THE NATIVE VEGETATION AND ITS ECOLOGY IN THE KHUZISTAN RIVER BASINS

by

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CHAPTER I

FACTORS INFLUENCING NATURAL VEGETATION

a) TOPOGRAPHICAL FACTORS

In Khuzistan the great vegetation zones are mostly determined by the general topography of the river basins which rise from sea level to an approximate altitude of 4,500 m. This contrasting topography creates important climatical differences.

The great Khuzistan plain is only approximately a quarter (40,000 ha) of the entire land surface of our territory, but about half of it (78,000 km^2) is situated above 1,500 m altitude, and about 45,000 km^2 are above 2,000 m.

Relief is particularly contrasted in the Bakhtiari and Karun basins (whence absence of roads), where are the highest mountains, together with the deepest and narrowest valleys. The North-Western mountains (Kermanshah-Khorramabad-Borudjerd areas) are smaller and their valleys are sometimes very wide, wherefrom an extensive agriculture has developed, but also a very great decline of the natural vegetation took place.

On the whole, topography is closely related to the lithological nature of the mountains: the schistose and metamorphic zones in the North and North-West, as well as zones of gypseous marls on the border of the plain, have a much less accentuated relief than the zones of conglomerates and especially of hard limestones which constitute the greatest part of the mountains.

Considered in more detail, topography plays an important role in the conservation of vegetation, or at least in the conservation of the best species: contrary to what we might believe, it is very often on the slopes, sometimes very eroded, that good forage species, or the last remains of forests, can be encountered, when relatively level areas have much too often a poor flora deprived of forage species. Very often the last good plants of a level area are found on a small bank. The reason is that horizontal soils, not cultivated at present, have often been so much trampled upon an compressed by cattle that infiltration and aeration are too poor to allow for the development of a normal vegetation.

As a matter of fact, it has now been proved that throughout the Orient, where there is a prolonged summer drought, the search for native plants is more fruitful on the slopes than on the horizontal soils; numerous species, which could easily grow on level lands, can now only be found on slopes, or even amongst steep rocks. This is the case in Khuzistan for several important grasses in the lower zone (*Cenchrus*, *Hyparrhenia*, etc.) as well as for several species of trees and shrubs (in particular the big juniper of high mountains).

b) CLIMATOLOGICAL FACTORS

Zones of vegetation, and geographical distribution of most of the species are determined essentially by climatological factors.

There is at present approximately 32 meteorological stations in our territory to which can be added 19 stations, situated in adjacent regions. But only 12 stations, and 8 outside, have been in operation for a number of years sufficient to give reliable monthly averages of temperature and rainfall.

Studying all the existing data, we have tried, on the basis of monthly averages of stations sufficiently long-established, as well as on the altitudes and latitudes, to calculate the probable averages of a certain number of more recent stations, for which we did not sometimes have more than one or two years of measurements. In general, the averages of temperatures thus obtained, less variable from year to year, are much closer to reality than averages of rainfall. In the appendix we have given the results obtained, with reservation as to the validity of averages for certain posts. Pluviothermic diagrams have been established for about 40 stations, of which 17 are quite reliable. From these diagrams it has been possible to estimate

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approximately the duration of the period of active vegetation (average temperature above 10°C) and the duration of the period of theoretical drought (rainfall in mm. less than the double of the temperature in centigrades).

We have attached a reproduction for our territory of the annual precipitation map published by the Iranian Meteorological Service; this map is only a first approximation, and it is very likely that the zone receiving 400–500 mm per year covers larger surfaces, in particular in the South-East. On the basis of present rainfall data, but also on vegetation types found in the course of our surveys, we have indicated on this map the areas where rainfall has probably—or certainly—been under-estimated, and sometimes over-estimated.

The main gap in our knowledge concerns rainfall in the high mountains, in particular above 2,000 m. According to measurements made on various mountains of the world, it is certain that rainfall does not increase regularly with altitude, but it is difficult to say at which mean altitude is the zone of maximum rainfall situated. In our territory, it is probably between 1,500 m (for the mountains bordering the plain) and 2,300 m (for the high mountains of the center). However, it seems doubtful to us, keeping in mind the vegetation, that rainfall is much more than 1,000 mm in the wettest areas.

Furthermore, we must keep in mind that, in the major part of mountains of average altitude (and in particular in the calcareous mountain masses with deep valleys) and because of the abrupt and irregular rains, a great quantity of water is not absorbed and runs off immediately.

What is common to all our territory, is the lack of rain at least during the whole summer (July-August-September completely dry), and at most from June to November.

The dry season is appreciably longer in the South-Eastern part than in the North-West: 7 months at Shiraz and 5 1/3 months at Kermanshah, for the same altitude and annual rainfall. This is due to the difference in latitude causing a rise in temperatures from North to South, especially in winter: in January, 2.0°C at Kermanshah, and 6.3°C at Shiraz; in July 27.1°C at Kermanshah and 28.6°C at Shiraz.

Temperatures are at least as important for plants as rainfall.

In the low-lying areas, the high summer temperatures (more than 35°C in the Khuzistan plain), which are amongst the highest in the world, have a very strong influence on the vegetation of non-irrigated lands; the growth of plants (apart from species specially adapted like Chenopodiaceae) can take place only at the end of winter and at the beginning of spring.

On the other hand, in the high mountains (for example at 2,000 m of altitude) the period for growth—whatever the rainfall—is situated between the months of May and August (April to July in the South-West), because the temperatures at the beginning of spring are too low.[1]

[1] On 10th June, at 3,500 m altitude, on Mount Elvend, vegetation was only starting, and already at this elevation certain areas can keep snow all the year round.

On the plains like in the mountains the period of September to November (end of the drought season) corresponds with a relative rest of herbaceous vegetation. The mountain species have therefore also a relatively short vegetation cycle, and much more difficult to prolong than in the plains, irrigation being inefficient when temperatures are too low.

Summing up, the factors limiting the growth of plants are: at low altitude, insufficient rainfall and high summer temperatures; at high altitude, the low spring temperatures and secondarily the summer drought. There are therefore very few possibilities for the development of a rich non-irrigated agriculture in the whole of our territory. The best conditions for this development are doubtlessly between 1,000 m and 1,500 m altitude, but this is just the zone where the smallest proportion of land can be cultivated because of the extent of steep slopes and rocks.

It must be added that the study of monthly averages alone does not give a sufficient idea of our territory's climates; in fact, these climates are much more

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than they appear from the averages, and this is because of considerable variations in rainfall and also strong variations of extremes and averages of temperatures (particularly in winter) from one year to another. These climatic irregularities must have a great influence on vegetation, preventing for example certain species to multiply, or by killing young plants.

The annual range of the average monthly temperatures is from 20°C (at Bushir) to 28°C (at Arak and other northern stations). This range is less in the South-West (22–24°C) than on the plains (24°–26°C). The average range for the whole of the stations is of the order 25°. Altitude does not seem to play a part in these figures. Everywhere they indicate a very Continental climate which is of the same kind as in the eastern part of the Syrian desert and the South of Afghanistan.

In spite of these thermic differences (not to be neglected) which we can note between the North-West and the South-East (comparing stations of the same altitude), we have however noticed that many species amongst the most important—trees or perennial grasses— have more or less the same limits in altitude, whatever the latitude. For example the Persian oak (*Quercus persica*), the main tree all over the forest belt, begins at about 800 m and ends at about 2,500 m either near Kazerun, or in the Bakhtiari country and Karkheh basin; the upper limit of *Hyparrhenia hirta* is situated near 1,000 m north of Kazerun, as well as in the Dez and Karkheh valleys; the lower limit of *Bromus tomentellus*, the fundamental species of summer pastures, is found at about 1,500 m in the Kotal Doktar (near Shiraz), as well as around Kermanshah.

This regularity in the altitude limits could perhaps be explained by the fact that in the South-East higher temperatures bring an earlier drought and that the period of active and non-irrigated vegetation, more precocious in the South-East, has however the same duration as in the North-West (Shiraz 9 – 7 = 2 months; Kermanshah 7 1/3 – 5 1/3 = 2 months). Another explanation could be that the differences of temperature between the North-West and the South-East are especially marked in winter, the period during which vegetation is at rest, hence much less sensible to variations of temperature. It seems therefore that winter is simply shorter for the southeastern plants, which only advances their period of development by about one month in relation to the same species growing in the North-West; the same climatic phases occur at the same altitudes, but at periods slightly different.

We do not wish to say however that the flora is not subject to any changes from North-West to South-East, but we have not noted that common species have limits of altitude appreciably higher in the South-East than in the North-West. This was very useful for the establishment of our phytogeographical map.

c) LITHOLOGICAL AND PEDOLOGICAL FACTORS

The Khuzistan plain is formed essentially from fine silts, more or less saline in depressions flooded in winter, and in irrigated (but badly drained) areas of cultivation. Great sandy areas can also be found here (particularly West of the great bend of Karkheh river) which result from the destruction of sandstone hills and outcrops. Other hills appear here and there, especially in the North and East, formed from marls more or less gypseous with a few layers of conglomerates. Rocks of the same types constitute the first mountain foothills and extend in all the petroleum-bearing zone.

The main part of the mountains, from the region of Kermanshah to that of Shiraz, is made of hard and massive limestones and more or less marly limestones, with here and there layers of marls and a few thick conglomerates. These mountains form a geological zone which was the most strongly folded.

Finally in the North and North-East there extends an area of mountains, more or less rounded, formed from ancient rocks, generally metamorphic and schistose for the most part. Granite are extremely localised (Mt. Elvend).

In our climate the influence of the chemical nature of the sub-soil is appreciable only in the cast of certain plants; the soils intervene much more by their texture and permeability than by their richness or poverty in carbonates. The distinction between "calciphilous" and "calcifugous" plants is much less apparent than in temperate and humid climates of the Orient, below a certain altitude (about 2,000 m) almost all soils contain a certain percentage of

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carbonates and their pH is almost always basic. On the contrary, in high mountains the soils are always decalcified with a pH on more or less neutral, or sometimes acid in humid depressions where the snow remains for a very long time.

Gypseous and saline soils have almost always a very characteristic flora; certain species (*Onobrychis "gypsorum*", *Teucrium oliverianum*, *Astragalus anacardius*, etc.) are only found on gypsum; others (*Aeluropus*, *Tamarix macrocarpa*, *Halocnemum strobilaceum*, etc.) exist only when the soil contains a certain percentage of chlorides.

Finally, sands (siliceous or gypseous) have always a particular flora, especially when they form moving dunes (*Tamarix stricta, Calligonum, Aristida, Pennisetum dichotomum*, etc.).

The lithological nature of the sub-soil played a great part, not only in the formation of the present topography, but also in the destruction and conservation of certain types of vegetation.

