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SaudiVeg ecoinformatics: Aims, current status and perspectives



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Abstract During the last decade many electronic databases of vegetation plots were established in many countries around the world. These databases contain valuable phytosociological information assisting both governmental and NGO (Non-governmental organizations) agencies to formulate strategies and on-ground plans to manage and protect nature resources. This paper provides an account on aims, current status and perspectives of building of a vegetation database for the Central Region (Najd) of Saudi Arabia – the founding element of the Saudi Vegetation Database (SVD). The data stored by the database are sample plots (vegetation relevés) collected according to the field techniques of the Braun-Blanquet approach (lists of taxa accompanied by semi-quantitative cover assessment), and are accompanied by general vegetation characteristics such as vegetation layering and cover, information on life-form of the recorded species, geographical coordinates, altitude, soil typology, topography and many more. More than 2900 vegetation-plot records (relevés) have so far been collected in the Najd region; of these more than 2000 have already been stored using the Turboveg database platform. These field records cover many habitats such as depressions, wadis (dry river beds), agricultural lands, sand dunes, sabkhas, and ruderal habitats. The ecological information collected in the database is currently the largest set of vegetation data collated into a database in the Middle East. These data are of great importance for biodiversity studies in

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Saudi Arabia, since the region is recording a loss of biodiversity at a fast rate due to environmental problems such as global warming and land-use changes. We envisage that this database would catalyze further data collection on vegetation of the entire Arabian Peninsula, and shall serve as one of the most important datasets for classification and mapping of the vegetation of the Kingdom of Saudi Arabia.

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1. Introduction

Eco-informatics and biodiversity informatics are two recent and closely related disciplines (Bisby, 2000; Canhos et al., 2004; Bekker et al., 2007; Guralnick and Hill, 2009; Dengler et al., 2011a,b, 2012a). Collating large vegetation data sets is one of the current major focus areas of eco-informatics. The ongoing research in this field aims at ensuring that vegetation data are properly archived and made accessible to both academic studies as well as practical applications. Saudi Arabia is a country experiencing rapid economic, social and climate changes having direct impact on the natural vegetation. It is therefore that the collation of vegetation data in Saudi Arabia became important for agencies funding data collection, as well as for those that use such data to support policy decisions and assessment of compliance with legal obligations of nature resource management and conservation. Accessible vegetation data of known quality are required to meet these obligations. In recent years, the resurgence of interest in vegetation monitoring has resulted in proliferation of data collection activities at local level (e.g. the Department of Conservation agencies, territorial local authorities, and private consultants). However, these data are often not archived or made accessible in a way that would allow the tackling of issues spanning large temporal or spatial scales of national interest. Adequate documentation and storage of data are especially important in long-term studies observing vegetation plots (Dengler et al., 2012b). This activity is one of the pillars of a successful biomonitoring.

In order to meet the demands of modern nature resource management and conservation, Saudi Vegetation Database (SVD) has been founded within a two-year project aimed at creation of a publicly accessible, internet-based tool. The major aim of the SVD is to provide a public repository for vegetation plot data that researchers may use to access freely for the purpose of viewing, searching, downloading, and using vegetation-related information. There are no geographical restrictions for data submission to the Saudi Vegetation Database, but the initial geographical focus is the Central Region (Najd) of Saudi Arabia. As in September 2015, the SVD held about 2900 plots covering much of the Central Region of Saudi Arabia.

This paper reviews the initial stages of building of the SVD, as an essential first step in developing a comprehensive ecological information system for Saudi Arabia. This is the first vegetation database in the Kingdom of Saudi Arabia, containing up-to-date list of plants taxa prepared by taxonomists of the Saudi Flora Group covering to date 2281 vascular plants (<http://plantdiversityofsaudi-arabia.info/index.htm>; Migahid 1978; Chaudhary 1999–2001; Collenette, 1999). The SVD also provides a solid foundation for new vegetation-analytical

studies in the fields of vegetation classification, resource mapping, and biodiversity assessment.

The driving motivations underpinning the SVD are:

- (1) implementation of an international approach to address pressing scientific questions that have been spurred by the progressing climate and land-use changes occurring in Saudi Arabia;
- (2) harmonization of the efforts of building the vegetation database in Saudi Arabia with the rest of the world; and
- (3) archiving the legacy vegetation data sets that are in danger of being lost.

Here we present a brief background on the conceptual framework of the database, preliminary inventory of the existing vegetation data sets, and some of the potential products. The ultimate goal of this project is to develop the national vegetation database as the prime repository for ecological data in the Kingdom on vegetation structure and composition, aimed specifically at:

- (1) enhancement of (i) archival data storage of nationally important datasets in the Central Region (Najd) of Saudi Arabia; (ii) availability of the archived data to users, while protecting the interests of data providers, and (iii) encouraging the scientists to use these stored vegetation data;
- (2) collation and evaluation (i) of the extensive knowledge and diverse experience of vegetation scientists from Saudi universities and other research organizations, (ii) of the extensive literature on structure, variability and distribution of vegetation in the Central Region (Najd) of Saudi Arabia, and above all, (iii) of the many national and regional vegetation data and maps already existing, through a well-organized, national collaborative scheme;
- (3) construction of a Standard Plant Species Checklist for Saudi Arabia that would enhance standardization of taxonomic concepts and serving as a crucial communication tool between taxonomists and ecologists;
- (4) facilitating construction of a comprehensive biological information system (modelled on the SynBiosys (Schaminée et al., 2007) platform; Biodiversity models or Biodiversity Monitoring Data Portal) (Schaminée et al., 2007) collating vegetation-plot data, spatial data (vegetation maps), geographic and socio-economic data sets and allowing detection, assessment and prediction of environmental changes; and
- (5) providing baseline data for formulation of the first vegetation classification system and for construction of the first comprehensive vegetation map of the Arabian Peninsula.

