woods, basalt slopes	0
Onosma obtusifolium	Çobandere	38,22	39,99		Stony pastures	
Onosma papillosum	Porsuk - Bor	34,57	37,54	1400	Steppe	2
Onosma papillosum	Koraş	33,76	37,12		Steppe	2
Onosma proponticum	Safraköy	28,83	41,01	0	Sandy fields	0
Onosma pulchrum	Yarpuz	36,43	37,06	1000-1600	Decidious forest	0
Onosma sorgerae var. sorgerae	Gökpınar	37,33	38,66	1800	Stony steppe and rocky places	2
Onosma strigosissimum	13 km West of Antalya	30,60	36,84	0	Limestone rocks on coast	0
Onosma subulifolium	Kargı	34,48	41,13	250	Open rocky slopes on poor soil	2
Onosma tschichatschevii	Çataloğlan - Yaylacık	35,80	38,17	1200		2
Ophrys isaura	Gülnar- Bozağaç	33,38	36,32	850	Macchie, Quercus forest on extremely calcareous soil	2
Ophrys lycia	Ağıllı	29,68	36,22	500	Meadows, macchie	0

Origanum boissieri	Gülek Pass	34,79	37,28	1500-2000	Shady rocks	2
Origanum husnucan-baseri	Gökbel - Çökele	32,38	36,65	1350	Clearing of Pinus nigra forest and calcerous rocky places	2
Origanum husnucan-baseri	Above Gümüşkavak	32,28	36,49	1200-1300	Clearing of Pinus nigra forest and calcerous rocky places	2
Origanum munzurense	South of Ovacık	39,47	39,27	1700	Steppic slopes	2
Origanum solymicum	Kuşdere - Kesme Pass	30,49	36,59	400	Calcareous rocks and slopes, sometimes in Pinus woods	2
Origanum solymicum	Çıralı	30,47	36,38	60	Calcareous rocks and slopes, sometimes in Pinus woods	2
Ornithogalum demirizianum	Haymana - Yenice 5.km	32,54	39,43			0
Ornithogalum euxinum	Alibeyköy	28,86	41,13			2
Ornithogalum improbum	Gölcük / Bozdağ	28,10	38,31	1550-1850		2
Ornithogalum joschtiae	Uludağ	29,21	40,07	2000		2
Ornithogalum kuereanum	Küre	33,70	41,81			2
Ornithogalum macrum	11 km Southeast of Cevizli near Çakıllı Pass	31,80	37,12	1200	Roadside, slopes	0
Ornithogalum mysum	12 km East of Emet	29,38	39,34	1600-2180		0
Ornithogalum pascheanum	Hills south of Lake Abant	31,29	40,60	1300-1650		2
Ornithogalum sorgerae	10 km North of Andırın	36,42	37,55	900	Fallow	2
Orobanche armena	Near Kağızman	43,14	40,16			2
Orobanche sideana	Side	31,41	36,79	0	Sand dunes	0
Oxytropis engizekensis	Taşpınar ve Körsulak / Mount Engizek	37,10	37,83			3
Paeonia mascula subsp. bodurii	Above Çamlıyayla / Çan	26,72	40,10	400-750	Open rocky places on andezite rock outcrops	2
Papaver arachnoideum	Gümüşhane - Zigana	39,35	40,53	1300	In open vegetation on igneous rocks, shale or sand	2
Papaver arachnoideum	2 km south of Bilecik Station	30,01	40,13		In open vegetation on igneous rocks, shale or sand	0
Papaver arachnoideum	Osmancık - Kargı	34,71	41,10		In open vegetation on igneous rocks, shale or sand	2
Papaver arachnoideum	Between Doğanşehir - Pazarcık	38,26	38,35		In open vegetation on igneous rocks, shale or sand	2
Papaver arachnoideum	Pozantı	34,87	37,43		In open vegetation on igneous rocks, shale or sand	2
Papaver commutatum subsp. euxinum	Lake Borabay	36,03	40,90	800	In fields or in open vegetation on sandy or limestone scree	2
Papaver commutatum subsp. euxinum	Keltepe / Sorgun Yayla	32,45	41,07	800	In fields or in open vegetation on sandy or limestone scree	2
Papaver guerlekense	Between Bozburun and Söğütköy	28,08	36,68	0-50	Rocky limestone slopes	2
Papaver guerlekense	Gürlek	28,96	36,94	0-50	Rocky limestone slopes	2
Paracaryum amani	13km Southwest of Yarpuz	36,34	36,97	1525-2300	Rocky slope	0
Paracaryum erysimifolium	Kuruçay	38,47	39,64		Uncultivated hills	0
Paracaryum shepardii	İskenderun / Amanos Mountains	36,27	36,57	1600		2
Paronychia chionea var. latifolia	Sencan Stream / Bakırdağ	35,87	37,96	1800		2
Paronychia davisii	Yukarıbeycik / Tahtalı Mountains	30,44	36,54	1800-2200	Rocky slopes and screes	3
Paronychia kayseriana	Mount Bakır	35,79	38,09	1400	Fallow field	2
Paronychia kurdica subsp. kurdica var. fragilis	25 km North of Şereflikoçhisar	33,36	39,12	900	Rocky places	0
Paronychia saxatilis	Mount İspiriz	43,88	38,10	3200	Rocky limestone slopes	2
Paronychia turcica	Mount Pelli (Alacabük)	42,77	38,41	3000		2
Pentanema alanyense	Gevne Valley	32,40	36,65	1240	Clearings of Pinus nigra on calcerous rocks	2

Peucedanum arenarium subsp. urbanii	Kaz Mountains	26,86	39,70	1500		2
Phlomis amanica	Arsus	35,89	36,41	90	Slopes	0
Phlomis brunneogaleata	Kahramanmaraş-Göksun 24.km	36,70	37,69	1300	Fallow fields	0
Phlomis integrifolia	Arapkir	38,24	38,57	750	Steppe	2
Physoptychis haussknechtii	Mount Durmuş / Sivas to Ulaş 27.km	37,01	39,52	1500-1600		0
Pilosella sandrasica	4km Southwest of Ağla	28,79	37,05	500	Clearing in Pinus brutia forest, on serpentine	0
Poa pseudobulbosa	Akdağ by lake	32,19	36,83	2200-2300	Shady rocks, valley sides	2
Poa speluncarum	Lamas Stream / Mara	33,96	36,73	1300		2
Poa speluncarum	Kamışdere / Ermenek	32,95	36,76	1400-1500	Moist shady caverns, scree	2
Polygala inexpectata	Berendi Road above Ayrancı Dam	34,05	37,27	1200	Steppe	2
Polygala inexpectata	Koraş	33,76	37,12	1400	Steppe	0
Polygonum afyonicum	Kocayayla / Akdağ	30,10	38,19	1500	Cleared forest	2
Polygonum ekimianum	Around Karagöl / Mount Ahır	36,92	37,64	1650	High mountain steppe	2
Polygonum praelongum	Kumköy	30,95	36,88		Roadsides	0
Polygonum samsunicum	Ladik on road to Aslantaş	35,89	40,91		Open Quercus forest, calcareous ground	2
Potentilla carduchorum	Above Kemer /Kotum (Kucuksu) / Mount	42,32	38,44	3000	Mountain slopes	0
Potentilla carduchorum	Mount Pelli above Pelli	42,77	38,41	3050	Mountain slopes	2
Potentilla carduchorum	Pisvanik above Arpit / Kavuşşahap	43,01	38,27		Mountain slopes	0
Potentilla carduchorum	West of Cilo Tepe / Mount Cilo	44,01	37,49		Mountain slopes	2
Potentilla davisii	Around Kurudere / Geyran Yayla	29,17	37,25	1450-1750	Rocks	3
Potentilla discipulorum	Hürmüz / Mount Kamboz	41,99	38,30	1900		0
Potentilla nerimaniae	Çığlıkara / Elmalı	29,92	36,72	1900-1950	On calcareous	2
Potentilla nerimaniae	Maşda - Ören	29,47	36,83	1900-1950	On calcareous	2
Potentilla pulvinaris subsp. pulvinaris	Demirkazık	35,19	37,82	3350 - 3650	Cliffs, rocks, crevices	2
Potentilla pulvinaris subsp. pulvinaris	Kızıl Hill / Bolkar	34,73	37,46	2450	Cliffs, rocks, crevices	2
Potentilla umbrosa subsp. desrescens	Karakol / Ilgaz	33,80	41,08		Wet places, alpine pastures	2
Potentilla umbrosa subsp. desrescens	Karagöl	39,08	40,38	1800-2000	Wet places, alpine pastures	2
Prangos heyniae	Korualan - Bozkır 1.km	32,34	37,00	1330	Calcerous slopes	0
Prangos heyniae	Hadim - Taşkent 4.km	32,48	36,96	1450	Calcerous slopes	0
Prangos platychloenae subsp. engizekensis	Küçükyeşil Yayla / Mount Engizek	37,24	37,80	2100-2700	Rocky slopes	2
Prenanthes oyukludagensis	Mount Oyuklu	32,88	36,85	2000	Dolamit rocks on subalpine communities	3
Prunus kurdica	Muş - Varto 32.km	41,52	39,02	1430	River banks	0
Prunus kurdica	Noreg Angag / Murat Valley	41,90	38,72	1300	River banks	2
Puccinellia anisocloda subsp. melderisiana	13 km South of Ankara	32,81	39,80		Saline soil and basalt hills	2
Puccinellia anisocloda subsp. melderisiana	Konya - Ankara 190.km	32,93	39,36		Saline soil and basalt hills	2
Puccinellia bulbosa subsp. caesarea	İncesu - Develi	35,23	38,44	1100-1200	Salt steppe	2
Pyrus anatolica	7 km North of Uşak	29,38	38,74	1000	Remnants of Quercus pubescens forest	2
Pyrus salicifolia var. serrulata	Bacirge	44,60	37,71			0
Pyrus yaltrikii	Solhan	41,06	38,97	1200		2
Ranunculus bingoeldaghensis	Hınıs - Ortaköy	41,69	39,41	2600	Mountains	2
Ranunculus dissectus subsp. ermenekensis	Damlaçal / Ermenek	32,98	36,79	1700-1750	Cedrus libani forest	3
Ranunculus pedatus subsp. trojanus	Menderes Stream / Erenköy	26,79	39,80		Mountain rocks	2
Ranunculus poluninii	Kotum (Kucuksu)	42,32	38,44	2300	Limestone ravine	0
Reaumuria sivasica	Kelkit Valley / Suşehri	38,09	40,17	700-800	Gypsaceous hills	0
Reseda armena var. scabridula	Southernmost side of Lake Tortum	41,60	40,60	1100	Chalk slopes	2

