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Rare dune plant species in Samsun Province, Turkey

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Samsun (Türkiye) İli'ndeki nadir kumul bitki türleri

Abstract: In the present study, the rare species of the city Samsun which distributed in sand dune ecosystem were investigated. The study was carried out in the localities Çobanyatağı (Terme), Sindel, Hürriyet and Costal (Çarşamba), Cernek, Sahilkent (Bafra) and Doyran (Alaçam) of Samsun sand dune. Sand dune communities were sampled from April 2010 to July 2012 by using minimal area method in 16 m^2 plots. The coastal sand dunes of Çobanyatağı, Sindel, Cernek, Sahilkent (Bafra) and Doyran (Alaçam) is consist of upper beach/driftline, primary/embryonic, main, transitional and, fixed dune zones) while the fixed zone is totally disappeared and transitional zone is significantly interrupted in the localities Costal and Hürriyet especially due to the building settlement. Rare species on each coastal dune zones in all localities were determined according to the rarity index formula. As a result, each locality was assessed independently, and it is indicated that the rarity index of 47 species is low.

Key words: Black Sea, Coastal habitats, Rarity index

Özet: Bu çalışmada Samsun ilinde kumul ekosistemlerde yayılış gösteren nadir türler araştırılmıştır. Araştırma Samsun kıyısında Çobanyatağı (Terme), Sindel, Hürriyet ve Costal (Çarşamba), Cernek, Sahilkent (Bafra) ve Doyran (Alaçam) lokalitelerinde yürütülmüştür. Kumul komuniteleri Nisan 2010'dan Temmuz 2012'ye kadar, en küçük alanlar metodu kullanılarak 16 m^2 lik örnek parseller şeklinde örneklenmiştir. Çobanyatağı, Sindel, Cernek, Sahilkent ve Doyran lokalitelerinde üst kumsal (sürüklenme çizgisi), primer kumul, esas kumul, geçiş kumulu ve stabil kumul zonlarından oluşurken, Costal ve Hürriyet lokalitelerinde ise özellikle yerleşim alanlarının açılması nedeniyle stabil kumul zonu tamamen yok olmuş, geçiş zonu da önemli derecede kesintiye uğramıştır. Nadirlik indeks formülü ile her lokalitede bulunan zonların nadir türleri belirlenmiştir. Sonuç olarak her bir lokalite bağımsız olarak değerlendirilmiş ve nadirlik indeks formülüne göre 47 türün nadirlik indeksinin düşük olduğu tespit edilmiştir.

Anahtar Kelimeler: Karadeniz, Kıyı habitatlar, Nadirlik indeksi

1. Introduction

Coastal dune ecosystems are located in a very narrow area on earth, but they have the highest biodiversity compared to other ecosystems (Carranza et al., 2008). Dune ecosystems are habitat with their specific plant species, vegetation types and highest endemism ratio and local biodiversity values (Honrado et al., 2010). Many sand dune plants can not survive except for coastal dune habitats. Especially in recent years, due to the increasing anthropogenic factors, very sensitive coastal dune areas suffer damage, and they are under threat of extinction. So, many plant species in coastal dunes face to extinction (Ağır et al., 2014, 2016a; Kutbay et al., 2017)

The coastal dunes which are dynamic structures are the transition (ecotone) regions between terrestrial and aquatic ecosystems (Acosta et al., 2005; Carboni et al., 2009; Miller et al., 2010). The dune ecosystems gain a complex structure as a result of the effects of environmental factors towards the inner parts (Ağır et al., 2016b, 2017). This complex structure leads to the change of the dune morphology and consequently to the inclusion of different plant communities (Attore et al., 2013; Prisco et al., 2012), and causes differences in the spatial distribution of the dune plants (Attore et al., 2013). In the protected coastal dunes, vegetation is hardly associated with geomorphological and sedimentological characterization (Fenu et al., 2012).

The coastal dunes are a natural barrier against the spread of saltwater and wind erosion (Spanau et al., 2006). Coastal dune vegetation plays an important role in dune stabilization. Therefore, the loss of plant species in the dune vegetation makes the dunes permeable to wind and wave erosion (De Lillis et al., 2004). Sand dunes, which are sensitive to wave erosion, play an important role in maintaining the sediment balance (Ağır et al., 2017). However, climate change and anthropogenic effects disrupt the natural structure of the dune vegetation (Ağır et al., 2016b). These factors cause narrowing of the distribution areas of the plants in the dune areas and thus cause the extinction of the plant species (Stancheva et al., 2011). For this reason, new studies should be carried out in these areas in order to determine the biodiversity and conservation procedures of these areas (Carranza et al., 2008).