The products of this database project are poised to assist managers to protect and restore vulnerable species, communities and habitats, to improve land-use practices, and to forecast vegetation reactions to changes in climate and land-use and such data are useful in conservation, landscape research; and assists regional councils, university-based academics and others. It will undoubtedly serve as an important tool for education and raising public awareness.

2. Material and methods

2.1. Study area

Central Region (Najd) of Saudi Arabia has been selected as the primary 'seed region' for the SVD prototype.

The SVD currently collates vegetation (and associated data) from the Central Region (Najd). We consider this region as the 'seed' element of the Database serving creating and testing of a prototype of the SVD. In the sequel we present the basic geographic features of the selected region, and discuss the structure of the SVD.

We have selected this region since it is facing major ecological and socio-economic challenges, including pressure on water supply for consumption and irrigation, increasing agricultural production including sheep and cattle grazing, increasing environmental pollution, exploitation of natural resources through hunting, harvesting of thatching material and collecting of medicinal plants as well as preservation of biodiversity (Vincent, 2008; Alatar et al., 2012, 2015; El-Sheikh et al., 2013).

2.1.1. Topography, geology and soils

The Central Region (Najd) of Saudi Arabia extends between (23° 00' N, 45° 38' E and 26° 45' N, 45° 57' E). Tuwayq Mountains, wadis, depressions called 'raudhas', saline inland sabkhas, and extensive gravel, rocky and sandy deserts are the main physiographic features of the central province of a large Najd Plateau that is divided into Higher Najd in the west and Lower Najd in the east (Fig. 1).

The dominant topography of the Central Region is characterized by nearly parallel sequences of several prominent crescent-shaped, north-south running escarpments called Tuwayq Mountains. They extend for about 1200 km and reach altitudes up to 1000 m above sea level, and tower about 240 m above the adjacent plains (Al-Nafie, 2008; El-Sheikh et al., 2013). These ridges are mainly built of hard marine limestone, capped with Upper Jurassic limestone. This hilly country and open plains, except for depressions, are supporting very sparse vegetation.

The Najd landscapes are dissected by an extensive system of large wadis that flow eastward from the mountains in the west to the plains of Najd. These wadis are not continuous, and at times covered and buried by sand dunes of the Dahna Desert. The wadis receive supply of runoff water along with fine soil from the elevated places; they offer the best habitat for development of vegetation. Remnants of dense vegetation can be found along the stretch, reflecting a wetter climate of the past (Chapman, 1978; Chaudhary and Al-Jowaid, 1999; Ghazanfar and Fisher, 1998; Al-Nafie, 2008). As the study area of wadis is located at the intersection of three main habitats such as sand dunes, rocky hills and depression, the vegetation of the wadis

is controlled by topography and soil type. Despite harsh environment, wadi ecosystems support diverse habitat complexes, and accordingly the vegetation also varies much as well. During winter, vegetation of the main wadi and its tributaries support various plant communities, some of perennial nature (composed of trees, shrubs and sub-shrubs) and some of seasonal nature (dominated by mesophytic herbs and grasses). The wadi habitat complex can be topographically divided into plateau, slope, and wadi bed.

In depressions, where the soil is composed of loam and silt, the vegetation is dominated by annual plants. There are several raudhas in the region, most of which are located close to sand dunes, and are influenced by the vegetation of both sand-dunes and rocky habitats. Trees are rare in the Central Region.

Sand dunes dominate the Central Region and are considered a continuation of the Dahna Desert. The Dahna is a narrow belt of complex linear dunes that emerges from the eastern edge of An Nafud near the long. 43° N and swing in a gentle 1200 km arc toward the northern Rub'al Khali. The topography comprises a cuesta landscape of cover rocks gently dipping eastward toward the Gulf. Smaller Nafud, such as the Nafud As Sirr, Nafud Qunayfidah and Nafud Ash Thuwayraz broadly mirror the arcuate trend of An Nafud. Probably the major source of sand is alluvium transported in north-west direction into the Wadi Ar Rimah system. This wadi system becomes buried by sand in the Buraydah area and emerges from the sands of Ad Dahna as Wadi al Batin. The parallel longitudinal dunes of Ad Dahna are quite widely spaced and lack crescent slip faces because the westerly winds, which dominate An Nafud to the north-west, have much less influence on the dunes of Ad Dahna. The deflection of the longitudinal dunes to the south is in response to the shamal winds that can cause sand drift problems on the main highway between Riyadh and the Gulf coast. In the southern Ad Dahna active barkhan dunes have been observed moving across stable longitudinal dunes. In the Khurays area, Anton (1984) described the development of a 0.4 m thick palaeosol between reddish stabilized dunes and the sands of active dunes. Thus, these dunes of Ad Dahna follow the general sequence observed in the Nafud and the Rub'al Khali with older, stabilized dunes overlain by younger active dunes (Vincent, 2008).

