

## OVERVIEW OF BIOTOPE TYPES OF SOCOTRA ISLAND

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### ABSTRACT

The study describes main biotopes of Socotra Island. The biotopes were distinguished and described during complex field observations on more than 250 localities of Socotra between years 1999-2004. Classification of biotopes is based on differences in physiognomy, structure and species composition of the vegetation component of present biocoenoses. Groups of biotope types differ, above all, in the physiognomy and structure of vegetation. Biotope types are divided according to composition of dominant species. In this manner, 13 groups of biotopes and 39 biotope types were distinguished and described.

**Keywords:** Socotra Island, biotope type classification, geobiocoenological approach

### INTRODUCTION

The present condition of biotopes on the island of Socotra is the result of long-term activities of man on the landscape, particularly through cattle grazing. The structure and species composition of biotopes distinguish in relation to the type and intensity of anthropogenic impacts, which show different consequences in particular types of geobiocoenoses with a range of permanent ecological conditions.

There are various approaches to biotope classification (e.g. Chytrý et al., 2010; Pahlsson, 2008). We utilised the geobiocoenological approach (Maděra, 1998), based on the comparison of the natural (potential) and current state of geobiocoenoses in the landscape. In differentiating the current state of geobiocoenoses in the landscape, a formation-physiognomical approach is used. The basis of differentiation are variations in the structure and species composition of the vegetation components of biocoenoses, the most important functional and ecological properties of which are defined by natural conditions and by the type and intensity of anthropogenic impacts.

Classification of biotopes is based on differences in physiognomy, structure and species composition of the vegetation of present biocoenoses. The condition of vegetation is an apposite and relatively easily differentiable bioindicator of the status of ecosystems in the landscape, their ecological stability and biodiversity.

On the basis of differences in the composition of vegetation in present biocoenoses, groups of biotope types and within them individual biotope types were differentiated with respect to various classifications of Socotra vegetation (De Sanctis et al., 2013; Brown & Mies, 2012; Kürchner et al., 2006; Miller et al., 2004; Mies & Beyhl, 1996; Miller & Cope, 1996; Walker & Gillison, 1982; Popov, 1957). Groups of biotope types vary, above all, in

the physiognomy and structure of vegetation. Biotope types are divided according to composition of dominant species.

Classification of biotopes creates background for biotope mapping and is utilised as a base for agroforestry practices.

## METHODS

Groups of biotope types are divided according to physiognomy and vertical structure of vegetation being marked in capital letters. From the viewpoint of methodology, the most difficult task was to determine criteria for the division of forests, woodlands, groves and shrubs in order to give a true picture of the biotope richness as much as possible. To classify biotopes dominated by woody species, the height of co-dominant trees was used and the canopy closure of trees and shrubs in agreement with the worldwide classification of forests and woodlands (FAO, 2001). Thus, long-lived woody species taller than 5 m with a single stem exceeding a diameter of 7.5 cm at breast height (dbh over 7.5 cm) and branching into a crown at a certain height are considered to be trees (Jenik, 1998).

Biotope types are usually named according to physiognomy and key species of plants; italics give also a name in the Socotra language. Our local collaborator Mr Mohamad Salem Abdullah al-Keybani from the village of Shibhon proposed names in the Socotra language.

The method of classification and names of biotope types make it possible to complete other types or to use more detailed classification of subtypes. Types of biotopes in natural and semi-natural condition of the vegetation component of biocoenoses are most valuable from the viewpoint of preserving the biodiversity. Their segments form the framework of ecological stability, a base of the ecological network of Socotra.

## RESULTS

Classification system of Socotra biotopes consists of 13 groups of biotope types and 39 individual biotope types. Each of the biotope types is characterized by name in English and local name, geobiocoene type, basic characteristics, function importance, distribution, the type and intensity of anthropogenic impacts, woody species composition and the canopy closure of the main crown level of trees and spatial structure.

### *Explanation to geobiocoenological formula of geobiocoene types:*

Vegetation zone–trophic range–hydric range

For characteristics of geobiocoenological classification units see already published paper by Habrová & Buček (2010).

### *Explanation to assessment of function importance:*

W (water-management importance), S (erosion control importance), P (production importance), B (biodiversity importance).

Scale of function importance assessment: 1 (low), 2 (medium), 3 (high).

## F. FORESTS

Communities of trees with canopy density minimally (30)40%, trees are at least 5 m high.

### Category: F.1.

**Name: dragon's blood tree forest, ariob**

**Geobiocoene type: 3-BD-D-3**

**Characteristics:** semi-deciduous forests of the third vegetation zone on limestone bedrock with optimum conditions for *Dracaena cinnabari*; woody species from the family *Burseraceae* predominate on igneous rocks.

**Importance:** W2, S2, P2, B3

**Distribution:** at present, remnants of dragon's blood tree forests only in the region of Firmihin.

**Type and intensity of anthropogenic impacts:** natural vegetation on places formerly little affected by pasture; at present effects of pasture are considerable, in past dragon's blood was harvested. Currently increased impacts of felling trees for the purpose of development.

**Vegetation:** in the tree layer, *Dracaena cinnabari* predominates, various species of the family *Burseraceae* are admixed, viz. *Boswellia dioscorides*, *Boswellia* sp. A, *Commiphora planifrons*, *Commiphora ornifolia* and *Euphorbia socotrana*; in the shrub layer, *Croton socotranus* and *Jatropha uncostata* dominate, common species are *Trichocalyx orbiculatus*, *Lycium sokotranum*, *Cissus hamaderoensis*, *Buxanthus pedicellatus*, *Withania riebeckii*, *Heliotropium nigricans*, *Rhus thyrsoflora*, *Cryptolepis intricata*. As for herbs *Aloe perryi* is a typical species (Fig 1).