Reseda germanicopolitana	Çankırı - Kalecik 5.km	33,61	40,56	700-750	Gypsum slopes	0
Reseda tomentosa var. glabrata	Hasanova	38,57	39,54		Gypsum slopes	2
Reseda tomentosa var. glabrata	Tuzla	39,08	39,64		Gypsum slopes	2
Rhododendron ponticum subsp.ponticum var heterophyllum	Kumludere	40,32	40,98	50-100	Quercus - Carpinus forest	2
Rhodotamnus sesillifolius	Gölbaşı Yayla / Mount Tiryal	41,62	41,23	2150	Moist banks and igneous cliff ledges	0
Ricotia tenuifolia	Finike - Elmalı	30,03	36,52	600		2
Ricotia tenuifolia	Mount Çalbalı	30,37	36,80	600		2
Ricotia varians	Toka Yayla / Dedegöl Mountains	31,37	37,37	1900-2400	Screes	2
Roemeria carica	İçmeler / Marmaris	28,23	36,80	20	Macchie under forest, etc	0
Rosularia blepharophylla	2-3 km Southwest of Ergani	39,73	38,26	810	In cracks of limestone outcrops	2
Rosularia muratdaghensis	Kesik söğüt / Mount Murat	29,68	38,94	2100	Rocky igneous slope	2
Rosularia sempervivum subsp. amanensis	Ufacık Yayla	36,20	36,96	1700	Serpentine rocks	2
Rosularia serpentinica var. gigantea	Marmaris-Mugla 3.km	28,27	36,88	150	On serpentine	2
Rosularia tauricola	Harççgedik / Mersin - Arslankoy	34,48	36,98	760	Calcerous rock	2
Rubia davisiana	20 km South of Elmalı / Slopes above Lake Avlan	29,96	36,60	1200	Limestone cliff crevices	0
Rubia davisiana	Söğüt Yayla / Sivridağ	30,46	36,84	1300	Limestone cliff crevices	2
Rubia davisiana	Pass south of Hafizbey	30,50	37,18	1150	Limestone cliff crevices	0
Rumex amanus	Hatay - Yayladağ	36,12	36,04	800-1000	Macchie	2
Rumex bitynicus	Lake Iznik	29,33	40,44		Humid depressions	2
Salix purpurea subsp. leucodermis	Uluca Stream / Yumaklı	28,29	37,32	1200-1400	Pinus nigra forests, by streams	2
Salix purpurea subsp. leucodermis	Eskere	28,95	37,24	1200-1400	Pinus nigra forests, by streams	0
Salix rizeensis	Başköy / Cimil	40,79	40,74	2100	Open thickets	2
Salix trabzonica	Of - Bayburt	40,23	40,58	2100	Rocky slopes	2
Salsola cyrenaica subsp. antalyense	Kaş	30,10	36,25			3
Salsola grandis	Nallıhan - Beypazarı	31,64	40,12	450-550	Marly substrates containing gypsum and other soluble salts	2
Salvia adenocaulon	Hamitseydi Pass	32,81	36,50	1500-1700	Exposed rocks	0
Salvia nydeggeri	51km South of Altınyayla	29,46	36,73	1000	Corniferus forest	0
Salvia odonthochlamys	Hürmüz / Mount Kambos	42,27	38,12	2100		2
Salvia quezelii	Mersin - Fındıkpınar	34,43	36,87	500-1300	Calcareous rocks	2
Salvia quezelii	Namrun / Bolkar Mountains	34,60	37,17	500-1300	Calcareous rocks	2
Salvia sericeo-tomentosa	Zorkun Yayla	36,35	36,97	800-1000	Slopes in Pinus woods	0
Salvia smyrnea	Mount Nif	27,38	38,38	920	Open rocky and gravelly places	2
Salvia tigrina	Mount Musa	35,94	36,18	800	Hedges	2
Saponaria halophila	Kurugöl / Çaltı	29,76	37,69	1000	Dry lake bed with soda	3
Saponaria halophila	76 km North of Konya	32,84	38,47		Salt Marshes	2
Sartoria hedysaroides	Taşkent - Alanya 12.km	32,51	36,85	1500-1750	Rocky slopes	2
Sartoria hedysaroides	Taşkent - Alanya 25.km	32,43	36,79	1500-1750	Rocky slopes	2
Satureja aintabensis	Dülükbaba	37,36	37,16	610	Dry calcereous places	2
Satureja amani	Mount Kışlıcı	36,39	36,80			2
Scabiosa hololeuca	Eskişehir - Kütahya 18.km	30,33	39,73	880		0
Scabiosa hololeuca	Dudaş	29,62	39,39			2
Scabiosa paucidentata	38 km North of Finike at Bey Dağı	29,95	36,56	850-900	Maquie	0
Scabiosa sulphurea	Palandöken (Tek Dağ)	41,19	39,81	1980-2750		2
Scorzonera amasiana	Southwest of Mount Kırklar	35,80	40,66	360-800	Rocky slopes	2
Scorzonera lasiocarpa	Çevlik	35,93	36,12	100	Limestone cliffs by the sea	2
Scorzonera longiana	Çobanlar - Oyuklu Yayla / Gazipaşa	32,56	36,33	1900-2000		2
Scorzonera mirabilis	Diz Stream / Mount Cilo	44,01	37,49	1700	Rocky slopes	2
Scrophularia amana	Şenköy	36,14	36,05	1000	Crevices of limestone rocks	0