In the Central Region there are no permanent water-courses, however pools persist in the wadi beds and there is a series of spring-fed pools along the foot of the mountains. Seasonal springs originate in these wadis after substantial rainy events and often create shallow pools along the banks and in depressions. Inland salt depressions are a common feature in the Central Region of Saudi Arabia. Other wetlands are created close to large cities; these artificial wetlands received water from the refuse water discharge, irrigation, and from industrial areas. Wetlands are important landscape elements as they fulfill a diverse set of ecological and social and economic functions.

2.1.2. Anthropogenic habitats

Anthropogenic habitats originate in and around urban and rural settlements, and are a result of human activities associated by anthropogenic factors (Shaltout and El-Sheikh, 2003). In Saudi Arabia these habitats are mainly concentrated in high-disturbed sites, such as roadsides, building sites, abandoned agriculture lands, and fields under agricultural

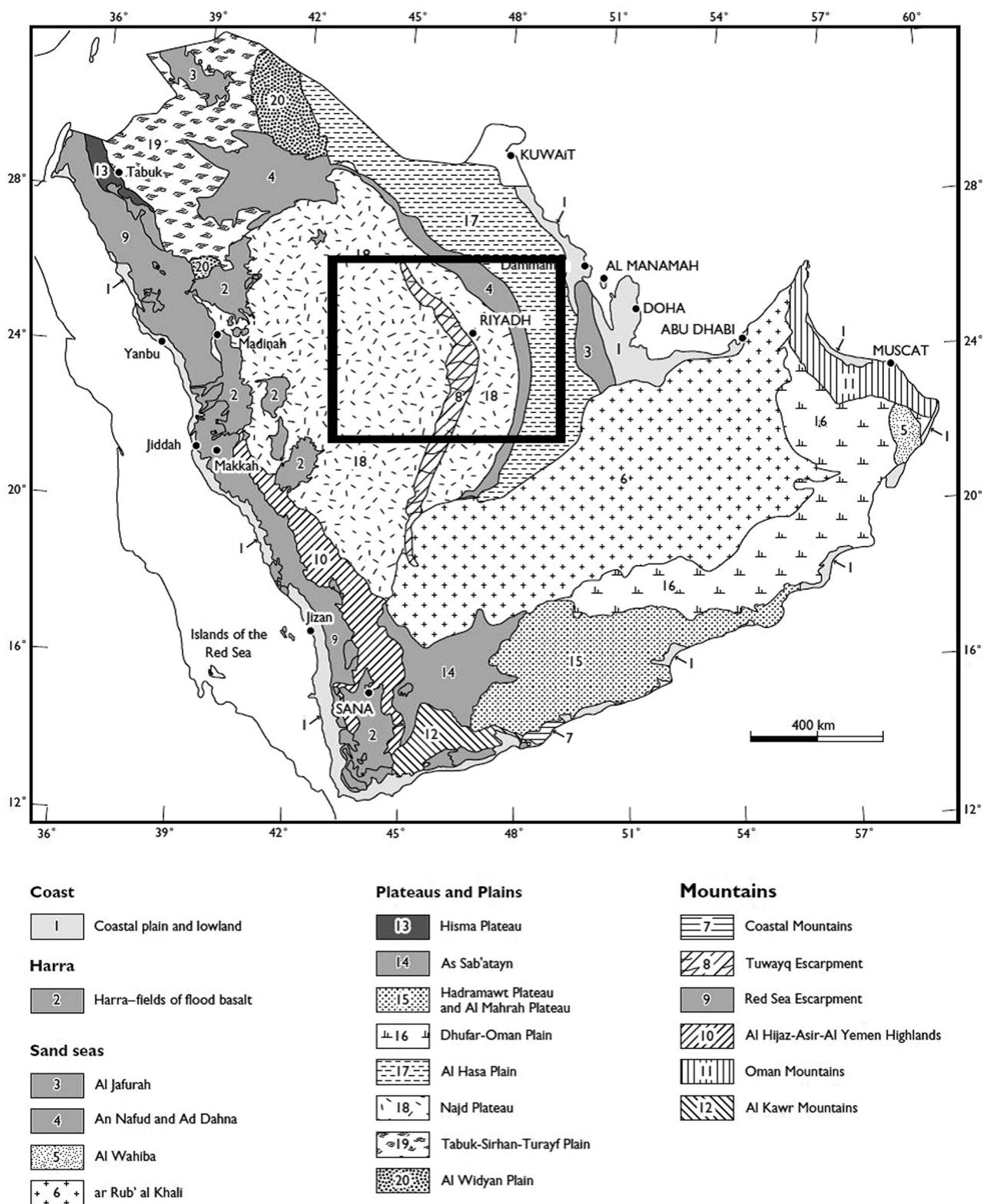


Figure 1 Main physiographic regions of the Arabian Peninsula (according to Vincent, 2008) and the position of the study area (black rectangle).

crops. Agriculture lands in the Central Region are vulnerable to invasion of alien weedy flora, gaining competitive advantage due to disturbance of the original native vegetation and disproportionate input of nutrients.

