CONSERVATION AND SUSTAINABLE USE OF DRYLAND AGROBIODIVERSITY IN LEBANON
LEB/G34-GEF/UNDP

Republic of Lebanon
Office of the Minister of State for Administrative Reform
Center for Public Sector Projects and Studies
(C.P.S.P.S.)

Indigenous Agroecological Zoning

Rami Zurayk, PhD

1. Introduction

This is the second and final report submitted to the UNDP's "Conservation and Sustainable Use of Dryland Biodiversity project, as a partial fulfillment of the contract established between UNDP and Dr. Rami Zurayk. This document reports on a participatory investigation carried out during 2000-2001 in the three target sites of Aarsal, Ham and Nabha, in order to document and understand the indigenous agroecological zoning.

2. Methodology

2.a Approach

The investigation relied principally on a combination of participatory field methods and Geographic Information Systems (GIS). GIS was used primarily as a tool of analysis and presentation. Participatory field methods were selected as these have become an established procedure for investigating indigenous resource management systems and for complementing information obtained in more formal surveys especially in data-poor environments (Webber and Ison, 1994). One of the main advantages of participatory investigations is that they help provide a holistic vision from the perspective of the end-user, and makes use of their experience, which is integrated with that of the researchers, in order to broaden the common knowledge-base (Chambers, 1994a, 1994b).

2.b Team

Meetings were arranged that brought together the project team and the local focal points in each of the project sites. The group usually consisted of 2-3 researchers and an equal number of local people with good knowledge and experience of the area. The participatory investigations took the form of relaxed semi-structured interviews following a guiding framework, which outlined the sequence of events and points to remember. The researchers behaved mostly as active listeners and observers.

2.c Tools

The classical participatory investigations tools (maps, sketches, diagrams, ranking) were used. The participants were provided with sheets of white paper and asked to draw the resource maps of the target sites according to their perceptions. The information obtained include: local soil types and their classification and distribution within the landscape, local agroclimatic information, local land use systems and indigenous agroecological zoning. These information were then transformed into geographic data using a Global Positioning System (GPS). The data from the GPS was then entered in GIS format (ArcInfo), and overlaid with the base maps of the 3 sites in order to produce a geo-referenced agro-ecological map.

2.d Field validation

One or more of the local participants accompanied the field team to locate the boundaries of the different soil and agroecological zones in the field. This particular step was necessary but very lengthy, as each site required an average of 5 visits with a team composed of 3 persons (local guide, GPS operator, driver). Hundreds of data points were acquired in each site, in order to enable the accurate drawing of the zones boundaries.

2.e Mapping

Two kinds of maps are attached to this report: hand drawn maps (local team) and GIS maps

3. Indigenous agroecological zones

3.a Aarsal

i) Agroecological zones

Aarsal is by far the largest of the 3 sites (290 km^2). This affects the scale of the information that is obtained, and the degree of precision and details that can be achieved within the scope of this work. The people of Aarsal distinguish 3 general areas in their lands: The highlands (Jurd), the valleys (Wadis) and the steppe (Plain). These are further divided into 6 different farming zones (Map 1 - Sketch 1)

Zone 1: **The High Jurd**
Zone 2: **The Middle Jurd**
Zone 3: **The Low Jurd**
Zone 4: **The Wadis**
Zone 5: **The Eastern Area**
Zone 6: **Western Area**

Some agroclimatic characteristics of these areas appear in Table 1. In these agroecozones, the climatic conditions are sufficiently uniform to determine potentials and constraints for crops. In the classification process, climatic data is not measured, but inferred from the duration of the snow cover and the incidence of frost, which are used as indicators of temperature and moisture (Table 1). Ecological indicators of local climates are also used to delineate the agroecological zones. The distribution of *Poterium spinosum*, a thorny ground-bush usually characteristic of the more humid highlands of the Western mountain range of Lebanon, delineates the limits of the Western ecozone. Similarly, the occurrence of *Artemiasa herba-alpa*, a desert plant, delineates the Eastern steppe. The result of the indigenous agroecological zoning is a landscape division that is clearly delineated and that is commonly used and recognized by the entire community.

ii) Soils

The participatory team was also asked to provide heir perception of the soils of Aarsal. Soil

variability in Aarsal is limited due to the relatively homogeneous parent rock formation (Cenomano-Turonian hard limestone). Yet, due to variations in local climate and in landform, several soil types may be distinguished. These are named by the local people in relation to their geographic location (ex: the soils of Rahweh, in the middle Jurd). Our inquiry about the difference among different soil types revealed that the local farmers categorize their soils in different classes, which reflect their agronomic potential, following a multi-descriptors system that includes depth, color, texture/water relations, and any other existing limitations (see Chart 1). Farmers do not carry out soil investigations for the purpose of determining these descriptors, but learn about them during land preparation and planting operations. Knowledge has evolved dramatically over the past decade as new agricultural technologies, especially mechanical tillage, have allowed literally a more "in-depth" perception of soil.

Sketch 1: Hand drawn agroecological map of Aarsal

3.b Ham-Maaraboun

i) Agroecological zones

This is the smallest of the 3 sites, and it covers the lands of the villages of Ham and Maaraboun. A meeting was held in each of the 2 localities, and the information was then integrated. The farmers and herders of Ham and Maaraboun identified 5 different agroecological zones (see sketch 2).

Zone 1: **The Eastern Mountains** area extending from Dahr Hakl Al Hassah passing by Ain Al Safsafeh till Ain Al Bounaya: mountainous and rocky with steep slopes; the soils are light red in color. Indicator plants are Juniper, Oak and *Crataegus spp*. Mostly used for grazing; this zone has the coldest climate.

Zone 2: **Shmiss** (south-east exposed slopes, receive more direct sunlight) including Shmiss Ham, Shmiss Baroukha and Shmiss Al Midan; it is a mountainous area with greyish/yellowish soils. Indicator plants: *Poterium spinosum* (Ballan) and Summac. 70% of the area is used for grazing, the rest is rocky. The climate is moderate, and recently, some lands have been reclaimed for orchards, mainly by the people of Ham.

Zone 3: **The Saky**. These are central flat lands and include Saky Ham and Saky Maaraboun. It is an irrigated area. It has heavy red soils which is high in fertility, no rocks, and is planted with fruit trees. It has the warmest climate.

Zone 4: **Highland-Mazareh**. These are small flat areas within the mountains which have been reclaimed and are used for agriculture. They are sometimes irrigated from nearby streams and springs. They are mainly planted with cereals and fruit trees. They have heavy red soils which can be very dark and are considered to be very fertile, such as the soils of Tallet el Saoudah. The rocks include Basalt and Sandstone. They have a cold to moderate climate.

Zone 5: **Lowland-Mazareh**. It is similar to the zone 4, except for the climate which is moderate.

Sketch 2: Hand drawn agroecological map of Ham-Maaraboun

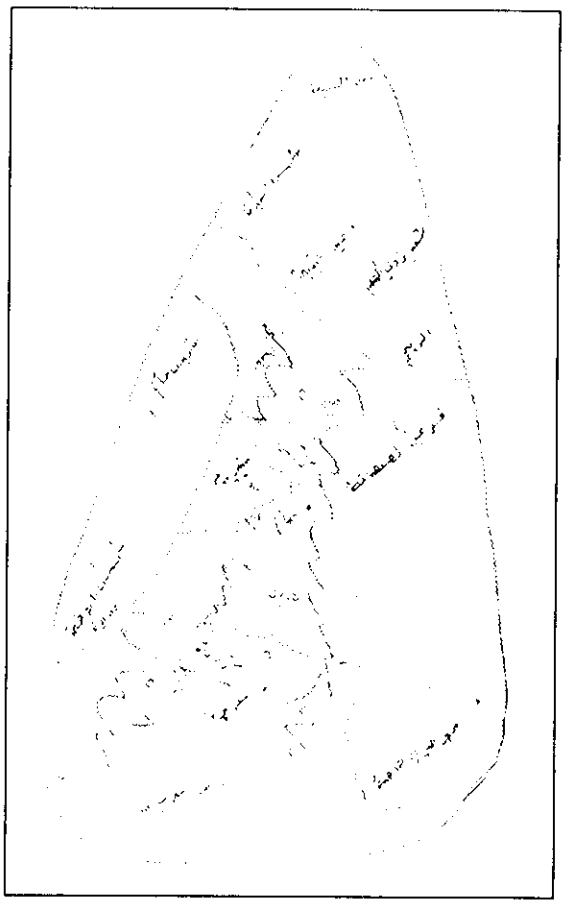


Table 2 summerizes the main agroecological characteristics of Ham-Maaraboun. Map 2 shows their geographic locations and extents.

ii) Soils

The specific soils knowledge that we were able to capture in Ham-Maaraboun was limited, although soil variability in this site is greater than elsewhere. As with other sites, fertility is perceived to be a combination of soil depth and color. Deep colors indicate higher fertility, as is the case with the soils of the Mazareh and the Soils of the Sakiy. It was not possible during the time frame of this consultancy to investigate further reasons for the lack of communication of the local knowledge.

3.c Nabha

i) Agroecological zones

The site of Nabha is divided into 5 agroecological zones, on the basis of general soil and climatic characters (see chart 1.) These zones are further divided into subzones depending on landform and related soils characters, specifically soil depth and rock outcrops. Only the main zones are described below, while the sub zones are reported on map 3.

Zone 1. **Ouyoun Ourghosh**. This zone extends from Dahr-El-Kadib at the eastern border of Nabha till Al-Korna Al-Alia. Land tenure is mostly communal. The climate is very cold. Most of the moisture is received as snow, which lasts from November till May, and renders the fields difficult to plough till early June. The vegetation is mostly sub-alpine shrubs and annuals. This zone is mostly used as for grazing and for cereal crops. We have to note that only a small part of this area is included in the project.

Zone 2. **The High Jurd**. Extends from Al-Korna Al- Alia till Al-Sawwana (excluded) and includes Al-Hamrat and Al-Tnoubat. Mostly communal land. The climate is cold and harsh. The snow cover remains till mid-end of April and the land is workable as of mid- May. Vegetation includes wild pear and plum trees. The land is very rocky. Some valley floors ("shouab") can be cultivated with wheat and barley but agriculture is rare, and this zone is mostly used for grazing. This is the uppermost limit of the wild almond, which is used to differentiate between the high jurd and the middle jurd.