Scrophularia libanotica subsp. libanotica var. Antalyensis	Altınkaya	31,12	37,23	750	Conglomerate rocks, in shade, c. 750 m.	2
Scrophularia mersinensis	Bozağaç- Ahırini / Gülnar	33,39	36,29	700	Limestone rocks in decidious Quercus forest	2
Scrophularia scopolii var. burdurensis	Divre - Karıncabeli / Gölhisar	29,51	37,14	1450	Forests, moist rocky slopes, stream sides, scrub	2
Scrophularia scopolii var. longirostrata	Han Boğazı Forest near Mount Geyik	32,14	36,81	1500-2300	Forests, moist rocky slopes, stream sides, scrub	2
Scrophularia scopolii var. parryi	Arpalık Valley	35,11	37,85	2190		2
Scrophularia serratifolia	11 km Northeast of Şerefiye	37,86	40,17	1900	Igneous slopes	0
Scutellaria orientalis subsp. carica	Below Karacasu	28,60	37,73	300-500	Chalky hills and slopes	0
Scutellaria orientalis subsp. tortumensis	Tortum Falls	41,68	40,67	1200	By the waterfall	0
Scutellaria rubicunda subsp. pannosula	Gözne	34,57	37,00	1200-1800	Among rocks	0
Scutellaria uzundereensis	Uzundere	41,55	40,54		Rocky Slopes	2
Sedum caroli-henrici	40km West of Bingöl	40,11	38,91	1500	Rocky volcanic slopes	0
Sedum cilicicum	Kuruseki	32,91	36,63	1100	Open quercus coccifera scrub	2
Sedum eriocarpum subsp. caricum	Armutalanı	28,25	36,86		On serpentine and limestone	0
Sedum eriocarpum subsp. caricum	2 km South of Kızılağaç / 20 km south of Muğla	28,36	37,07	600	On serpentine and limestone	0
Sedum hewittii	Southwest of Mount Ağrı	44,29	39,64	2750-3050	Wet loam	2
Sedum hispanicum var. planifolium	Mount Murat	29,68	38,94	1900-2000	Limestone rocks	2
Sempervivum brevipetalum	17 km West of Kağızman	42,96	40,10	1350	Rocky slopes	0
Sempervivum globiferum subsp. aghricum	Southwest of Lake Balık	43,52	39,72	2700	Open, steep boulder-strewn scree slopes	2
Sempervivum ispartae	0.5 km before the river between Selköse and Oruç Gazi Yayla	31,24	37,58	1300	On metamorphic rock	2
Sempervivum pisidicum	Yakaköy / Eğirdir	31,04	38,10		Limestone and metamorphic rocks	0
Sempervivum sorgarea	20 km East of Erciş	43,57	38,99	1900-2200	Slopes, in open vegetation	2
Senecio davisii	Mount Sat	44,16	37,35	2000	Sholy rocky slopes	2
Senecio hypochionaeus var. hypochionaeus	Kırkpınar / Uludağ	29,21	40,06	1300-2900	Rocky or grassy slopes	2
Senecio ovatifolius	Mount Tatoz / İkizdere - İspir	40,69	40,73	2000-2100		2
Serratula hakkiarica	Diz Stream / Mount Cilo	44,01	37,49	2285		2
Seseli ramosissimum	Mount Çalbalı	30,37	36,80	2100-2300	Rocky, stony ground on limestone	3
Sesleria araratica	Mount Ağrı (Greater)	44,30	39,70	2600-3000	Rocky slopes	2
Sideritis cilicica	Kuzucubelen - Mersin 1.km	34,44	36,84	600	Open Pinus brutia forest, limestone slopes, macchie	0
Sideritis cilicica	Feke - Belenköy	35,91	37,82	600	Open Pinus brutia forest, limestone slopes, macchie	2
Sideritis gulendamiae	Southeast of Aşağı Kepen	31,50	39,38	900-950	gypsum and marly steppe	2
Sideritis gulendamiae	West of Doğanoğlu	31,21	39,83	880-950	gypsum and marly steppe	2
Sideritis ozturkii	3km North of Çamlık / Derebucak	31,65	37,38	1450-1700	Serpentine rocky place and clearings of Pinus nigra	0
Sideritis trojana	Kaz Mountains	26,86	39,70	1500-1770	Stony mounttain slopes	2
Silene azirensis	Cimin / Keşiş Mountains	39,72	39,78	2700-2900	Steep igneous scree	2
Silene bolanthoides	Kaz Mountains	26,86	39,70	1700	Grazed alpine grassland	2
Silene brandiana	Çayıralan - Akdağ	35,64	39,31	1750	Calcareous rocks	0
Silene brevicalyx	Ağla Köyü-Fire watchtower/ Mount Sandras	28,81	37,07	1250	Open pinus nigra forest, on serpentine	3
Silene capillipes	Ermenek	32,89	36,64	1340		2

Silene capillipes	Ermenek - Mut 20.km	33,05	36,61			0
Silene caryophylloides subsp. binbogaense	Doğankonak / Göksun	36,43	38,26	1800-2150	Mountain steppes	0
Silene denizliense	Near Quarry / Çamlık	29,03	37,92	830	Calcerous rocky places	2
Silene ermenekensis	Damlaçal	32,98	36,79	1600	Rocky and stony places in open Juniperus excelsa forest	3
Silene fenzlii	Maden / Bolkar Mountains	34,62	37,45		Alpine	0
Silene isaurica	Kuyu	31,63	37,23	1800	Limestone pasture	2
Silene ispartensis	Dedegöl Mountains	31,21	37,81	1500		2
Silene lucida subsp. glandulosa	Mount Davraz	30,74	37,76	1700-1750		2
Silene lycaonica	Ulupınar Sancak Y.	32,23	37,10			2
Silene manissadjianii	Akdağ	35,87	40,81			2
Silene oligotricha	Pülümür - Mutu	39,74	39,39	1780		2
Silene salsuginea	Gölyazı - Lake Tersakan	33,17	38,56	900	Salt steppe	3
Silene salsuginea	Environs of Lake Akyay	32,92	38,62	1000	Salt steppe	2
Silene scytchicina	İkizdere	40,55	40,79	700	Terraced hillsides	0
Sonchus erzincanicus	Plain East of Erzincan / Ekşisu Marshes	39,61	39,70	1250	Subsaline marsh	2
Sorbus caucasica var. yaltrikii	Şenyuva, Kaleköprü / Çamlıhemşin	40,95	41,00	1750-1950	Subalpine scrub	2
Sorbus caucasica var. yaltrikii	Kelezhev / Altıparmak	41,34	40,95	1500		2
Sorbus caucasica var. yaltrikii	12 km above Sarigöl	41,44	41,06	1900		2
Spergularia sezer-zengii	Hamur - Murat River	42,99	39,61	1650	Sandy places by river banks	0
Stachys anamurensis	Around Kızılalan / Anamur - Kazancı	33,09	36,81	1400	Calcerous rock crevices in degraded Abies, Cedrus and Juniperus forests	0
Stachys bayburtensis	Mount Kop	40,45	40,06	2050-2100		2
Stachys baytopianum	Mardin - Diyarbakır	40,50	37,62			2
Stachys butleri	Düden Waterfall	30,71	36,89	50-90	Damp rocks by waterfall	2
Stachys chasmosericea	Beşkonak	31,20	37,14	750	Limestone brecias	0
Stachys choruhensis	South East of Mount Kaçkar	41,23	40,85	2300-2700	Rock-strewn alpine pasture, on siliceous substrate	2
Stachys distans var. cilicica	Silifke - Mersin 41.km	34,18	36,49	10	Dried-up river bed, rocks by the sea	0
Stachys munzurdagensis	30 km Southeast of Ovacık	39,22	39,36	1800	Limestone screes	2
Stachys sivasica	West of Deredam	37,92	39,98	1400	Calcerous and serpentine rocks	2
Stachys sivasica	Karabayır Pass / Suşehri	37,83	40,17	1500	Calcerous and serpentine rocks	2
Stachys tundjeliensis	Mount Sultanbaba	39,48	39,32	2000	Mountain slopes, in quercus	2
Stachys willemsei	Van - Hakkari 22.km on road to the ruins of Çavuştepe	43,43	38,35		Damp places	0
Stefanoffia insoluta	Western Dedegöl Mountains / Sütçüler	31,12	37,51	2300	Cliffs	2
Symphytum pseudobulbosum	Polonezköy	29,21	41,11	0	Shady places near sea level	0
Symphytum savvalense	Şevvaltepe / Murgul	41,56	41,28	1300	Forest clearings	2
Symphytum silvaticum subsp. silvaticum	Above Maçka	39,61	40,82	1200	Wet meadows	2
Symphytum silvaticum subsp. silvaticum	1 km North of Hamsiköy	39,47	40,71	1200	Wet meadows	0
Symphytum silvaticum subsp.sepulcrale var hordokopii	Hordokop (Kozağaç) above Maçka	39,57	40,81	670	Among rocks	0
Tanacetum densum subsp. laxum	Gökpınar	37,33	38,66	1800	Limestone rocks and screes	2
Tanacetum germanicopolitanum	Çakmaklıdere	33,63	40,53	800-850	Derelict vineyards, chalky hill-steppe	3
Tanacetum munzurdaghensis	İtyokuşu / Ovacık	39,22	39,36	1500-2500		2
Taraxacum anatolicum	Horasan - Ağrı 54.km	42,61	39,81	2500	Mountaineous regions	0
Taraxacum davisii	Değirmenköy	43,51	38,52	2300	Wet meadows in mountain regions	0
Taraxacum leucochlorum	Çumra - Küçükköy	32,83	37,68	980	Cultivated Land	0