**Fig. 1: Dragon's blood tree forest**



### Category: F.2.

**Name: mangrove forest, akrhom**

**Geobiocoene type: 1-S-5**

**Characteristics:** belts of forests on the sea coast

**Importance:** W1, S1, P2, B2

**Distribution:** in the southern and western coast of the island in the region of Neet and Shuab, remnants of the biotope in Noged.

*Type and intensity of anthropogenic impacts:* natural vegetation, impacts of grazing low; formerly, the biotope was extended also on the northern coast where it was destroyed during the last 20 years (Fig 2).

*Vegetation:* monocoenoses of *Avicennia marina*

**Fig. 2: Mangrove forest**



Category: F.3.

*Name:* **deciduous frankincense forest, emhar**

*Geobiocoene type:* 2-BD-3, 3-BD-3

*Characteristics:* deciduous forests of the second vegetation zone (particularly) on igneous rocks with species of the family *Burseraceae*.

*Importance:* W2, S2, P3, B3

*Distribution:* at present, remnants of forests in the region of Homhil and in the vicinity of Taakes and Mkalehim, in valleys (wadi) of Ayhaft and Daneghan; possible occurrence in some poorly explored remote valleys.

*Type and intensity of anthropogenic impacts:* natural vegetation formerly little affected by grazing; at present effects of pasture considerable not allowing regeneration of the stands.

*Vegetation:* in the tree layer, *Boswellia elongata* predominates, other species such as *Commiphora ornifolia*, *Commiphora socotrana*, *Sterculia africana* var. *socotrana*, *Lansea transulta*, *Dracaena cinnabari* occur in smaller numbers; in the shrub layer, *Croton socotranus*, *Jatropha uncostata*, *Acacia pennivenia*, *Adenium obesum* ssp. *socotranum* and *Trichocalyx* spp. predominate (Fig 3).

**Fig. 3: Deciduous frankincense forest**



Category: F.4.

**Name: montane forest, shirmihin min hadzer**

**Geobiocoene type: 4-B(BC)-3, 5-B(BC)-3**

**Characteristics: evergreen montane forests at the highest locations on granite bedrocks**

**Importance: W3, S3, P3, B3**

**Distribution: in mountain regions of the Haggeher - Skant Mts.**

**Type and intensity of anthropogenic impacts: natural vegetation in regions little affected by pasture**

**Vegetation: in the tree layer, one or more species predominate, i.e. *Pittosporum viridiflorum*, *Dracaena cinnabari*, *Spiniluma discolor*, *Euphorbia socotrana*, *Euclea divinorum*; *Sideroxylon fimbriatum* occurs as a scattered species, in the shrub layer, there are *Croton sulcifructus*, *Cephalocroton socotranus*, *Carphalea obovata*, *Hibiscus scottii*, *Rhus thyrsoiflora*, *Allophylus rubifolius*, *Osyris quadripartita*, *Clerodendrum galeatum* etc. Ferns *Pteridium aquilinum* occur abundantly in the undergrowth of forests (Fig 4).**

**Fig. 4: Montane forest**



Category: F.5.

**Name: debris forest, *ebjben***

**Geobiocoene type:** 2-C(CD)-3

**Characteristics:** forests on slopes, on nutrient-enriched substrates

**Importance:** W2, S3, P3, B3

**Distribution:** on slopes in wide valleys (e.g. Ayhaft, Daneghan).

**Type and intensity of anthropogenic impacts:** natural vegetation in regions little affected by pasture, at present impacts of pasture are more intense, regeneration of woody species does not occur.

**Vegetation:** in the tree layer, following species predominate: *Sterculia africana* var. *socotrana*, admixed *Euphorbia arbuscula*, *Commiphora ornifolia*, *Lansea transulta*, *Boswellia socotrana*, *B. ameero*, exceptionally *Maerua angolensis* var. *socotrana*, in the shrub layer eg *Jatropha unicostata*, *Adenium obesum* ssp. *socotranum*, *Acridocarpus socotranus*, *Anisotes diversifolius*. *Ledebouria grandifolia* is a typical herbaceous species.

## **W. WOODLAND**

**Communities of trees with canopy density lower than (30)40%, minimally 5-10%, trees are at least 5 m high**

Category: W.1.

**Name: dragon's blood tree woodland, *ariob***

**Geobiocoene type:** 3-BD-D-3, (4-BD-D-3)

**Characteristics:** semi-deciduous woodlands of the third vegetation zone on limestone bedrocks with optimum conditions for *Dracaena cinnabari*.

**Importance:** W2, S2, P2, B3

**Distribution:** in the eastern half of the island in the region of Dixam, Shibhon, Firmihin, Momi, Kilim, Hamadero, Sirahan etc. smaller groups; the proportion of the biotope amounts to about 1% of the whole area of the island (Kral & Pavliš, 2006).

**Type and intensity of anthropogenic impacts:** close-to-nature vegetation, in the past, effects of pasture medium; during recent 100 years, these impacts are considerable, populations of trees are in the stage of disintegration, spontaneous regeneration does not occur, gradually, the biotopes converts to the biotope of croton shrubs (S.2.4.) or dwarf shrubs with *Buxanthus pedicellatus*.