2.2. Climate

The mean minimum and maximum annual temperatures in the Central Region span 15 °C and 37 °C, respectively. The

maximum daily temperature often reaches 47 °C during July–August, while the lowest minimum temperature touches just below 3 °C in some extreme cold days during winter. The rainfall in the Central Region is highly variable. The mean annual precipitation is less than 20 mm, of which 80% is received from December through April and the prevailing winds from north (Fig. 2).

2.3. Field data collection

Developing a comprehensive Saudi Vegetation classification system of plant community types requires collation of large

amount of data. Unfortunately, so far the SVD could rely on only few historical data sources (e.g. Baierle et al., 1985; Shaltout and Madi, 1996; Alfarhan, 2001, 2002). Most of the previous studies were not collected according to a standard protocol and therefore lack some basic vegetation data. We identify, therefore, the need for a standard data protocol, such as those by Mucina et al. (2000) or Jennings et al. (2009), as indispensable.

New data sets were collected by sampling vegetation during spring season (March and April 2012, 2013, 2014 and 2015). The vegetation data were collected from vegetation in typical habitats that repeatedly occur across the landscapes. In the

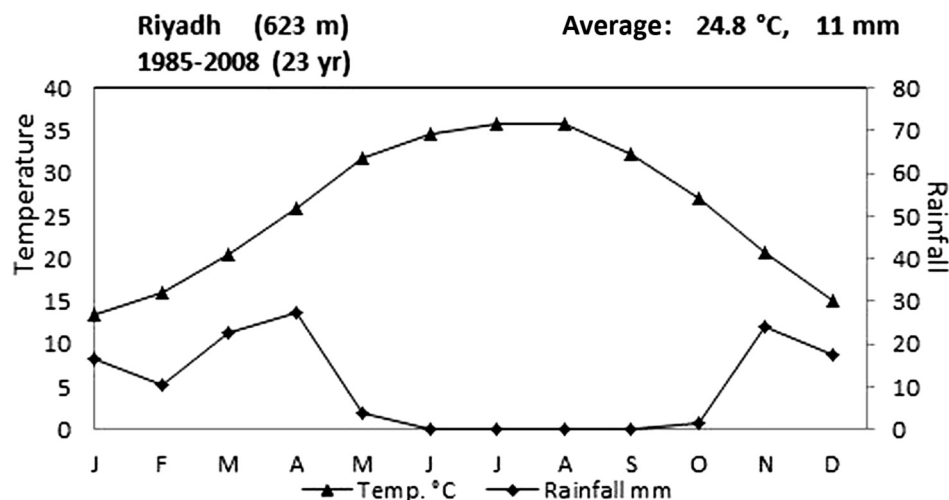


Figure 2 Climatic diagram of Riyadh region (King Khaled Airport, Riyadh, 2009).

Table 1 Fact sheet on a Saudi Vegetation Database (SVD). This fact sheet uses format of Global Index of Vegetation-Plot Databases (see Dengler et al., 2012b).

Saudi Vegetation Database 'SVD'

Scope: All available phytosociological relevés (mainly vascular plants but also non-vascular plants) of open and woody vegetations, from validated sources, principally collected in Najd (Central Region), but also in neighboring regions, with known geographical localization, with plot size preferably 10 m², with recorded abundance and/or cover estimation (for each species and vegetation layers).

Status: ongoing capture

Period: 2012-2014

Database manager(s): Mohamed El-Sheikh (el_sheikh_eg@yahoo.co.uk)

Owner: King Saud University

Web address:

Availability: according to a specific agreement

Online upload: no

Online search: no

Database format(s): TURBOVEG

Export format(s): TURBOVEG, Excel, plain text file

Publication: El-Sheikh, M.A., Thomas, J., Alatar, A. A., Hegazy, A. K., Abbady, G. A., Alfarhan, A. H., Okla, M. I. (2013). Vegetation of Thumamah Nature Park: a managed arid land site in Saudi Arabia. *Rend. Fis. Acc. Lincei* (2013) 24:349–367.

Plot type(s): normal plots

Plot-size range: 0.1-10,000 m²

Non-overlapping plots: 26,180

Estimate of existing plots: 2000

Completeness: 90%

Total plot observations: 2900

Number of sources:

Valid taxa: 2281

Countries: SA 100%

Forest: 0% — **Non-forest:** wetland: 3%; depressions: 13%; wadi: 12%; natural: 10%; semi-natural: 50%; anthropogenic: 12%

Guilds: all vascular plants: 95.5%; bryophytes (terricolous or aquatic): 0.4%; 0.06 lichens (terricolous or aquatic): 2%; algae (terricolous or aquatic): 0.2%; non-terricolous taxa (epiphytic, saxicolous, lignicolous): 2%