Taraxacum waltheri	Lake Sapanca	30,24	40,70	50	Pasture	2
Teucrium ekimii	Kuruçay Stream / Beldibi - Kemer	30,56	36,68	40-50	Shady limestone cliffs	2
Teucrium odontites	Near Fethiye	29,12	36,62		Crevices of vertical rocks	0
Teucrium odontites	Çamdağ Tunnel	30,56	36,60	50	Crevices of vertical rocks	2
Teucrium odontites	Mut	33,43	36,64		Crevices of vertical rocks	2
Teucrium paederotoides	Nafak	37,43	37,01	600	Limestone fissures	2
Thermopsis turcica	Gölçayır	31,33	38,47	950-1050	Marshy lakeside	0
Thesium oreogetum	Mount Artos	43,10	38,23	3660	Scree	2
Thlaspi aghricum	2 km Southwest of Hamur	42,97	39,60	1700	Sloping meadows	0
Thlaspi cariense	Serçegediği / Ağla - Eskere	28,82	37,10	1700	Pinus nigra forest on serpentine	3
Thlaspi cariense	1 km East of Marmaris	28,29	36,85		Clearings in Pinus Brutia forest	0
Thlaspi crassum	Demirkazık	35,19	37,82	3500	Alpine scree and glaical moraine	2
Thlaspi dolichocarpum	Karagöz	36,46	36,95	800-1600	Mountain slopes, Pinus Brutia forest	2
Thlaspi eigii subsp. eigii	Zorkun	36,35	36,97	1000-1500	Pinus brutia and pinus nigra subsp. pallasiana forest, on mountain slopes	2
Thlaspi eigii subsp. samuelssonii	Cassius, prope transitum ad Ainel Aramie	35,97	35,95	750	Pinus forest	2
Thlaspi leblebicii	Mount Sandras	28,84	37,09	2000-2100	Rocky serpentine slopes	2
Thlaspi papillosum	Mount Honaz	29,29	37,68	2200	Alpine slopes, often near melting snow	2
Thlaspi papillosum	Akdağ	29,95	38,30	2200-2570	Alpine slopes, often near melting snow	2
Thlaspi rosulare	Mount Susuz	35,11	37,41			2
Thlaspi sintenisii	Mount Karakaya	40,33	40,44	2700-3300	High Alpine screes	2
Thlaspi syriacum	Hasanbeyli	36,56	37,14			0
Thlaspi valerianoides	Müküş - Gedik	41,85	38,00	2900	High Alpine	3
Thlaspi watsonii	Çuh (Güzeldere) Pass	43,97	38,16	2800	Dry slopes	2
Thymus aznavourii	Safrakköy	28,83	41,01		Dry open hillsides, fields and lake margins on clayey soil	0
Thymus canoviridis	Mount Karakaya	41,60	39,50		Cushion steppe and open ground on limestone	2
Thymus cariensis	Fethiye- Köyceğiz,43.km	28,58	36,99	70	Macchie, open Pinus brutia woodland	0
Thymus cherlereoides var isauricus	Mount Geyik	32,17	36,89	0-2800	Open rocky and gravelly ground	2
Thymus cherlerioides var. oxyodon	Manavgat-Serik	31,31	36,84	10	Open rocky and gravelly ground	0
Thymus convolutus	Kemaliye Kata	38,49	39,26		Open rocky ground	2
Thymus leucostomus var. gypsaceus	10 km North of Çankırı	33,57	40,67	670	Gypsum steppe	0
Thymus pectinatus var. pallasicus	Lake Palas	35,77	39,02	1300	Open steppe on gypsaceous or calcerous slopes	2
Thymus praecox subsp. praecox var. laniger	Akdağ	35,87	40,81			2
Thymus pulvinatus	Kaz Mountains	26,86	39,70			2
Thymus spathifolius	21km Southeast of Sincan	38,07	39,44	1500	Gypsaceous steppe slopes	0
Thymus spathifolius	Hasanova	38,57	39,54	1500	Gypsaceous steppe slopes	0
Tordylium brachytaenium	Kourmalou / Loryma	28,03	36,57		Rocky places	2
Tordylium ebracteatum	Bozburun	28,06	36,69	50-100	Limestone sea cliffs	0
Tragopogon fibrosus	Büyükdere	38,68	40,44		Hills	2
Tragopogon oligolepis	Mount Sandras	28,84	37,09	1500-2000	Moist gravelly or stony flats on serpentine with sufficiently deep mineral soil	2

Tragopogon subacaulis	Mount Spil	27,45	38,57	1830	Calcerous rock	2
Trifolium batmanicum	Hüseyin Kara	41,04	37,84	800	Basalt soils in Amygdolus orientalis open shrub formation	3
Trifolium euxinum	Keltepe / Sorgun Yayla	32,45	41,07	1300	Ungrazed pastures	2
Trigonella arenicola	Lara	30,80	36,86	0	Sand dunes	0
Trigonella cilicica	Gülek Pass	34,79	37,28	820	Pinus brutia forest	2
Trigonella halophila	Tuzla	35,09	36,70	0	Sand dunes	0
Trigonella halophila	Mersin - Pompeiopolim	34,58	36,78	0	Sand dunes	2
Trigonella polycarpa	Kumköy	30,95	36,88	5	Sandy coasts, gravelly places, Pinus forests near sea level	0
Trigonella pseudocapitata	Göztepe / Fethiye - Çameli	29,15	36,97	1600	Rocky calcareous pasture	2
Trigonosciadium intermedium	Kemaliye - Sanduk	38,46	39,29		Fields	0
Tripleurospermum baytopianum	Kurudağ	26,90	40,75	200	Pinus brutia forest	2
Tripleurospermum corymbosum	5 km East of lake Balık	43,66	39,75	1250	By streams & in water meadows	2
Tripleurospermum hygrophilum	From Naipköy to Işıklar	27,38	40,87	800-900	Montane meadows, fields	2
Tripleurospermum hygrophilum	Mount Yamanlar	27,15	38,55	850-980	Montane meadows, fields	2
Uechtritzia armena	Keşiş Mountains	39,73	39,80		Amongst shrubs	2
Valeriana speluncaria var. glabriuscula	Anamur - Saray Mahallesi	32,82	36,08		Calcerous rocks	2
Ventenata eigiana	Kuruca Pass	40,26	38,95	1800	Mountain steppe in Quercus scrub on volvanic substrate	0
Verbascum adenocaulon	Çamardı	34,96	37,83		Hills	2
Verbascum afyonense	Between Köroğlu Hill - Yongalı Hill / Bayat	30,92	38,99	1450		2
Verbascum afyonense	Koçubaba	33,88	40,07	1300-1370	Mixed quercus forest	0
Verbascum agastachyum	Gorge of Çarşamba Stream / Bozkır-Konya	32,61	37,39	1080	Limestone rocks and scree	2
Verbascum ballsianum	9 km South of Perveri	37,80	37,78	980-1250	Limestone slopes, Quercus scrub	2
Verbascum ballsianum	Mount Ahır	36,92	37,62	915-1250	Limestone slopes, Quercus scrub	3
Verbascum birandianum	Baskil	38,82	38,57	680-690	Pastures, steppe	0
Verbascum coronopifolium	Mount Murat	29,68	38,94	1200-2100	Rocky mountain slopes	2
Verbascum cymigerum	Yeniyörük	33,36	36,24	470-700	Macchie, wheat fields	0
Verbascum dalamanicum	Fethiye-Muğla 48.km	28,80	36,82	300	Pinus brutia forest	0
Verbascum decursivum	İspir - İkizdere 15.km	40,92	40,53	1550	Volcanic rocks	0
Verbascum degenii	Şile	29,62	41,18	0	Coastal sands and dunes	2
Verbascum degenii	Terkos	28,60	41,35	0	Coastal sands and dunes	2
Verbascum demirizianum	Köyceğiz - Fethiye 7.km	28,74	36,92	0	Beaches	0
Verbascum dudleyanum	Southern side of Lake Salda	29,69	37,51	1130-1170	Wet places by lake and streams, serpentine	2
Verbascum dumulosum	Termessus	30,51	36,91	900-1000	Ruins, in crevices	2
Verbascum eleonorae	Yarpuz- Yağlıpınar	36,43	37,05	1050-1320	Pinus forest	2
Verbascum flabellifolium	South of Lake Salda	29,68	37,52	1170	Quercus scrub	2
Verbascum germaniciae	Near Araban	37,76	37,40	690	Open scrub, dry banks and slopes	3
Verbascum germaniciae	Maraş - Göksun 25. Km	36,70	37,68	690	Open scrub, dry banks and slopes	0
Verbascum germaniciae	Araplar	36,75	37,42	900	Open scrub, dry banks and slopes	0
Verbascum globiferum	5 km North of Ergani	39,73	38,31	1000	Limestone slopes	0
Verbascum globiferum	3-5 km South of Siirt	41,91	37,90	700	Limestone slopes	2
Verbascum gracilescens	West of Lake Tortum	41,63	40,63	1050-1100	Limestone slopes	2
Verbascum gracilescens	Meydanlar	41,75	41,17	1050	Limestone slopes	2
Verbascum gypsicola	2 km before Çayırhan	31,70	40,11	500	On gypsaceous slopes in steppe	0
Verbascum gypsicola	Ankara - Nallıhan 140.km	31,49	40,11	700-800	On gypsaceous slopes in steppe	0
Verbascum hadschinense	6 km North of Saimbeyli	36,11	38,04	1150	Limestone rocks, dry slopes	0
Verbascum inulifolium	Silifke - Gülnar 23-24.km	33,72	36,35	780-840	Pinus brutia forest, macchie	2
Verbascum isauricum	18 km South of Ermenek	32,84	36,55	720	Pinus forest, limestone slopes	2