The aim of the present study is to determine the rarity indexes of coastal dune plant species for each dune zone. So we reveal the latest status of plant species in studied coastal dune area.

2. Materials and Method

The research area which includes both Gölardı Nature Conservation Area (Terme) and, Cernek Lake Wildlife Protection Area (Bafra), covers 149 km of coastline in Samsun from Terme to Alaçam. Seven localities which include characteristic dune zones [upper beach or drift line (A), embryonic or primary dune (B), main dune (C), transitional (D) and fixed dune (E) zones] (Figure 1) were chosen.

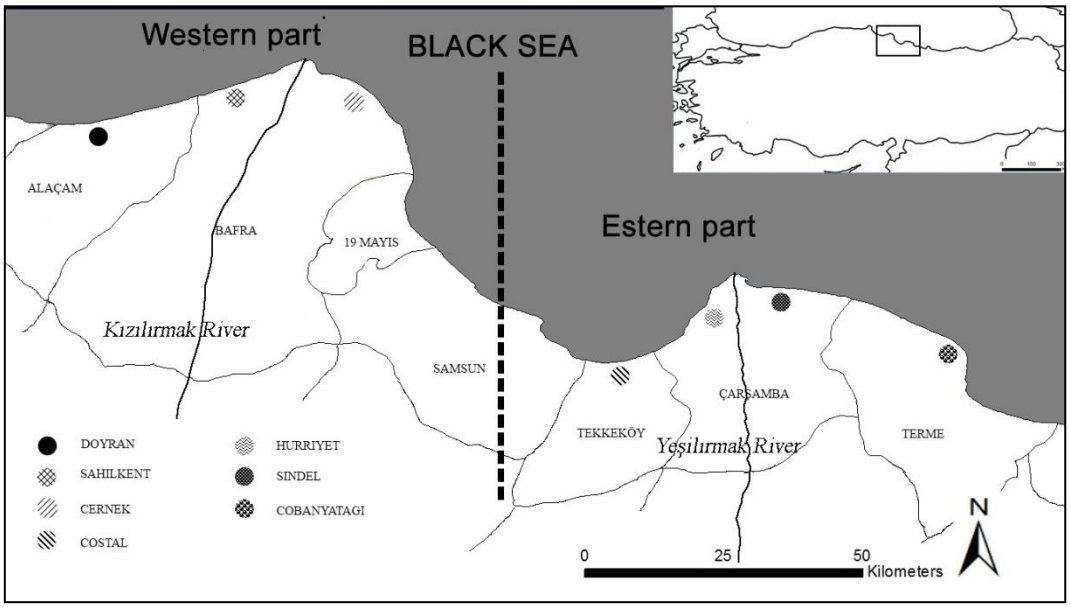

Figure 1. Localities of the research areas.

Seven vegetation plots were chosen from each locality and each zone. Plot size was determined by minimal area method. 4x4 m^2 plots were choosed from each communities of the vegetation zonation: upper beach or drift line, embryonic dune, main dune, transition and fixed dune zones from homogenous places in April–September 2010-2012. The vascular plant list and cover value of each species in all plots were registered according to Braun-Blanquet method (Braun-Blaunqet, 1964).

Taxonomic nomenclature was followed according to Guner et al. (2012).

The species rarity index formula has been developed from the rarity index formula used for sample plots (Acosta et al., 2009).

$$S_j = \frac{\left(\frac{\sum_i I_{jk}}{N}\right)\left(\frac{N_j}{N}\right)}{10}$$

Sj: presence coefficient of i species (between 0 and 1). If "Sj" is close to 0, species is rarely. If "Sj" is close to 1, species is abundant. $\sum_i I_{jk}$: Total density of J species in all sample plots. N: Total sample plots. Nj: Number of sample plots with J species. 10: fixed number (to be between 0 and 1). Sj>0.05 (no rarely), 0.01<Sj<0.05 (moderate rarely) and Sj<0.01 (very rarely) ranges were used for the detection of rare species.