Environmental data: altitude: 1%; slope aspect: 12%; slope inclination: 7%; surface cover other than plants (open soil, litter, bare rock etc.): 14%; soil pH: 7-8%; other soil attributes: 1%; land use categories: 77%

Performance measure(s): cover: 100%

Geographic localization: point coordinates less precise than GPS, up to 1 km: 6%; small grid (not coarser than 10 km): 94%; political units or only on a coarser scale (> 10 km): 100%

Sampling periods: 1930-1960: 0.3%; 1970-1999: 0.5%; 2000-2009: 8.1%

Information as of 2012-07-17; further details and future updates available at <http://www.NA>

Central Region, these included dry and wet habitats, saline inland habitats, sandy dune habitats, wadi habitats, springs, calcareous ridge habitats, and moist rich 'rawdhat' meadows. Usually the preferred size of vegetation plots in desert was quite large (e.g. 50 m × 50 m) due to scattered occurrence of plants and formation of non-continuous plant cover. These plots are floristically and structurally homogeneous areas that are representative of the plant communities repeatedly occurring in similar habitats within a region. Within each sample plot, a full list of all the plant species was made and for each species, an estimate of projected percentage cover was recorded. Besides the floristic information, also data on the vertical structuring of the vegetation as well as cover of particular layers was recorded.

Geographic characteristics on the sampled sites were also collected; these included co-ordinates, elevation, slope and aspect, landform, bedrock, parent material, physical and chemical characters of soil, land use and disturbances, and active-layer depth (for more detail see Table 1).

At a later stage, these data will be forming basis for creation of two types of data matrices: (1) those containing the plant-species-cover data, and (2) those containing the other environmental data presumed to act as drivers of the vegetation patterns. These data matrices can then be used to describe, classify, and analyze plant species and plant communities in relation to environmental characteristics. The information in these data matrices also serves as the principal source for vegetation mapping.

3. Expected outcomes

3.1. Current status of the Saudi Vegetation Database

3.1.1. Conceptual framework of the Saudi Vegetation Database

The Saudi Vegetation Database is a project undertaken by members of the Saudi Vegetation and Flora Group of the Department of Botany and Microbiology of the King Saud University (Table 2). The plant-community data of the SVD will be intimately linked to the plant species lists embedded within in the Saudi Flora Database (Fig. 3). The output of both databases will be made available to researchers and the general public through SynBioSys and Biodiversity Monitoring Data Portal (websites are under construction).

The database has been created using the application software Turboveg for Windows (<http://www.synbiosys.alterra.nl/turboveg>; Hennekens and Schaminée, 2001). The justification for using Turboveg is that it is the most widely used vegetation database tool and lends itself well to other software packages developed in Europe for vegetation classification and analysis, such as JUICE (Tichý, 2002). Turboveg is an application for the front-end management of vegetation data. Eventually the data should be stored in a client server database such as the open source database object-relational system (web under construction). The standardized Saudi Species List has been incorporated into the Turboveg as the initial important step in the developing the SVD database.

We have first prioritized the data entry to include the published digital data sets with complete vascular and non-vascular plant species lists collected according to a set of protocols. We have also entered data from unpublished and non-digital sources. A special effort was made to retrieve

Table 2 Geographical position and nature of sampled habitats pertinent to data captured in SVD as on November 2014.

Localities	Coordinates		Sampled habitats
	N	E	
Raudhat Khuraim (Najd)	25° 21' 19.73"	47° 17' 54.71"	Depression
Al-Kharj	24° 09' 41.5"	47° 24' 19.1"	Ruderal and wetlands
Al-Hair	24° 23' 4.67"	46° 5' 37.21"	Wetlands
Muzahimiyah	24° 27.8' 46"	46° 12.648"	Sand dunes
Jibalah	24° 46.1' 16"	43° 52.798"	Hillocks
Huraimla	25° 04' 27.2"	45° 58' 24.4"	Protected wadi
Wadi Aljufair	23° 50' 00.0"	46° 14' 00.0"	Wadi
Wadi Almarshkar	26° 54' 05.6"	45° 19' 51.79"	Depressions
Thumamah	25° 12' 15.8"	46° 38' 18.0"	Protected wadis and hillocks
Hotat Bani Tamim	23° 26' 54.8"	46° 32' 04.4"	Wadi
Alaowshaziya	26° 00' 47.39"	44° 10' 18.68"	Salt pan
Alqasab	25° 13' 03.1"	45° 33' 13.6"	Salt pan
Alawshaziyah (Alqassim)	26° 23' 23.3"	43° 47' 42.5"	Salt pan
Rawdhat Khuraim	25° 24' 43.20"	47° 15' 22.75"	Depressions
Rawdat Alkhafs	25° 26' 41.09"	46° 29' 01.00"	Depressions
Rawdhat Banban	24° 58' 43.60"	46° 32' 10.71"	Depressions
Alqassim region	26° 07' 08.51"	43° 56' 33.59"	Arable lands
Alghat region	25° 56' 42.4"	45° 03' 09.3"	Protected wadi
Wadi Nissah	24° 14' 53.58"	46° 39' 43.81"	Wadi
Taef-Riyadh transect	24° 37' 07.27"	46° 38' 28.83"	Desert plains
Alghada at Al-Qasseim	21° 24' 53.11"	42° 27' 38.57"	Protected sand dune
Alkharj	26° 02' 44.15"	43° 49' 17.79"	Protected sand dune
Alkharj	24° 06' 16.03"	47° 23' 25.08"	Wetlands
Salbuokh	25° 04' 22.3"	46° 26' 56.0"	Wetlands
Dikhla, N of Riyadh	25° 18' 40.87"	46° 10' 41.47"	Wetlands

critical legacy data sets that are in danger of being lost or whose authors have died. Data collected with incomplete species lists or by non-experts have been given low priority. Key consultants have worked at their home institutions to prepare their data for inclusion in the database. Two workshops have been held to help coordinate the efforts.