In particular, it is thanks to the predominance of hard limestones that there still exists a great forest belt in the mountains, because limestones have been generally an unsurmountable obstacle to the extension of cultivated lands. If those mountains were on the contrary of schistose nature (like those of the North) the valleys would be much wider, slopes less steep, arable lands more extensive, and it is almost certain that man would have completely de-forested the country. Nothing would indicate at present that the natural climax of these mountains is the oak forest.

d) HUMAN FACTORS

Although the composition of the flora in each region of the Middle East was originally well determined by local climates, it is however man who has given to the natural vegetation its present aspect, in general very different from what it would be if natural factors were the cause only. In our territory (as in many others) this human influence dates from prehistoric times, and it has only intensified and increased in the course of ages.

Man certainly had to exploit nature according to his needs and to the development of civilizations, but this uncontrolled exploitation has too often destroyed the natural biological equilibrium: forests have been destroyed on very large areas, pastures have become poorer and poorer, the most useful species have become rare, ill-managed irrigation has brought salt up to the surface, but in particular the decay or destruction of the natural vegetative cover in the mountains has seriously modified the rivers' regime, and erosion has assumed such an extent that the major part of old forest or pasture soils has been destroyed. More or less everywhere rocks appear on the surface, and this general impoverishment has forced man to abandon many lands once cultivated, and on which pastoral vegetation often could not reestablish itself. Each year Khuzistan's rivers carry to the sea millions of cubic meters of silt taken from the soils of the mountains and of the plains.

Human influence on natural vegetation has manifested itself in many ways:

- destruction of forest trees by fire, peeling of the bark, or the ax, removal of the stumps
- plowing of forest or pasture soils (most of the time for cultivation of dry-farmed wheat),
- overgrazing of natural grasses by herds, progressive disappearance of these grasses to the benefit of undesirable or harmful species,
- removal of bushy or somewhat woody species with a view to their utilization as fuel

• trampling and compressing of the soils by domestic animals, wherefrom bad water infiltration
• impoverishment of the soils in organic matter,
• finally, increase of streaming and final erosion of the soil.

One of the most serious consequences—though very seldom mentioned—of human action is the progressive degradation of microclimates due to the disappearance of ligneous plants and the lowering of the average height of the vegetative cover. Wind has thus a greater action on herbaceous plants and on soils; variations of temperatures on and in the soil are much more important, evaporation is much more intense, and even in the absence of erosion the more xerophilous species (in particular the thorny ones) gradually take the place of the good forage species, physically (overgrazing) and physiologically (increasing aridity of the microclimate) defavourized.

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In our territory the destructive action of man has been so intense that one can say that certain regions, on the plains as well as in the high mountains, have at present a vegetation very different, not only in its aspect but in its botanical composition, from what it was 2,000 or 3,000 years ago; and this without any notable change in the general climate. On immense stretches of the range, the dominant plants, or at least those which are common, are only weeds, little or not at all palatable.

We must finally mention for areas at present completely devoid of trees, the deplorable custom of utilizing all the manure for fuel, whence the rapid impoverishment of the lands, their final abandonment and the always greater extension of the ploughing in the range lands.

There still exists in the mountains a great forest zone, but because of almost permanent overgrazing by sheep and mostly by goats, the herbaceous vegetation of these forests has become very poor (very often reduced to little palatable annual species, drying up very quickly), soils are strongly eroded and trees cannot multiply. If to all that is added the intensive and uncontrolled manufacture of charcoal, and a terrible waste of felled trees, (the people having the custom of building each year new dwellings with leafy branches for more coolness in summer), we can easily imagine that after half a century not much will be left of the present forest belt…

CHAPTER II

BOTANICAL RESEARCHES IN THE KHUZISTAN RIVER BASINS

At present the flora of Iran is estimated at approximately 7,000 species, but a great part of these plants are generally limited to the Caspian area, to Khorassan or to Baluchistan. In our territory the flora probably contains between 2, 000 and 2,500 species of vascular plants. But a great number of these plants are rare or very rare and hardly play any role in the vegetative cover. The more or less common species are probably not more than 800 in number.

Our territory's flora comprises a great many species existing principally in Syria; but they are mostly annuals which develop in springtime and therefore escape from the great summer heat. On the contrary, the perennial species are for the most part different from those of Syria, though they often look rather similar. Some species of Afghanistan can be found in our territory, especially in the mountains.

Our knowledge of the flora of Iran is still very deficient. There does not exist a general reference book allowing a botanist to identify himself the greatest number of plants he can find in Iran. The "Flora Orientalis" from Boissier remains the basic work. But it is difficult to use and it dates from 1880. Many Iranian species have been discovered since that date.

The "Flore de l'Iran", published by Parsa is relatively recent, but it is also very difficult to use because of the numerous mistakes of all kind in the text as well as in the typography of the book. The author has assembled, without having the time to make careful check or synthesis, all that had been published before his time on Iranian plants. In that book it is easy to notice that very few botanical explorations had been made up to now in Khuzistan. In fact, many species which are relatively common in Khuzistan are not mentioned for this province in the Flora of Parsa, especially most of the Chenopodiaceae. The northern part of our territory has been better studied, though still very incompletely.

For the taxonomical viewpoint many species have not been identified accurately by the botanists; either the same species has been described several times under different names, or several different species have been grouped under the same denomination. An enormous work of synthesis remains to be done on the botanical documents gathered up to now, work which can only be done in the great herbariums of Europe, in particular in Vienna, where Professor Reichinger can be considered as the best authority on the flora of the Middle-East. But it is still more necessary to undertake new botanical exploration sin the areas which have been up to now insufficiently explored, many species being known only from one herbarium sample, often ill developed or in bad condition, so that characteristics given a specific are too often only individual or accidental.

Some of the species we have gathered in 1959 had probably never been discovered before. Several of them are fodder species of the genus *Onobrychis*. We have also found a new species of perennial *Lotus* which is one of the most interesting species for Khuzistan.

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It is obvious that the identification of the plants we have gathered could only be done in part.

A great number of these species could easily be identified because we had already studied them in Syria. But for species encountered only in Iran this work was much more difficult, and we did not have sufficient time to complete all the identifications that could be done without leaving Iran. On the whole, almost all the plants collected have at least been given their generic name. In identification of the species we have particularly tried to identify correctly species of practical importance, and first of all fodder and forest species. Moreover, it will be possible to identify later a great number of these species which are not yet identified, since three similar collections have been made, one of which will remain in Tehran.

We only found certain plants too young, or too advanced in their development, or still to grazed by animals, so that through lack of flowers and fruits their identification is almost impossible.[2]

Finally it must be added that from the practical point of view the identification of species is not always sufficient because many species, especially forage plants, are represented by several ecological varieties or "ecotypes", without their morphological characteristics being clearly different. For example, it is almost certain that the *Aristida plumosa*, from the sands of Khuzistan, those from gypsum hills of Agh-Jari, those from the conglomerates of Dezful, those from the marls of the Dez Valley, and finally those from the area of Qum, are plants ecologically different. The *Hyparrhenia hirta* of Khuzistan is certainly different from the North African one; *Pennisetum orientale*, calciphilous and strongly xerophilous in our region, cannot be the same plant as the one which received that name in Mediterranean Syria, which is calcifugous and grown in pine forests. These questions of ecotypes will have to be carefully studied when multiplication experiments will be undertaken in nurseries.

HERBARIUM

The collection assembled in Ahwaz contains approximately 1750 sheets of herbarium, representing approximately 1020 species. Each plant has been given a number at the time of gathering; another number in Roman characters indicates the day of harvest; a letter of the alphabet indicates the exact spot where the plant was found. Of course the same plants have the same numbers in the Ministry's herbarium, as well as in the FAO ecologist's collection, so that the latter will be able to communicate further new identifications. A complete list of dates and places where the plants were found is attached to the herbarium. All the samples have been treated with mercurium and chloride to prevent destruction by insects.

There is also a collection of photographs, in black and white and in color, representing certain species in their natural habitat, or certain types of vegetation.

[2] The difficulty in some identifications will be understood if we consider that the Flora of Parsa mentions for Iran: 565 *Astragalus* (and we found new ones), 213 *Cousinia*, 92 *Silene*, 82 *Allium*, 76 *Nepeta*, 74 *Euphorbia*, 69 *Acantholimon*, 66 *Salvia*, 52 *Onobrychis* (and we have new ones), etc.

CHAPTER III

PHYTOGEOGRAPHY

a) SUMMARY DESCRIPTION OF THE VEGETATION

The most characteristic feature of the vegetation in our territory, which is striking when we fly over it by plane, is its division into three large regions oriented from North-West to South-East:

I– A lower belt devoid of forests, agricultural, pastoral or semi-desert which includes the plain and the low mountains up to about 800–900 m in altitude; the most part of the flora is made of annual species;
II– A mountain forest belt, which covers the greatest part of the folded limestone zone o f the Zagros range, whose principal tree is the Persian oak.
III– A mountain belt now devoid of forests, agricultural and pastoral, situated at the North-East of the former; its vegetation consists mainly of perennial species.

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1. THEORETICAL CLIMAXES

It is almost sure that in prehistoric times, and assuming that the climate was then very little different from the present one, all our territory was covered by forests more or less dense except for the mountains situated above 3400 m, and the normal zones of erosion.

The great forest zones must have thus been as follows:

1– from 0 to 300 m approx.: *Tamarix* spp., *Populus euphratica*, *Phoenix dactylifera* (date palm) in the more humid parts; and in dry parts: *Ziziphus spina-christi*, *Pistacia khinjuk*, *Ficus carica* (2 sub-species), *Tamarix stricta* (sands)
2– from 300 to 800 m approx.: *Pistacia khinjuk*, *Ficus carica*, *Ziziphus spina-christi*, *Amygdalus scoparia*, *Pistacia atlantica*: in the valleys: *Tamarix* spp., *Populus euphratica*, *Salix* spp.
3– from 800 to 1500 m approx.: *Quercus persica* (prevailing), *Pistacia khinjuk*, *Pistacia atlantica, Celtis* sp., *Acer cinerascens*, *Amygdalus* spp., *Prunus* sp., etc.; in the valleys: same species as in lower altitude with in addition *Platanus orientalis*.
4– from 1500 to 2500 m approx.: *Quercus persica*, *Pistacia atlantica*, *Acer cinerascens*, *Fraxinus syriaca*, *Crataegus* spp., *Pirus syricaca*, *Celtis* sp., *Juglans regia*, *Amygdalus* spp., *Juniperus excelsa*, *Prunus mahaleb*, *Lonicera nummularifolia*, etc.; in the valleys *Platanus orientalis*, *Salix* spp., *Fraxinus* sp.
5– from 2500 to 3400 m approx.: *Juniperus excelsa, Lonicera nummularifolia*.

These lists correspond to theoretical climaxes which we can deduce from the present vegetation, from the sea level to the highest mountains. In the mountains with a drier climate (Shahr-Kord area) certain species (*Quercus, Fraxinus, Celtis*) have probably never existed.