Verbascum isauricum	Ermenek - Mut 19.km	33,05	36,61	1170	Pinus forest, limestone slopes	0
Verbascum lachnopus	Gündüzbey - Eskişehir 1.km	30,21	39,96	1020	Quercus scrub	0
Verbascum latisepalum	Tefenni - Altınyayla 17.km	29,72	37,19	1210	Field margins	0
Verbascum leiocarpum	Kemaliye - Arapkir 17.km	38,57	39,21	900-1000	Limestone rocks, rocky slopes	0
Verbascum leptocladum	Antalya - Bucak 11.km	30,62	36,97	0-250	Pinus brutia forest	2
Verbascum leuconerum	Ermenek-Sarıvadi / Mount Göksu	32,84	36,59	1000	Pinus forest	2
Verbascum linearilobum	Buluklu	34,59	36,88	60-270	Volcanic slopes, macchie	0
Verbascum linearilobum	Ceyhan - Erzin	35,96	36,93	60	Volcanic slopes, macchie	2
Verbascum linearilobum	Payas (Yakacık)	36,21	36,76	100	Volcanic slopes, macchie	0
Verbascum luciliae	Salihli - Borlu 26.km	28,32	38,64	250	Rock crevices, volcanic slopes	0
Verbascum luciliae	Kiçir - Hisarköy	28,70	39,24	900	Rock crevices, volcanic slopes	2
Verbascum luciliae	Geyre	28,71	37,72	250-900	Rock crevices, volcanic slopes	0
Verbascum maeandri	Söke - Priene	27,37	37,70	30-100	Riversides, scrub	2
Verbascum murbeckianum	Bitlis - Tatvan 2.km	42,12	38,42	1630	Field margins	0
Verbascum myrianthum	Boğazhan	35,78	40,73	400-600	Bushy and steppic slopes	2
Verbascum myrianthum	Turhal	36,07	40,39	650	Bushy and steppic slopes	0
Verbascum nudatum var. spathulatum	Manavgat - Akseki 19.km	31,62	36,75	50	Macchie, phrygana, Quercus scrub, Pinus forest	0
Verbascum orbicularifolium	Silifke - Kırobası 8.km	33,96	36,44	0	Quercus scrub, dry river beds	0
Verbascum orbicularifolium	Silifke - Mersin 21.km	34,12	36,46	0	Quercus scrub, dry river beds	0
Verbascum pallidiflorum	Zara - Şerefli 20.km	37,73	40,05	1640	Quercus scrub, Pinus forest	0
Verbascum pestalozzae	Fesleğen Yayla - Karçukuru / Mount Çalbalı	30,42	36,86	1800-2100	Limestone rocks	2
Verbascum petiolare	Kozan - Feke 32.km	35,89	37,73	610	Pinus forest, gravel	0
Verbascum petiolare	Hasanoğlu / Gürümze	35,81	38,01	1220	Pinus forest, gravel	2
Verbascum pumilum	Yavşan	33,12	38,76		Dry hills, shore of salt lake	0
Verbascum pumilum	Near Sille	32,42	37,93		Dry hills, shore of salt lake	0
Verbascum reeseanum	Altınyayla - Tefenni 3.km	29,54	37,03	1200	Pinus nigra forest	0
Verbascum reeseanum	Below Tuzlabeli	29,16	36,88	1420	Serpentine scree	2
Verbascum rubricaule	Bucakkışla	33,03	36,96	750	Bushy open places	0
Verbascum scamandri	Kaz Mountains	26,86	39,70		Mountain slopes	2
Verbascum scaposum	Samandağ	35,97	36,09	100-900	Pinus forest, Quercus scrub, macchie	2
Verbascum serpenticola	Dırmil Pass	29,58	36,96	1600	Serpentine scree	0
Verbascum sorgerae	Çiçek (Dedegöl) Mountains	31,21	37,81	1500-1800	Mountain steppe, rocky slopes, Juniperus and Cedrus forest	2
Verbascum spectabile var. isandrum	Baklabostan - Yenice	32,31	41,20	300-1990	Rocky limestone slopes, Quercus scrub, pastures	2
Verbascum spodiotrichum	Çıralı	30,47	36,38	0	Limestone rocks and ruins	0
Verbascum stepporum	21 km Northwest of Ceylanpınar	39,95	36,99	380	Steppe	0
Verbascum stepporum	Near Viranşehir	39,79	37,22	380	Steppe	3
Verbascum subserratrum	Pınarbaşı - Sarız 6.km	36,45	38,70	1520	Fallow fields	0
Verbascum transolympicum	1 km North of Soğukpınar / Uludağ	29,11	40,07	1160	Pinus sylvestris forest	0
Verbascum trichostylum	Erzincan - Refahiye 52.km	38,95	39,90	2000	Roadsides, wheatfields, serpentine slopes	0
Verbascum urobracteum	Eskişehir - Kütahya 35.km	30,16	39,66	900	Roadsides	0
Verbascum varians var. trapezunticum	Eşiroğlu	39,68	40,87		Quercus scrub, steppe, rocky slopes, lava rubble	0

Verbascum varians var. trapezunticum	Boztepe	39,17	41,07	150	Quercus scrub, steppe, rocky slopes, lava rubble	2
Veronica cuneifolia subsp. massicytica	Near Temel Village towards Girdev Yayla	29,66	36,76	2000-2500	Open Pinus nigra and Juniperus forest and scrub, rocky and grassy slopes, scree	2
Veronica quezelli	30km fom Elmalı / Akdağ	29,69	36,81	2700-2800	Rocky Slopes	2
Vicia canescens subsp. argaea	Mount Erciyes	35,45	38,53	3000	Screes	2
Vicia eristallioides	13 km from Kumluca to Kemer	30,40	36,40	550	Hillside among limestone boulders fallow field,cultivated land in terra rosa	0
Vicia glareosa	Above Ovacık	39,22	39,36	2900	Limestone screes	2
Vicia parvula	Akyarma Pass	32,53	40,61	1400-1500	Stony slopes	0
Viola bocquetiana	Karagöl Valley / Ovacık	39,22	39,36	1800	Crevices in stony slopes	2
Viola sandrasea subsp. cilicica	Acıman Yayla / Aladağlar	35,17	37,79	1900	Ophiolitic rocks	2
Viola sandrasea subsp. sandrasea	Mount Çiçekbaba	28,82	37,09	3000	Near snow patches	2

APPENDIX C: Code of the Nearest Neighbor Distance Function in Visual Basic Script