3.2. Data storage and analysis

3.2.1. Characteristics of the Turboveg database structure

The vegetation and accompanying environmental and geographic data are collated using Turboveg for Windows (<http://www.synbiosys.alterra.nl/turboveg>; Hennekens and Schaminée, 2001) which is a database program designed for the storage, selection, and export of vegetation data (relevés). Data can be imported to Turboveg manually (separate relevés or tables) and automatically (import of data files). Several filters are available to export the selected relevés to enable

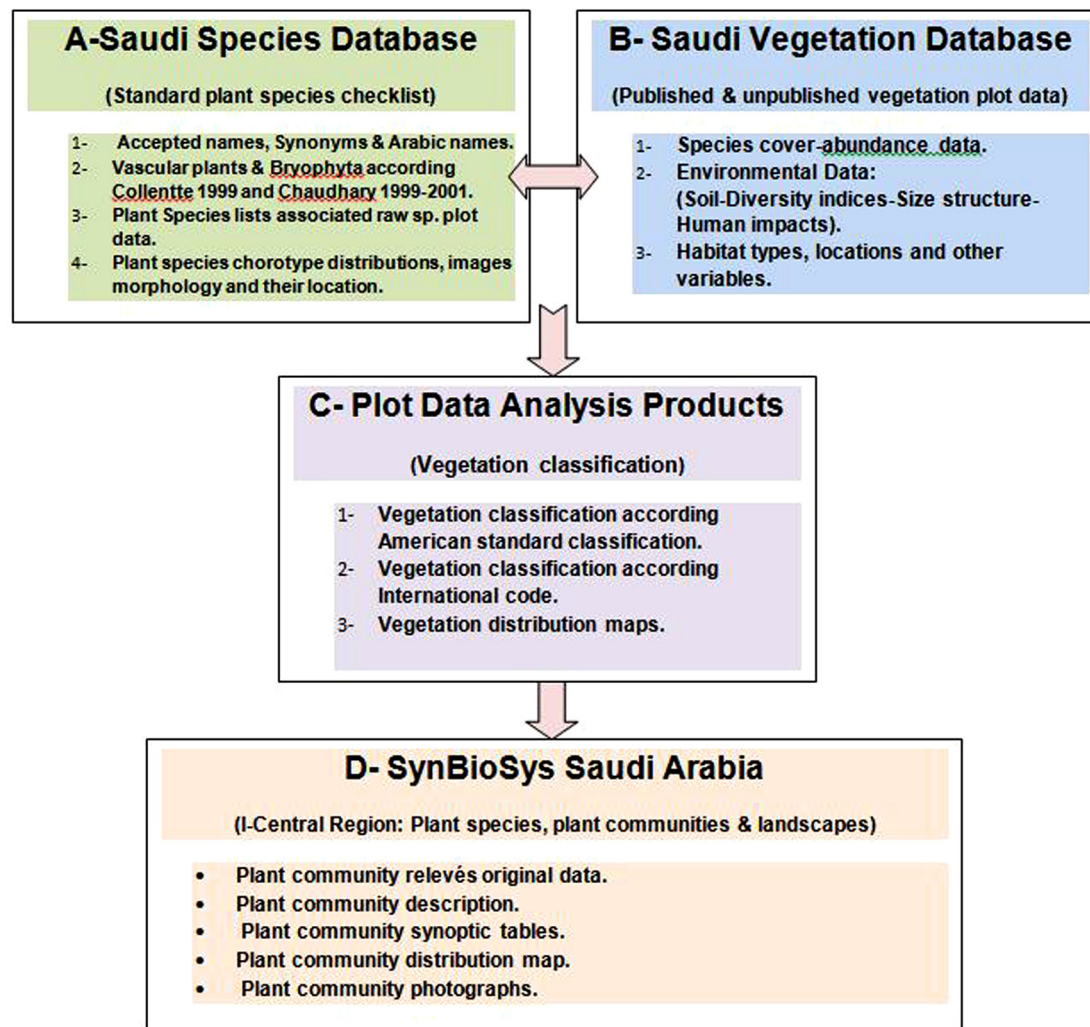


Figure 3 Conceptual diagram of the structure of the Saudi Species and Vegetation Databases and projected product developments.

further analysis with various programs (e.g. Excel, MS Access, ArcView, ArcGIS, Google Earth, and special vegetation data analytic software packages such as TWINSPAN, CANOCO, PC-ORD, MULVA, SYNTAX, and JUICE). The core of the standard structure of the table is pre-predefined, yet new fields can easily be added both on the header data (e.g. data from soil analyses) and or data on species data (e.g. new fields on phenology, chorotype, etc.).