**Vegetation:** in the tree layer, *Dracaena cinnabari*; various species of the family *Burseraceae* are admixed (particularly *Boswellia dioscorides*, *Boswellia ameero*, *Commiphora planifrons*, *Commiphora ornifolia*) and *Euphorbia socotrana*, in the shrub layer, *Croton socotranus* and *Jatropha unicostata* predominate, species *Trichocalyx* spp., *Lycium sokotranum*, *Cissus hamaderoensis*, *Buxanthus pedicellatus*, *Withania* spp., *Rhus thyrsoiflora*, *Gnidia socotrana*, *Cryptolepis intricata* are rather frequent. *Aloe perryi* is a typical species of herbs. The biotope is also related to the occurrence of geophytes, e.g. *Babiana socotrana* growing under crowns of *Dracaena cinnabari* trees (Fig 5).

**Fig. 5: Dragon's blood tree woodland**



Category: W.2.

**Name: deciduous frankincense woodland, emhar (ekeshi, téli)**

*Geobiocoene type:* 2-BD-3, 3-BD-3.

*Characteristics:* deciduous woodlands of the second vegetation zone (in the third vegetation zone in the north of the island on igneous rocks) with species of the family *Burseraceae*.

*Importance:* W2, S2, P2, B3

*Distribution:* scattered throughout the island.

*Type and intensity of anthropogenic impacts:* close-to-nature vegetation; formerly medium-affected by pasture, at present impacts of pasture considerable not allowing the regeneration of the stands.

*Vegetation:* in the tree layer, there are one or more species of the family *Burseraceae*: *Boswellia elongata*, *B. ameero*, *B. socotrana*, *Commiphora ornifolia*, *C. parvifolia*, other species such as *Maerua angolensis* var. *socotrana*, *Commiphora socotrana*, *Sterculia africana* var. *socotrana*, *Lannea transulta*, *Dracaena cinnabari* scattered, in the third vegetation zone on igneous rocks in the north of the island e.g. *Sideroxylon fimbriatum*, *Grewia turbinata*, *Euclea divinorum* etc., in the shrub layer *Croton socotranus*, *Jatropha unicostata*, *Acacia pennivenia*, *Adenium obesum* ssp. *socotranum*, *Trichocalyx* spp., *Vernonia cockburniana* (Fig 6).

**Fig. 6: Deciduous frankincense woodland**



Category: W.3.

**Name: montane woodland, shirmihin min hadzer**

**Geobiocoene type:** 4-B-3, 5-B-3

**Characteristics:** evergreen montane woodlands of the fourth and fifth vegetation zones at the highest altitudes on granite bedrocks.

**Importance:** W3, S3, P3, B3

**Distribution:** in mountain regions of the Haggeher - the Skant Mts.

**Type and intensity of anthropogenic impacts:** natural vegetation in regions little affected by grazing; frequent felling of trees for the construction of houses.

**Vegetation:** in the tree layer, there are one or more species of *Pittosporum viridiflorum*, *Dracaena cinnabari*, *Spiniluma discolor*, *Sideroxylon fimbriatum*, *Euphorbia socotrana*, *Euclea divinorum*, in the fourth vegetation zone *Commiphora planifrons*, in the shrub layer *Croton sulcifructus*, *Cephalocroton socotranus*, *Dirachma socotrana*, *Pulicaria lanata*, *Rhus thyriflora*, *Allophylus rubifolius*, *Hibiscus scottii*, *Carphalea obovata*, *Osyris quadripartita*, *Clerodendrum galeatum* etc. In the undergrowth, a fern *Pteridium aquilinum* is an abundant species and particularly herb *Begonia socotrana* in the fifth vegetation zone.

Category: W.4.

**Name: savanna woodland, ekeshi-ejhahab**

**Geobiocoene type:** 1-BD-3

**Characteristics:** deciduous woodlands of the first vegetation zone on the southern coast on loess substrates.

**Importance:** W1, S2, P2, B3

**Distribution:** only on a very small area on the southern coast in the region of Quareh.

**Type and intensity of anthropogenic impacts:** close-to-nature vegetation, at present considerably affected by pasture and felling of trees for the construction of houses.

**Vegetation:** in the tree layer, there are *Commiphora ornifolia* and *Maerua angolensis* var. *socotrana*, less frequent are *Dendrosycios socotrana*, *Euphorbia arbuscula*, in the shrub layer *Croton socotranus*, *Jatropha unicostata*, *Cissus subaphylla* etc.

Category: W.5.

**Name: riverine woodland, edlet**

**Geobiocoene type:** 1-CD-4, 2-CD-4

**Characteristics:** deciduous woodlands on edges of valleys (wadi).

**Importance:** W2, S2, P3, B2

**Distribution:** scattered throughout the island in riverbeds and on elevated places of valleys (wadi).

**Type and intensity of anthropogenic impacts:** close-to-nature vegetation, at present considerably affected by grazing and felling trees for the construction of dwellings. *Ziziphus spina-christi* regenerates particularly as a shrub thanks to intensive grazing.

**Vegetation:** *Ziziphus spina-christi* predominates, shrubs *Buxanthus pedicellatus*, *Acridocarpus socotranus*, *Croton socotranus*, *Ficus cordata* ssp. *salicifolia*, *Cissus subaphylla*, *Croton socotranus* etc. also occur. A neophytic herbaceous species *Argemone mexicana* is typical of the category (Fig 7).

**Fig. 7: Riverine woodland**



Category: W.6.

**Name: debris woodland, ebjben**

**Geobiocoene type:** 2-C(CD)-3

**Characteristics:** woodlands on slopes and bases of hillsides on nutrient-enriched substrates.

**Importance:** W2, S3, P2, B3

**Distribution:** on slopes in “wadi”(Ayhaft, Danekan)

**Type and intensity of anthropogenic impacts:** natural vegetation, at present largely affected by grazing, regeneration of woody species does not occur.