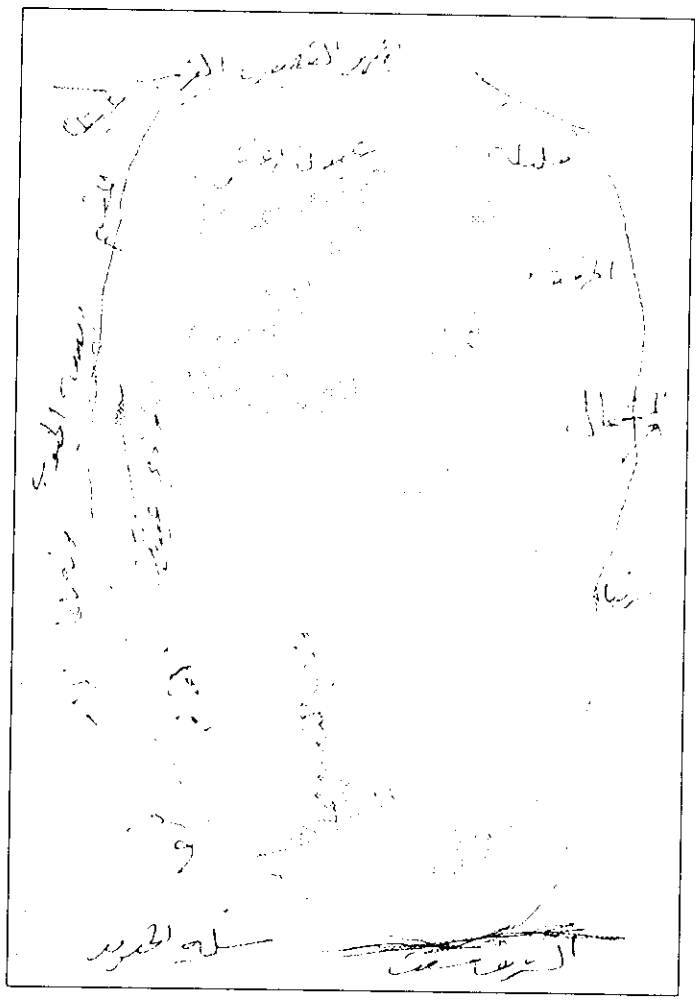
Zone 3: **The Middle Jurd**. Qornet el Hommos and Al-Sawwana. These lands are relatively flat and currently used for barley production. The climate is moderate and the soils are productive and suitable for agriculture. The land is workable as of the end of April, as the snow cover only lasts till mid April.

Zone 4: **The Low Jurd and the Wadis**. Al- Azra, Wadi Ghannit, Wadi Al-Damdoum, Qornet el Qasr, Mrah el Khokh. These lands have good, deep soil and moderate climate, and are generally considered to be the most suitable for agriculture in the mountainous zone of Nabha, as the snow only lasts till the end of March, which makes the land workable as of early April. Mostly under private tenure, these lands form the backbone of the fruits production in Nabha. They are however prone to water erosion as they receive a significant quantity of rainfall. A recent flood washed away much of the soil and people deserted their lands seeking for jobs in the city. Nowadays, agriculture has declined, and an oak forest ecosystem has replaced the

orchards and fields. This is not without economic value as the oak trees are used for heating and charcoal production.

Zone 5: **Al-Sahl**. This is the land leading to the Bekaa plain. The slopes are mild and the climate moderate, with snow remaining till mid-March, making the land workable as of early April. The main crops include: wheat, barley, chickpea, lentils and vetch. Tobacco has been recently introduced.

Sketch 3: Hand drawn agroecological map of Nabha



ii) Soils

Indigenous soil knowledge in Nabha is well developped and the local classification relies on difened characters. Soils are generally differentiated on the basis of Tibah and Tarawah, two indicators that reflect:

a. Fertility and absence of rock (Tibah)

b. Consistency and crusting (a combination of water relation, texture and clay types) (Tarawah)

The fertility of the soils is further related to soil color, with the darker colors indicating higher fertility. In Nabha, 3 soil types were identified on the basis of color.

a. The Red soils, with 5 sub-types arranged as a catena that reflects the depth of the red color Sahl (deepest red) low Jurd (Damdoum) Middle Jurd (Sawwanah) High Jurd (Hamrat) and the Dhour (lightest). Red soils of the elevation are believed to be more appropriate for trees as they give "coolness". Our observations indicated that they are better structured and more decalcified, which results in granulation and better drainage

b. The Black soils, thought to be the most fertile (Tariyyeh)

c. The White soils of the Dhour elevations. These are the least fertile, although they are free of rocks and retain moisture longer due to their fine texture and their poor structure.

4. Notes and conclusions

One of the outcomes of this study was the understanding and description of the indigenous agroecological zoning process. The process is systematic, and integrates climate and soil attributes (Chart 1).

It appears that soil depth and soil color are the most important descriptors in the indigenous soil classification in the 3 sites. Soil depth has direct implications on crop yield and moisture reserve. Soil color is the second descriptor in the indigenous soil taxonomy, as it is locally believed to be related to fertility. Light colored soils (locally described as pale yellow or grayish) are believed to be less fertile than red or brown soils. Field survey data in Aarsal showed that soil color ranged from strong brown (7.5YR 5/6) to very pale brown (10YR 7/4), and that there was a positive association between color and total CaCO3 content.

Several studies of Lebanese soils (Gèze, 1956, Lamouroux, 1972; Darwish and Zurayk, 1997) confirm the CaCO3/color association. For instance, under good drainage, soils formed on hard limestone (such as the Aarsal soils) will become decarbonated and rubefied, which imparts them with a characteristic reddish color. These same soils will remain brown and calcareous if drainage is insufficient to induce decalcification and oxidation of Fe, which is the case of most of the soils of Aarsal. Where erosion is intense, and AC horizons evolve, these are often lighter in color due to the contribution of the weathered parent material, hence the lighter shades and the large $CaCO_3$ content. Thus, it appears that a connection between $CaCO_3$ and specific aspects of soil fertility may be justified, especially at very high levels of $CaCO_3$.

Soil texture and water relations (a combination of permeability and moisture holding characteristics) constitute the third descriptor. Finally, the presence of a limitation, such as a petrocalcic horizon serves as a fourth descriptor. Thus, in their indigenous soil classification, the local community relies on physical factors that can be observed visually. This supports earlier findings (Kundiri et al., 1997, Briggs et al., 1998), which show color and texture to be the key soil characteristics for farmers in Nigeria and Egypt.

The agroecological zones formed the basis for the initial soil investigations, and, as a result, the geographic distribution of soil units in the map that was produced was meaningful to the PRA participants. It must be noted, however, that a map in which soil units are represented as clearly delineated polygons falls short of fully reflecting the local soils knowledge. The discussions that were held after the map was presented to the community revealed that soils are not perceived by the local people as clearly defined patches on the landscape, with well delineated boundaries. They form a continuum in which different soil types intergrade into one another, in a perspective that more faithfully represent reality. When asked to name the

soil in a land area of manageable size, farmers will often answer "mostly this, with some of that". This soil naming process, which does away with boundaries, is very similar to that used in Highland New Guinea (Sillitoe, 1998), and allows flexibility to adapt to changes in the landscape, which is necessary in the dissected highland areas where the relief can create a multitudes of soil types. This process conflicts, however, with the classical soil mapping approach in which parcels with specific landscape characters are represented as clearly delineated polygons.

It is also interesting to note that people's perception of size is strongly influenced by the importance of the land resource type in their livelihoods. For example, when comparing the 2 maps, we note that the Ham group has drawn an oversized Mazraa for Ham and a small Sakiy for Maaraboun area. The opposite is seen for the Maaraboun map
Maaraboun relies mainly on its large Sakiy for agricultural production while Ham's relies mainly on its Mazareh

5. List of local participants in the investigations

Aarsal

Khaled al Shabb Member in the ARDA (local association)
Kassem al Shabb President of ARDA
Mohammad Fleity, Farmer
Ali Mustafa Kronbeh Farmer
Abou Ahmad Fleity Livestock herder

Ham and Maaraboun

In Ham:

Hassan Mourad, Mayor
Talal Mourad, Farmer
Ali Mourad, Farmer
Majed Mourad, Farmer
Ali Abbas, Farmer

In Maaraboun:

Hassan Kassem, Farmer
Attieh Yehya, School teacher
Mohammad Abd-El-Majid, Farmer

Nabha

Nadim Amhaz: Sheep herder and bee keeper
Mohammad Amhaz: Farmer
Hussein Amhaz: University student. Helps his father and uncle during his free time in those activities he deems would let him gain some experience
Hussein Khattar Amhaz: Farmer

Table 1. Indigenous agroecological zones and their characteristics in Aarsal

Ecozone	Landform	Land cover/Land use	Climatic characters
Low Jurd	Steep lands, abrupt, rocky	Grazing, quarrying, some grapes and annual cropping	Snow: December-mid-March Frost: December-April
Middle Jurd	Hills and some flat depressions > 10 ha	Cherry and apricot orchards. Orchards on 15° slopes, few soil conservation practices	Snow: Mid November- April Frost: October-April
High Jurd	Narrow erosion terraces, small fields between hills	Wheat/chickpea, some cherry orchards, Pastoralism	Snow: November-April Frost: October-mid-May
Eastern area	Mostly steppic plain dissected by flood routes and bordered with foothills	Mostly pastoralism, with overwintering sites Vegetation dominated by *Artemiasa herba-alpa*	Windy Snow: December-March extending to mid-April on the foothills Frost: as snow
Western area	Hilly with encased valleys	Cherry-apricot orchards, vineyards. Presence of *Poterium spinosum*, locally considered as an indicator of temperate microclimate	Snow: Occasionally in January-February Frost: January-March
Wadis	Valleys of the Low Jurd hills. Old terraced fields with some flood control measures	Vineyards, figs. Urban expansion	Snow: December-mid-March Frost: December-mid-March

