Vegetation Dynamics on the Dry Sea Floor of the Aral Sea

in: "Sustainable Land-Use in deserts", by Breckle,S.-W., Veste,M. & Wucherer,W. (eds.) 2001, Springer/Heidelberg. p. 52-68

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Keywords. Primary succession, succession stages, vegetation development

Abstract. The dry sea floor of the Aral sea is a new terrestrial surface, where plants (including seedbank) and animals have not existed before, and it is actively populated by organisms. The dry sea floor (Aralkum desert) is the largest area worldwide where a primary succession takes place. Unintentionally, mankind has created a huge experiment, an experimental set, a laboratory of nature with thousands of local events. The new knowledge on vegetation dynamics in the Aralkum desert, which is a mosaic of sand and salt desert ecosystems, is very important for the understanding of the ecosystem dynamics in the whole Central Asian area. The succession on the dry sea floor has continued for 40 years. We are able to determine the age of the drying and of the ecosystems. This is important to identify major mechanisms that determine the rate and direction of ecosystem changes on the dry sea floor. The distribution and dynamics of the vegetation and ecosystems were surveyed along some new transects. On the dry sea floor barchan and salt deserts have spread. The present and future development of the drying sea is characterized by the creation of salt desert flats. Along the former coast line the inhabitants of adjacent villages are using the dry sea floor more and more as grazing area and for hay production.

Introduction

The Aral Sea, in 1960 the fourth largest sea on the globe, is in a critical process of drying out. The development of separate smaller independent water bodies is now a reality. A new dry surface area of about 40 000 km^2 is exposed. This is the new desert called Aralkum. The dry sea floor is a new area, where land plants (including seedbank) and animals have not existed before. It is actively invaded by organisms. The formation of plant communities, soils, a new groundwater level, aquifers, all components and processes of ecosystems is occurring simultaneously. The dynamics on the drying sea floor is unique. The dry sea floor is the largest area worldwide where a primary succession is taking place. For our purposes here we will define succession as the replacement of one ecosystem by another or the colonization of the new surface. Unintentionally, mankind has created a huge experiment, an experimental set, a laboratory of nature with thousand of local events with an open end. There are two questions to ask:

- What is this new desert?
- What does this mean for the people in the Aral Sea Region?

In 1977 a complex research program was started in Central Asia to study the negative effects of the drying process of the Aral Sea and the change in the discharge of the Amu - and Syrdarya (under the leadership of the Geographical Institutes of Moscow). Transects were set up at different coastal areas, stretching from the former coast to the present coastline. The distribution of the soils and the vegetation was surveyed along these transects. One of the authors had participated in this program (Wucherer 1979, 1984, 1990; Kabulov 1990). This program was stopped in the mid 1980s. At present, the ecological situation on the dry sea floor is different compared to 15 years ago:

- The diversity of landscapes and plant communities has increased enormously.
- Barchanes and salt deserts spread out on the dry sea floor.
- Salt dust is blown into the atmosphere and hundreds of km into adjacent areas.

In 1990 the UNESCO program started with special emphasis on the delta areas. The problems of the Aralkum desert itself have not been touched since the middle of the 1980s. Therefore a new research program as the logical continuation of the BMBF and UNESCO initiatives in the Aral Sea region resulted in an international BMBF project: Successional Processes on the Dry Aral Sea Floor and Perspective of Land Use. This project has two important aims:

- The study of the ecosystem dynamics in the Aralkum desert. The research and evaluation of the ongoing processes and a prognosis for future scenarios are vital for this area.
- What measures can be taken to accelerate the natural colonization by plants? Are experimental plantings on the dry sea floor successful?

At present, the dry sea floor of the Aral Sea is a huge salt flat. According to several estimations, it is the source of many million tons of salt and dust blown out by wind annually and transported to rather distant adjacent areas with irrigated fields and settlements. The present and future development of the drying sea is characterized by the creation of salt desert flats. It is high time for strict measures to minimize the salt dust output.