**Vegetation:** in the tree layer, there are *Sterculia africana* var. *socotrana*, *Euphorbia arbuscula*, *Commiphora ornifolia*, *Lanea transulta*, *Boswellia socotrana*, *Maerua angolensis* var. *socotrana*, in the shrub layer *Jatropha unicastata*, *Adenium obesum* ssp. *socotranum*, *Acridocarpus socotranus*, *Anisotes diversifolius* etc. *Ledebouria grandifolia* is a typical herbaceous species (Fig 8).

**Fig. 8: Debris woodland**



## **S. SHRUBLAND**

*Communities of shrubs, subshrubs and lignifying herbs differentiated according to the height of the tallest stratum and canopy.*

### **S.1. TALL SHRUBLAND**

*Height 2-5 m, further differentiation according to canopy:*

- closed (canopy density 70-100%)
- open (canopy density 30-70%)
- sparse (canopy density 10-30%).

#### Category: S.1.1.

*Name: evergreen montane shrubland, shirmihin yezler*

*Geobiocoene type: 4-B-3, 5-B-3*

*Characteristics: evergreen mixed montane shrublands in the fourth and fifth vegetation zones.*

*Importance: W3, S3, P3, B3*

*Distribution: in the fourth and fifth vegetation zones of the granite Hageher Mts.*

*Type and intensity of anthropogenic impacts: close-to-nature vegetation in a region little affected by cattle grazing.*

*Vegetation: In the tree layer, sometimes reserved trees of *Pittosporum viridiflorum*, *Hypericum balfourii*, *Sideroxylon fimbriatum*, *Dracaena cinnabari* etc., in the shrub layer *Allophylus rubifolius*, *Cephalocroton socotranus*, *Carphalea obovata*, *Croton sulcifructus* and *Rhus thyrsoflora* predominate. *Cocculus balfourii*, *Hypericum scopulorum*, *Hibiscus scottii*, *Euryops arabicus*, *Graderia fruticosa*, *Ruellia insignis*, *Coelocarpum haggierensis*, *Vernonia unicata* also occur; in the herb layer, *Begonia socotrana* is rather striking and a fern *Pteridium aquilinum* is also abundant.*

#### Category: S.1.2.

*Name: Ficus shrubland, etob*

*Geobiocoene type: 2-CD-4*

*Characteristics: high shrublands with *Ficus cordata* ssp. *salicifolia*.*

**Importance:** W1, S1, P1, B1

**Distribution:** scattered groups in valleys (wadi).

**Type and intensity of anthropogenic impacts:** close-to-nature vegetation particularly affected by stump extraction and establishing date-palm plantations.

**Vegetation:** monocoenoses of *Ficus cordata* ssp. *salicifolia*.

**Category:** S.1.3.

**Name:** **succulent shrubland, esofid**

**Geobiocoene type:** 2-CD-2(3), 1-CD-2(3)

**Characteristics:** high deciduous shrubs dominated by succulent species particularly on stony soils

**Importance:** W1, S2, P1, B2

**Distribution:** particularly in the northern and central part of the island on igneous rocks

**Type and intensity of anthropogenic impacts:** close-to-nature vegetation considerably affected by grazing (*Adenium obesum* is a poisonous species, *Dendrosicyos socotrana* gradually disappears).

**Vegetation:** *Adenium obesum* ssp. *socotranum* predominates, besides *Dendrosicyos socotrana* as well as other species such as *Jatropha unicostata*, *Croton socotranus*, *Euphorbia arbuscula*, *Cissus subaphylla* etc. (Fig 9).

**Fig. 9: Succulent shrubland**



**Category:** S.1.4.

**Name:** **myrrh tree shrubland, laakam**

**Geobiocoene type:** 2-BD-3, (3-BD-3)

**Characteristics:** high deciduous shrubs in the second (third) vegetation zone dominated by *Commiphora socotrana*.

**Importance:** W1, S2, P1, B2

**Distribution:** scattered in the second vegetation zone throughout the island.

**Type and intensity of anthropogenic impacts:** close-to-nature vegetation considerably affected by pasture.

*Vegetation: Commiphora socotrana* predominates, besides *Jatropha unicostata*, *Croton socotranus*, *Trichocalyx* spp., *Lycium sokotranum*, *Cissus subaphylla* etc., at higher altitudes also *Commiphora planifrons* and *Gnidia socotrana*.

## S.2. LOW SHRUBLAND

Height to 2 m, further differentiation according to canopy:

- closed (canopy density 70-100%)
- open (canopy density 30-70%)
- sparse (canopy density 10-30%).

Category: S.2.1.

Name: **Croton shrubland, meterhel**

Geobiocoene type: 1-BD-3, 2-BD-3

*Characteristics:* low deciduous shrubs dominated by *Croton socotranus* in the first and second vegetation zones.

*Importance:* W1, S1, P1, B2

*Distribution:* the most widespread biotope of the island

*Type and intensity of anthropogenic impacts:* impacts of cattle grazing considerable, croton stems are used for the construction of dwellings and as fire wood; due to uprooting the biotope is converted to biotope S.2.2. (S.2.3.), due to grazing to biotope S.3.1.

*Vegetation:* *Croton socotranus* predominates, less frequent are: *Jatropha unicostata*, *Cissus subaphylla*, *Commiphora socotrana*, *Lycium sokotranum*, *Trichocalyx* spp., *Ziziphus spinachristi*, *Euphorbia arbuscula*, rarely also *Dendrosicyos socotrana*, *Adenium obesum* ssp. *socotranum*; dwarf shrubs such as *Placopoda virgata*, *Zygocarpum coeruleum*, *Ballochia* spp., *Indigofera nephrocarpa*, *Senna* spp., *Tephrosia apollinea*, *Pulicaria stephanocarpa* etc. also occur (Fig 10).