3. Results

Sixty-seven coastal dune character species were determined. The distribution of character species which is given in Table 1. 11 species in upper beach or drift line dune (A) zone, 18 species embryonic or primary dune (B) zone, 9 species the main dune (C) zone, 9 species transitional (D) dune zone, 20 species in fixed dune (E) zone were determined. Also, floristic regions, growth forms and life spans of the species were determined.

Plant species belonging to five floristic regions, Irano-Turanian, Euro-Siberian, Mediterranean, South America and Paleo Temporal, were determined in the study area of coastal dune vegetation.

Seven species of upper beach or drift line dune zone belong to a floristic region (Irano-Turanian, Euro-Siberian, Mediterranean, South America, and Paleo Temporal) while four species do not belong to any floristic region. Ten species were herbaceous, only *Tournefortia sibirica* L.var. *sibirica* was shrub. The life span of five species were annual while the others are perennial (Table 1).

Most of the species of the embryonic or primary dune zone, belong to the Mediterranean floristic region while two of them, *Agrostis stolonifera* L. and *Hypochoeris radicata* L. were Euro-Siberian floristic elements, and only *Gundelia tournefortii* L. was Irano-Turanian floristic element. 17 species were herbaceous, and only *Medicago marina* L. was shrub species (Table 1).

In the main dune zone, *Cionura erecta* (L.) Griseb., *Euphorbia peplis* L. and *Vulpia fasciculata* (Forsskal) Fritsch were Mediterranean elements. *Echinops orientalis* Trautv. was Irano-Turanian element and *Xanthium spinosum* L. was South America element. Many of species were annual, and one species was shrub (Table 1).

In transitional dune zone, four species belong to Euro-Siberian, Mediterranean and Paleo Temporal floristic regions. There are one tree and shrub species in this dune zone. The other plants were herbaceous. Two species were annual, and seven species were perennial (Table 1).

The fixed dune zone was the richest zone in all zones about plant species with 20 plant species. Seven species were Mediterranean floristic elements, four species were Euro-Siberian floristic elements and only *Trifolium arvense* L. var. *arvense* was Paleo Temporal floristic element. Many species have got herbaceous growth form, and only *Jurinea kilaea* Azn. was shrub species. Seven species were perennial, and 13 species were annual (Table 1).

Table 1. Dune zone, floristic region, growth form and life span features of sand dune plant species in studied areas (Med: Mediterranean, Ir-Tr: Irano-Turanian, Eu-Sib: Euro-Siberian, Paleo Temp: Paleo Temporal, Sam: South America).