2. PRESENT FORESTS

The most frequent species at present are: at low altitude: *Tamarix* and *Ziziphus*; at the food of the mountains: *Pistacia khinjuk, Ficus carica, Amygdalus scoparia*; in the mountains: *Quercus persica, Amygdalus* spp., *Pistacia atlantica*, and secondarily *Acer, Prunus*, and *Crataegus*. The abundance and the resistance of oaks between 1,000 and 2,300 m altitude is remarkable over the whole of the folded limestone zone. By contrast, on the dry soils of the plain onlly a few *Ziziphus* remain, probably kept by the local people because of their fruits. Forests of *Pistacia*, too close to the cultivated plains, have been almost totally destroyed. Finally, in the high regions, forests of *Juniperus excels*a have nearly all been destroyed and the last trees can only be found on steep slopes and limestone clif*Fraxinus syriaca*, most of them above 2,500 m of altitude. Contrary to the oaks, these trees reproduce themselves with great difficulty.

All present forests are more or less xerophilous, for even when they are relatively thick, their herbaceous flora (whose most common perennial grass is *Hordeum bulbosum*) is not so very different from that of unwooded areas. Many annuals exist, up to at least 1,500 m and most of these herbs dry

up at the end of spring or in summer. As a matter of fact it is difficult to find herbaceous species closely related to the presence of trees; most of them can maintain themselves when trees have been felled.

The least damaged forests seem to have localized in different places of the Karun and Ab-e Khersan basins. Unfortunately the major part of forests is in a piteous condition; deforestation has been intensified during the last centuries, and it has possibly never been as active as today; large stretches in the limestone zone have only but dwarf trees found at wide intervals. Almost anywhere trees are felled, burnt, rooted out, for the production of charcoal and for the extension of cultivated lands. In addition, each summer local people guild themselves new dwellings with leafy branches.

It is very difficult to get an idea of the herbaceous flora of the ancient forests because overgrazing has extended everywhere, and palatable species have been for the greater part destroyed, replaced by annuals, thorny shrubs or species that animals dislike. Very often it is evident that agriculture has penetrated deeply into the forests, and then was abandoned.

Herds of goats play more than ever a great role in this impoverishment of the forest flora, and they destroy young tree shoots soon after their germination.

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Finally, forest soils are almost everywhere very eroded, and often have been reduced to stones, almost without any herbaceous vegetation.

These forest zones are probably the poorest in good forage species, they have been replaced by annuals of no value (especially by *Aegilops*) and above 1500 m by non-palatable perennial species: *Astragalus, Phlomis, Onosma*, etc.

3. HERBACEOUS VEGETATION AT LOW ALTITUDE

The vegetation of the plain and of the bordering low mountains consists principally of annual species, many of which are very short and dry up very soon. The most prevalent grass is almost always the undesirable *Stipa capensis.* In the absence of erosion, little permeable soils are often covered by lichens, mosses and even liverworts; in other parts *Carex stenophylla*, of no forage value, settles in and invaded very extensive areas, which for the whole of Khuzistan could be calculated in thousands of square kilometers.

Thus at low altitudes pastures are often very poor and of an ephemeral duration; their productivity is extremely low during dry years.

A slightly better and more lasting vegetation—a few perennial grasses—is sometimes to be found on the sands (*Aristida plumosa*) or on certain areas moderately saline (*Aeluropus repens*). Chenopodiaceae (annual or perennial) play an important part in the vegetation of the plain, in particular on saline soils, but these species are of no value as forage. They can be distinguished from other herbs by their long period of growth which extends from spring to the beginning of winter.

On the hills of the petrol-bearing zone (marls, gypsum and conglomerates) where *Pistacia khinjuk* in the past formed forests, remains of ancient pastures can be found here and there, which include a good proportion of perennial species, among which a few forage species (*Hyparrhenia, Cymbopogon, Aristida, Poterium, Onobrychis, Lotus*). But ligneous species and shrubs are too often rooted out by peasants for fuel, so that the microclimate of these pasture lands has become extremely severe.

4. HERBACEOUS VEGETATION ON THE MOUNTAINS

From about 1500 m of altitude, annual species become much less abundant; at 2,000 m most of them are found only in cultivated lands, and above 3,000 m they have practically disappeared.

North-East of the great forest belt, mountains are nearly completely devoid of trees and bushes, with the exception of a few relics which prove that these regions were nut on this state in the past. On the other hand it is in this great zone that the best range lands are found, thanks to the presence of good perennial forage species (*Bromus, Festuca, Agropyrum, Stipa, Onobrychis, Astragalus*, various Labiatae, Cruciferae and Compositae). Overgrazing has unfortunately reduced the abundance of these species, and much too often vegetation consists principally of thorny species (*Astragalus, Acantholimon, Acanthophyllum, Eryngium, Cousinia*), or herbs (*Phlomis, Onosma, Stachys, Euphorbia*,

tall Umbelliferae). On trampled soils we notice the abundance of *Poa bulbosa*, grass of little interest, already found at low altitude.

The dominant feature of these deforested mountains is the considerable and sometimes amazing extent of areas at present or once cultivated without irrigation (generally giving very poor crops). These lands in spite of a rainfall often superior to 500 m p/a are in fallow on approximately 2/3 of the areas tilled at present. It is only the massive rocks, generally limestone or conglomerates, or the too high altitude that limit the uncontrolled extension of cultivation. Schistose mountains, very extensive in the North-East, are very often tilled up to their rounded summit, whence a spectacular erosion.

Thus we can see a rich flora of weeds in the mountainous arable lands; these weeds have practically replaced the pastoral vegetation over extensive areas. The following species: *Phlomis persica, Gundelia tournefortii, Salvia syriaca*, and in the less dry depressions: *Goebelia alopecuroides* and *Glycyrrhiza glandulifer*a, are often so abundant that we could think they are cultivated.

In certain regions (for example South of the plain of Shahr-Kord) it seems that cultivated surfaces must have been even more extensive in the past, because *Phlomis persica* is the predominant plant over much of the range lands, which are besides very poor in forage species. This weed, accompanied by a few others, is regularly found on

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cultivated or abandoned lands, from the province of Kermanshah (and probably from Azerbaijan), as far as Shiraz, passing through the regions of Borudjerd, Azna and Shahr-Kord.

Finally the undesirable *Carex stenophylla*, replaced above 2000 m by a rather similar species is often predominant on certain dry soils with little or no slope, in particular in the areas of Kermanshah and Malayer, eliminating other species and greatly reducing infiltration of water by the extreme density of its underground parts. This invading species, found now from Lebanon to Turkestan, is in full extension in the low plains as in the mountains, and we have even found a rather thick oak forest (at 2100 m of altitude in the Bakhtiari mountains) whose herbaceous vegetation was nothing but *Carex*, or nearly so.

It is still possible to find places where pastoral vegetation is relatively well preserved. This is often the case on passes which separate two valleys, and on banks situated between a road and cultivated fields. It is only in the latter case that we have some chance of harvesting seeds of good forage species

Above 2500 m lands are rarely cultivated, and as the present forests hardly exceed this altitude, these high regions are entirely pastoral. But here again t eh vegetation has been strongly modified by overgrazing, and although certain grasses can climb up to more than 3700 m, (*Oryzopsis molinioides, Stipa* sp., *Festuca* sp.) the unpalatable species are the most common, often even there are no others. Normally this "alpine" type of vegetation, which we find over all the high mountains of the Middle-East, is characterized by the abundance of thorny species in hemispherical cushions (*Astragalus, Acantholimon, Acanthophyllum*). This is called the tragacanth vegetation, excellent for soil fixation. But those cushions have been cut for centuries by the mountaineers how use them as fuel, and these plants are even an object of regular trade, since we have come across a lorry loaded with *Acantholimon* on the road to Shahreza. Hence, this type of vegetation tends to disappear gradually in the high mountains, and it has already practically disappeared over some ones.[3] Finally, there remains no more than *Phlomis, Stachys, Euphorbia, Eryngium, Cousinia, Ferula*, all of them unpalatable, or simply stones and rocks.

b) THE GREAT PHYTOGEOGRAPHICAL ZONES OF THE KHUZISTAN RIVER BASINS

The drawing up of a phytogeographical map presents many problems, in particular that of a choice of vegetative species or types of vegetation which, by their importance and regularity of their importance and regularity of their geographical distribution, make it possible to characterize each

[3] *Onobrychis cornuta*, a thorny species which forms the thickest cushions (up to 1 m 50 in diameter) inmost of the mountains of the Middle East, from Lebanon to Heart, has already been practically eliminated from our mountains, as we happened to find it once only, in the region of Sisakht.

natural region. Although each species has its own geographical distribution and though the vegetation does not change abruptly from one region to another, it is necessary to choose as objectively as possible the limits (always a little arbitrary) which must separate the different zones. These limits can only be determined by certain factors whose importance for the vegetation is of the first order. These factors can be the rainfall, especially in the plains; summer or winter temperatures, therefore altitude (in particular in the mountains; lithology (but in general only within the same climatic zone); or even human influence, when the latter has very profoundly modified the vegetation, for example by destroying completely primitive forests. The consideration of all these factors has been utilized in our map: in the Khuzistan plain the most determining factor of the vegetation is rainfall, lithology playing a secondary role (sandy regions). In the mountains it is the altitude that best allows us to map the great types of vegetation, but on the high Eastern plateaus and in the North human influence together with lithology and topography, has created sub-zones independent of the climate.

We therefore propose to classify the phytogeographical zones in the following manner:

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Zone A – Arid zone of Khuzistan—less than 200 mm rainfall p/a
Zone B – Semi-arid zone of Khuzistan—between 200 – 300 mm p/a
Zone C – Dry zone of Khuzistan—more than 300 mm and less than 900 m altitude
Zone D – Lower mountain zone—between 900 and 1500 m of altitude
Zone E – Medium mountain zone—between 1500 and 2000 m of altitude
Zone F – High mountain zone—between 2000 and 3000 m of altitude
Zone G – "Alpine" zone—above 3000 m of altitude.

These zones cover approximately the following areas:

Zone A:	20,000 km^2	Zone E:	33,000 km^2
Zone B:	15,000 km^2	Zone F:	41,000 km^2
Zone C:	25,000 km^2	Zone G:	4,000 km^2
Zone D:	21,000 km^2	TOTAL:	159,000 km^2

Because of deforestation or great differences in the rainfall, the zones D, E and F have been divided into sub-zones: D1, E1, F1 being forest zones; D2, E2, F2 being devoid of forests: F 3 being semi-steppic and F4 being steppic zone.

1 – ZONE A. ARID ZONE OF KHUZISTAN

This zone comprises approximately the South-Western part of the plain which receives less than 200 mm of annual precipitations. It is essentially formed from fine silts, and no hard rocks or sand dunes are to be found there. A considerable part is covered by saline marshes which partly dry up in summer. All soils are more or less saline, sometimes severely—in particular in the South-Eastern part—which limits considerably agricultural possibilities. Erosion is very active on all surfaces with a slight relief, and arable lands seem to be in constant regression because of this erosion.

Flora – Outside the marshes, lands seem almost desertic and the flora is very poor, not only in species, but also in individuals. The most abundant species are halophilous Chenopodiaceae.

If no account is taken of the cultivation of date-palms near the coast, the arborescent vegetation is almost nil: only here and there are some *Tamarix* (especially *T. macrocarpa*) reduced to a bushy state. *Populus euphratica* must exist in a few places near rivers (fresh water) as well as other *Tamarix*. A few bushes of *Suaeda fruticosa* and some rare *Lycium barbarum* are also found.