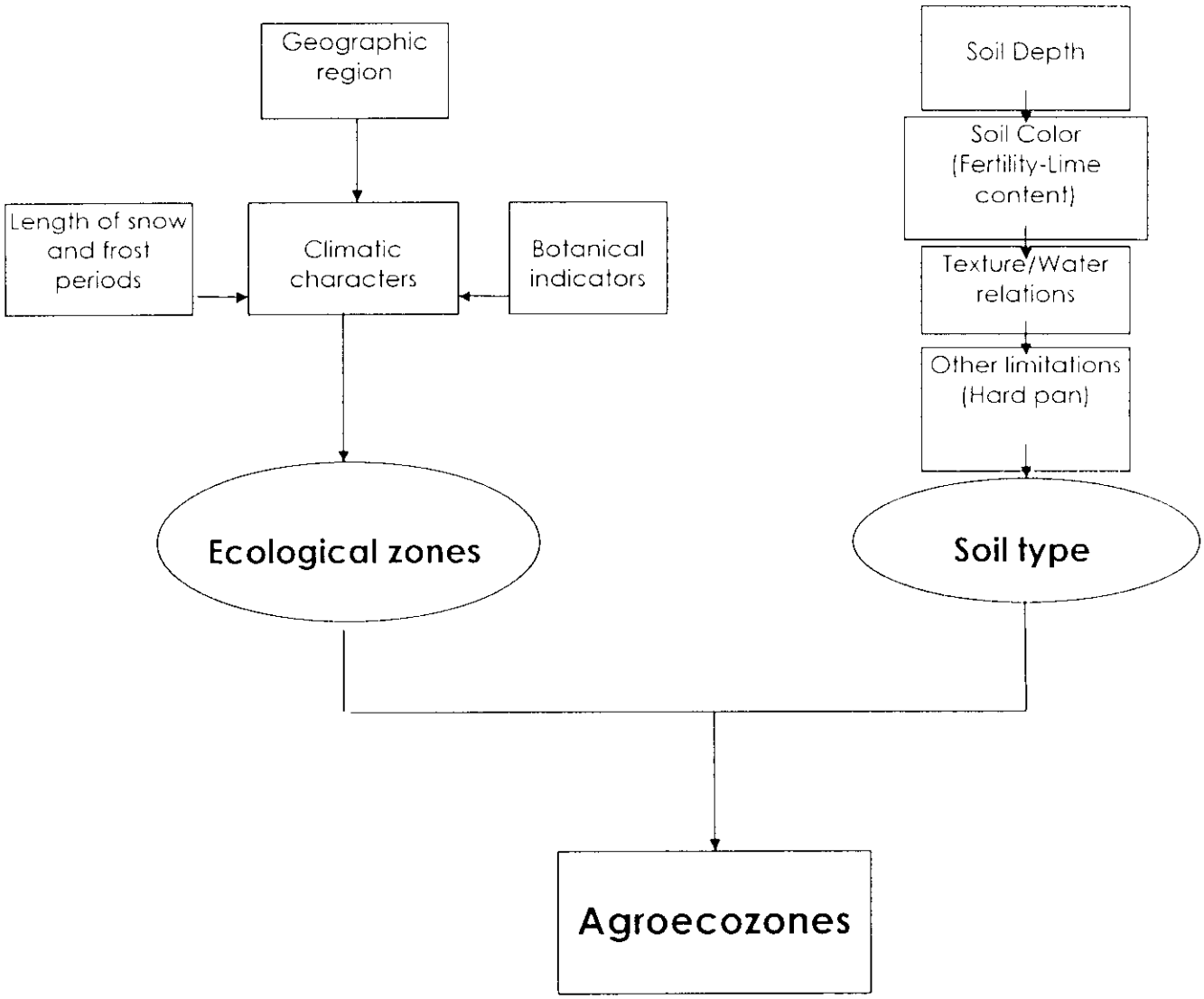
Table 2 Indigenous agroecological zones and their characteristics in Ham-Maaraboun

Ecozone	Landform	Land cover/land use	Climatic characters
Eastern Mountains	Mountainous and rocky with steep slopes	Zaarour (indicator plant), 95% of the area used for grazing	Cold climate
Shmiss	Mountainous area	*Poterium spinosum* (Ballan) and Sumac (indicator plants), 70% of the area used for grazing	Moderate climate
Saky	No rocks Irrigated area	Fruit trees	Warm climate
Highland - Mazareh	Flat areas Irrigated	Cereals and fruit trees	Cold-moderate climate
Lowland - Mazareh	Generally flat areas Partly irrigated	Cereals and fruit trees	Moderate climate

Table 3 Indigenous agroecological zones and their characteristics in Nabha

Ecozone	Landform	Land cover/land use	Climatic characters
Ouyoun Ourgosh	Mountain, steep slopes	Xerophytes, bushes, annuals Used for grazing	Hard climate Snow remains till May
High Jurd	Rocky-steep	Wild almond, bushes	Hard-moderate Snow till end April
Middle Jurd	Rocky, some cultivated "shouab".	Wild pear and plum trees	Moderate climate. Snow: remains till mid-April
Low Jurd	Wadis and slopes	Cereal crops, tobacco and fruit trees. Oak, pistachios, cherry, almond and pear trees	Warmer climate Snow: remains till end of March
Al Sahl	Plain, hills	Wheat, barley, chickpea, lentils, kersanneh, newly tobacco has been introduced	Moderate climate Snow remains till mid-March

Chart 1: Framework for indigenous ecological zoning.



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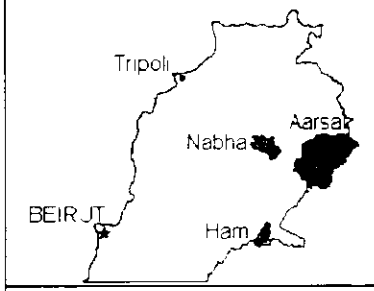
Map no. 1

Agroecological zoning

Site: Aarsal

Legend:

- Low Jurd
- Eastern Area
- High Jurd
- Middle Jurd
- Wadis
- Western Area
- Village



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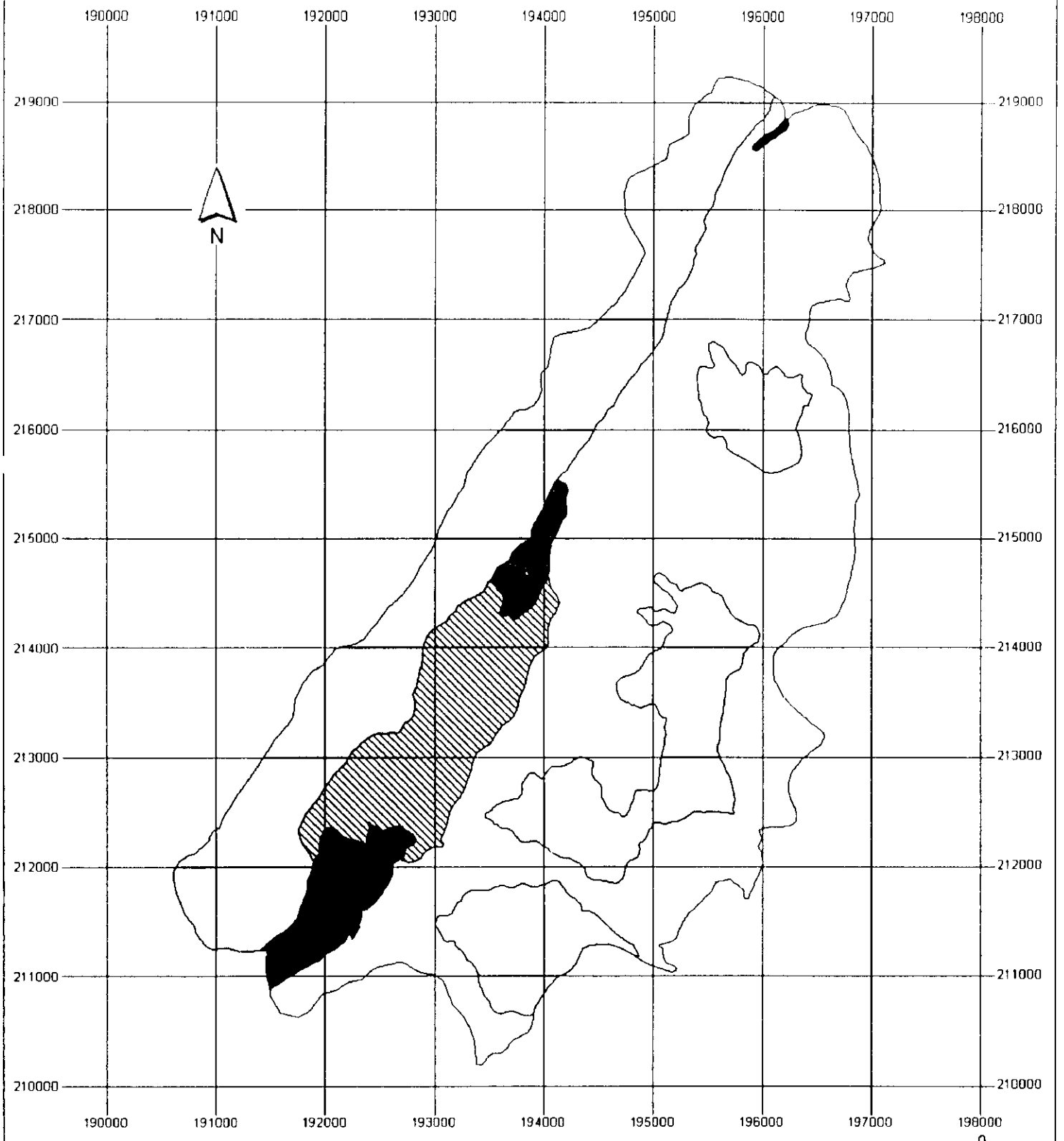

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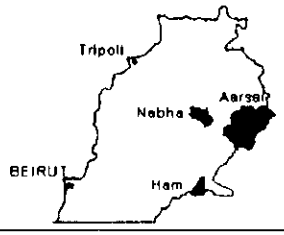