Species	Zone	Floristic Region	Growth Form	Life Span
Cakile maritima Scop.	A	Med	Herbaceous	Annual
Calystegia soldanella (L.) R.Br.	A	-	Herbaceous	Perennial
Digitaria ischaemum (Schreber ex Schweigger) Mühlenb.	A	-	Herbaceous	Annual
Eryngium maritimum L.	A	Med	Herbaceous	Perennial
Euphorbia paralias L.	A	Med	Herbaceous	Perennial
Parapholis incurva (L.) C.E. Hubbard	A	-	Herbaceous	Annual
Salsola ruthenica L.	A	Paleo-Temp	Herbaceous	Annual
Apocynum venetum L.subsp. *sermatiense*	A	Med	Herbaceous	Perennial
Xanthium strumarium subsp. *cavanillesii* (Schouw) D.Löve & Dans.	A	Ir-Tr	Herbaceous	Annual
Tournefortia sibirica L.var. *sibirica*	A	Eu-Sib	Shrub	Perennial
Achillea maritima (L.) Ehrend. & Y.P. Guo subsp. *maritima*	B	Med	Herbaceous	Perennial
Agrostis stolonifera L.	B	Eu-Sib	Herbaceous	Perennial
Ammophila arenaria (L.) Link subsp. *arundinacea* H. Lindb. Fil.	B	Med	Herbaceous	Perennial
Crepis foetida L. subsp. *rhoeadifolia* (M.Bieb.) Čelak.	B	-	Herbaceous	Annual
Cynanchum acutum L. subsp. *acutum* L.	B	Med	Herbaceous	Perennial
Cynoglossum creticum Mill.	B	-	Herbaceous	Perennial
Elymus farctus (Viv.) Runemark ex Melderis subsp. *bessarabicus* (Savul. et Rayss) Melderis var. *bessarabicus*	B	Med	Herbaceous	Perennial
Glaucium flavum Crantz	B	-	Herbaceous	Perennial
Gundelia tournefortii L.	B	Ir-Tr	Herbaceous	Perennial
Hypochoeris radicata L.	B	Eu-Sib	Herbaceous	Perennial
Juncus littoralis C.A. Meyer	B	Med	Herbaceous	Perennial
Medicago marina L.	B	-	Shrub	Perennial
Medicago polymorpha L.var. *polymorpha*	B	-	Herbaceous	Annual
Pancratium maritimum L.	B	Med	Herbaceous	Perennial
Raphanus raphanistrum L.	B	Med	Herbaceous	Annual
Schoenoplectus triqueter L.	B	-	Herbaceous	Perennial
Scolymus hispanicus L.	B	Med	Herbaceous	Perennial
Stachys annua L. (L.) subsp. *annua* var. *annua*	B	Med	Herbaceous	Perennial
Centaurea iberica Trev. ex Sprengel	C	-	Herbaceous	Annual
Cenchrus incertus M. A. Curtis	C	-	Herbaceous	Annual
Cionura erecta (L.) Griseb.	C	Med	Shrub	Perennial
Cyperus capitatus Vandelli	C	-	Herbaceous	Annual
Echinops orientalis Trautv.	C	Ir-Tr	Herbaceous	Annual
Euphorbia peplis L.	C	Med	Herbaceous	Annual
Silene otites (L.) Wibel	C	-	Herbaceous	Annual
Vulpia fasciculata (Forsskal) Fritsch	C	Med	Herbaceous	Annual
Xanthium spinosum L.	C	SAm	Herbaceous	Annual
Crataegus monogyna Jacq. var. *azarella*	D	Paleo-Temp	Shrub	Perennial
Eleagnus rhamnoides (L.) A.	D	-	Tree	Perennial
Imperata cylindrica (L.) Raeusch.	D	-	Herbaceous	Perennial
Medicago x varia Martyn	D	-	Herbaceous	Perennial
Petrorhagia saxifraga (L.) Link	D	Eu-Sib	Herbaceous	Perennial
Phleum exaratum Hochst. ex Griseb. subsp. *exaratum*	D	-	Herbaceous	Annual
Teucrium chamaedrys L. subsp. *chamaedrys*	D	-	Herbaceous	Perennial
Trifolium stellatum L.	D	Med	Herbaceous	Annual
Verbascum sinuatum L.var. *sinuatum*	D	Med	Herbaceous	Perennial
Anagallis arvensis L.var. *arvensis*	E	Med	Herbaceous	Annual
Anchusa hybrida Ten.	E	Med	Herbaceous	Perennial
Bromus racemosus L.	E	Eu-Sib	Herbaceous	Annual
Cota tinctoria var. *tinctoria* L.	E	-	Herbaceous	Perennial
Daucus broteri Ten.	E	Med	Herbaceous	Annual
Echium plantagineum L.	E	-	Herbaceous	Annual
Elymus elongatus (Host) Runemark subsp. *elongatus*	E	-	Herbaceous	Perennial
Jurinea kilaea Azn.	E	Eu-Sib	Shrub	Perennial
Kickxia commutata (Bernh. ex Reichb.) Fritsch subsp. *commutata*	E	Med	Herbaceous	Annual
Lagurus ovatus L.	E	Med	Herbaceous	Annual
Medicago littoralis Rohde ex Lois. var. *littoralis*	E	-	Herbaceous	Annual
Plantago scabra Moench.	E	-	Herbaceous	Annual
Polypogon monspeliensis L. (Desf.)	E	Med	Herbaceous	Annual
Prunella vulgaris L.	E	Eu-Sib	Herbaceous	Perennial
Satureja hortensis L.	E	-	Herbaceous	Annual
Silene dichotoma Ehrh.var. *dichotoma*	E	Eu-Sib	Herbaceous	Annual
Sophora alopecuroides L.var. *alopecuroides*	E	-	Herbaceous	Perennial
Teucrium polium L.	E	-	Herbaceous	Perennial
Trifolium arvense L.var. *arvense*	E	Paleo-Temp	Herbaceous	Annual
Trifolium resupinatum L.var. *resupinatum*	E	Med	Herbaceous	Annual

The rarity index of 67 species were calculated. According to the calculated rarity index the status of 47 species were determinated as moderate rarely and very rarely.