Studies along Transects

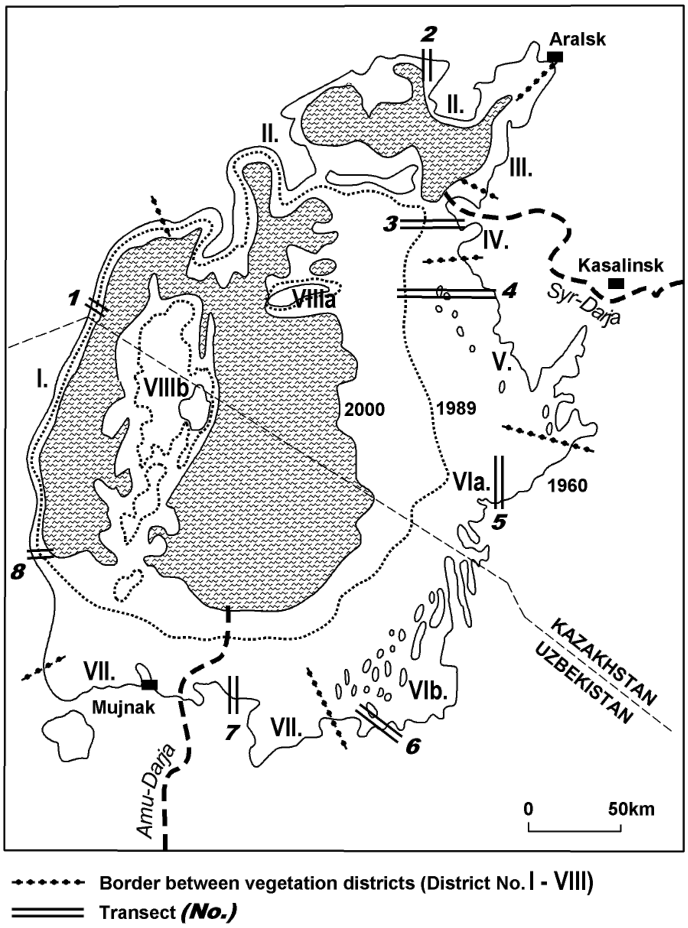

Fig. 1. Transects, vegetation and succession districts on the coast of the Aral Sea

The new knowledge of vegetation dynamics in the Aralkum desert, which is a mosaic of sand and salt desert ecosystems, is very important for the understanding of the ecosystem dynamics in the whole Central Asian area. The dry sea floor is a huge open area, open for invasion by plants and animals. For such an invasion process two different terms were proposed: autotropic succession (Begon et al. 1986) and syngenetic succession (Sukachev 1938, 1954). Sukachev emphasizes syngenesis as being the main mechanism for a succession, driven by the vitality and competitive force of the plants. Certainly, succession is a complex process, interrelated with the exogenesis, endoexogenesis and syngenesis of plant communities. Succession is a process controlled by tolerance, inhibition and other successional mechanisms (Drury and Nisbet 1973; Connell and Slatyer 1977; Glenn–Lewin et al. 1992). In the first few years after the drying process of the sea floor, the exogenic factors dominate the ecosystem dynamics. The study of the mechanisms of the ecosystems dynamics and the ecological attributes of the dominant species is of great importance for clarifying the following open questions:

- Which geological, geomorphological and edaphical processes are affecting the present ecosystem development?
- Which mechanisms are governing the development of salt desert and sand desert (barchanes)?
- Will there be an ecological limitation to colonization by plants, and where it will be?

Figure 1 surveys the distribution of the old and new transects for studying the dynamics of the vegetation and ecosystems. The transects stretch from the old coast line to the present one. Along the transects, groundwater level, distribution of soils and vegetation types were studied. The long-term transects were set up at the end of the 1970s and at the beginning of the 1980s. The data set now covers 19–23 years. The main vegetation types are: halophytic, psammophytic, tugai and salt meadow communties. The halophytic plant communities are formed by eu- and hemihalophytic vegetation on saline soils. Plant species are mainly shrubs, semishrubs, perennials and annuals from the Chenopodiaceae (*Halostachys, Halocnemum, Salicornia, Suaeda*), some Tamaricaceae, Limoniaceae and Zygophyllaceae. The cover percentage is often rather high, 10–100%. The great variability of this vegetation is a matter of the very varying salinity and water availability. The typical soils are marsh and coastal solonchaks, degraded and sandy coastal solonchaks as well as takyr-like solonchaks. The halophytic vegetation is present on the dry sea floor of the 1970s, 1980s and 1990s. The psammophytic vegetation consists of eu- and mesoxerophytic shrub and semishrub vegetation on desalinized sands. The specific canopy of these plant communties is determined by vigorous species of *Haloxylon* and *Salsola* (Chenopodiaceae), *Calligonum* (Polygonaceae) and some species of Fabaceae and Poaceae. The main canopy is about 0.5–2.0 m but can reach 5 m. The plant cover percentage is about 20–60%. The sandy soils are preliminary with no or only very slight formation of horizons. Wind erosion causes the development of a complicated relief. The psammophytic vegetation is most dominant on the dry surface areas from the 1960s, partly from the 1970s and rare from the 1980s. The typical tugai biome is represented by the shrubs and small woods of the delta regions and lake bays. The characteristic species of this vegetation type are mainly the *Populus* species from the subgenus *Turanga, Elaeagnus oxycarpa* and shrubs from the Tamaricaceae. They depend on available groundwater and are only slightly resistant to salinity. The salt meadow vegetation is mainly composed of reed communities with many perennial hemicryptophytes (*Puccinellia* and *Limonium* species, *Aeluropus littoralis, Karelinia caspica* etc.), which also can withstand soil salinity. The typical pattern of landscapes, vegetation types and soils is striated. This banded pattern is most characteristically seen along the east coast of the Aral Sea (Ishankulov and Wucherer 1984).