3.2.2. Vegetation data

The table not only gives information on the availability of data per plots, but also on plots and time series. The exact GPS positions were recorded for each plot and few individual plants present in the observatory and at 100 m² or less scale. In most cases the numbers of monitored plots were consistent over the years. This is an indication of several special research activities that were conducted here and offered additional data beyond the standard procedures.

3.2.3. Environmental and geographic data

Vegetation databases of plant species occurrence in conjunction with environmental measurements can be a powerful tool

in understanding ecological relations or predicting the effect of external drivers on ecological processes and species reactions (Schaminée et al., 2009). The header data contain a growing number of data, we add the described the abiotic measurement and are actively searching for new data to add (e.g. soil physical and chemical characteristics, plant species diversity indices, land use type, human impact levels, life-forms, chorotypes, geographical coordinates, altitude, soil typology, topography, elevation, slope and aspect).

The list of the data parameters of collated in the SVD is featured in Table 3.

3.3. Standard species list

A single standard and accepted list of vascular plant and bryophytes species names and their synonyms is an essential first step toward construction of the SVD. The taxonomists of the Saudi Flora and Ecology Group of the Department of Botany and Microbiology have developed the list that has already been uploaded onto the Turboveg platform in 2012 (Fig. 3); the list is available at: <http://www.plantdiversityofsaudiarabia.info/Biodiversity-Saudi-Arabia/Flora/Checklist/>.

Table 3 The list of the field-data parameters and examples of the data are collated in the SVD. NA: not available.

Type of variable	Name of variable	Format/units	Source	Example
Geographic	Province	Text	Topographic map of Saudi Arabia	Central Region (Najd)
Geographic	Locality	Text	Topographic map of Saudi Arabia	Ibex Nature Reserve
Geographic	Latitude	Deg/min/sec seconds	GPS measurements in the field	23° 27' 02.0"
Geographic	Longitude	Deg/min/sec	GPS measurements in the field	46° 30' 59.6"
Geographic	Altitude	Meters	GPS measurements in the field or topographic map	881 m
Plot size	Area	Values m ²	Field observations	50 m × 50 m
Plot coordinates	Latitude	Deg/min/sec	GPS measurements in the field	23° 27' 02.0"
Plot coordinates	Longitude	Deg/min/sec	GPS measurements in the field	46° 30' 59.6"
Plot Altitude	Altitude	Meters	GPS measurements in the field or topographic map	850 m
Habitat	Type of habitat	Text	Field observations	Bottom of wadi
Habitat	Soil texture	Text	Lab analysis	Sandy silt
Habitat	Soil sand	Values in %	Lab analysis	60.0
Habitat	Soil silt	Values in %	Lab analysis	26.0
Habitat	Soil clay	Values in %	Lab analysis	04.0
Habitat	Soil organic matter	Values in %	Lab analysis	3.49
Habitat	Soil pH	Value	Lab analysis	7.51
Habitat	Soil EC	Values in m mhos cm ⁻¹	Lab analysis	0.54
Habitat	Sodium content	Values in ppm	Lab analysis	781,029
Habitat	Calcium content	Values in ppm	Lab analysis	4091
Habitat	Potassium content	Values in ppm	Lab analysis	917,541
Habitat	Magnesium content	Values in ppm	Lab analysis	217,215
Habitat	Manganese content	Values in ppm	Lab analysis	28
Habitat	Ferrous content	Values in ppm	Lab analysis	1166
Habitat	Nitrogen content	Values in ppm	Lab analysis	2.3
Habitat	P content	Values in ppm	Lab analysis	60.3
Habitat	Human status	Text	Field observations	Protected
Species data	Projected cover	Values in %	Field observations	80
Species data	Density	Values in ha ⁻¹	Field observations	NA
Species data	Frequency	Values in %	Field observations	NA
Species data	Presence/absence	Text	Field observations	NA

The list is compiled in a database format that includes plant descriptions, photographs, and information on ecology, habitat, and geographic (chorotype) distribution. Sources of information are listed under bibliographic references. All lists are combined into a single list for the vegetation database and synonymous names are included.

3.4. Current extend of the SVD

With 2900 relevés computerized and stored in the Saudi Vegetation Database, SVD has a plot density of 2.0 per square kilometer (Fig. 4). According to the recent compilation of the metadata on electronic vegetation databases, SVD belongs to the countries/regions with the highest plot density in the Central Region (Najd). Analyses show that the relevés compiled in SVD are rather heterogeneous. As is undoubtedly the case in many vegetation databases, they are biased toward sites and land cover classes/vegetation types of special nature or interest. As the Najd region is a desert with discontinuity of plant communities due to uneven rainfall and are subject under intense of land use dynamics; the distributed data strongly affect phytosociological classification (Knollová et al., 2005), and most analyses of long-term changes (Haveman and Janssen, 2008; Jansen and Dengler, 2010).