In upper beach or drift line dune zone, the rarity index of 4 species, *Cakile maritima* Scop., *Parapholis incurva* (L.) C.E. Hubbard, *Apocynum venetum* L. subsp. *sermatiense*, *T. sibirica* var. *sibirica*, are low. The rarity indexes of *T. sibirica* var. *sibirica*, *P. incurva* and *A. venetum* subsp. *sermatiense* is Sj<0.01, while it is 0.01<Sj<0.05 for *C. maritima* (Table 2).

In embryonic or primary dune zone, the rarity index of *A. stolonifera*, *Cynoglossum creticum* Mill., *G. tournefortii*, *Schoenoplectus triqueter* L., *Glaucium flavum* Crantz, *Raphanus raphanistrum* L., *Scolymus hispanicus* L. is Sj<0.01 while the index of *Ammophila arenaria* (L.) Link subsp. *arundinacea* H. Lindb. Fil., *Cynanchum acutum* L. subsp. *acutum* L., *H. radicata*, *Medicago polymorpha* L. var. *polymorpha* and *Stachys annua* L. (L.) subsp. *annua* var. *annua* is 0.01<Sj<0.05 (Table 2).

Table 2. Rarity indexes of sand dune plant species in studied areas.

Species		Zone	Rarity index	Species		Zone	Rarity index
C. maritima	r	A	0.038	*C. monogyna* var. *azarella*	r	D	0.011
P. incurva	rr	A	0.002	*I. cylindrica*	rr	D	0.001
A. venetum subsp. *sermatiense*	rr	A	0.001	*M. x varia*	r	D	0.011
T. sibirica var. *sibirica*	rr	A	0.006	*P. saxifraga*	rr	D	0.003
A. stolonifera	rr	B	0.001	*P. exaratum* subsp. *exaratum*	r	D	0.014
A. arenaria subsp. *arundinacea*	r	B	0.042	*T. chamaedrys* subsp. *chamaedrys*	rr	D	0.005
C. acutum subsp. *acutum*	r	B	0.029	*T. stellatum*	rr	D	0.001
C. creticum	rr	B	0.001	*A. arvensis* var. *arvensis*	r	E	0.048
G. flavum	rr	B	0.004	*A. hybrida*	rr	E	0.001
G. tournefortii	rr	B	0.001	*B. racemosus*	r	E	0.042
H. radicata	r	B	0.039	*E. plantagineum*	rr	E	0.002
M. polymorpha var. *polymorpha*	r	B	0.019	*K. commutata* subsp. *commutata*	rr	E	0.002
R. raphanistrum	rr	B	0.001	*L. ovatus*	r	E	0.015
S. triqueter	rr	B	0.001	*M. littoralis* var. *littoralis*	rr	E	0.001
S. hispanicus	rr	B	0.001	*P. scabra*	rr	E	0.002
S. annua subsp. *annua* var. *annua*	r	B	0.021	*P. monspeliensis*	rr	E	0.001
C. iberica	rr	C	0.001	*P. vulgaris*	rr	E	0.003
C. incertus	rr	C	0.001	*S. hortensis*	r	E	0.025
C. erecta	r	C	0.019	*S. dichotoma* var. *dichotoma*	r	E	0.047
E. orientalis	rr	C	0.001	*S. alopecuroides* var. *alopecuroides*	r	E	0.018
E. peplis	rr	C	0.007	*T. polium*	r	E	0.019
S. otites	rr	C	0.001	*T. arvense* var. *arvense*	rr	E	0.001
V. fasciculata	rr	C	0.001	*T. resupinatum* var. *resupinatum*	rr	E	0.001
X. spinosum	rr	C	0.001				

r; rarely, rr; very rarely

In the main dune zone, the rarity indexes of *Centaurea iberica* Trev. ex Sprengel, *Cenchrus incertus* M. A. Curtis, *E. orientalis*, *E. peplis*, *Silene otites* (L.) Wibel, *V. fasciculata*, and *X. spinosum* was calculated under 0.01 while it is between 0.01 and 0.05 for *C. erecta* (Table 2).