We have not studied the flora of marshes, but we noticed that it consisted mainly of *Aeluropus littoralis* in the parts dry in summer, and in the less saline parts of *Phragmites stenophylla* and a few Cyperaceae: *Scirpus, Eleocharis, Cyperu*s.

In depressions not too dry, *Aeluropus repens* is sometimes rather abundant but this high percentage of salt favors *Halocnemum strobilaceum*, the most characteristic perennial species of severely saline soils, associated with other halophilous Chenopodiaceae (annuals): *Salsola crassa, S. incanescens, Suaeda* sp., *Bassia eriophora*, etc. The least saline soils can sometimes support low bushes of *Haloxylon salicornia*.

A certain number of small annuals have a brief period of growth in March: *Sphenopus divaricatus*, *Statice spicata, Spergularia marina*, *Tetraciclis salsa*, *Hordeum marinum*, *Frankenia pulverulenta, Plantago coronopus*, all more or less halophilous.

On the lands cultivated at present or in the past the following perennials: *Prosopis stephaniana* and *Astragalus maurorum*, and along paths: *Atriplex leucoclada* (or a neighbouring species?) can be locally abundant.

We noticed that the flora of this region does not show any real tropical character and that it is very similar to the flora of saline lands in the Syrian desert. It has therefore been wrong to classify the Kuzistan plain in the great "sahara-sindian" zone as has been done by certain phytogographs and botanists: it still forms part of the great "irano-turanian" zone.

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1 – ZONE B. SEMI-ARID ZONE OF KHUZISTAN

This zone comprises approximately the section of the plain receiving between 200 and 300 mm of rain p/a. Its South-Western limit passes through Susengerd and South of Dezful. Its North-Eastern limit could be placed at a dozen kilometers South of Dezful and of Shustar, and at the foot of the Agha-Jari hills.

That zone is much less homogenous than the previous one. It is in great part silty, with large areas more or less saline and some marshes, but it also contains almost all the sandy areas and the dunes of Khuzistan, and some low sandstone or marl-gypseous hills which have served as a refuge for a good many plants cultivated lands are often saline, but less than in the North.

Erosion is very active on silty soils, in particular East of Ahwaz and South of Shustar. Sand dunes North-West of Ahwaz have a tendency to spread progressively Eastward.

Ecologically sandy soils are much more favourable to vegetation than silty soils, because infiltration is perfect there, evaporation much slower and the soil surface cannot form compressed crusts as on silty soils.

The five rivers of Khuzistan cross this zone, their waters loaded with mountain silt, but degradation of ancient irrigation systems and lack of drainage have brought salt to the surface, and the desertion of great stretches of land at one time cultivated, which no pastoral vegetation ahs been able to claim back. All lands are more or less utilized as range-lands (cultivated lands, after wheat harvest), but their value as forage vegetation, made up in majority by ephemeral annuals, is extremely low, especially on silty soils and on sands moving, or invaded by *Carex stenophylla*. Nevertheless the flora of this region is much richer than that of Zone A.

It is only on the islands and in large river bands that we can still find some rather thick remains of natural forests.

Arborescent flora:

Under dry conditions, it is reduced to a few *Paliurus spina-cristi*, disseminated here and there in the plain and to some *Tamarix stricta* localized in the great dunes which spread in the bend of the Karkheh river. Other *Tamarix*[4] are found almost always reduced to a bushy state, on some sandy places (*Tamarix meyeri, T. mannifera*), in saline depressions (*T. macrocarpa, T. tigrensis*, etc.) and along the rivers' shores (non-saline humid soils). Near rivers and canals there still exist some woods of *Populus euphratica* (reaching a height of 15 m near Haftapeh), associated to various *Tamarix* and *Lycium*[5] Climate is probably too warm for *Platanus orientalis* and for *Salix*, which do not seem to exist in the plain.

Bushy species:

On hills more or less gypseous, we can find bushes of *Periploca aphylla* and principally of *Astragalus fasciculifolius*. On sand dunes: *Calligonum* (2 or 3 species) and *Calotropis procera*. In silty zones and croplands: *Suaeda fruticosa, Ziziphus nummularia, Capparis sicula, Lycium barbarum* and another *Lycium.* On non-saline humid soils: *Vitex agnus-*

[4] Taxonomy and ecology of the *Tamarix* in the Middle East are still very mixed up.

[5] *Lycium barbarum* can reach a height of 7 m in these woods of *Populus euphratica*.

castus. We can also mention *Prosopis stephaniana*, typical crop-weed which, when not cut, can become a bush 2 or 3 m high.

Herbaceous flora:

Because of the climate, but also because of human influence, the herbaceous flora is mainly composed of small annual and ephemeral species. Three undesirable species must in particular be mentioned because their extension has sometimes become very great on non-saline and slightly eroded range-lands.:

Carex stenophylla, a very short perennial species, creeping and non-palatable, whose rhizomes and roots occupy completely the top layer of the soil, thus preventing infiltration and eliminating definitely all other grasses. Many large areas are covered by this plant near Susengered, East of Ahwaz, South-East of Haftapeh, etc.

Stipa capensis, an annual grass, harmful by its seeds which pierce the skin of sheep; it has spread itself considerably in the dry areas of Syria, Iraq and Khuzistan where it is found on almost all non-cultivated and non-saline soils. It is one of the

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rare grasses which can live on compressed soils covered by lichens.

Imperata cylindrica, a strong perennial grass with deep rhizomes, non-palatable; has invaded certain irrigated areas, and even dry pastures where it has replaced other perennial species (for ex. S-E of Haftapeh).

Among field weeds we must mention *Alhagi maurorum* (perennial and thorny) which is everywhere and is very abundant, and *Carthamus oxyacantha* (annual and thorny). Phar, so abundant in other steppic areas is not common in Khuzistan. *Poa bulbosa* is to be found in many places on non-saline silty soils, but it is on the way to extinction (over-grazing) it is not very interesting because of its weak rooting and its ephemeral development.

We can only quote 4 or 5 palatable perennial grasses: on moderately saline soils: *Aeluropus repens* and *Aeluropus littoralis* (the latter better but less xerophilous and for tat reason rarer); on sandy soils: *Aristida plumosa*, locally abundant; on sandstone rocks: *Cenchrus ciliaris*, now rare; and *Cynodon dactylon*, here and there on the borders of cultivated lands and roads.

Only one palatable perennial legume: *Onobrychis pinnata*, rare and found only on sandy-gypseous soils, SE of Haftapeh and East of Ahwaz.

Four types of vegetation are particularly characterized in this zone and are determined by the soil composition:

a) flora of saline soils:

ligneous species: *Tamarix* (3 species at least, including *T. macrocarpa*)

perennial herbs: *Aeluropus littoralis*, *Aeluropus repens*, *Cressa cretica*, *Halocnemum strobilaceum*, *Atriplex leucoclada*.

annual herbs: *Hordum murinum*, *Sphenopus divaricatus*, *Halocharis sulphurea*, *Salsola crassa*, *Statice spicatum*, *Spergularia marina*, *Plantago coronopus*, *Pulicaria divaricata*, *Trigonella anguinea*, *T. uncata*, *T. "khuzistania"*, *Pholiurus persicus*, *Bassia eriophora*, etc.

When the salt content becomes high, the flora becomes poorer, graminae disappear, there only remains but Chenopodiaceae (especially *Halocnemum*) and vegetation loses all its forage value.

b) flora of sand dunes:

ligneous species: *Tamarix* sp. (especially *T. stricta*), *Calligonum* spp., *Ephedra* sp.(rare), *Calotropis procera*.

perennial herbs: *Aristida caloptila* (rare), *Aristida plumosa*, *Convolvulus* sp., *Pennisetum dichotomum*, *Cyperus conglomeratus* (very abundant), *Echinops* sp., *Heliotropium* sp, *Cistanche tubulosa* (parasite).

annual herbs: *Scleropoa memphitica*, *Neurada procumbens*, *Lotus pusillus*, etc.

c) flora of very sandy soils and of sandstone hills:

It is by fare the richest flora of zone B. More than 100 species, most of them annuals, could be found:

ligneous species: *Tamarix* sp., *Calligonum* sp., *Ephedra* sp., *Helianthemum lippii*, *Astragalus spinosus*, *Salsola* sp. (5)

perennial herbs: *Aristida plumosa*, *Cenchrus ciliaris* (rare), *Heliotropium persicum*, *Convolvulus* sp., *Poa bulbosa*, *Haplophyllum* sp., etc.

annual herbs: *Schismus arabicus*, *Lotus pusillus*, *Ononis serrata*, *Psammogeton setifolius*, *Stipa capensis*, *Anisoscyadium orientale*, *Pteranthus dichotomus*, *Plantago cylindrica*, *Cornulaca aucheri*, *Ifloga spicata*, *Medicago laciniata*, *Silene setacea*, *Launaea* sp. *Koelpinia linearis*, *Scabiosa palaestine*, *Astragalus* spp., *Ononis reclinata*, *Schimpera persica*, *Hymenocarpus nummalarius*, *Plantago ovata*, *Bromus danthoniae*, *Eremopyrum orientale*, *Asphodelus fistulosus*, *Filago spathulata*, *Arnebia* spp., *Emex spinosus*, etc. etc.,

d) flora of hills and gypseous soils:

ligneous species: *Astragalus fasciculifolius*, *Halocharis* sp. (?), *Gymnocarpos decandron*, *Ephedra* sp., *Lycium* sp.

perennial herbs: *Onobrychis pinnata*, *Teucrium oliverianum*, *Erysimum blancheanum*, *Teucrium polium*, *Fagonia* sp., *Achillea conferta*, *Erodium glaucophyllum*, *Aristida plumosa* (particular ecotype?), etc.

Annual species are numerous, but little characteristic of gypseous soils.

3) ZONE C. DRY ZONE OF KHUZISTAN

This zone is heterogenous because the aspect of its flora changes a lot with altitude. However its limits are well marked by the distribution of the most important perennial grasses (*Hyparrhenia*, *Cymbopogon*) which exist already in the least arid parts of the plain and do not rise above 900–1000 m of altitude. As the oak forests often start at about 800 m, zones C and D are slightly intermixed between 800 and 1000 m. This is why the altitude of 900 m has been chosen as the theoretical limit. In fact, it is at this altitude that end the *Ziziphus*, characteristic trees of the plain.

Thus this zone comprises the peripheral part of the plain (receiving appreciably more than 300 m rainfall p/a) and the whole of the hills and low mountains which constitute the petrol-bearing zone. Not much limestone is found there, but some conglomerate and sandstone masses, and principally marls more or less gypseous.

It extends from the middle of the Karkheh valley up to the East of Gash-Saran.

Due to the gypsum solubility and lack of cohesion of the marls, erosion is intensive in all this zone and relief is particularly broken, especially in the South-East, where the rains are more violent and more irregular. Silty areas are relatively few, and alluvial grounds are more or less stony. Gypseous soils are very extensive and are little suited to agriculture. The bottom of the valleys and ravines is often rather salty, at least below 400 m of altitude.