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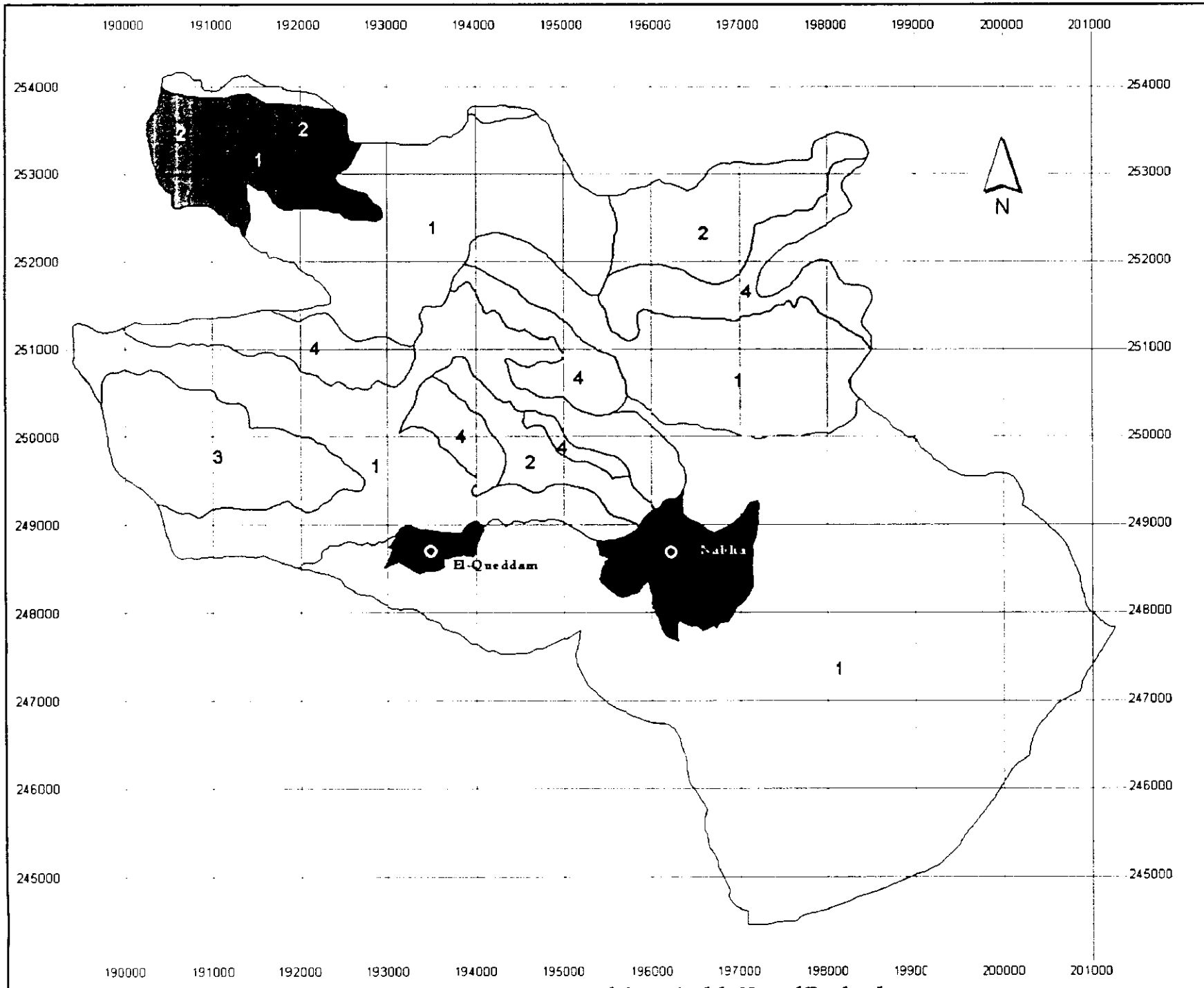
Legend:
- Saky
- Lowland-Mazareh
- Highland-Mazareh
- Eastern mountains
- Shmiss
- Villages

Map no. 2

Agro-ecological zones

Site: Ham-Maaraboun



Map no. 3

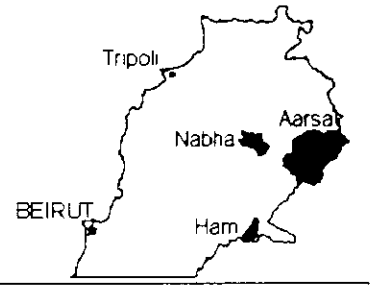
Agro-ecological zones

Site: Nabha

Legend:

- Sahl
- Low Jurd
- Middle Jurd
- High Jurd
- Ouyoun Ourghosh
- Villages

1. Deep productive soil with little limitations for agriculture
2. Rock outcrops + lithic soils
3. Discontinuous soils
4. Natural soil under rock fragments



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CONSERVATION AND SUSTAINABLE USE OF DRYLAND AGROBIODIVERSITY IN LEBANON
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Preliminary agroecological zoning and target site selection

Rami Zurayk PhD

1. Introduction: Project background. Tasks/TORs

This is the first report submitted to the UNDP's "Conservation and Sustainable Use of Dryland Agro-Biodiversity" project as partial fulfillment of the contract established between The UNDP and Dr. Rami Zurayk in his capacity as soil conservation and management specialist. This report covers Task 1"Site selection and preliminary agro-ecological classification" as detailed in the terms of reference attached to the consultant's contract.

2. Materials and methods

2.a Definition of terms

Target site: Locations in the Baalbeck area where project activities are focused (Map 1). These target sites cover the various ecological environments of the Baalbeck regions and include:

Aarsal: Mountainous arid zone located in the north of the Anti Lebanon range.

Ham-Maaraboun: Mountainous semi-arid zone located in the central Anti-Lebanon range.

Nabha: Mountainous/plain located on the eastern slopes of the Lebanon range.

Monitoring sites: Areas within target sites where project activities are to be undertaken and changes in biodiversity monitored (Figure 1).

2.b Approach

i) Preliminary agroecological zoning

The preliminary agro-ecological classification was conducted following the standard procedure of integrating climatic information (in this case mean annual rainfall data) with land information (soils and topography). In or case, the integration is coarse because a) the sources of data have limited reliability due to measurement methods, type of data (for instance, mean annual rainfall should not be used as a single climatic indicator), and the scale of the maps from which some of the data was extracted (1:200,000). It is our opinion, however, that information on Mean Annual Rainfall is overestimated, especially regarding the precipitations received in the past 10 years. The data from the rainfall map was extrapolated from 1960 climatic data, none of which was obtained from weather stations located within the sites. However, this is the best available data, and it can give a good indication of the different ecological zones of the 3 sites when used with caution. Whenever there was a need, information pertinent to the geology of the sites and to the

current land use were also used in order to refine the process of selection of the target areas.

ii) Monitoring site delineation

The monitoring sites were delineated through discussions with the project team, based on the results of the preliminary agroecological zoning and on the initial data obtained by the project team and the consultants. This data is specifically related to the presence of project target species.

2.c Data sources

i) Elevations map

The contours map (50 m intervals) was manually digitized from the 1:20,000 maps developed by the Department of Geographic Affairs of the Lebanese Army (1962). The slope map was derived from the contour map using ArcTIN and DTM, by generating a tin from which a grid was derived. The grid was then converted to slope polygon coverage with the desired slope classes in Arc View.

ii) Rainfall map

This map was manually digitized from the 1:200,000 map developed by the Department of Geographic Affairs of the Lebanese Army (1962). The information combines rainfall and snow precipitation.

iii) Soils map

A soil map of every site was clipped from the digitized soil map of Lebanon (Gèze, 1956) published by the Ministry of Agriculture of Lebanon. This map (1:200,000) was produced using aerial photographs as well as geological and topographical maps for delineating soil mapping units, which are identified using a French-based classification system. This classification system will be used in this report. However, the soil names will also be translated into English.

iv) Land cover/land use map

The land cover/land use map was extracted from the digital land cover/land use map produced from Landsat images, published by the FAO (1990) and digitized by Khatib and Alami consultants. The scale of the map is 1:50,000. Field visits allowed the ground truthing of the land use types.

3. Preliminary Agroecological zoning

3.a Aarsal

i) Topography

The largest of all sites (290 km^2), Aarsal has also the most varied topography. Elevations span from 1,400m to 2,600m AMSL. In practice, most accessible areas are located below 2,200m, as the remaining area forms the Syrian-Lebanese No Man's Land. The landscape is generally dessicated and consists of a large Eastern Area (Badia), the valleys surrounding the village (Wadi), which include the western area of Aarsal, and the mountainous zone (Jurd) (Map 1).

ii) Soils

The soils of Aarsal are mostly discontinuous (presence of significant rock outcrops). The most common soil type, covering 60% of the territory, is the Yellow Mountain Soils (Sols Jaunatres de Montagne), located in the Highlands (Jurd). The soils of the Eastern area consist of an association of grayish soils (Sols Blancs Grisatres) and of yellow subdesertic soils (Sols Jaunatres Subdesertiques). These cover a further 15% of the area. The discontinuous Terra Rossa (Sols Rouges Discontinus) forms the soils of the Wadis and constitute 10% of the soil resources. Map 1 shows the geographical distribution of these main soil types, and Table 1 shows their main characteristics.

iii) Rainfall

According to the rainfall map of Lebanon, the Aarsal area is divided into 3 main rainfall areas: a highland area receiving 500mm annually, a middle area receiving 400-500mm and a lower elevation area receiving 300-400mm. The validity of this data is, however, limited. From personal experience of the area and some preliminary measurements, we believe that there are 3 main rainfall zones: The Jurd, which receives up to 350 mm/year including snowfall, the Wadis, including the Western area, which receive around 250 mm/year and the Eastern area receiving less than 200mm/year (Map 2).

iv) Preliminary zoning

Based on the integration of the topography, soils and rainfall (as amended by our observations), we can delineate three main ecozones in Aarsal (Map 3):
The Eastern area, mostly flat with minor hills, receiving very little precipitation. The area is mostly used for grazing and the range is very degraded.
The Wadis and Western areas where the precipitation are adequate for supporting semi-arid vegetation especially in the wadis where rainfall is

naturally harvested in the valley floors. The area is mostly planted to grapes with some annual cropping.
The Jurd, where most of the precipitation is received as snow. This area used to be grazed but is now being converted to cherry and apricot orchards which are adapted to the soils and the climate.

v) Monitoring site selection

One large target area subdivided into 2 sub-areas was selected to cover most of the Wadis and part of the Western Jurd area. The degraded Eastern area was not represented due to its ecological and land use status. The total area of the monitoring site is 44.6 km^2 (Map 3).

3.b Ham

i) Topography

Ham-Maaraboun is the smallest of all sites. It consists of a depression starting at 1300m ASL, and running NE, bordered on the eastern side by a ridge reaching a maximum elevation of 1,900m (Map 4).

ii) Soils

Most of the soils of Ham-Maaraboun belong to the discontinuous red soils (45%). On the elevated summits the yellow mountain soils dominate, while mixed soils "Sols de Mélange", formed on the early cretaceous geological formation may be found in appreciable quantities (34%) between 1700m and 1900m. These soils are especially interesting for agrobiodiversity as they include sandy patches as well as basaltic patches (Table 1 and Map 4).

iii) Rainfall

Ham-Maaraboun falls within one rainfall zone, 500-600mm/year. However, as with the other sites, the validity of this data is limited and values are probably overestimated by 100mm (see section 3.iii).

iv) Preliminary zoning

The integration of the elevation, rainfall and soil data allows the preliminary zonation of three areas: The "lowland" dominated by the discontinuous red soils, The middle elevation lands, dominated by the "sols de melange" and the crests, dominated by the yellow mountain soils (Map 5).

v) Monitoring site selection

Based on the above analysis, a monitoring site covering the three soil types and the elevation ranges in the form of a transect was selected (Map 5). The

size of the selected monitoring is 10 km^2 and includes nearly all the terrain variations.