In transitional dune zone, *Imperata cylindrica* (L.) Raeusch., *Petrorhagia saxifraga* (L.) Link, *Teucrium chamaedrys* L. subsp. *chamaedrys* and *Trifolium stellatum* L. rarity indexes were under 0.01 value. *Phleum exaratum* Hochst. ex Griseb. subsp. *exaratum*, *Medicago x varia* Martyn, and *Crataegus monogyna* Jacq. var. *azarella* were between 0.01 and 0.05 (Table 2).

Finally, in fixed dune zone, 16 species were found moderately rare, and very rarely status considering calculated indexes. The rarity indexes of *Anagallis arvensis* L. var. *arvensis*, *Bromus racemosus* L., *Lagurus ovatus* L., *Satureja hortensis* L., *Silene dichotoma* Ehrh. var. *dichotoma*, *Sophora alopecuroides* L. var. *alopecuroides* and *Teucrium polium* L. is 0.01<Sj<0.05 (Table 2) while it is Sj<0.01 for *Kickxia commutata* (Bernh. ex Reichb.) Fritsch subsp. *commutata*, *Plantago scabra* Moench, *Prunella vulgaris* L., *Trifolium resupinatum* L. var. *resupinatum*, *Anchusa hybrida* Ten., *Echium plantagineum* L., *Medicago littoralis* Rohde ex Lois. var. *littoralis*, *Polypogon monspeliensis* L. (Desf.), *T. arvense* var. *arvense*.

4. Discussions

As reported in previous researches performed on Mediterranean coastal dunes (Acosta et al., 2009), species diversity on Black Sea district tends to increase with the distance from the shoreline. The results of this study, which shows a gradualy increase in terms of the number of the species from seashore to internal parts of the dune zone, is compatible with the resarches mentioned above.

A few plant species can survive in harsh ecological conditions such as high salinity, unstable substrate, wave effect etc. This is the reason of the low number of species

in the places close to the sea at dune zones. In drift line zone, not only these harsh factors but also the activities such as agriculture, tourism, trampling, construction of houses and roads, waste disposal, and plantation of trees and shrubs (Agır et al., 2014) also have a negative role on the plant species richness. As a result of the factors mentioned above in driftline dune zone, the number of the character species are very few. In this study, only *C. maritima, P. incurva, A. venetum* subsp. *sermatiense* and *T. sibirica var. sibirica* determined as the character species for the drift line zone. Primary dune (or embryonic) zone also has low plant biodiversity. Species in this zone can resist to deep sand burial, and they are an important impeding factor for the movement of sand which is forced by the sea winds (Attorre et al., 2013; Agir et al., 2014). The rarity index values of the species in the primary/embryonic dune zone is low. Especially, the rarity indexes of *A. stolonifera, C. creticum, G. tournefortii, S. triqueter, G. flavum, R. raphanistrum, S. hispanicus* are the lowest. *Achillea maritima* which is important for the stability of dune zones (Honrado et al., 2010; Agır et al., 2014) and which is is also a character species of this zone is also rare.

Almost all species in the main dune zone are rare because this zone has similar properties with primary dune zone. In this zone, plant communities tend to be permanent and less exposed to harsh conditions (Maun, 2009; Acosta et al., 2007, 2009; Attorre et al., 2013), but it was exposed to the high disturbance regarding salt spray, dune movement, and tourism activities. So plant density and diversity gradually decreases.

The rarity index values of species of transitional and fixed dune zones are low. These two zones include more exclusive species (i.e., *Euphorbia terracina* L., *Jurinea kilea* Azn.) than the other zones (Acosta et al., 2009). It is known that inundation has a pronounced regulatory effect on the distribution and abundance of plant species (Deegan and Harrington, 2004).

It is found that density and number of dune plant species are gradually decreasing. The coastal dune species in the Central Black Sea Region have been affected by the disturbance factors such as wave action, dense tourism activities, sand extraction, etc.. Extreme physical stress and disturbance factors act shaping community zonation even at very small spatial scales in coastal dune ecosystems (Carboni et al., 2010). Sustainable management programmes in coastal sand dunes should be included in the conservation of species poor-habitats containing unique or endangered species elements (Acosta et al., 2009).

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