The average summer temperatures in this zone are very high (up to 39°C in July, and they can go above 33°C at 900 m). Rainfall can reach 500 mm p/a in some points.

In spite of its sharp relief this zone has therefore a certain lithological and climatical unity.

The natural flora (at least 500 species) is certainly much richer than that of zone B, as a result of a smaller extent of cultivated lands, a greater rainfall and a much more varied topography.[6]

No forests—except sometimes above 700 m—but numerous isolated trees or bushes indicate that in the past forests reached down even into the plain.

As soon as we penetrate into the hills we notice the great extent of range-lands but the strong perennial substeppic grasses, that should predominate everywhere, have at present disappeared over large areas, and they have often taken refuge amongst rocks and on stony slopes. Ligneous species are very scanty because of their use as fuel. Vegetation is therefore mainly composed of annual species. Non-eroded soils are generally compressed by trampling of herds, so much so that

[6] It is in that zone that the greater number of submediterranean species, especially annuals, are found. These belong to the syro-lebanese flora.

they become covered by lichens, mosses and liverworts (*Riccia* spp.). In fact most of these cryptograms are found on all clayey steppic soils of the Middle East.

Arborescent species:

In the past, forests must have consisted mostly of *Pistacia khinjuk* and of *Ziziphus spina-christi*. At present *Ziziphus* is often common nearby cultivated lands; *Pistacia* has most often taken refuge in rocky parts.

Other species: *Amygdalus scoparia*, *Ficus rupestris*, *Ficus johannis*, *Pistacia atlantica* (from 600 m), *Quercus persica* (from 800 m).

In the bottom of the valleys one can find *Populus euphratica*, *Tamarix* sp., *Salix* spp., *Nerium oleander* and some rare *Platanus orientalis*.

Bushy species:

Periploca aphylla (in the most arid parts), *Astragalus fasciculifolius* (common), *Zygophyllum eurypterum* (S-E), *Ephedra* sp., *Atraphaxis aucheri*, *Convolvulus leiocalycinus* (rare, near Gach-Saran), *Amygdalus podoperae* [???] (in the SE and probably *Amygdalus orientalis*

Near cultivated grounds: *Lycium barbarum*, *Ziziphus nummularia*, *Capparis sicula*, *Prosopis stephaniana* (already found in zone B). In the bottom of valleys: *Vitex agnus-castus*

Perennial grasses:

Hyparrhenia hirta (rather common, often abundant on rocks)
Cymbopogon laniger (not very common, but sometimes abundant)
Aristida plumosa (2 ecotypes on gypsum or on conglomerates)
Pappophorum persicum (rare)
Tricholaena teneriffae (rare, rocks)

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Aristida caerulescens (rather common, rocks)
Stipa barbata (very localized)
Hordeum bulbosum (only above 600 m)
Poa bulbosa (everywhere)
Cynodon dactylon (rather common but mostly near crops)
Aeluropus repens (saline soils)
Andropogon annulatus (rare, rocky beds of torrents)

All these species are more or less palatable, and certain of them remains green nearly all the year round.

Perennial

Herbaceous legumes: *Onobrychis pinnata* (common on gypseous soils), *Onobrychis acaulis*, *Onobrychis "gypsorum"* (on gypsum rocks), *Lotus "khuzistanicus"* (on gypseous marls, conglomerates and limestone, green all the year round), *Astragalus anacandius* (gypseous soils).

Other perennial weeds: (we only quote the principal ones)

Convolvulus (several very common species), *Carex stenophylla*, *Teucrium polium*, *Erodium glaucophyllum* (gypsum), *Phlomis bruguieri*, *Teucrium oliverianum* (gypsum), *Lactuca orientalis*, *Echinops* sp., *Achillea conferta* (gypsum), *Achillea santolina*, *Reseda* sp., *Anchusa strigosa*, *Poterium lasiocarpum*, *Salvia palaestina*, *Scrophularia xanthoglossa*, *Linum balansae*, *Verbascum* spp., etc.

With crops: *Alhagi maurorum*, *Glycyrrhiza glabra* (deep soils), etc.

Annual species: (They form the major part of the flora; we only quote the most abundant ones).

Stipa capensis (extremely common, especially on overgrazed gypseous soils).
Aegilops triuncialis (and other species), *Hordum murinum*, *Bromus tectorum*, *Bromus danthoniae*, *Centaurea phyllocephala* spp., *Oliveria orientalis*, *Daucus* sp., *Plantago* spp., *Lygia pubescens, Gypsophila* sp., various Cruciferae, etc., etc.

In the fields: *Carthamus* spp., (especially *C. flavescens*), *Erucaria aleppica*, *Crozophora verbascifolia*, *Hirschfeldia adpressa* (from 400 mm rainfall p/a), *Euphorbia lanata*, etc.

Also found in this zone a good number of *Trifolium* and *Medicago*, annuals more or less Mediterranean.

It will be noticed that zone C is distinguished from Zone B by its richness in perennial grasses, by its poverty in the Chenopodiaceae and halophilous species, and by the presence of a good number of arborescent or bushy species.

It differs from the following zones by the extreme abundance of *Stipa capensis*, by its poverty in *Astragalus* and perennial *Euphorbia* and by the absolute predominance of annual species.

4. ZONE D—LOWER MOUNTAIN ZONE

Situated between 900 m and 1500 m in altitude it is principally a transition zone, consisting of more or less steep slopes and generally narrow valleys which may from time to time assume an appearance of canyon. This zone does not cover large surfaces in the South-East and in the Centre, but it is more extensive in the North-West (Karkheh basin) because of the lowering of mountains.

Lithologically that zone consists essentially of limestones, either hard or more or less marly, with conglomerates and some small alluvial plains where the valleys become larger (for example in the North West). Gypsum rocks are exceptional.

Active erosion is principally localized on the marly slopes, and it is there that the greater part of silts carried by the rivers originates.

Climatically all that zone receives an average of at least 400 m rain p/a and much more in certain regions. It is colder in winter in the NW than in the SE. This zone is a typical forest zone, but forests are most often very degraded here, or even completely destroyed. The main tree is *Quercus persica*, which in certain regions begins already in the higher part of zone C. The primitive forest soils have rarely been conserved, and that because of intensive overgrazing (especially by goats) and erosion. In general trees are small, or even reduced to bushes, and they are very sparse.

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Vegetation consists essentially of annuals (frequent predominance of *Aegilops*) on soils more or less skeletal. There are very few interesting forage species, for the various good species of zone C hardly exceed 900 m of altitude, and the good mountain forage species only start at about 1500 m. The only perennial grass relatively common is Hordum bulbosum, but it is of little interest because of its weak rooting and its palatability limited to a short period in spring. The more or less shrubby ligneous species are also not numerous and not very abundant. The whole flora of this zone clearly appears less rich than that of zones C and E.

Arborescent species:

Quercus persica (very common) — *Acer cinerascens*
Pistacia khinjuk — *Pistacia atlantica*
Fraxinus syriaca (not common) — *Cercis siliquastrum* (Karkheh basin)
Celtis caucasica (localized) — *Crataegus azarolus*
Ficus rupestris — *Ficus johannis*
Amygdalus scoparia (very common, but rarely arborescent)

At the bottom of valleys: *Platanus orientalis*, *Populus euphratica*, *Salix* spp., *Tamarix* sp.

Bushy species:

Amygdalus scoparia (very abundant), *Prunus tortuosa* (common), *Astragalus fasciculifolius* (very abundant), *Rosa* spp., *Marsdenia erecta* (common), *Vitex agnus-castus* (bottom of valleys)

Low ligneous species:

Noaea mucronata, *Onosma* sp., *Astragalus ecbatanus* and some other thorny *Astragalus*.

In this zone *Acantholimon* and *Acanthophyllum* are rare.

Perennial grasses:

Poa bulbosa (common) — *Stipa barbata* (not common)
Hordeum bulbosum (common) — *Pennisetum orientale* (rare, rocks)
Agropyrum aucheri (rather common) — *Melica inaequiglumis* (rocks)
Cynodon dactylon (near crops)

Perennial legumes: *Onobrychis scrobiculata* (rare, Karkheh basin), *Onobrychis haussknechtii* (rare)

Other perennial herbs: (we only quote the most important ones)

Carex stenophylla, *Poterium* spp., *Teucrium polium*, *Hypericum* spp., *Lactuca orientalis*, *Convolvulus* spp., *Phlomis bruguieri*, *Phlomis brachyodon*, *Dianthus* sp., *Onosma* sp., *Ankyropetalum* sp., *Euphorbia macroclada*, *Galium coronatum*, *Anchusa strigosa*, *Helichrysum* sp., *Ferulago* sp., *Polygonum setosum*, *Salvia palaestina*, *Centaurea myriocephala*, *Picris strigosa*, *Echinops* sp., *Serratula behen*, *Eryngium campestre*, etc. *Peganum harmala* is sometimes abundant on dry wast lands.

In cultivated fields: *Alhagi maurorum*, *Glycyrrhiza glandulifera*, *Achillea santolina*, *Salvia syriaca*, *Centaurea behen*, *Teucrium parviflorum*, *Gundelia tournefortii*, *Alcea* sp.

Annual species: (we only quote the most important ones)

Zoegea leptaurea, *Aegilops triuncialis* (and other species), *Triticum dicoccoides* (abundant in the NW), *Centaurea phyllocephala*, *Pimpinella* sp., *Phleum exaratum*, *Bromus tectorum*, *Bromus danthoniae*, *Boissiera pumilis*, *Heteranthelium piliferum*, *Matthiola oxyceras*, *Crepis* sp., *Silene linearis*, *Xeranthemum squarrosum*, *Lygia pubescens, Filago spathulata*, *Helianthemum salicifolium*, *Trifolium campestre*, *Trifolium angustifolium*, *Bupleurum gerardi*, *Scabiosa olivieri*, *Scabiosa palaestine*, *Onobrychis squarrosa*, *Cephalaria dichaetophora* (forests) etc., etc.

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In cultivated fields: *Carthamus* spp., *Cephalaria syriaca*, *Heliotropium* sp., *Euphorbia aleppica*, *Crozophora* sp., *Hordum murinum*, *Turgenia latifolia*, *Centaurea solstitialis*, *Centaurea pallescens*, *Onopordum* sp., *Vaccaria segetalis*, etc., etc.

This zone differs from the following one by its great poverty in grasses and perennial legumes, as well as in shrubby species more or less ligneous. Even *Astragalus* are not very common, nor are *Euphorbia* and Labiatae.

On our map, we have indicated a sub-zone D1 and a sub-zone D2. This latter is localized a the North of the present forest limit. It constitutes the bottom of broad valleys in Kermanshah are a, and its lowest altitude is 1300 m It is almost entirely cultivated and its flora consists mainly of weeds. Here and there non-arable soils support a very degraded pastoral vegetation, where *Carex stenophylla* often spreads itself widely, associated with undesirable species: *Phlomis bruguieri*, *Euphorbia macroclada*, *Cousinia cylindracea*, *Gundelia tournefortii*, etc.