3.c Nabha

i) Topography

Nabha's site (60 km^2) is divided into 2 distinct topographic areas each occupying nearly 50% of the total area: the Lowlands, with limited slope, spanning between 950m and 1200 m, and the Highlands (jurd) within an elevation range of 1200-1900m (Map 6).

ii) Soils

The majority of the soils of Nabha belong to the discontinuous red soils group (53%). Other discontinuous red soil associations in the low elevation zone cover a further 40%. Thus, except for patches of yellow mountain soils and white Renzinas (sols blancs grisatres), Nabha's soils can be clearly divided into 2 interrelated pedological formations, the characteristics of which appear in table 1 (Map 6).

iii) Rainfall

The Nabha site spans over a broad range of rainfall regimes, due in great part to the broad elevation range. The lower plain is located in the 400mm-500mm rainfall regime, while precipitations can exceed 700mm on the highlands (including snow). However, the limitation to the rainfall data presented in section 3.iii apply to the Nabha site (Map 7).

iv) Preliminary zoning

Based on the combination of elevation, rainfall and soils, 2 general zones can be identified: 1) The Lowlands, relatively flat, with an elevation range of 900-1200m, a rainfall regime of 350mm-450mm and discontinuous red soils associations with or without hard pans; 2) the Highlands, (1200m-1900m) dominated with discontinuous red soils, with a steeper terrain and falling within the 500-700mm rainfall zone. These receive most of their precipitation as snow (map 8).

v) Site selection

A target area that represents the Highlands and the Lowlands, with particular emphasis on the highland zones, (as the lowlands are mostly used for semi-intensive cropping) was selected (Map 8). The uppermost elevation zone, with yellow mountain soils, was not included as it limited in area, generally denuded and poorly accessible. The area of the monitoring site is 17 km^2.

Table 1: Soil type characteristics

Soils	***Texture***	***$CaCO_3$ content***	***pH***	***Fertility***	***Current agricultural uses***	***Limitations***
Discontinuous red soils	Generally clayey	Calcareous, but can be decalcified	Neutral	Variable but generally good	Almond, figs, olives, vines, tobacco, vegetables	Discontinuous
Rouges discontinus	*Généralement argileuse 30-60%*	*Calcaires mais peuvent être décalcifiés*	*neutre*	*Variable mais généralement favorable*	*Amandiers, figuier, olivier, vignes, tabac, cultures maraîchères*	*discontinus*
Alluvions	Fine sands, silts	High 20-60% 4-30% active	Alcaline 7.2	Intermediate	----------	----------
Alluvions	*Sables fins, limons, argile très rare.*	*Riche en calcaire 20-60%* *4-30% actif*	*Alcalin 7.2*	*Moyennement riche*	----------	----------

Soils	***Texture***	***$CaCO_3$ content***	***pH***	***Fertility***	***Current agricultural uses***	***Limitations***
Discontinuous yellow mountain soils (Discontinuous)	Coarse Clay 20-40%	Low 3-10%	Slightly acidic 6.4-7%	Very variable, generally good	Wooded, used to be cedar, juniper, fir...	Discontinuous
Jaunâtre de Montagne (discontinus)	*Eléments grossiers* *Argile 20-40%*	*Faible en calcaire 3-10%*	*Légèrement acide 6.4-7%*	*Très variable, nettement favorable.*	*Boisé, autre fois cèdre, genévrier, sapin...*	*(discontinus)*
Mixed soils on calcareous marl and sandstone	Balanced	High 30-60% 5-20% active	Neutral 6.9-7.1	Balanced	Fruit trees, for all cultivations except intensive cereals production	Risk of chlorosis Risk of landslides
de mélange discontinus sur marnes calcaires et grés siliceux alternant	*Equilibré*	*Forte* *30-60% total* *5-20% actif*	*Neutre* *6.9-7.1*	*équilibré*	*Fruitiers, toutes les cultures sauf les céréalières de caractère intensif*	*Risque de chlorose* *Dangers de glissements et éboulements en grande masses*

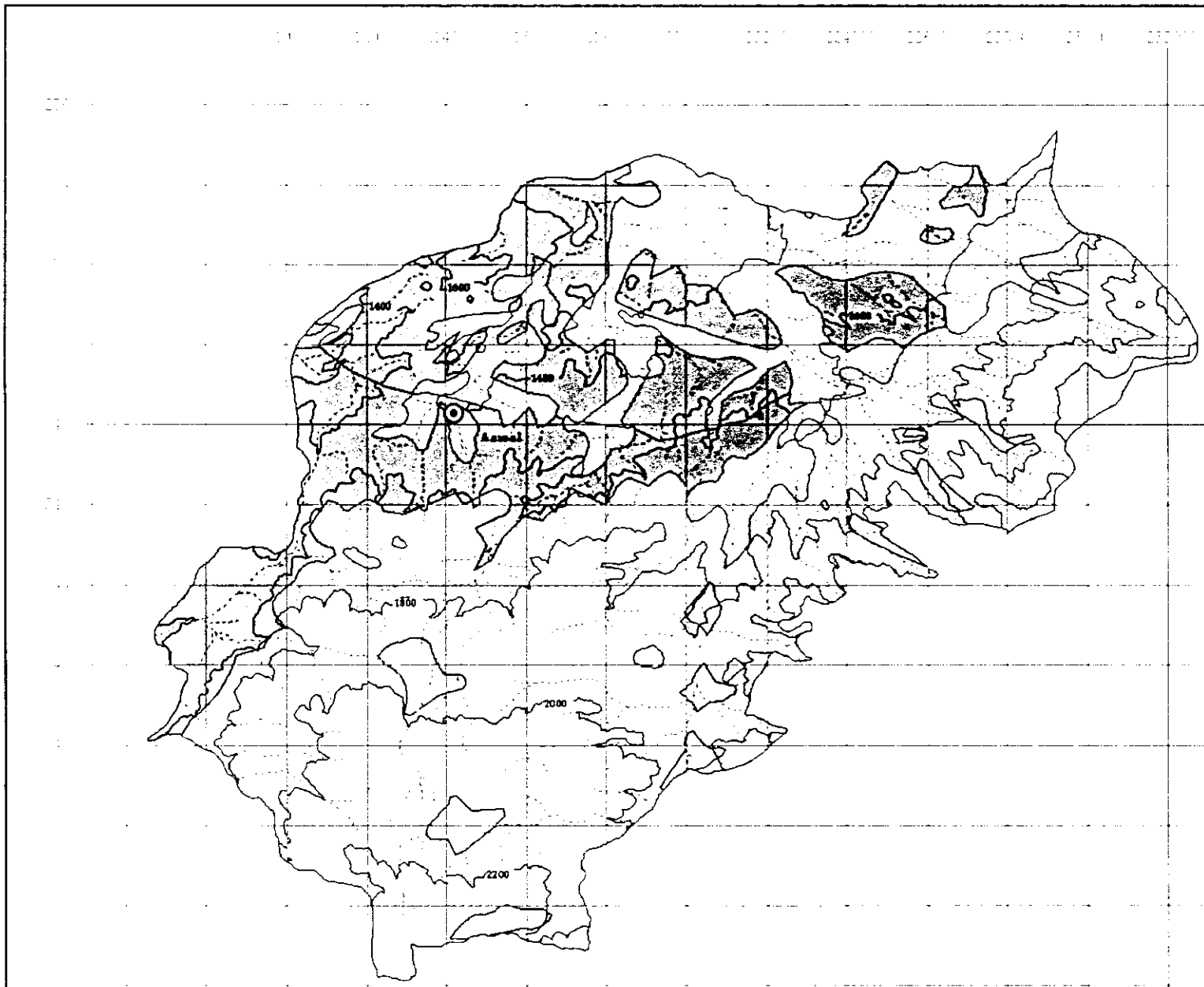
Soils	***Texture***	***$CaCO_3$ content***	***pH***	***Fertility***	***Current agricultural uses***	***Limitations***
White rendzimes, grayish soils (Discontinuous)	< 20% clay	60-80% total 20-40% active	Alcaline 7.2-7.6	Weak	Sparsely covered Olives, walnut, vines, some woodlands	Surface can be crusty (Discontinuous)
blanc grisâtre - rendzimes blanches- *(discontinus)*	*< 20% argile*	*60-80% total* *20-40% actif*	*Alcalin* *7.2-7.6*	*Sols pauvres* *Forte chlorose*	*Parfois nu et désolé.* *Oliviers, noyers, vignes, certaines boisements*	*Tendance à se recouvrer d'une croûte calcaire* *(discontinus)*
Light brown	Silty clay Clay 15-25%	Relatively high 15-30% total 4-7% active	Alcaline 7.4-7.6	Intermediate	---------	Calcipan in sub soils
Châtains claires	*Limono-sableux* *Argile 15-25%*	*Relativement elevée* *15-30% total* *4-7% actif*	*Alcalin* *7.4-7.6*	*Moyennement riche*	---------	*Accumulation dans l'horizon inférieur d'une croûte calcaire*

Soils	***Texture***	***$CaCO_3$ content***	***pH***	***Fertility***	***Current agricultural uses***	***Limitations***
Discontinuous black or grey	Very clayey Clayey-calcareous	Very variable usually high 3.5-87% total 0-36% active	Alcaline 7.2-8	Variable, generally intermediate. Low horizons have weak fertility	Cereals	Can be very productive with fertilizers applications
Noirs ou gris discontinus	*Très argileux* *Argilo-calcaire*	*Très variable, habituellement forte* *3.5-87% total* *0-36% actif*	*Alcalin* *7.2-8*	*Variable, richesse moyenne apparente.* *Les horizons inférieurs pauvres*	*Céréales*	*Emploi des engrais + grainage on atteindrait réellement une grande fertélité.* *Discontinus*
Yellow subdesertic stony	Fine sand 35-65% Clay 4-11%	Significant 30-45% total 4-20% active	Alcaline 7.4	Low	----------	Need irrigation
Jaunâtre subdésertique + cailloutis	*Sable fins 35 à 65%* *Argile 4 à 11%*	*Considérable* *30-45% total* *4-20% actif*	*Alcalin 7.4*	*Pauvres*	----------	*Pas d'exploitation agricole sans irrigation*

Map no. 1

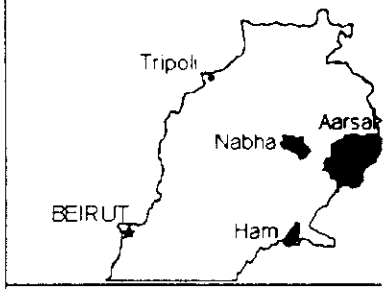
Soils

Site: Aarsal



Legend:

- Streams
- 200m Elevation contours
- Sols blancs grisatres discontinus associés à des sols noirs ou gris discontinus
- Sols chatins clairs steppiques associés à des sols rouges
- Sols jaunatres de montagne
- Sols jaunatres de montagnes associés à des sols blancs grisatr + Cailloutis et blocs
- Sols jaunatres de montagnes discontinus
- Sols jaunatres subdesertiques + Cailloutis et blocs residuels
- Sols rouges discontinus associés des sols noirs ou gris discontinu



Scale: 1/150000

2 0 2 4 Km

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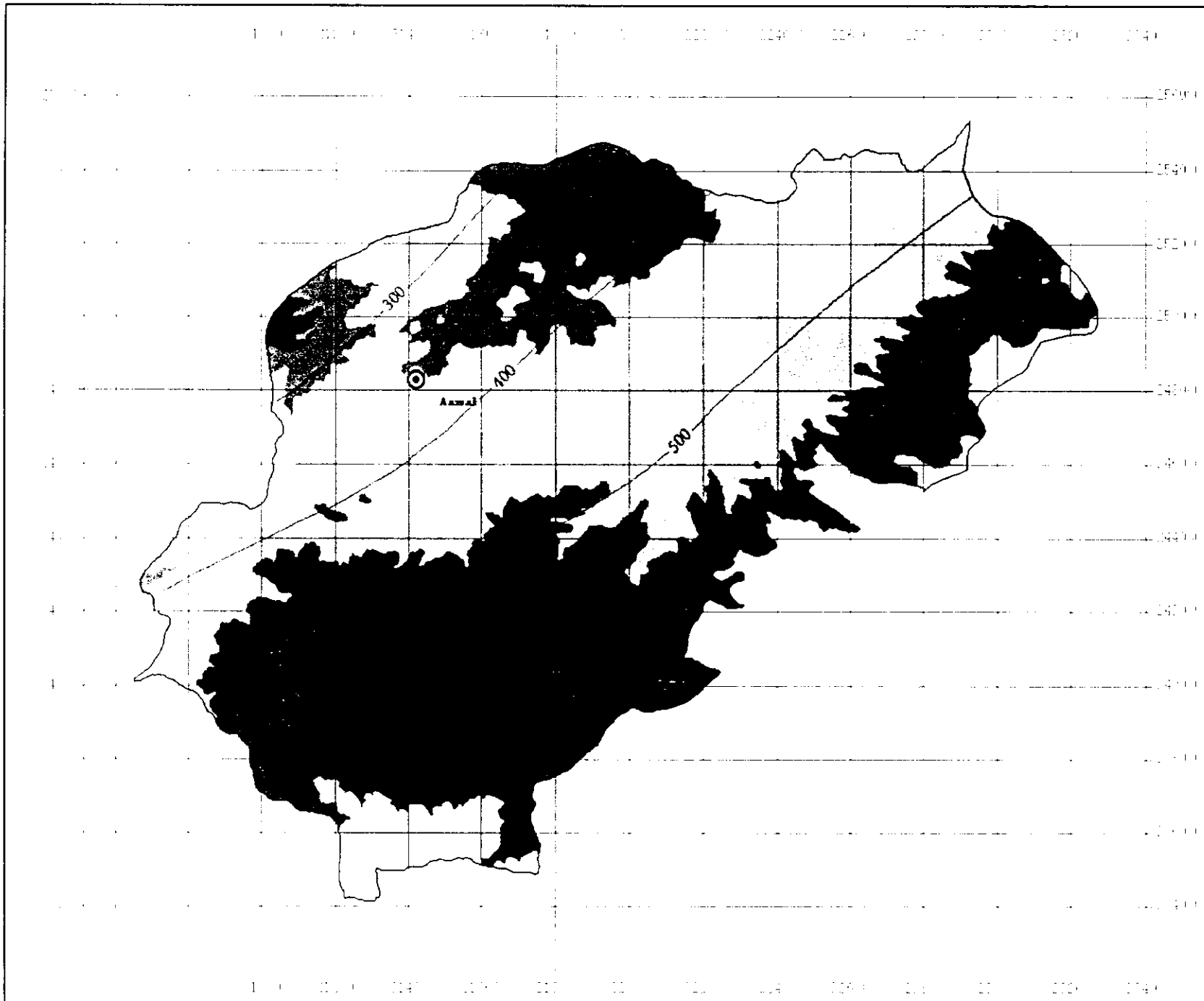
Map no. 2

Elevation & rainfall ranges

Site: Aarsal

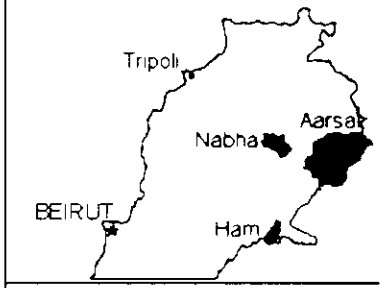


Legend:

100m rainfall contour

Source: Carte pluviometrique du Liban, 1971

1000-1200
1200-1400
1400-1600
1600-1800
1800-2000
2000-2200
2200-2400



Scale: 1/150000

2 0 2 4 Km

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Map no. 3

Preliminary zoning & monitoring site

Site: Aarsal

Legend:

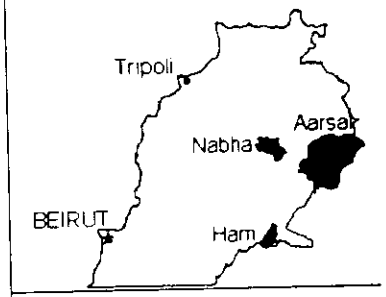
Monitoring site boundari

Village

Eastern Area

Jurd

Wadis



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Scale: 1/150000

2 0 2 4 Km

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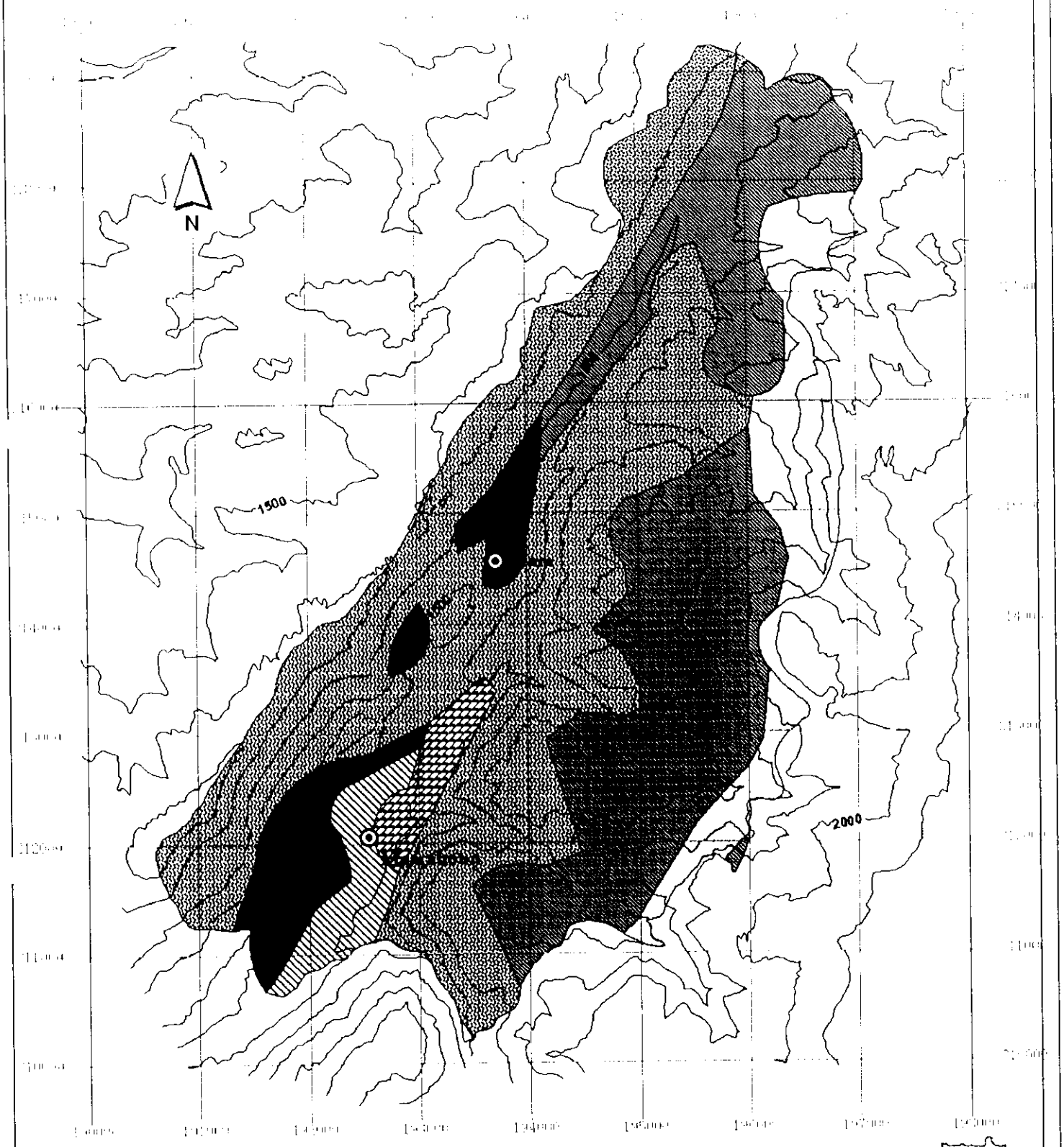

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Scale: 1/50000
0 1 2 Km

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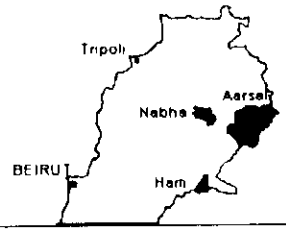