4. Conclusions

4.1. Further expansion of the SVD

Field work yielding new data sets and collation of historical data to be entered into the SVD is on-going. First datamining using the SVD has been attempted and data analyzed (classified) to set standards for the formulation of a new vegetation classification system in the country. The results of these efforts will be published elsewhere. Preparatory steps in formulating a new project on vegetation mapping of a large portion of the central regions of Saudi Arabia have also been taken. This project will use the vegetation-plot data as one of the major sources for modelling of the potential natural vegetation. Vegetation bibliography and gazetteer of vegetation surveys is in preparation. We plan to make the SVD accessible through a web-based application. It is proposed to provide download options so that checklists and plant community information can be customized and retrieved.

4.2. Perspectives on the practical application of the SVD

The expected growth of the database with existing and addition of new data will change its applicability. For building an optimally structured vegetation database, however, a gap

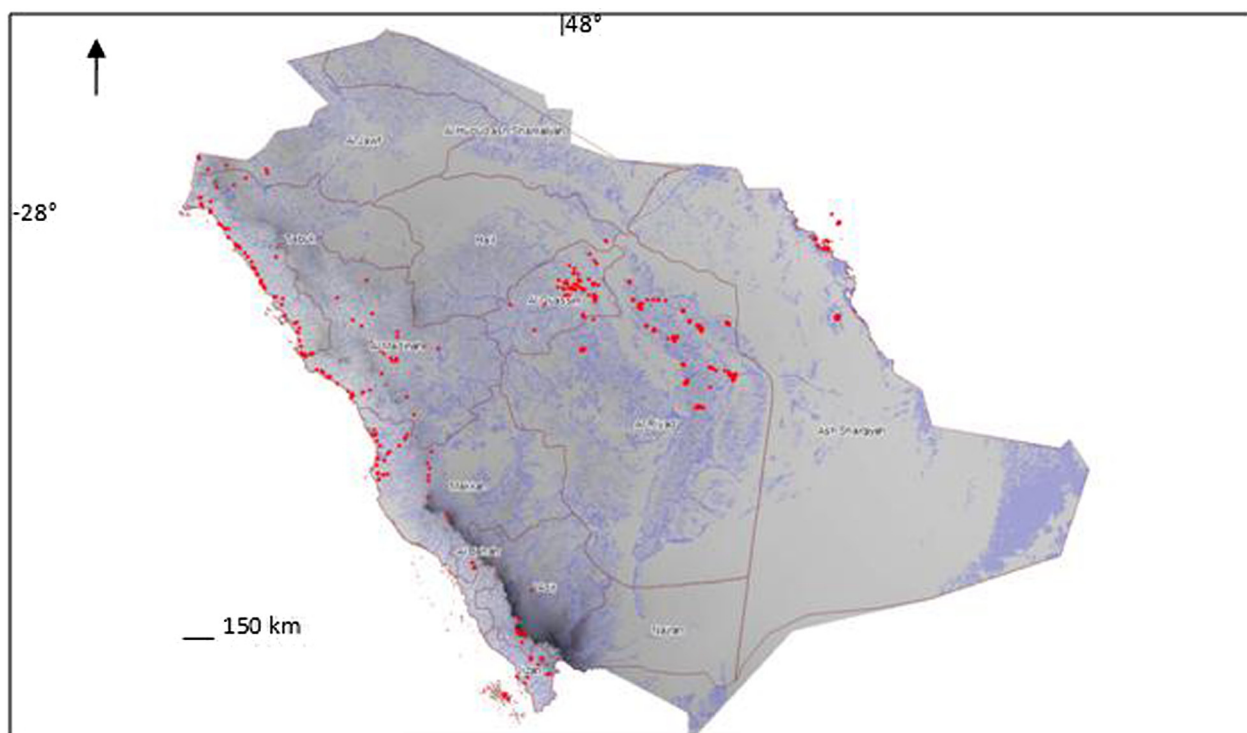


Figure 4 The distribution map of the relevé data already stored in the National Vegetation Database of Saudi Arabia as on November 2014.

analysis leading to an appropriate sampling scheme should be completed, taking into account the aims of future applications. For instance, in order to complete and synthesize the typology of the SVD Nature types, we should examine further if some important areas or land cover classes/vegetation types are still under-sampled or not. If this is the case, then additional field sampling could remedy the lack of data from some areas.

As we have shown, concerns in nature policy can strongly influence research projects (topic and area) and the related sampling efforts. As in Europe, NATURA 2000, the environmental protection system prevailing in member countries of Arabia also have an impact on developing vegetation databases. Indeed vegetation plot data are useful for member states to assess various habitats and thereby define the conservation status of existing protected areas. For the improvement of vegetation datasets, monitoring schemes for SVD and vegetation sampling are to be revised in every six years.

The ecological information collected in the database is currently the largest set of vegetation data collated into a database in the Middle East. These data are of great importance for the future of biodiversity studies in Saudi Arabia as the region is losing its biodiversity at an alarming rate due to environmental problems like global warming and ongoing land-use changes. We envisage that this database would serve as seed for large data collection on vegetation of the entire Arabian Peninsula and shall serve as one of the most important data sets in mapping vegetation of the Kingdom of Saudi Arabia.

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