Private Sub Command1_Click()

```
Dim z, t As Variant, dosya
Dim MyArray(), sayac, a, b, c, d, e, f As Variant
Dim mal() As Integer
Dim MinArray() As Variant
Dim maxall, minall As Variant
Dim X, Y As Integer
Dim s As String
Dim ind, tind
Close #0
Close #1
dosya = TextBox10.Text
ek = "c:\cs.txt"
Open dosya For Input As 1
sayac = 0
While Not EOF(1)
   Input #1, X, X
   sayac = sayac + 1
Wend
Close #1
TextBox1.Text = sayac & " points so far"
Open dosya For Input As 1
ReDim MyArray(sayac - 1, 1)
ReDim mal(sayac - 1)
ReDim MinArray(sayac - 1)
ListBox1.Clear:ListBox2.Clear:ListBox3.Clear:ListBox4.Clear:ListBox5.Clear
maxall = 0: minall = 100
For X = 0 To sayac - 1
   MinArray(X) = 100
Next
For X = 0 To sayac - 1
      Input #1, t, z
      MyArray(X, 0) = CDec(t): MyArray(X, 1) = CDec(z)
     ListBox1.AddItem t
     ListBox2.AddItem z
Next: a = 0: b = 0: c = 0
For X = 0 To sayac - 1
   For Y = 0 To sayac - 1
   If (X = Y) Then
      MinArray(X) = MinArray(X)
  ElseIf Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2) < MinArray(X)
 Then
 MinArray(X) = CDec(Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2))
  mal(X) = Y + 1
      End If
   Next:
   ListBox4.AddItem mal(X): Next
For X = 0 To sayac - 1
   ListBox5.AddItem X + 1
   ListBox3.AddItem MinArray(X)
   If MinArray(X) < minall Then minall = MinArray(X)
```

```
    If MinArray(X) > maxall Then maxall = MinArray(X)
    Next
Label2.Caption = "  0" & "-" & Round(((maxall - minall) / 12 + minall), 2)
Label3.Caption = Round(((maxall - minall) / 12 + minall), 2) & "-" & Round(((maxall - minall) / 6 + minall), 2)
Label4.Caption = Round(((maxall - minall) / 6 + minall), 2) & "-" & Round(((maxall - minall) / 4 + minall), 2)
Label5.Caption = Round(((maxall - minall) / 4 + minall), 2) & "-" & Round(((maxall - minall) / 3 + minall), 2)
Label6.Caption = Round(((maxall - minall) / 3 + minall), 2) & "-" & Round((5 * (maxall - minall) / 12 + minall), 2)
Label7.Caption = Round((5 * (maxall - minall) / 12 + minall), 2) & "-" & Round(((maxall - minall) / 2 + minall), 2)
Label8.Caption = Round(((maxall - minall) / 2 + minall), 2) & "-" & Round((7 * (maxall - minall) / 12 + minall), 2)
Label9.Caption = Round((7 * (maxall - minall) / 12 + minall), 2) & "-" & Round((8 * (maxall - minall) / 12 + minall), 2)
Label10.Caption = Round((8 * (maxall - minall) / 12 + minall), 2) & "-" & Round((3 * (maxall - minall) / 4 + minall), 2)
Label11.Caption = Round((3 * (maxall - minall) / 4 + minall), 2) & "-" & Round((5 * (maxall - minall) / 6 + minall), 2)
Label12.Caption=Round((5 * (maxall - minall) / 6 + minall), 2) & "-" & Round((11 * (maxall - minall) / 12 + minall), 2)
Label13.Caption = Round((11 * (maxall - minall) / 12 + minall), 2) & "-" & Round(maxall, 2)
    Label14.Caption = "     R1  "
    Label15.Caption = "     R2  "
    Label16.Caption = "     R3  "
    Label17.Caption = "     R4  "
    Label18.Caption = "     R5  "
    Label19.Caption = "     R6  "
    Label20.Caption = "     R7  "
    Label21.Caption = "     R8  "
    Label22.Caption = "     R9  "
    Label23.Caption = "     R10  "
    Label24.Caption = "     R11  "
    Label25.Caption = "     R12  "
     d = 0: e = 0: f = 0: g = 0: h = 0: h1 = 0: h2 = 0: h3 = 0: h4 = 0
     For X = 0 To sayac - 1
    If MinArray(X) < ((maxall - minall) / 12 + minall) Then
    a = a + 1
    ElseIf MinArray(X) < ((maxall - minall) / 6 + minall) Then
    b = b + 1
    ElseIf MinArray(X) < ((maxall - minall) / 4 + minall) Then
    c = c + 1
    ElseIf MinArray(X) < ((maxall - minall) / 3 + minall) Then
    d = d + 1
    ElseIf MinArray(X) < (5 * (maxall - minall) / 12 + minall) Then
    e = e + 1
    ElseIf MinArray(X) < ((maxall - minall) / 2 + minall) Then
    f = f + 1
    ElseIf MinArray(X) < (7 * (maxall - minall) / 12 + minall) Then    g = g + 1
    ElseIf MinArray(X) < (2 * (maxall - minall) / 3 + minall) Then     h = h + 1
    ElseIf MinArray(X) < (3 * (maxall - minall) / 4 + minall) Then    h1 = h1 + 1
    ElseIf MinArray(X) < (5 * (maxall - minall) / 6 + minall) Then    h2 = h2 + 1
    ElseIf MinArray(X) < (11 * (maxall - minall) / 12 + minall) Then     h3 = h3 + 1
    ElseIf MinArray(X) <= maxall Then    h4 = h4 + 1
    End If
Next
min1 = "Minimum  : ": max1 = "Maximum : "
ty = MsgBox(min1 & minall & vbCrLf & max1 & maxall, , "Minimum & Maximum")
TextBox2.Text = a
TextBox3.Text = b
TextBox4.Text = c
TextBox5.Text = d
TextBox6.Text = e
TextBox7.Text = f
TextBox8.Text = g '+ d + c + b + a + f
```

```
TextBox9.Text = h '+ g + d + c + b + a + f
TextBox11.Text = h2 ' + g + d + c + b + a + f + h
TextBox15.Text = h1 '+ h2 + g + d + c + b + a + f + h
TextBox12.Text = h3 '+ h2 + g + d + c + b + a + f + h
TextBox13.Text = h4 '+ h2 + g + d + c + b + a + f + h
Dim gr(12, 0) As Variant
gr(0, 0) = a / sayac
gr(1, 0) = (b + a) / sayac
gr(2, 0) = (c + b + a) / sayac
gr(3, 0) = (d + c + b + a) / sayac
gr(4, 0) = (e + d + c + b + a) / sayac
gr(5, 0) = (f + e + d + c + b + a) / sayac
gr(6, 0) = (g + f + e + d + c + b + a) / sayac
gr(7, 0) = (h + g + f + e + d + c + b + a) / sayac
gr(8, 0) = (h1 + h + g + f + e + d + c + b + a) / sayac
gr(9, 0) = (h2 + h + g + f + e + d + c + b + a + h1) / sayac
gr(10, 0) = (h3 + h + g + f + e + d + c + b + a + h1 + h2) / sayac
gr(11, 0) = (h4 + h + g + f + e + d + c + b + a + h3 + h2 + h1) / sayac
  With MSChart1
    .ChartData = gr()
    .Visible = True
     End With
Close #1
End Sub
Private Sub ListBox1_Click()
ind = ListBox1.ListIndex : tind = ListBox1.TopIndex
ListBox1.ListIndex = ind: ListBox2.ListIndex = ind: ListBox3.ListIndex = ind: ListBox4.ListIndex = ind
ListBox1.TopIndex = tind:ListBox2.TopIndex = tind:ListBox3.TopIndex = tind:ListBox5.TopIndex = tind
ListBox5.ListIndex = ind:ListBox4.TopIndex = tind
End Sub
Private Sub ListBox2_Click()
ind = ListBox2.ListIndex:tind = ListBox2.TopIndex
ListBox1.ListIndex = ind :ListBox2.ListIndex = ind:ListBox3.ListIndex = ind:ListBox4.ListIndex = ind
ListBox1.TopIndex = tind:ListBox2.TopIndex = tind:ListBox3.TopIndex = tind:ListBox4.TopIndex = tind
ListBox5.TopIndex = tind:ListBox5.ListIndex = ind
End Sub
Private Sub ListBox3_Click()
ind = ListBox3.ListIndex:tind = ListBox3.TopIndex
ListBox1.ListIndex = ind:ListBox2.ListIndex = ind:ListBox3.ListIndex = ind
ListBox4.ListIndex = ind:ListBox1.TopIndex = tind:ListBox2.TopIndex = tind:ListBox3.TopIndex = tind
ListBox4.TopIndex = tind:ListBox5.TopIndex = tind:ListBox5.ListIndex = ind
End Sub
Private Sub ListBox4_Click()
ind = ListBox4.ListIndex : tind = ListBox4.TopIndex
ListBox1.ListIndex = ind :ListBox2.ListIndex = ind:ListBox3.ListIndex = ind:ListBox4.ListIndex = ind
ListBox5.ListIndex = ind:ListBox1.TopIndex = tind:ListBox2.TopIndex = tind:ListBox3.TopIndex = tind
ListBox4.TopIndex = tind:ListBox5.TopIndex = tind
End Sub
Private Sub ListBox5_Click()
ind = ListBox5.ListIndex
tind = ListBox5.TopIndex
ListBox1.ListIndex = ind:ListBox2.ListIndex = ind:ListBox3.ListIndex = ind:ListBox4.ListIndex = ind
ListBox5.ListIndex = ind:ListBox1.TopIndex = tind:ListBox2.TopIndex = tind:ListBox3.TopIndex = tind
ListBox4.TopIndex = tind:ListBox5.TopIndex = tind
End Sub
Private Sub UserForm_Initialize()
TextBox10.SetFocus
MSChart1.Visible = False
TextBox10.Text = CurDir & "\"
End Sub
```