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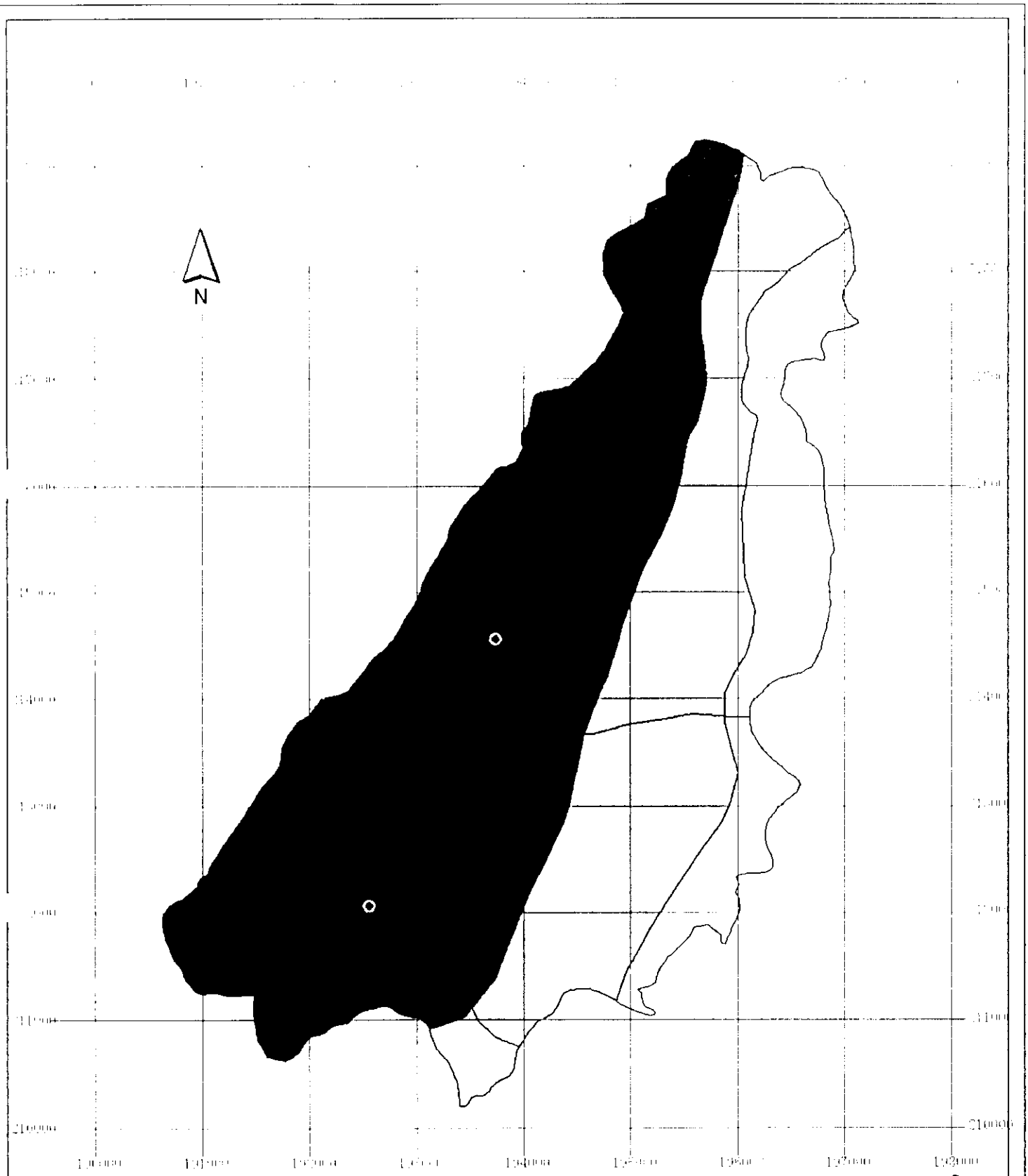
Legend:
- Alluvions fluviatiles récentes
- Eboulis et glissements en masse
- Sols de mélanges (discontinus) sur marnes, calcaires et grès siliceux alternant
- Sols jaunatres de montagnes discontinus
- Sols rouges discontinus
- 100 m contour lines

Map no. 4

Soils



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Scale: 1/50000
0 1 2 Km

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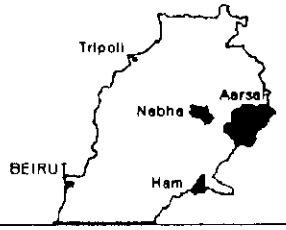

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Legend:

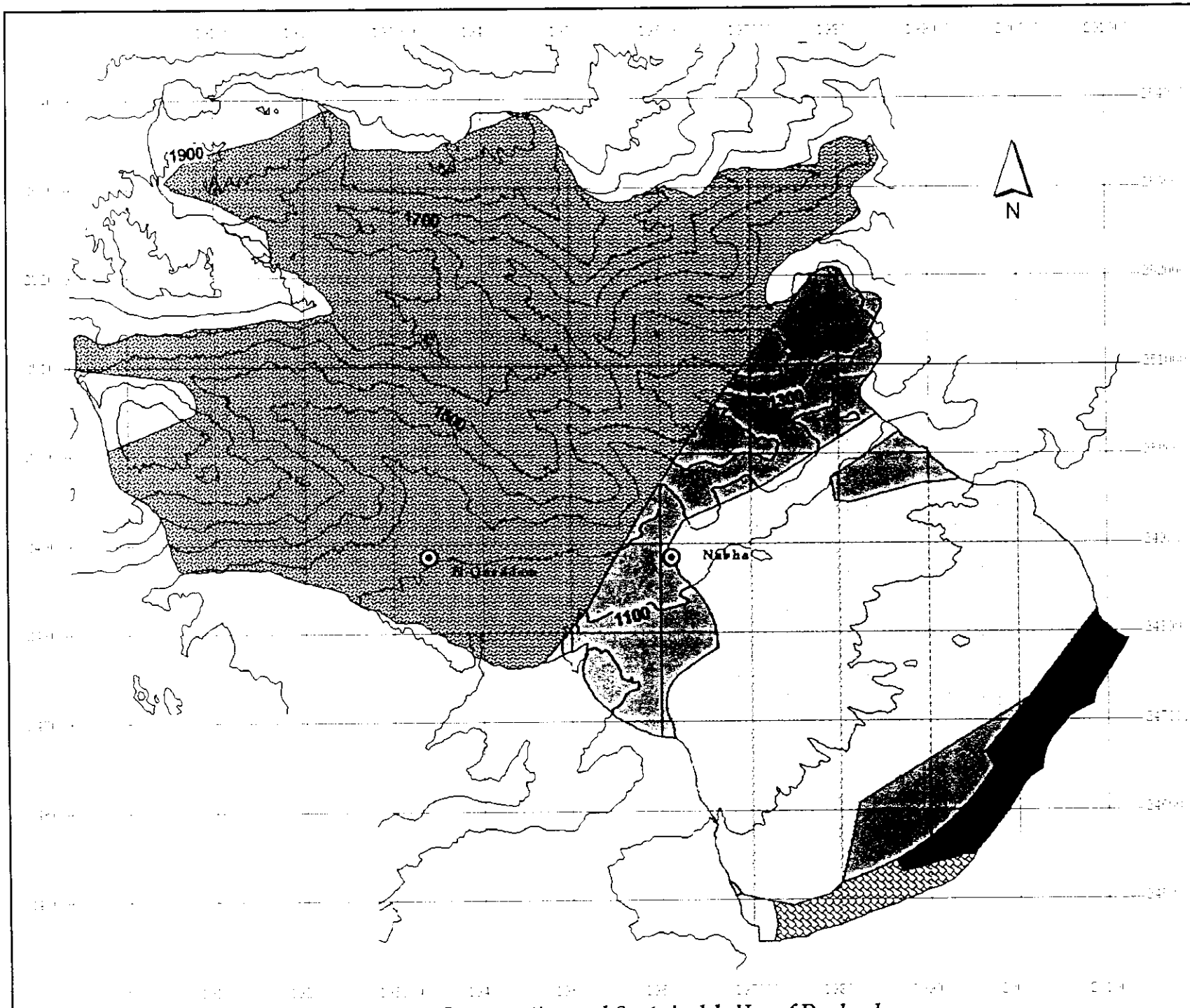
Monitoring site boundaries

Crests

Middle elevation lands

Map no. 5

Preliminary zoning & monitoring site



Map no. 6

Soils

Site: Nabha

Legend:

- 100m Elevation contours
- Alluvions associés à des sols chatins clairs
- Cones de déjection torrentiels
- Sols blancs grisatres
- Sols jaunatres de montagnes discontinus
- Sols rouges discontinus
- Sols rouges discontinus associés à des sols noirs ou gr discontinus
- Sols rouges discontinus associés à des sols noirs ou gr discontinus + Poudingues

Scale: 1/60000 0 1 2 Km

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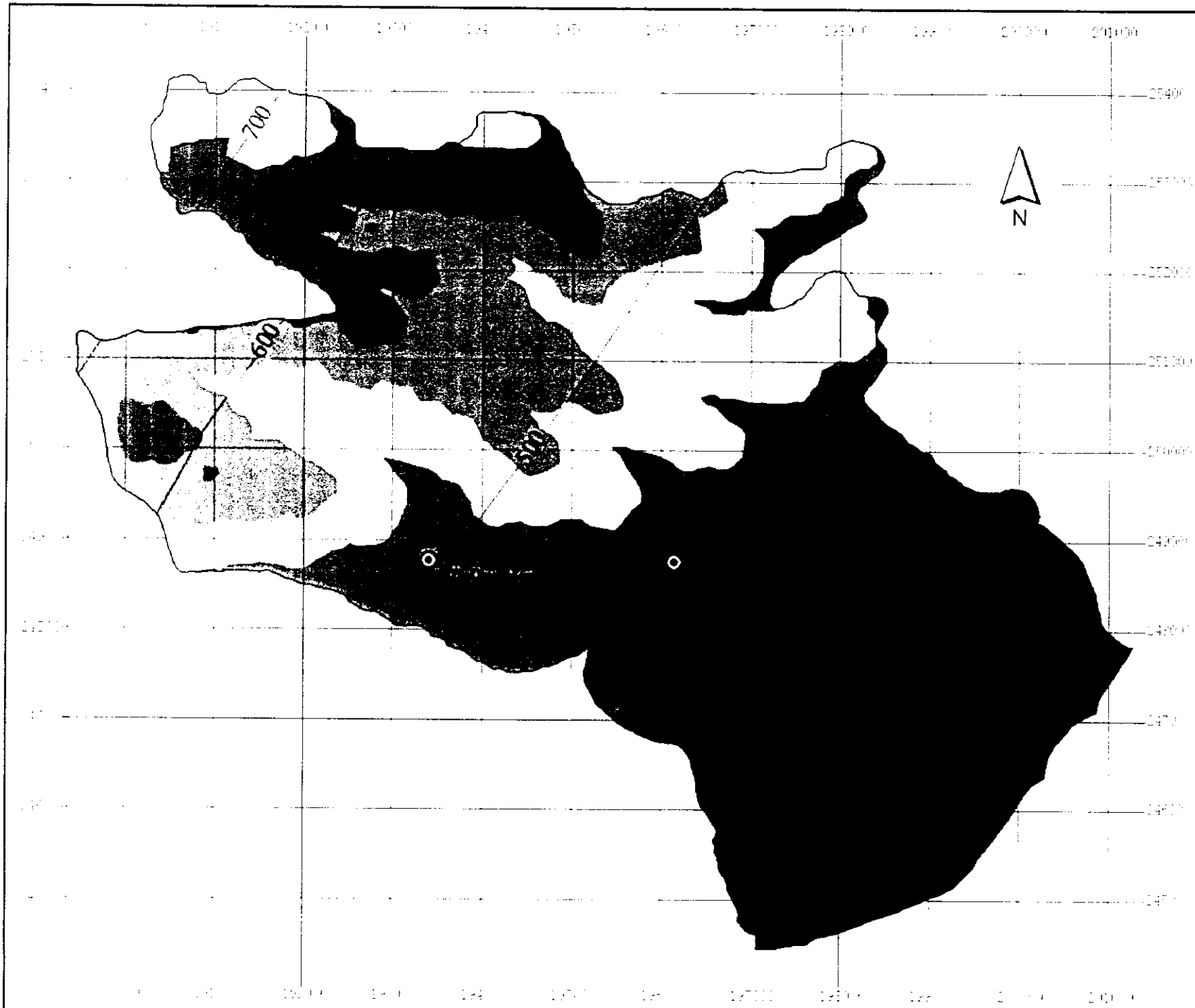