**Fig. 10: Croton shrubland**



Category: S.2.2.

**Name: *Jatropha shrubland, seborhi***

**Geobiocoene type:** 2-BD-3, 3-BD-3

**Characteristics:** low deciduous shrubs particularly on stony soils in the second (third) vegetation zone.

**Importance:** W1, S1, P1, B1

**Distribution:** scattered on stony soils particularly on igneous rocks and limestone.

**Type and intensity of anthropogenic impacts:** considerable impacts of cattle grazing; the category often originated due to clearing croton stems for the construction of dwellings.

**Vegetation:** *Jatropha unicostata* predominates, *Adenium obesum* ssp. *socotranum* often occurs as well as *Lycium sokotranum*, *Cissus subaphylla*, *Placopoda virgata*, *Zygocarpum coeruleum*, *Ballochia* spp. and dwarf and low shrubs from the family *Leguminosae*, exceptionally *Croton socotranus*, *Vernonia cockburniana*, *Grewia erythraea* etc.

Category: S.2.3.

**Name: *mixed deciduous shrubland, shirmihin d'efer***

**Geobiocoene type:** 1-BD-3, 2-BD-3, (3-BD-3)

**Characteristics:** mixed deciduous shrubs particularly on slopes in the first and second (third) vegetation zones.

**Importance:** W1, S1, P1, B2

**Distribution:** scattered throughout the island.

**Type and intensity of anthropogenic impacts:** considerable impacts of cattle grazing; clearing crotons for the construction of dwellings is also frequent.

**Vegetation:** *Croton socotranus* and *Jatropha unicostata* predominate, besides *Lycium sokotranum*, *Ziziphus spina-christi*, *Trichocalyx* spp., *Cissus subaphylla*, *Adenium obesum* ssp. *socotranum*, *Placopoda virgata*, *Commiphora socotrana*, *Vernonia cockburniana*, *Maerua angolensis* var. *socotrana*, *Euphorbia arbuscula* etc. (Fig 11).

**Fig. 11: Mixed deciduous shrubland**



Category: S.2.4.

**Name: low shrubland with *Croton socotranus* and/or *Buxanthus pedicellatus*, *meterhelmaatan***

*Geobiocoene type:* 3-BD-D-3, 4-BD-D-3

*Characteristics:* semi-deciduous shrubs in the third (fourth) vegetation zone on limestone plateaus.

*Importance:* W2, S2, P2, B2

*Distribution:* particularly in the eastern part of the island on limestone plateaus of Dixam, Shibhon, Firmihin, Sirahan and other.

*Type and intensity of anthropogenic impacts:* vegetation considerably affected by goat and cattle grazing; originally, *Dracaena cinnabari* forests and woodlands probably occurred at these locations.

*Vegetation:* the highest cover is represented by *Buxanthus pedicellatus* and *Croton socotranus*, reserved trees of *Dracaena cinnabari* are often, besides *Lycium sokotranum*, *Cryptolepis intricata*, *Jatropha unicostata*, *Ochradenus socotranus*, *Withania* spp., *Gnidia socotrana*, *Aloe perryi*, *Euryops arabicus*, *Trichocalyx* spp., *Kalanchoe farinacea*, *Cissus hamaderohensis*, *Commiphora planifrons* also occur, in the fourth vegetation zone *Punica protopunica*, *Euphorbia socotrana* and other.

Category: S.2.5.

**Name: *Lycium* shrubland, *serhan***

*Geobiocoene type:* 2-BD-3

*Characteristics:* shrubs predominated by *Lycium sokotranum* on (probably) former pastures.

*Importance:* W1, S1, P1, B1

*Distribution:* in the western part of the island in the region of Maaleh (polje).

*Type and intensity of anthropogenic impacts:* vegetation obviously originated through the degradation of pastures.

*Vegetation:* *Lycium sokotranum* predominates, sometimes *Jatropha unicostata*, *Commiphora socotrana*, *Vernonia cockburniana* and various species of grasses are admixed.

Category: S.2.6.

**Name: *Tamarix* shrubland, *etahal***

*Geobiocoene type:* 1-A(BD-S)-1(2)

*Characteristics:* (halophyte) low shrubs occurring on dunes on the sea coast probably rooting in deeper loess horizons; it refers to small-area biotopes forming a mosaic in dunes.

*Importance:* W1, S1, P1, B1

*Distribution:* particularly on the southern coast of the island in the region of Noked.

*Type and intensity of anthropogenic impacts:* vegetation affected by camel grazing and sometimes also by grubbing for the purpose of date palm planting.

*Vegetation:* monocoenoses of *Tamarix nilotica*.

Category: S.2.7.

**Name: low coastal shrubland, *karshebhon***

*Geobiocoene type:* 1-S-4

*Characteristics:* vegetation on the seacoast more or less affected by saline winds.

*Importance:* W1, S1, P1, B2

*Distribution:* a narrow belt along the coast; preserved particularly in the region of Neet and Shuab.

*Type and intensity of anthropogenic impacts:* close-to-nature vegetation affected by goat grazing.

*Vegetation:* *Limonium socotranum* or *Limonium paulayanum*, often *Acacia sarcophylla* and other mostly halophyte shrubs from the family *Chenopodiaceae*, eg *Atriplex griffithii*, besides *Aristida adscensionis*, *Zygophyllum qatarense*, *Pulicaria stephanocarpa* etc.