Note: The absence of cettain species (in particular pernennial grasses) in this zone is not always due to altitude but to the too heavy rainfall. In fact: *Aristida plumosa* exists at 1800 m of altitude towards Shahreza and dominates the grazing lands SW of Tehran.
Pappophorum persicum exists at 1500 m East of Arak.
Pennisetum orientale, which in our territory does not exceed 1100 m, van be found at 1700 m South of Isfahan.

On the other hand, *Hyparrhenia hirta* is certainly limited in altitude by too low temperatures, for it requires a rather warm winter.

5. ZONE E—MEDIUM MOUNTAIN ZONE

Like the preceding one, this zon is much less developed in the S-E and the Centre than in the N-W, where it becomes much more important.

Approximately 2/3 of that zone (sub-xone E1) are included in the great forest belt: 1/3 in the Karkheh basin and 1/3 in the whole of the remaining basins. Rocks are principally calcareous, with some parts made of marls or conglomertes. The last third (sub-zone E2), situated North of the present forest limit, is an agricultural snd pastoral zone, with a varied sub-soil where ancient rocks (more or less metamorphic) are prevailing.

We thought it logical to make this zone start at 1500 m because it is near that altitude that the principal perennial grasses of the high mountains appear (especially Bromus tomentellus and Festuca valesiaca, as well as a number of ligneous species. The upper limit (2000 m) is a little arbitrary; it corresponds more or less to the end of numerous annual species, but also to the appearance of bushy *Astragalus* and of "tragacanth" vegetation. It is also at this altitude that snow stocking in winter starts (approximately till the end of April, at 2000 m).

It is certainly in that zone that precipitations reach their maximum; usually more than 500 mm p/a, and in certain points probably 1200 mm. But precipitations can also decrease locally to less than 400 mm p/a, in particular in the areas of Malayer, Negavend, and Songor. Winters are cold, especially in the North-East, where January average temperature is definitely below zero. Summers are rather warm, but not much more in the SE than in the North.

This zone is very little cultivated in the calcareous part (E1) but agriculture is extensive in the North, due to the predominance of metamorphic rocks and the much softer relief.

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In the whole, the vegetation of that zone is much better than the vegetation of the preceding one. Forests are less degraded, and pastures, without really being good are much richer in palatable perennial species. Indeed, the number of perennial species increases with the altitude, whilst the number and abundance of annuals decreases gradually. Besides, these latter grow mainly among crops and fallows, and perennials are found mainly in pastures and forests.

The fundamental tree is still *Quercus persica*, at least when it has not been destroyed.

Unfortunately, in wooded areas overgrazing has seriously impoverished the herbaceous flora, and forage species have become rare.

In this zone we begin to see frequently small thorny shrubs of *Astragalus*, *Acantholimon*, *Acanthophyllum* ("tragacanth" vegetation) which become more abundant over 2000 m (Zones F and G). Perennial Labiatae (*Phlomis, Salvia, Stachys, Teucrium*) take a great part in the herbaceous vegetation.

The flora of cultivated lands (whether irrigated or not) is particularly rich in annual as in perennial species.

In some valleys, irrigated fodder crops (alfalfa, sainfoin, Persian clover) have a certain importance. The vine and fruit trees are favoured by the climate of that zone.

Arborescent species: (in general absent from sub-zone E2)

Quercus persica (very common)
Pistacia atlantica
Celtis caucasica (or *C. tournefortii*?)
Pirus syriaca
Amygdalus eleagnifolius
Lonicera nummularifolia
Acer cinerascens
Fraxinus syriaca
Crataegus azarolus
Ficus rupestris
Crataegus ambigua
Juniperus excelsa (very rare)

At the bottom of the valleys: *Platanus orientalis*, *Populus euphratica* (rather rare), *Tamarix* sp., *Salix* spp., *Elaeagnus angustifolia*, *Crataegus monogyna*, *Ulmus campestris*.

Bushy species: (principally in sub-zone E1)

Prunus tortuosa (and neighbouring species), *Amygdalus carduchorum*, *Amygdalus scoparia* (localized on eroded marls up to 1850 m, and up to 2000 m in the SE), *Rhamnus persica*, *Amygdalus horrida* (sub-zone E2), *Berberis integerrima* (localized), *Rosa* spp., *Astragalus fasciculifolius* (or very similar species), *Astragalus* spp. (thorny), *Convolvulus leiocalycinus* (SE only), *Daphne angustifolia*

Low ligneous species:

Thorny: *Acantholimon* spp., *Acanthophyllum caespitosum*, *A. squarrosum*, *Noaea mucronata*, *Astragalus* spp. (numerous species)

Non-thorny: *Onosma* sp., *Artemisia aucheri* (localized, E2), *Stellera lessertii* (in the driest parts of E2)

Perennial grasses: (in general much less abundant in E1 than in E2)

Bromus tomentellus (common but mostly in E2) *Poa bulbosa* (very common)
Festuca valesiaca (common) *Agropyrum aucheri* (very common)
Stipa barbata (and neighbouring species, common *Stipa lagascae* (rather common)
Oryzopsis holciformis (rather rare) *Arrhenatherum kotschyi*
Hordeum bulbosum (common, mostly in E1) *Secale montanum*
Melica inaequiglumis (rocks) *Cynodon dactylon* (near crops)
Andropogon ischaemum (localized in moister depressions, near crops
Alopecurus ventricosus and *Elymus elatius* (rather humid soils)

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Perennial herbaceous legumes:

Onobrychis scrobiculata (N-W), Onobrychis melanotricha (and neighbouring species), *Onobrychis lunata* (NW of E1), *Astragalus chaborasicus*, *A. brachyodontus*, *A. curvirostris*, and other *Astragalus*. Most of them are especially abundant outside the forest zone.

Other perennial herbs: (we only quote the most common)

Salvia acetabulosa, *Centaurea squarrosa*, *Stachys inflata*, *Teucrium orientale*, *Teucrium taylorii*, *Onosma* spp., *Silene* spp., *Convolvulus* spp., *Carex stenophylla*, *Scirpus holoschoenus*, *Teucrium polium*, *Cousinia cylindracea* (and other *Cousinia*), *Lactuca orientalis*, *Pterocephalus canus*, *Alyssum alpestre*, *Phlomis bruguieri*, *Phlomis orientalis*, *Euphorbia megalantha* (and other *Euphorbia*), *Echinops* sp., *Scabiosa kuirdica*, *Gypsophila* sp., *Eryngium campestre*, *Serratula behen*, *Stachys lavandulifolia*, *Ziziphora clinopodioides*, *Scutellaria persica*, *Thymus* sp., *Hypericum* spp., *Acantholimon bromifolium*, *Crucianella glauca*, *Euphorbia macroclada*, *Morina persica*, *Dianthus* spp., *Marrubium* sp., *Linum album*, *Erysimum crassipes*, *Trichodesma aucheri*, *T. molle*, *Gundelia tournefortii*, various big Umbelliferae, etc., etc.

Among crops: *Salvia syriaca*, *Achillea santolina*, *Phlomis persica*, *Euphorbia* spp., *Gundelia tournefortii*, *Alcea* sp., *Centaurea behen*, *Scrophularia xanthoglossa*, *Convolvulus arvensis*, *Alhagi maurorum* (up to 1800 m), *Agropyrum* sp.. On deeper and moister soils: *Glycyrrhiza glandulifera* and *Goebelia alopecuroides* are extremely abundant. In drier climates are sometimes found fields covered by *Hulthemia persica*, characteristic of the North of Iran. Finally waste lands and cemeteries in the North are often invaded by *Peganum harmala*.

Annual species: They are rather abundant among crops and comprise mostly Gramineae, Cruciferae, Leguminosae, and Umbelliferae.

Bromus tectorum, *Bromus danthoniae*, *Boissiera pumilio*, *Triticum dicoccoides*, various *Aegilops*, *Lathyrus aphaca*, *Vicia peregrina*, *V. villosa*, *V. ervilia* (sometimes cultivated), *Lathyrus cicera*, *Astragalus camplorhynchus* [sic?], *Trigonella incisa*, *Goldbachia laevigata*, *Alyssum* spp., *Lepidium* sp., *Malcolmia* sp., *Bupleurum* sp., *Turgenia latifolia*, *Papaver* sp., *Silene conoidea*, *Valerianella* spp., *Zoegea* sp., *Ziziphora persica*, *Vaccaria segetalis*, *Galium tricorne*, *Delphinium* spp., etc.

Remarks: The major part of herbaceous species has been observed particularly in sub-zone E2. Many of them can be found in sub-zone E1, but they are generally less abundant, and the palatable species are sometimes rather rare.

The northern limit of the present forest belt, between Kermanshah and Azna, is artificial and entirely due to human action. Moreover there exists some remains of forest in the great mountain of massive limestones situated NE of Kermanshah, as well as on a hill between Azna and Arak.

5. ZONE F—HIGH MOUNTAIN ZONE

Contrary to the two preceding zones, this zone is not as wide in the Karkheh basin than in the other basins; it extends mostly in the present great forest belt but, as most of the trees hardly exceed the altitude of 2500 m, it consists mainly of pastures.

It is probable that by placing this zone between 2000 m and 3000 m of altitude

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we have included types of vegetation too different from one another, and that the zone could have been subdivided into two parts, the lower part Fa (2000–2500 m) corresponding to the upper limit of the oak tree, the upper part (2500–3000 m) which can only support forests of Juniperus (or in open thickets *Lonicera*, *Amygdalus*, *Daphne*), but in fact it is almost entirely pastoral because of the almost complete destruction of that tree. In order to adopt this division it would have been necessary to conduct many more explorations above 2500 m, so that these two belts cold have been well differentiated by their herbaceous flora, what would probably be difficult.

The absence of forests in the North and North-East made us divide this zone firstly into two sub-zones, F1 and F2. But in addition the region of Shar-Kord and probably a small area North of Azna, having a climate definitely drier than the rest of the mountainous area, made us discern a sub-zone F3, with a much poorer flora, and even a sub-zone F4 (extremely reduced in our territory) where we begin to see the typical species of the central steppes of Iran, *Artemisia herba-alba*.

The Zone F probably does not receive as much precipitation as Zone E, but the greatest amount of water falls as snow, which, instead of running off as in the lower zones, accumulates during all winter. It only melts in April or May and thus plays a great role in the rivers' floods as this zone covers more than a quarter of the whole catchment basins.

Because of this accumulation of snow during several months, soils are generally completely decalcified.

Because of low temperatures the period of active vegetation is short: from 6 to 6 1/2 months at 2000 m. It is probably reduced to 4 months at 3000 m. Botanical explorations can therefore only take place within a period of time rather limited, most of the species flowering and bearing fruits in June and July. Several years would be necessary in order to accomplish a thorough study of these high regions.

Lithologically the sub-zone F1 contains principally limestone and some conglomerates, whereas the other sub-zones consist mostly of schists and other metamorphic rocks. There are also some high alluvial plains which are of course extensively cultivated, or had been cultivated formerly.