Map no. 7

Elevation & Rainfall ranges

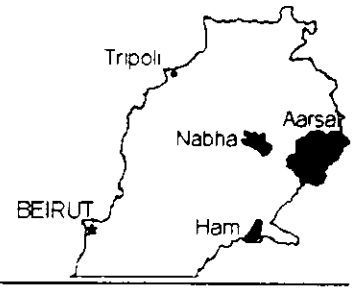
Site: Nabha

Legend:

100m rainfall contou

Source: Carte pluviometriqu du Liban, 1971

- 900-1100
- 1100-1300
- 1300-1500
- 1500-1700
- 1700-1900
- 1900-2100



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Map no. 8

Priliminary zonii & monitoring sit

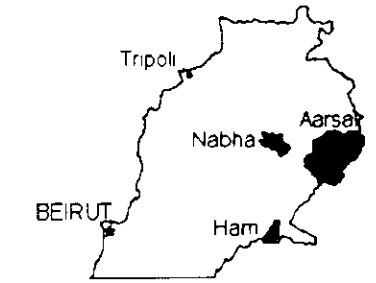
Site: Nabha

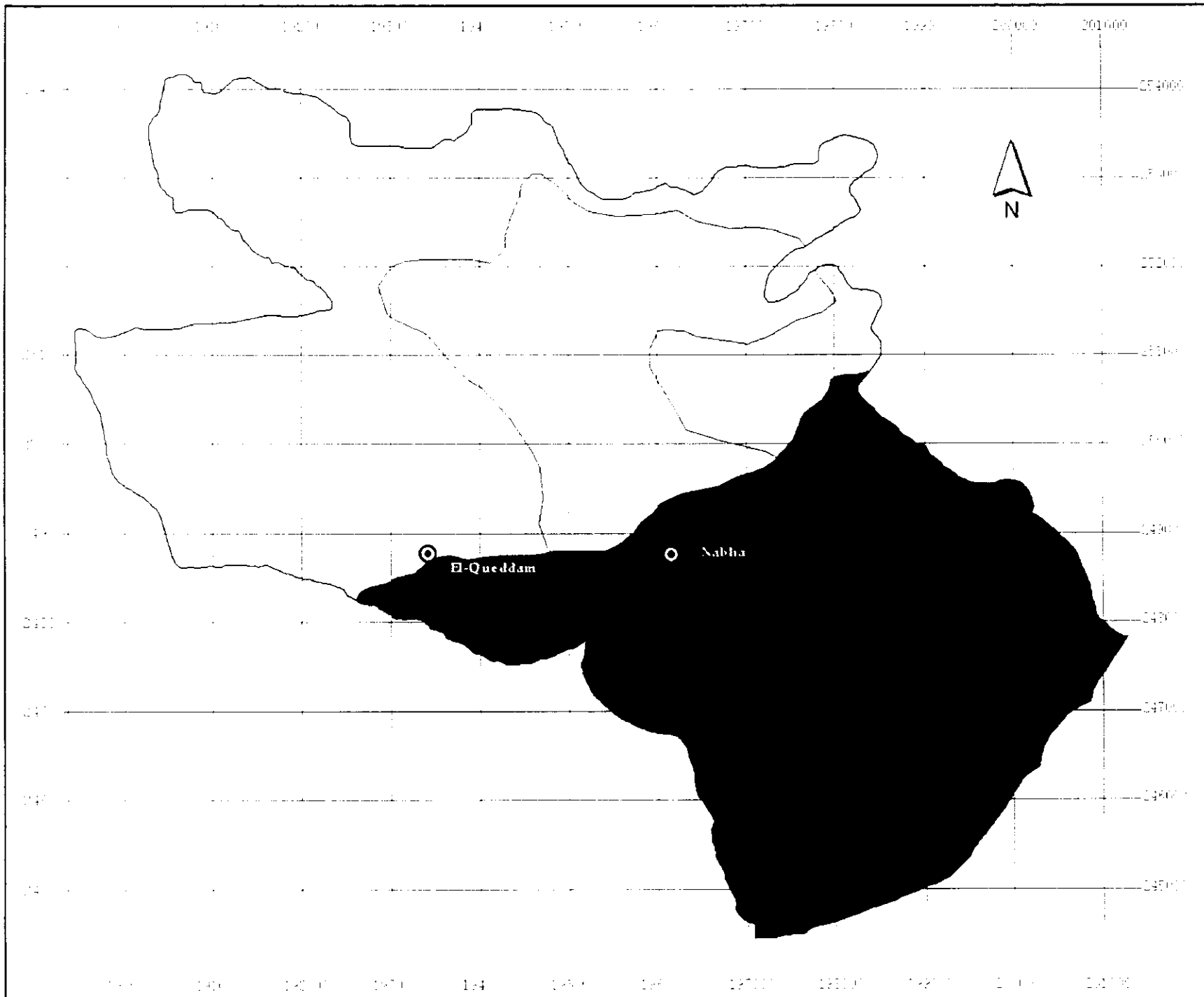
Legend:

Monitoring site boundar

High lands

Low lands





Scale: 1/60000 0 1 2 Km

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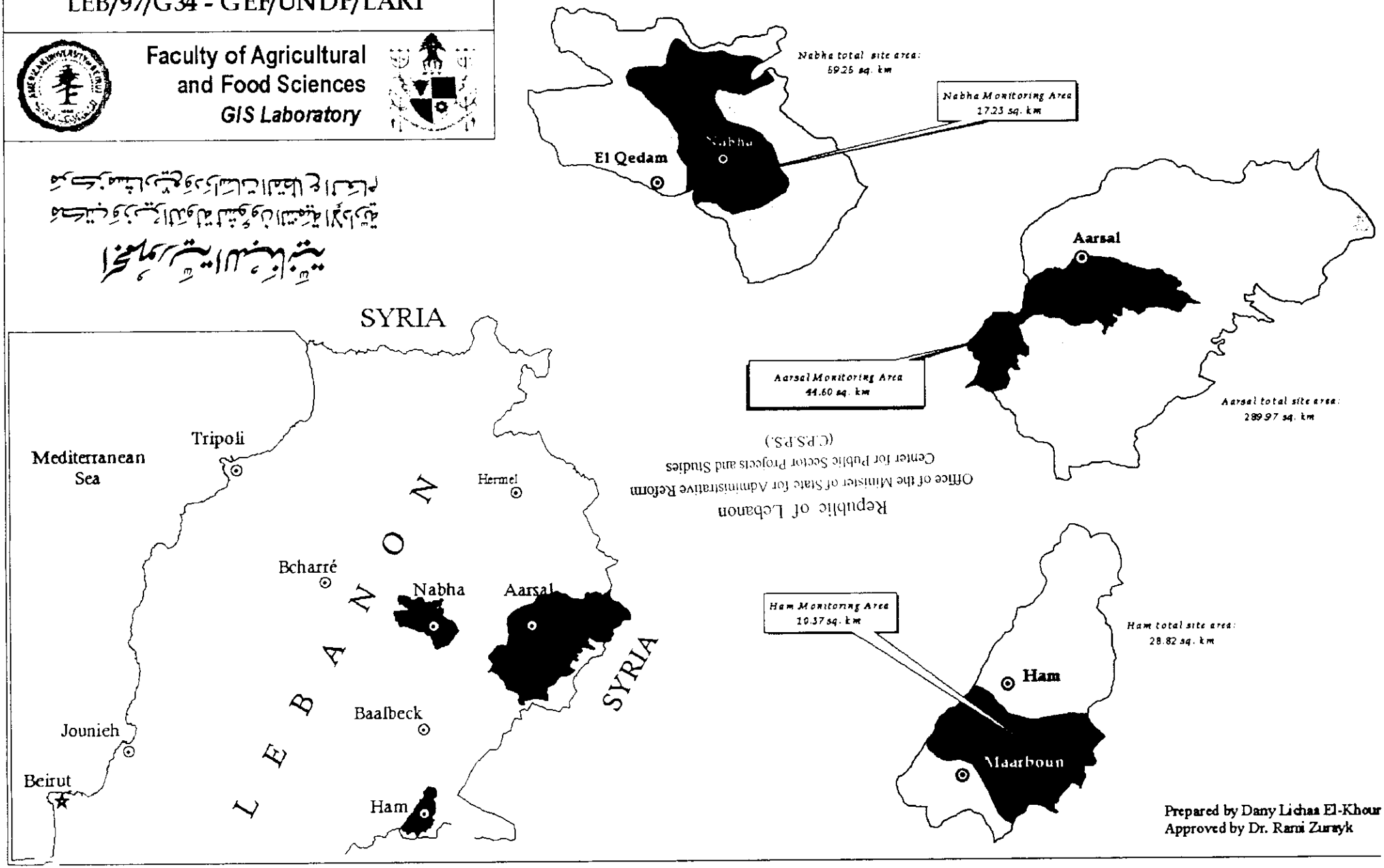
Figure 1:
Target Areas Geographic Location



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Office of the Minister of State for Administrative Reform
Center for Public Sector Projects and Studies
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