### **S.3. DWARF SHRUBLAND**

*Grazed woody plants with height 0.5-1 m, usually of sparse canopy density (less than 30%) (Fig 12).*

**Fig. 12: Dwarf shrubland**



#### Category: S.3.1.

*Name:* **dwarf shrubland of lowlands and low- altitude locations, shirmihin-digded'e**

*Geobiocoene type:* 1-BD-3, 2-BD-3

*Characteristics:* dwarf shrubs caused by grazing (browsing forms of shrubs) in lower vegetation zones.

*Importance:* W1, S1, P1, B1

*Distribution:* on coast plains particularly in the vicinity of settlements.

*Type and intensity of anthropogenic impacts:* degraded areas due to grazing and clearing trees for the purpose of house construction and obtaining fire wood.

*Vegetation:* mainly dwarf shrubs (browsing forms) occur: *Placopoda virgata*, *Ballochia* spp., *Commiphora socotrana*, *Lycium sokotranum*, *Zygocarpum coeruleum*, *Pulicaria stephanocarpa*, *Indigofera* spp., *Senna* spp., *Tephrosia apollinea*, rarely *Cissus subaphylla*, *Jatropha unicostata*, *Croton socotranus*, *Acacia edgeworthii* etc.

#### Category: S.3.2.

*Name:* **dwarf shrubland of higher locations, shirmihin-kozoho**

*Geobiocoene type:* 3-BD-3, 4-BD-3

*Characteristics:* semi-deciduous, due to grazing dwarf shrubs in higher vegetation zones.

*Importance:* W2, S1, P2, B1

*Distribution:* on localities affected by pasture at higher locations of limestone plains.

*Type and intensity of anthropogenic impacts:* it refers to locations adjacent to pastures thus effects of grazing are considerable; mostly poisonous species and species unsuitable for pasture occur there.

*Vegetation:* *Buxanthus pedicellatus* predominates, rarely *Croton socotranus*, besides *Lycium sokotranum*, *Solanum incanum*, *Rhus thyrsiflora*, *Aloe perryi*, *Cissus hamaderoensis*, *Euryops arabicus*, *Asparagus africanus*, *Zygocarpum coeruleum*, *Allophylus rubifolius*, *Cryptolepis intricata* and others.

Category: S.3.3.

*Name:* **dwarf coastal shrubland, karshebhon**

*Geobiocoene type:* 1-S-4

*Characteristics:* vegetation near the seacoast.

*Importance:* W1, S1, P1, B1

*Distribution:* on the sea coast on soils affected by saline winds, on the southern coast of the island in the region of Noked and Neet, in the north and in the eastern part of the island and elsewhere.

*Type and intensity of anthropogenic impacts:* vegetation considerably affected by goat and camel grazing.

*Vegetation:* *Limonium socotranum* or *Limonium paulayanum* and other mostly halophyte shrubs particularly from the family *Chenopodiaceae*, e.g *Atriplex griffithii*, *Aristida adscensionis*, *Zygophyllum qatarense*, *Salsola spinescens*, *Pulicaria stephanocarpa* etc.

Category: S.3.4.

*Name:* **aeolic dwarf shrubland, rah shirmihin**

*Geobiocoene type:* 2-BD(D)-2(3), 3-BD(D)-2(3)

*Characteristics:* vegetation of windy top parts of limestone plateaus on a limited hydric series; woody species do not reach standard dimensions there.

*Importance:* W1, S2, P1, B1

*Distribution:* mostly on edges of limestone plateaus on the southern coast and on uplands in the western part of the island.

*Type and intensity of anthropogenic impacts:* close-to-nature vegetation affected by goat grazing.

*Vegetation:* Typical representatives are: *Croton socotranus* reaching maximally 0.5(1) m, *Euphorbia spiralis*, *Gnidia socotrana*, *Jatropha uncostata*, *Cryptolepis intricata*, *Lycium sokotranum*, *Indigofera* spp., *Cissus hamaderoensis*, less frequently *Commiphora socotrana*, *Leucas* spp., in the west of the island *Pulicaria stephanocarpa* and others.

Category: S.3.5.

*Name:* **dwarf montane shrubland with *Hypericum scopulorum*, chirebebjehan**

*Geobiocoene type:* 4-B-3, 5-B-3

*Characteristics:* low shrubs on areas of former pastures in a montane region on igneous rocks of the fourth and fifth vegetation zones.

*Importance:* W2, S2, P2, B2

*Distribution:* isle-like areas in the Haggeher Mts.

*Type and intensity of anthropogenic impacts:* degraded sites on edges of pastures or former overgrowing pastures; *Allophylus rubifolius* is eliminated by pasture.

*Vegetation: Hypericum scopulorum* predominates, *Euryops arabicus*, *Cocculus balfourii* and *Allophylus rubifolius* are frequent species, *Rhus thyrsoflora*, *Hibiscus scottii*, *Carphalea obovata*, *Ballochia atro-virgata*, *Cephalocroton socotranus*, *Croton sulcifructus* etc. occur as admixed species. In some places, individual trees of *Commiphora planifrons*, *Sideroxylon fimbriatum*, *Dracaena cinnabari*, *Euphorbia socotrana* etc. occur there.

## R. ROCKS

### Category: R.1.

**Name: limestone rocks, tojo**

**Geobiocoene type:** 2-D-1, 3-D-1, (4-D-1)

**Characteristics:** vegetation of limestone rocks.

**Importance:** W1, S1, P1, B2

**Distribution:** on vertical edges of limestone plateaus or in deep ravines.

**Type and intensity of anthropogenic impacts:** natural vegetation, effects of grazing are related to the perpendicularity of rock walls; only slightly overhanging walls are quite unaffected.