There are still many crops up to 2400 m (and even sometimes up to 2600 M) in the regions without forests, but yields are generally very poor in the absence of irrigation. In the North and East, the abusive use of dry farming has caused a considerable erosion of the soils of metamorphic origin.

Vegetation consists mainly of perennial species, and annuals have practically disappeared by 3000 m of altitude. The florae comprises a great number of *Astragalus* species, in general thorny, among which several shrubby species in the shape of an umbrella which are quite characteristic of that zone, especially in the more or less forested parts.

Similarly in the North-East, it is near 2000 m of altitude or a little higher that the real typical vegetation of semi-arid mountains appears, with thick and thorny cushions of *Acantholimon*, *Astragalus* and *Acanthophyllum* ("tragacanth" vegetation); but this type vegetation is doubly dependent on human influence: it is overgrazing that favors the spreading of these species, and after it is man who removes them in order to utilize them for fuel. In reality, the normal vegetation of these high mountains, outside the wooded areas, should be pastures with perennial grasses dominating.

The botanical analysis of this important zone is difficult in view of the great variety of vegetation types, but mostly because of the practical impossibility to identify correctly any species, insufficiently studied or still not yet described in the floras, in particular most of the *Astragalus* and *Acantholimon*.

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a) <u>Sub-Zone F1</u>

In this sub-zone forests can each 2500 m or even 26000 m (with *Quercus*, *Pistacia*, *Acer*, *Amygdalus*, etc.); this is the case in the Bakhtiari mountains, but very often this forest belt has been entirely depleted. As in Zone E, the herbaceous flora of the wooded parts is poor in forage species, or at least these species are not at all abundant.

Above 2600 m of altitude the vegetation is entirely pastoral, with some rare Juniperus or Lonicera, and a few bushes of Amygdalus and Daphne. Forage species are more abundant, at least when they have not been completely replaced by non-palatable species

Arborescent species:

Quercus persica (very abundant, sometimes forms real forests)
Juniperus excelsa (rather rare, has taken refuge on rocky slopes)
Fraxinus syriaca (or neighbouring species? not very abundant)
Pistacia atlantica (rather common)
Celtis tournefortii (localized)
Prunus mahaleb (localized)
Pirus syriaca (rather common)
Colutea persica (rare, SE)
Lonicera nummularifolia (very common)
Acer cinerascens (very common)
Juglans regia (very rare)
Amygdalus eleagnifolius (very common)
Crataegus azarolus (very common)
Crataegus ambigua (not very common)
Cotoneaster nummularia (rare)

At the bottom of valleys: *Platanus orientalis*, *Salix* spp., Fraxinus sp., *Elaeagnus angustifolia*, *Crataegus monogyna*; *Populus nigra* is cultivated up to 2250 m on the southern slopes of Mt. Elvend. Also fruit trees and vine can be found up to 2300 m.

Bushy species:

All the preceding species when they have been damaged by man or browsed by goats.
Prunus tortuosa (very common), *Daphne angustifolia* (very common), *Rhamnus persica* (rather common), *Prunus diffusa* (SE), *Amygdalus carduchorum* (rather common), *Astragalus* spp. (the taller ones being *A. brachycalyx* [sic?], *A. adscendens* [sic?], *A. eriostylus* [sic?], *A. umbraculaeformis* [sic?], etc.) (common and often abundant), *Rosa* spp., *Berberis integerrima* (localized), *Convolvulus leiocalycinus* (SE), *Prunus incisa* (not very common)

The bushy vegetation of the very degraded forest comprises mostly:
Daphne, Lonicera, Prunus, Amygdalus and *Rosa*.

Thorny cushion-like species: ("tragacanth: vegetation)

Acantholimon spp. (at least 10 species), *Acanthophyllum* spp. (a few ones), *Astragalus* spp. (especially of the sub-genus "Tragacantha"; maybe 30 species or more), *Onobrychis cornuta* (now very rare).

Species with a ligneous basis:

Thorny: *Noaea mucronata*, *Astragalus* spp. (including *A. microphysa*, *A. acutus*, very common)
Non-thorny: *Pyrethrum myriophyllum*, *Jurinea* sp., *Phlomis anisodonta* (SE), *Euphorbia macrostegia* (SE), *Rubia pauciflora*, *Polygonum dumosum*, *Silene* spp., *Ziziphora clinopodioides*, *Nepeta* sp., *Achillea* sp., *Galium* sp., *Crucianella glauca*, etc.

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Perennial grasses:

Poa bulbosa, *Hordeum bulbosum*, *Secale montanum*, *Agropyrum aucheri*, *Oryzopsis holciformis*, *Arrhenatherum* sp., *Hordeum fragile*, *Melica* sp., *Dactylis glomerata*.
All these species can be found in the more or less wooded parts, and often also in pastures.
Bromus tomentellus, *Festuca valesiaca* (rare in the South) *Oryzopsis molinioides*, *Stipa barbata*, are peculiar to pastures, and therefore are more common above 250 m.

Perennial herbaceous legumes:

Onobrychis spp. (at least 5 species), *Trigonella elliptica*, *Astragalus* spp., *Cicer anatolicum*, *Hedysarum* sp., *Medicago sativa* (seems really indigenous in numerous places)

In more humid depressions: *Lotus corniculatus*, *Trifolium repens*, *Ononis leiosperma*; associated to the grasses: *Agrostis stolonifera*, *Poa pratensis*, *Alopecurus ventricosus*, and to *Poterium* sp., *Scirpus, Carex, Eleocharis*.

Other perennial herbaceous species: (we only quote the most important ones)

Thymus sp., *Phlomis orientalis*, (very abundant), *Euphorbia hebecarpa*, *Euphorbia bothriosperma*, *Carex* sp., *Silene* spp., *Teucrium orientale*, *Nepeta* spp., *Helichrysum* spp., *Stachys* spp., *Asperula glomerata* (on marls), *Centaurea squarrosa*, *Podanthum* sp., *Cephalaria* spp., *Rumex elburzensis*, *Fibigia suffruticosa*, *Delphinium* sp., *Aethionema* sp., B*upleurum irregulare*, *Onosma* sp., *Marrubium* sp., *Galium coronatum*, *Convolvulus* spp., tall Umbelliferae, etc.
Thorny species: *Eryngium billardieri*, *Morina persica*, *Cousinia* spp., *Echinops* sp., *Lactuca orientalis*.
Phlomis persica, *Salvia syriaca*, etc. are abundant on more or less cultivated soils.

Annual species: (They are particularly localized in crops)

Bromus danthoniae, *Bromus tectorum*, *Cephalaria syriaca*, *Centaurea solstitialis*, etc. *Polygonum polycnemoides* is a characteristic of level soils, little permeable and decalcified.

When the forest or pastoral vegetation has been completely degraded by man and goats, the following species can dominate or even become exclusive:
Phlomis orientalis, *Phlomis persica*, *Eryngium billardieri*, *Cousinia* spp., *Euphorbia* spp., *Lactuca orientalis*, *Noaea mucronata*, *Echinops* sp., *Morina persica*, finally the tall non-palatable Umbelliferae (*Ferula*, *Ferulago*, etc.)

b) Sub-Zone F2

In this essentially pastoral and agricultural sub-zone there are no more forests; we only find rare bushes and exceptionally small isolated trees. It is probable that the oak forest had never covered the section of this sub-zone which spreads on the border of our territory from the area of Malayer to the SE of Shar-Kord, but in the West it is certain that the oak forest extended before much more northwards, since there still exists a small forest at 2000 m, in the limestone mountain of Kuh-i-Parau, and some *Pistacia* on the rocky cliff of Bisitun.

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On the other hand *Juniperus excelsa*, more xerophilous, must have once existed on all these mountains, even those which are too dry for the oak. *Pistacia atlantica* must have existed at least up to Arak, because there are still a few ones left in the East of Zone F4.

This sub-zone should therefore be divided into two parts: 0ne in the NW, more humid and less cold, where the oak forest is climatically possible; the other one in the East, drier and colder, where only forests of rather xerophilous trees could be found (*Juniperus, Pistacia, Amygdalus, Crataegus, Pirus*).

Arborescent and bushy species: (rare and almost always reduced to the bushy stage)

Amygdalus eleagnifolius, *A. horrida*, *Pirus syriaca*, *Crataegus azarolus*, *Rhamnus persica*, *Prunus tortuosa*, *Daphne angustifolia*, *Pistacia atlantica*, *Celtis* sp., *Juniperus excelsa*(?).f

Low woody species:

Rosa sp., *Atraphaxis* sp., *Prunus incisa*, *Astragalus* spp. (thorny), *Acanthophyllum microcephalum*, and many species of the thorny cushion type such as *Astragalus*, *Acantholimon*, *Acanthophyllum*.

Species with a more or less ligneous basis:

Salsola canescens, *Pyrethrum myriophyllum*, *Noaea mucronata*, *Crucianella glauca*, *Ziziphora clinopodiodes*, *Silene* spp., *Ajuga chamaecistus*, etc.

Perennial grasses:

Poa bulbosa (very common) *Agropyrum aucheri* (very common)

Bromus tomentellus (very common)
Festuca valesiaca (rather common)
Stipa barbata (very common)
Stipa lagascae (rather common)
Oryzopsis holciformis (rare)
Oryzopsis molinioides (above 2500 M)
Melica sp. (rocks)
Agropyrum caespitosum (rare, rocks)
Hordeum bulbosum (common up to 2500 m)
Secale montanum (not very common)
Hordeum fragile (rare)
Dactylis glomerata (very rare)
Arrhenatherum kotschyi (rather common)

Perennial herbaceous legumes: (often abundant among pastures)
Astragalus chaborasicus (very common)
Astragalus brachyodontus (not common)
Astragalus curvirostris (very common)
Onobrychis spp. (especially *O. melanotricha*, very common)
Vicia tenuifolia (rare)
Astragalus siliquosus (localized, fallows)
Medicago sativa (not common)
Trigonella elliptica (rare)
Cicer anatolicum (rather common)
Numerous other *Astragalus*

Other perennial herbaceous species: (we only quote the most common)
Centaurea squarrosa, *Salvia acetabulosa*, *Phlomis orientalis*, *Pterocephalus canus*, *Teucrium orientale*, *Stachys inflata*, *St. lavandulifolia*, *Thymus* sp., *Euphorbia bothriosperma, E. megalantha*, *Onosma* spp., *Alyssum alpestre*, *Serratula behen*, *Helichrysum artemisioides*, *Teucrium polium*, *Hypericum helianthemoides*, *H. scabrum*, *Carex stenophylla*, *Achillea sulphurea*, *Polygonum paronychioides*, *Galium* sp., *Bufonia kotschyana*, a few big Umbelliferae (*Ferula, Smyrnium, Prangos*), etc. *Poterium* are rare.

Thorny: *Cousinia cylindracea* (and other species), *Eryngium billardieri*, *Echinops* sp., *Lactuca orientalis*, *Echinophora platyloba*.

Amongst crops, similar vegetation as in sub-zone F1; predominance of *Phlomis persica*, *Gundelia tournefortii*, *Salvia syriaca*, *Achillea santolina*, *Lactuca orientalis*, in dry fields; predominance of *Glycyrrhiza* and *Goebelia* in the moistest and deepest cultivated soils.