APPENDIX D: Code of the K Function in Visual Basic Script

Private Sub Comand2_Click()

```
Dim z, t As Variant, dosya
Dim MyArray(), sayac As Variant
Dim KArray() As Variant
Dim maxall, minall As Variant
Dim X, Y As Integer
Dim ind, tind
Close #1
dosya = TextBox10.Text
Open dosya For Input As 1
sayac = 0
While Not EOF(1)
   Input #1, X, X
   sayac = sayac + 1
Wend
Close #1
TextBox1.Text = sayac & " points so far"
Open dosya For Input As 1
ReDim MyArray(sayac - 1, 1)
ReDim MinArray(sayac - 1)
ReDim KArray(sayac - 1, sayac - 1)
ListBox1.Clear :ListBox2.Clear :ListBox3.Clear
maxall = 0: minall = 100
For X = 0 To sayac - 1
      Input #1, t, z
      MyArray(X, 0) = CDec(t): MyArray(X, 1) = CDec(z)
     ListBox1.AddItem t
     ListBox2.AddItem z
Next
For X = 0 To sayac - 1
   ListBox3.AddItem X + 1
   For Y = 0 To sayac - 1
   If (X = Y) Then
      minall = minall
      maxall = maxall
   ElseIf Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2) <= minall Then
         minall = CDec(Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2))
   ElseIf Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2) >= maxall
Then
         maxall = CDec(Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2))
   End If
   Next:   Next
    i1 = 0: i2 = 0: i3 = 0: i4 = 0:  i8 = 0: i7 = 0: i5 = 0: i6 = 0: i9 = 0: i10 = 0: i11 = 0: i12 = 0
  For X = 0 To sayac - 1
   For Y = 0 To sayac - 1
   If Not (X = Y) Then
      If Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2) <= ((maxall -
minall) / 24 +
 minall) Then
       i1 = i1 + 1
```

```
    ElseIf Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2) < (2 *
(maxall - minall) / 24 + minall) Then
     i2 = i2 + 1
    ElseIf Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2) < (3 *
(maxall - minall) / 24 + minall) Then
     i3 = i3 + 1
    ElseIf Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2) < ((maxall -
minall) / 6 + minall) Then
     i4 = i4 + 1
    ElseIf Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2) < (5 *
(maxall - minall) / 24 + minall) Then
     i5 = i5 + 1
    ElseIf Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2) < ((maxall -
minall) / 4 + minall) Then
     i6 = i6 + 1
    ElseIf Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2) < (7 *
(maxall - minall) / 24 + minall) Then
     i7 = i7 + 1
    ElseIf Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2) < (8 *
(maxall - minall) / 24 + minall) Then
     i8 = i8 + 1
    ElseIf Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2) < (9 *
(maxall - minall) / 24 + minall) Then
     i9 = i9 + 1
    ElseIf Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2) < (10 *
(maxall - minall) / 24 + minall) Then
     i10 = i10 + 1
    ElseIf Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2) < (11 *
(maxall - minall) / 24 + minall) Then
     i11 = i11 + 1
    ElseIf Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2) <= ((maxall
/ 2)) Then
     i12 = i12 + 1
   End If : End If
  Next: Next
  Label2.Caption = Round(((maxall - minall) / 24 + minall), 2)
  Label3.Caption = Round(((maxall - minall) / 12 + minall), 2)
  Label4.Caption = Round(((maxall - minall) / 8 + minall), 2)
  Label5.Caption = Round(((maxall - minall) / 6 + minall), 2)
  Label6.Caption = Round((5 * (maxall - minall) / 24 + minall), 2)
  Label7.Caption = Round(((maxall - minall) / 4 + minall), 2)
  Label8.Caption = Round((7 * (maxall - minall) / 24 + minall), 2)
  Label9.Caption = Round((8 * (maxall - minall) / 24 + minall), 2)
  Label10.Caption = Round((3 * (maxall - minall) / 8 + minall), 2)
  Label11.Caption = Round((5 * (maxall - minall) / 12 + minall), 2)
  Label12.Caption = Round((11 * (maxall - minall) / 24 + minall), 2)
  Label13.Caption = Round(maxall / 2, 2)
  Label14.Caption = "    R1  " :   Label15.Caption = "    R2  ":   Label16.Caption = "    R3  "
  Label17.Caption = "    R4  ":   Label18.Caption = "    R5  ":   Label19.Caption = "    R6  "
  Label20.Caption = "    R7  ":   Label21.Caption = "    R8  ":   Label22.Caption = "    R9  "
  Label23.Caption = "    R10  ":   Label24.Caption = "    R11  ":   Label25.Caption = "    R12  "
min1 = "Minimum  : ":max1 = "Maximum : ":sayac2 = sayac * sayac
ty = MsgBox(min1 & minall & vbCrLf & max1 & maxall, , "Minimum & Maximum")
Dim gr(12, 0) As Variant
gr(0, 0) = Round(i1 * 81.224 / sayac2, 3)
gr(1, 0) = Round(i2 * 81.224 / sayac2, 3) + gr(0, 0)
gr(2, 0) = Round(i3 * 81.224 / sayac2, 3) + gr(1, 0)
gr(3, 0) = Round(i4 * 81.224 / sayac2, 3) + gr(2, 0)
gr(4, 0) = Round(i5 * 81.224 / sayac2, 3) + gr(3, 0)
gr(5, 0) = Round(i6 * 81.224 / sayac2, 3) + gr(4, 0)
gr(6, 0) = Round(i7 * 81.224 / sayac2, 3) + gr(5, 0)
gr(7, 0) = Round(i8 * 81.224 / sayac2, 3) + gr(6, 0)
gr(8, 0) = Round(i9 * 81.224 / sayac2, 3) + gr(7, 0)
gr(9, 0) = Round(i10 * 81.224 / sayac2, 3) + gr(8, 0)
gr(10, 0) = Round(i11 * 81.224 / sayac2, 3) + gr(9, 0)
gr(11, 0) = Round(i12 * 81.224 / sayac2, 3) + gr(10, 0)
TextBox2.Text = gr(0, 0) 'round(i1 * 81.224 / sayac2, 3)
```

```
TextBox3.Text = gr(1, 0) 'Round(i2 * 81.224 / sayac2, 3)
TextBox4.Text = gr(2, 0) 'Round(i3 * 81.224 / sayac2, 3)
TextBox5.Text = gr(3, 0) 'Round(i4 * 81.224 / sayac2, 3)
TextBox6.Text = gr(4, 0) 'Round(i5 * 81.224 / sayac2, 3)
TextBox7.Text = gr(5, 0) 'Round(i6 * 81.224 / sayac2, 3)
TextBox8.Text = gr(6, 0) 'Round(i7 * 81.224 / sayac2, 3)
TextBox9.Text = gr(7, 0) 'Round(i8 * 81.224 / sayac2, 3)
TextBox11.Text = gr(8, 0) 'Round(i9 * 81.224 / sayac2, 3)
TextBox15.Text = gr(9, 0) 'Round(i10 * 81.224 / sayac2, 3)
TextBox12.Text = gr(10, 0) 'Round(i11 * 81.224 / sayac2, 3)
TextBox13.Text = gr(11, 0) 'Round(i12 * 81.224 / sayac2, 3)
With MSChart1
    .ChartData = gr()
    .Visible = True
End With
Close #1
End Sub
Private Sub ListBox1_Click()
ind = ListBox1.ListIndex :tind = ListBox1.TopIndex
ListBox1.ListIndex = ind:ListBox2.ListIndex = ind:ListBox3.ListIndex = ind
ListBox1.TopIndex = tind:ListBox2.TopIndex = tind:ListBox3.TopIndex = tind
End Sub
Private Sub ListBox2_Click()
ind = ListBox2.ListIndex :tind = ListBox2.TopIndex
ListBox1.ListIndex = ind:ListBox2.ListIndex = ind:ListBox3.ListIndex = ind
ListBox1.TopIndex = tind:ListBox2.TopIndex = tind:ListBox3.TopIndex = tind
End Sub
Private Sub ListBox3_Click()
ind = ListBox3.ListIndex:tind = ListBox3.TopIndex
ListBox1.ListIndex = ind:ListBox2.ListIndex = ind:ListBox3.ListIndex = ind
ListBox1.TopIndex = tind:ListBox2.TopIndex = tind:ListBox3.TopIndex = tind
End Sub
Private Sub UserForm_Initialize()
TextBox10.SetFocus
MSChart1.Visible = False
TextBox10.Text = CurDir & "\"
End Sub
```