**Vegetation:** on limestone rocks, typical woody species are: *Boswellia dioscorides*, *B. bullata*, *B. popoviana*, *B. nana*, *Dracaena cinnabari*, *Adenium obesum* ssp. *socotranum*, *Jatropha unicostata*, as for herbaceous species, there is e.g. *Kalanchoe farinacea* etc. (Fig 13).

**Fig. 13: Limestone rocks**



### Category: R.2.

**Name: granite and basalt rocks, tojo**

**Geobiocoene type:** 2-B-1, 3-B-1, 4-B-1, 5-B-1

**Characteristics:** vegetation on igneous rocks.

**Importance:** W1, S1, P1, B2

**Distribution:** in deep valleys on vertical walls and in the top part of the Haggeher Mts.

**Type and intensity of anthropogenic impacts:** natural vegetation, grazing on non-overhanging rocks only.

*Vegetation:* woody species of *Dorstenia gigas* and *Adenium obesum* ssp. *socotranum*; in mountains, young plants of *Dracaena cinnabari*, herbs *Begonia socotrana*, various species of ferns, cushion-like shrubs of *Helichrysum rosulatum*, *Helichrysum aciculare*, *Nirarathannos asarifolius*, *Hemicrambe fruticosa* etc.

## **DS. DESERT AND SEMI-DESERT**

Category: DS.1.

*Name:* **sand dunes, *agahal***

*Geobiocoene type:* 1-A(BD-S)-1

*Characteristics:* sporadic vegetation on sands; in deeper horizons, often loess or other rich substrates where woody species take roots.

*Importance:* W1, S1, P1, B1

*Distribution:* in coastal parts of the island, only in the first vegetation zone.

*Intensity of anthropogenic impacts:* close-to-nature vegetation; particularly in the south, impacts of camel grazing, in the north goat grazing.

*Vegetation:* in the northern coast *Acacia edgeworthii*, in the south *Tamarix nilotica*, *Limonium socotranum* and *Indigofera spiniflora* are frequent, sporadically a neophytic plant *Calotropis procera* occurs; *Arnebia hispidissima* is a typical representative of herbaceous species (Fig 14).

**Fig. 14: Sand dunes**



Category: DS.2.

*Name:* **solonchak desert, *milho***

*Geobiocoene type:* 1-S-4

*Characteristics:* areas affected by ground seawater with precipitated salts.

*Importance:* W1, S1, P1, B1

*Distribution:* extensive solonchaks occur in the region of Neet and other small-area localities are scattered also in the northern coast.

*Type and intensity of anthropogenic impacts:* in some regions, there is traditional salt mining.

*Vegetation:* no vegetation (Fig 15).

**Fig. 15: Solonchak desert**



## **W. WETLAND**

Category: Wt.

*Name:* coastal lagoons, **choor**

*Geobiocoene type:* 1-S-5

*Characteristics:* periodically waterlogged areas and shallow coastal lagoons particularly at estuaries of rivers; mangrove stands were frequent there.

*Importance:* W2, S1, P1, B2

*Distribution:* in the western and northern coast of the island.

*Type and intensity of anthropogenic impacts:* the lagoons often originated due to the conversion of mangrove stands thanks to their clearing by man or through goat grazing.

*Vegetation:* only algae.

## **DP. DATE PALM PLANTATIONS**

Category: DP.

*Name:* **date palm plantations, timher (hed'ob)**

*Geobiocoene type:* 1-(BD)CD-4, 2-(BD)CD-4

*Characteristics:* plantations of date palms at elevated locations of “wadi” or on the seacoast and river estuaries.

*Importance:* W1, S1, P3, B1

*Distribution:* isle-like throughout the island, larger areas in or near villages, in vicinity of the coast.

*Type and intensity of anthropogenic effects:* quite allochthonous vegetation

*Vegetation:* *Phoenix dactylifera*.

## G. GRASSLAND

### Category: G.1.

**Name: cleared mountain pastures on granite, kozoho**

**Geobiocoene type:** 4-B-3, 5-B-3

**Characteristics:** cleared pastures in the mountain region of the fourth and fifth vegetation zones, obviously of considerable age, on even or slightly sloped localities.

**Importance:** W2, S2, P3, B1

**Distribution:** particularly in the fourth vegetation zone; sporadically also in the fifth vegetation zone in the Haggeher Mts.

**Type and intensity of anthropogenic impacts:** the most suitable areas for the pasture of donkeys, cows but also of sheep and goats; originally, vegetation of shrubs and forests occurred obviously there.

**Vegetation:** grasses and other herbs predominate, e.g. *Craterostigma pumilum*, *Helichrysum balfourii*, *Anagallis arvensis* and other, on edges pastures *Rhus thyrsoflora*, *Allophylus rubifolius*, *Euryops arabicus*, *Cocculus balfourii* etc.

### Category: G.2.

**Name: pastures on limestone plateaus, kozoho**

**Geobiocoene type:** 3-BD(D)-3, 4-BD(D)-3

**Characteristics:** areas without woody vegetation on limestone plateaus in the third and fourth vegetation zones, often shallow soils and considerable proportion of limestone pavements.

**Importance:** W1, S1, P2, B1

**Distribution:** particularly in more humid parts of limestone plateaus.

**Type and intensity of anthropogenic impacts:** they often originated by long-term continuous effects of pasture when woody species could not naturally regenerate.

**Vegetation:** grasses and other herbaceous species such as *Craterostigma pumilum* predominate; *Aloe perryi*, *Kalanchoe farinacea*, *Lycium sokotranum*, *Solanum incanum*, *Croton socotranus*, *Euphorbia astemperi*, *Cryptolepis intricata*, *Withania spp.* etc. occur sporadically (Fig. 16).