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Annual species: They grow specifically among crops and they are more or less the same as in the sub-zone F1 (a few dozen approx. can be found.)

The flora of humid depressions is rather rich; are found a few good perennial legumes, in particular: *Lotus corniculatus*, *Trifolium pratense*, *Trifolium repens*, *Trifolium tumens*, *Trifolium fragiferum* and some other forage species, among which *Poterium* sp.

c) Sub-Zone F3

This sub-zone occupies a small territory in the region of Shar-Kord, and probably another one North-East of Asna. We visited it rather too late in the year to have a good knowledge of its flora, but it is certain that this region differs from the preceding one only by its greater dryness (not more than 300 mm rain p/a approx.) and its flora—rather poor and terribly overgrazed—seems to be only a selection from the most xerophilous species of Zone F2. Dry farming is very extensive; so is erosion.

In this zone are found again:
Bromus tomentellus, *Stipa barbata*, *S. lagascae*, *Poa bulbosa*, *Agropyrum caespitosum*, *Cynodon dactylon*, *Astragalus chaborasicus*, *Trigonella elliptica*, *Onobrychis melanotricha*; *Centaurea squarrosa*, *Phlomis orientalis*, *Euphorbia megalantha*, *Pterocephalus canus*, *Teucrium polium*, *Stachys inflata*, *St. lavandulifolia*, *Polygonum paronychioides*, etc.

Thorny: several *Astragalus* (of the series Tragantha and Microphysa) several of which are peculiar to that region, *Eryngium billardieri*, *Echinophora platyloba*, *Gundelia tournefortii*,

Acanthophyllum sp., *Acantholimon* spp., *Noaea mucronata*, *Lactuca orientalis*, *Cousinia* spp., (amongst which one species peculiar to that region).

Phlomis aucheri (special to the region), *Phlomis persica*, *Salvia syriaca*, *Glycyrrhiza glandulifera* and sometimes *Hulthemia persica* are common among crops.
Thymus sp., and *Scirpus holoschoenus* are in less dry parts.
Hertia angustifolia (rare) announces the steppe zone.

d) Sub-Zone F4

It only comprises a few square kilometers in our territory, East of Urudjan on the road to Shahreza. These are lands relatively horizontal, more or less pastoral, at an altitude of 2300 m approximately. Precipitation must be below 250 mm, for *Artemisia herba-alba* indicates the beginning of the steppic climate of Central Iran.

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The flora of the sub-zone F3 becomes considerably poorer; we only noticed *Bromus tomentellus* (we must not its great resistance to drought), *Phlomis persica*, *Poa timeolontis* (related to *Poa bulbosa*), *Polygonum dumosum, Onobrychis melanotricha*, *Phlomis aucheri*, and of course the inevitable *Lactuca orientalis*, and *Noaea mucronata*.

Looking better we could find *Stipa barbata*, but certainly not *Festuca valesiaca*.

Species which are an indication of steppic conditions are: *Artemisia herba-alba*, *Iris songarica*, *Eremurus* sp., *Cousinia* sp., *Hertia angustifolia*, *Silene* sp., *Hulthemia persica* and some *Acantholimon* very dense and not found in other regions.

When we proceed eastward (leaving our territory) Artemisia becomes predominant, species of Zone F3 disappear, even *Phlomis persica*, and it is *Hulthemia* which predominates amongst crops. Finally, when there are no more *Iris songarica*, we are really in the steppic zone, and Chenopodiaceae are associated to *Artemisia*.

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Remarks on Zone F: We were able to study particularly Zone F in its lower part, and we could exceed 2500 m of altitude only rarely (Mt. Elvend, Kuh-Rang, Ardekan pass and in the Bakhtiari mountains). It is therefore difficult for us to state with precision where lies the superior limit in altitude of a great number of species in that zone.

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7. ZONE G—"ALPINE" ZONE

We only penetrated in that zone at Mt. Elvend (up to 3650 m of altitude) which by its situation at the extreme North of our territory, by its relative isolation, and mostly by its granitic nature, can be taken with difficulty as an example for the whole of the other high mountains, which are on the contrary calcareous. Furthermore, this ascension, one on June 10th, was too early in the year for a good study of the flora above 3200 m. We have been able, however, to note the generic names of the most common species. The examination of the flora North of Ardekan (about 3000 m, and on limestone rocks) has allowed us to find some species common on Mt. Elvend, and this to decide the probability of their existence over the whole of Zone G.

We cannot state accurately where lies the extreme limit of vegetation. At the summit of Mt. Elvend the flora was still sufficiently dense and varied, with numerous small cushions of *Astragalus* and *Acantholimon*. It is therefore probable that some vegetation exists on the highest mountains (over the Karun basin) at least up to 4200 m and maybe higher.

In these high regions the period of vegetation is extremely short, without any doubt not more than 3 months at 3500 m. The flora consists only of perennial species; it is characterized essentially by thorny cushions (tragacanth vegetation), as well as by some species with a strong ligneous basis (*Pyrethrum*).

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Species with ligneous basis:

Ephedra sp., *Pyrethrum* sp., *Phlomis* sp., *Prunus incisa, Euphorbia* sp., *Galium* sp., *Thymus* sp., *Silene* sp., *Helichrysum* sp., etc.

"Tragacanth" species:

Acantholimon spp., *Astragalus* spp., *Acanthophyllum* sp., (not very abundant), and probably *Onobrychis* (rare)

Perennial grasses:

Oryzopsis molinioides, *Festuca* sp., (related to *ovina* group), *Poa reuteriana*, *Stipa* sp., *Agropyrum* sp. (cespitose), the 5 species to be found at the summit of Mt. Elvend . *Bromus tomentellus* can climb up to at least 3400 m.

There does not seem to be any forage legumes, at least on Elvend, but an interesting Onobrychis was found in abundance at 2900 m on Ardekan pass; it is very possible that it can be found higher.

Other herbaceous species:

Phlomis orientalis (or neighbouring species), *Marrubium* sp., *Euphorbia bothriosperma*, *Potentilla* sp., *Pimpinella* sp., *Silene* sp., *Scrophularia* sp., *Stachys* sp., *Carex* sp., *Arabis sulphurea*, *Cicer* sp., *Ranunculus* sp., *Inula* sp., and the thorny ones:
Noaea mucronata, *Eryngium* sp., *Cousinia* sp.

Bulbosa species:

Corydalis verticillaris, Tulipa polychroma, Geranium tuberosum, Colchicum brachyphyllum, Allium sp., *Ornithogalum* sp.

Because of soil decalcification in the high mountains it is probable that most of the plants found on Mt. Elvend also exist at similar altitudes on limestone mountains.

Finally, mention must be made of a very special type of vegetation which could very well belong exclusively to the Northern granitic mountains, because this vegetation is bound to the great and permanent humidity of certain slopes or depressions above 3000 m, condition much more difficult to realize on a more permeable calcareous sub-soil. This vegetation forms a very dense green carpet on a black soil, rich in humus, and definitely acid (podzol). This is very similar to what is often found in the high mountains of Europe, and this analogy is underlined by the presence of *Primula auriculata* and of *Polygonum bistorta*, species of the Alps. Of course, overgrazing prevents grasses to develop normally.

This vegetation is basically formed of *Carex* and grasses: *Carex caucasica*, *Festuca rubra*, *Poa* sp., etc., associated to *Lotus corniculatus* var., *Trifolium repens* var., *Veronica* sp., *Alchemilla* sp., and abundant mosses.

Characteristic species are: *Polygonum bistorta*, *Primula auriculata*, *Scirpus carnuus*, *Rumex* sp., *Pedicularis comosa*, *Barbarea* sp., *Fritillaria* sp., *Doronicum macrophyllum*.

It is very probable that this type of sward forming an homogenous vegetation is a relic of the last glacial period, but insofar as overgrazing aggravates erosion, it must tend to cover surfaces more and more reduced. These wide green patches create by the way a striking contrast with stony and more or less barren slopes which surround them, and whose vegetation is typically oriental.

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8. TYPICAL PASTORAL VEGETATION OF NORTHERN MOUNTAINS

In order to complete this phytogeographical chapter, we give below a list of the species usually to be found in most of the pastures of Zones E2 and F2 (approximately between 1800 and 2400 m) because this type of vegetation is certainly the most important one in the North, apart from the cultivated areas. The floristic composition is rather uniform when overgrazing is not too excessive.

Good forage species:

Bromus tomentellus
Festuca valesiaca
Onobrychis melanotricha
Astragalus chaborasicus

Mediocre forage species:

Poa bulbosa
Stipa barbata
Agropyrum aucheri
Astragalus curvirostris
Stipa lagascae
Hordeum bulbosum

More or less palatable species:

Pterocephalus canus
Teucrium polium
Thymus sp.
Pyrethrum myriophyllum
Alyssum alpestra
*Teucrium taylori*i
Fibigia suffruticosa
Stachys inflata
Marrubium sp.
Centaurea squarrosa
Ziziphora clinopodioides
Salvia acetabulosa
Hypericum helianthemoides
Achillea sulphurea
Teucrium orientale
Ajuga chamaecistus
Stachys lavandulifolia
Helichrysum sp.

Unpalatable species:

Phlomis orientalis
Onosma spp.
Trichodesma spp.
Euphorbia bothriosperma
Euphorbia megalantha
Euphorbia macroclada

Thorny species (unpalatable):

Acantholimon spp.
Acanthophyllum spp.
Astragalus spp.
Cousinia cylindracea
Noaea mucronata
Lactuca orientalis
Eryngium billardieri
Cousinia spp.

We notice that this list comprises mostly Labiatae, Compositae, Gramineae, and Leguminosae. If no account is taken of the thorny species, Labiatae represent 30% of the herbaceous species. Generally they represent much more if account is taken of their abundance and covering when overgrazing has destroyed a part of the best species.

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9. ECOLOGICAL CHARACTERISTICS OF THE GREAT PHYTOGEOGRAPHICAL ZONES

ZONES Surface km²	Theoretical limit	Precipitations (mm p/a)	Average temperature in Jan. °C	Average temperature in July °C	Lithology
G 4000		400 to 700	-15 to -4	+10 to +20	Limestones (very rarely granite or conglomerate
	3000 m				
F 41,000		300 (F3) to 1000	-6 to +2	+18 to +25	Limestones, schists, conglomerates, (very rarely granite)
	2000 m				
E 33,000		400 to 1200	-2 to +5	+23 to +28	Limestones, marls, schists, conglomerates
	1500 m				
D 21,000		400 to 700	+3 to +9	+26 to +33	Limestones, marls, schists, conglomerates, alluvium
	900 m				
C 25, 000		300 to 500	+8 to +13.5	+31 to +39	Gypsum, marls, conglomerates, very few limestones, alluvium
	P=300 mm				
B 15,000		200 to 300	+12 to +13	+36 to +38	Alluvium, sands, few gypsum and sandstones
	P=200 mm				
A 20,000		150 to 200	+12 to +12.5	+36 to +37	Clay alluvium