APPENDIX E: Code of the L Function in Visual Basic Script

Private Sub Command3_Click()

```
Dim z, t As Variant, dosya
Dim MyArray(), sayac As Variant
Dim KArray() As Variant
Dim maxall, minall As Variant
Dim X, Y As Integer
Dim ind, tind
Close #1
dosya = TextBox10.Text
Open dosya For Input As 1
sayac = 0
While Not EOF(1)
   Input #1, X, X
   sayac = sayac + 1
Wend
Close #1
TextBox1.Text = sayac & " points so far"
Open dosya For Input As 1
ReDim MyArray(sayac - 1, 1):ReDim MinArray(sayac - 1):ReDim KArray(sayac - 1, sayac - 1)
ListBox1.Clear:ListBox2.Clear:ListBox3.Clear
maxall = 0: minall = 100
For X = 0 To sayac - 1
      Input #1, t, z
      MyArray(X, 0) = CDec(t): MyArray(X, 1) = CDec(z)
     ListBox1.AddItem t:  ListBox2.AddItem z
Next
For X = 0 To sayac - 1
   ListBox3.AddItem X + 1
   For Y = 0 To sayac - 1
   If (X = Y) Then
      minall = minall
      maxall = maxall
   ElseIf Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2) <= minall Then
         minall = CDec(Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2))
   ElseIf Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2) >= maxall
Then   maxall = CDec(Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2))
   End If
   Next:   Next
   i1 = 0: i2 = 0: i3 = 0: i4 = 0:    i8 = 0: i7 = 0: i5 = 0: i6 = 0:    i9 = 0: i10 = 0: i11 = 0: i12 = 0

For X = 0 To sayac - 1
   For Y = 0 To sayac - 1
   If Not (X = Y) Then
      If Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2) <= ((maxall -
minall) / 24 + minall) Then
        i1 = i1 + 1
      ElseIf Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2) < (2 *
(maxall - minall) / 24 + minall) Then
        i2 = i2 + 1
      ElseIf Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2) < (3 *
(maxall - minall) / 24 + minall) Then
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        i3 = i3 + 1
      ElseIf Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2) < ((maxall -
minall) / 6 + minall) Then
        i4 = i4 + 1
      ElseIf Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2) < (5 *
(maxall - minall) / 24 + minall) Then
        i5 = i5 + 1
      ElseIf Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2) < ((maxall -
minall) / 4 + minall) Then
        i6 = i6 + 1
      ElseIf Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2) < (7 *
(maxall - minall) / 24 + minall) Then
        i7 = i7 + 1
      ElseIf Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2) < (8 *
(maxall - minall) / 24 + minall) Then
        i8 = i8 + 1
      ElseIf Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2) < (9 *
(maxall - minall) / 24 + minall) Then
        i9 = i9 + 1
      ElseIf Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2) < (10 *
(maxall - minall) / 24 + minall) Then
        i10 = i10 + 1
      ElseIf Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2) < (11 *
(maxall - minall) / 24 + minall) Then
        i11 = i11 + 1
      ElseIf Sqr((MyArray(X, 0) - MyArray(Y, 0)) ^ 2 + (MyArray(X, 1) - MyArray(Y, 1)) ^ 2) <= ((maxall
/ 2)) Then
        i12 = i12 + 1
      End If
      End If
    Next: Next

Label2.Caption = Round(((maxall - minall) / 24 + minall), 2):   Label3.Caption = Round(((maxall - minall) /
12 + minall), 2)
Label4.Caption = Round(((maxall - minall) / 8 + minall), 2):  Label5.Caption = Round(((maxall - minall) / 6
+ minall), 2)
Label6.Caption = Round((5 * (maxall - minall) / 24 + minall), 2): Label7.Caption = Round(((maxall -
minall) / 4 + minall), 2)
Label8.Caption = Round((7 * (maxall - minall) / 24 + minall), 2)
Label9.Caption = Round((8 * (maxall - minall) / 24 + minall), 2)
Label10.Caption = Round((3 * (maxall - minall) / 8 + minall), 2)
Label11.Caption = Round((5 * (maxall - minall) / 12 + minall), 2)
Label12.Caption = Round((11 * (maxall - minall) / 24 + minall), 2)
Label13.Caption = Round(maxall / 2, 2)
Label14.Caption = "     R1  ":Label15.Caption = "     R2  ":Label16.Caption = "     R3  ":Label17.Caption = "
R4  "
Label18.Caption = "     R5  ":Label19.Caption = "     R6  ":Label20.Caption = "     R7  ":Label21.Caption = "
R8  "
Label22.Caption = "     R9  ":Label23.Caption = "     R10  ":Label24.Caption = "     R11  ":Label25.Caption
= "     R12  "
min1 = "Minimum  : ":max1 = "Maximum : "
sayac2 = sayac * sayac
ty = MsgBox(min1 & minall & vbCrLf & max1 & maxall, , "Minimum & Maximum")
Dim gr(12, 0) As Variant
gr(0, 0) = Round(i1 * 81.224 / sayac2, 3) : gr(1, 0) = Round(i2 * 81.224 / sayac2, 3) + gr(0, 0)
gr(2, 0) = Round(i3 * 81.224 / sayac2, 3) + gr(1, 0) :gr(3, 0) = Round(i4 * 81.224 / sayac2, 3) + gr(2, 0)
gr(4, 0) = Round(i5 * 81.224 / sayac2, 3) + gr(3, 0):gr(5, 0) = Round(i6 * 81.224 / sayac2, 3) + gr(4, 0)
gr(6, 0) = Round(i7 * 81.224 / sayac2, 3) + gr(5, 0):gr(7, 0) = Round(i8 * 81.224 / sayac2, 3) + gr(6, 0)
gr(8, 0) = Round(i9 * 81.224 / sayac2, 3) + gr(7, 0):gr(9, 0) = Round(i10 * 81.224 / sayac2, 3) + gr(8, 0)
gr(10, 0) = Round(i11 * 81.224 / sayac2, 3) + gr(9, 0):gr(11, 0) = Round(i12 * 81.224 / sayac2, 3) + gr(10, 0)

Dim lr(12, 0) As Variant
lr(0, 0) = Sqr(gr(0, 0) / 3.14159265358979) - Round(((maxall - minall) / 24 + minall), 2)
lr(1, 0) = Sqr(gr(1, 0) / 3.14159265358979) - Round(((maxall - minall) / 12 + minall), 2)
lr(2, 0) = Sqr(gr(2, 0) / 3.14159265358979) - Round(((maxall - minall) / 8 + minall), 2)
lr(3, 0) = Sqr(gr(3, 0) / 3.14159265358979) - Round(((maxall - minall) / 6 + minall), 2)
lr(4, 0) = Sqr(gr(4, 0) / 3.14159265358979) - Round((5 * (maxall - minall) / 24 + minall), 2)
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lr(5, 0) = Sqr(gr(5, 0) / 3.14159265358979) - Round(((maxall - minall) / 4 + minall), 2)
lr(6, 0) = Sqr(gr(6, 0) / 3.14159265358979) - Round((7 * (maxall - minall) / 24 + minall), 2)
lr(7, 0) = Sqr(gr(7, 0) / 3.14159265358979) - Round((8 * (maxall - minall) / 24 + minall), 2)
lr(8, 0) = Sqr(gr(8, 0) / 3.14159265358979) - Round((3 * (maxall - minall) / 8 + minall), 2)
lr(9, 0) = Sqr(gr(9, 0) / 3.14159265358979) - Round((5 * (maxall - minall) / 12 + minall), 2)
lr(10, 0) = Sqr(gr(10, 0) / 3.14159265358979) - Round((11 * (maxall - minall) / 24 + minall), 2)
lr(11, 0) = Sqr(gr(11, 0) / 3.14159265358979) - Round(maxall / 2, 2)
TextBox2.Text = lr(0, 0) :TextBox3.Text = lr(1, 0)
TextBox4.Text = lr(2, 0):TextBox5.Text = lr(3, 0)
TextBox6.Text = lr(4, 0):TextBox7.Text = lr(5, 0)
TextBox8.Text = lr(6, 0):TextBox9.Text = lr(7, 0)
TextBox11.Text = lr(8, 0) :TextBox15.Text = lr(9, 0)
TextBox12.Text = lr(10, 0):TextBox13.Text = lr(11, 0)

With MSChart1
    .ChartData = lr()
    .Visible = True
End With
Close #1
End Sub

Private Sub ListBox1_Click()
ind = ListBox1.ListIndex:tind = ListBox1.TopIndex
ListBox1.ListIndex = ind:ListBox2.ListIndex = ind:ListBox3.ListIndex = ind:ListBox1.TopIndex = tind
ListBox2.TopIndex = tind:ListBox3.TopIndex = tind
End Sub

Private Sub ListBox2_Click()
ind = ListBox2.ListIndex:tind = ListBox2.TopIndex
ListBox1.ListIndex = ind:ListBox2.ListIndex = ind:ListBox3.ListIndex = ind
ListBox1.TopIndex = tind:ListBox2.TopIndex = tind:ListBox3.TopIndex = tind
End Sub

Private Sub ListBox3_Click()
ind = ListBox3.ListIndex:tind = ListBox3.TopIndex
ListBox1.ListIndex = ind:ListBox2.ListIndex = ind:ListBox3.ListIndex = ind
ListBox1.TopIndex = tind:ListBox2.TopIndex = tind:ListBox3.TopIndex = tind
End Sub

Private Sub UserForm_Initialize()
TextBox10.SetFocus
MSChart1.Visible = False
TextBox10.Text = CurDir & "\"
End Sub
```