**Fig. 16: Pastures on limestone plateaus**



## D. DEGRADED LAND

### Category: D.1.

**Name:** degraded land, *digded'e*

**Geobiocoene type:** 1-BD-3, 2-BD-3

**Characteristics:** areas degraded by excessive cattle grazing with the occurrence of only poisonous woody species.

**Importance:** W1, S1, P1, B1

**Distribution:** particularly in vicinity of larger settlements such as Hadibo, Kadub, Kalansia etc.

**Type and intensity of anthropogenic impacts:** areas completely converted due to the impact of pasture and grubbing.

**Vegetation:** *Senna holosericea* and *Tephrosia apollinea* (Fig 17).

**Fig. 17: Degraded land**



### Category: D.2.

**Name:** erosion rills and gullies on mountain pastures, *ned'rehen*

**Geobiocoene type:** 4-B-3, 5-B-3

**Characteristics:** due to excessive pasture and road construction erosion rills and gullies originated; it refers to small-area biotopes only.

**Importance:** W3, S3, P1, B1

**Distribution:** scattered in the Haggeher Mts.

**Type and intensity of anthropogenic impacts:** the rills and gullies originated nearly exclusively by activities of man or excessive grazing.

**Vegetation:** *Senna obtusifolia*, *S. socotrana*, *Gnidia socotrana*, *Aerva revoluta* etc.

## U. URBAN LAND

Category: U.

*Name: built-up land (urban land), kajher*

*Geobiocoene type: 1-BD-3, 2-BD-3, 3-BD-3*

*Characteristics: built-up areas.*

*Importance: W1, S1, P1, B1*

*Distribution: in all regions of the island, particularly along the coast and in vicinity of “wadi”.*

*Type and intensity of anthropogenic impacts: quite converted areas.*

*Vegetation: various native and introduced species; in home gardens, the occurrence of various autochthonous grasses and herbaceous species which, thanks to grazing control, are able to flower and produce fruits forming thus a sort of a seed bank.*

## WA. WADI

Category: Wa.

*Name: wadi, ed'hajo*

*Geobiocoene type: 1-CD-4, 2-CD-4, 3-CD-4*

*Characteristics: gravel to boulder beds of periodically flooded bottom of valley.*

*Importance: W3, S1, P1, B1*

*Distribution: in all regions of the island.*

*Type and intensity of anthropogenic impacts: mainly without direct influence.*

*Vegetation: at warm locations nearly without vegetation, at higher locations on permanently waterlogged areas herbaceous species *Exacum affine*, *Juncus acutus* etc. (Fig 18).*

**Fig. 18: Wadi**



## DISCUSSION

The biotopes were distinguished and described during complex field observations on more than 250 localities of Socotra between years 1999-2004. Results of field observations also enable to create geobiocoenological typological system describing natural (potential) state of the landscape. Geobiocoenological typological system of the Socotra island consist of 5 altitudinal vegetation zones, 5 trophic ranges and 3 inter-ranges (expressing soil conditions), 5 hydric ranges (expressing water condition in soil), 26 groups of geobiocoene types (Buček et al., 2003; Habrová, 2004; Habrová & Buček, 2010).

The method of classification and names of biotope types make possible to complete other types or to use more detailed classification of subtypes. Types of biotopes with natural and semi-natural conditions of the vegetation component of biocoenoses are most valuable from the viewpoint of preserving the biodiversity. Their segments form a framework of ecological stability, a baseline for the ecological network of Socotra.

One of the most interesting types of biotopes is F.1 – Dragon`s blood tree forest (ariob), has been continuously monitored by Mendel University experts since 1999. It is a climax biotope within geobiocoene type 3-BD-D-3 (3 = third altitudinal vegetation zone, BD = mezotrophic-bazic trophic inter-range, D = bazic trophic range, 3 = normal hydric range) and it is characterized as semi-deciduous forests on limestone bedrock with optimum conditions for *Dracaena cinnabari* (with min. 30 % of tree coverage). Among another tree species belongs various *Burseraceae* as *Boswellia dioscorides*, *Boswellia* sp. A, *Commiphora planifrons*, *Commiphora ornifolia*, also *Euphorbia socotrana*; in the shrub layer, *Croton socotranus* and *Jatropha uncostata* dominate, common species are *Trichocalyx orbiculatus*, *Lycium sokotranum*, *Cissus hamaderohensis*, *Buxanthus pedicellatus*, *Withania riebeckii*, *Heliotropium nigricans*, *Rhus thyriflora*, *Cryptolepis intricata*. As for herbaceous species, *Aloe perryi* is a typical one. Nowadays, only limited area (Firmihin) is occupied by DC forests, majority of this geobiocoene type is covered by various degradation stages of F.1, i.e. W.1. – Dragon`s blood tree woodland, S.2.4. Low shrubland with *Croton socotranus* and/or *Buxanthus pedicellatus*, S.3.2. Dwarf shrubland, and G.2. Pastures.

## CONCLUSION

Biotope classification system of Socotra Island consists of 13 groups of biotopes and 39 individual biotope types. There are 5 forest biotope types, 6 woodland and 16 shrubland biotope types.

The biotope classification was used in the construction of a map of the vegetation cover of Socotra by means of satellite imagery interpretation (Král & Pavliš, 2006). A map of the current state of vegetation made it possible to specify important segments of the landscape and to create a framework of ecological stability as a baseline for the ecological network of Socotra. Geobiocoenological approach to biotope classification enables utilisation of the results in the planning of agroforestry management, including creation of new forest or woodland biotopes by planting valuable tree species.

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