Factors Influencing Vegetation Development

Primary succession can be considered from the viewpoint of time, habitat and the plants (Bradshaw 1993).

Time and Age

The succession on the dry sea floor has been active for about 40 years. The time factor plays no active role, but influences indirectly the vegetation development. Species which arrived rather late are often not able to establish themselves in reasonable numbers. Either the ecological conditions have changed and became unfavourable or other species have already occupied the relevant ecological niche. The momentaneous stabilization of the sea level of the Small Aral Sea has demonstrated that a whole set of species has established on the coastal solonchaks very rapidly, especially under conditions of a stabilized groundwater level. The change in the ecological factors leads to a change in colonization rate and thus to a change in the time sequence of the succession. We know the annual sea water level since 1961, so that we are able to determine almost exactly the age of the drying process of a distinct portion of the sea floor and thus the development of the relevant ecosystems. This is important to identify major mechanisms that determine the rate and direction of ecosystem changes on the dry sea floor.

Plant Sources

On the dry sea floor alone, to date 266 plant species have been reported (Wucherer et al., see this volume). The precondition for colonization by plants is the surrounding flora and its seed production. It is mainly the flora of the old Aral terraces along the old coast line and the adjacent mainland all around the Aral Sea. The given scheme (Fig. 1) indicates the main directions and specialities of the vegetation development on the dry sea floor. It depends on the geomorphological and landscape pattern as well as on the pattern of the vegetation units along the coast (Lymarev 1969; Ishankulov 1980; Kurochkina et.al. 1983). The districts I–II (Fig.1) on the north and west coasts of the Aral Sea lack the old Aral terraces almost completely, or these are very narrow belts (only 10–20 m up to some 100 m). The azonal flora of the Aral terraces and the steep slopes of the Chinks are the main sources for the seed bank (Colour Plate 3). The zonal plant communities of the former mainland are hardly relevant as a source for colonization with plants and for formation of vegetation units on the dry sea floor. It is remarkable that on the dry sea floor area from the 1960s there is an essential proportion of Brassicaceae and Chenopodiaceae but a sparse representation of Fabaceae and Polygonaceae. In the districts III and VI, the belt of the Aral terraces is continuous and relatively broad (some 100 m to 3–5 km). The azonal vegetation of the Aral terraces and the zonal psammophytic plant communities of the sand deserts Kyzylkum and Priaralskii Karakum are the sources for the plant species for the dry sea floor. The Polygonaceae and Fabaceae are significantly richer on those areas of the dry sea floor from the 1960s and 1970s than the Brassicaceae and Chenopodiaceae. In the delta districts IV and VII the irregular floods of the rivers are an important factor. These inundations led to an extensive distribution of seeds and an activation of the seed bank already present on the dry sea floor. Mainly the Tamaricaceae, Limoniaceae, Asteraceae and Chenopodiaceae are conspicuous. Within district V only the halophytic communities and the zonal communities (*Artemisia terrae-albae*, *Anabasis salsa*, *Haloxylon aphyllum*) are present on the Aral terraces. Here, mainly Chenopodiaceae dominate the dry sea floor from the 1960s and 1970s. Within the island district VIII the belt of the Aral terraces is interrupted. Again, here the zonal vegetation units are of no importance for the colonization processes. The flora of the Aral terraces and of the distinctly lower Chinks is poor in comparison with the mainland. The composition of flora of the former coast is different in each district and influences the course of the succession on the dry sea floor.

Exogenic Factors

These are the sea and river floods, the geological and geomorphological, climatical, edaphical and eolian factors. The areas adjacent to the coastline are subject to inundations. The pattern of sedimentation, as well as the former geological history of the Aral Sea determine the particle size distribution and sedimentation layers of the new soils of the dry sea floor. The geomorphological structure of the Aral Sea basin is complicated. Plains predominate in the eastern part of the depression with an inclination of 0.2° to 0.6°. Therefore the present coast line is situated up to 100 km away from the former eastern coastline. On the west coast, between the plateau Ustyurt and the islands Barsa–Kelmes and Vozrozhdenie, the inclination of the plain is steeper and amounts to 2°–5°. Correspondingly, the dry sea floor belt is only 4–10 km wide.

The new alluvial deposits of the retreating Aral Sea cover 1–6-m older layers. The salinization of the substrate varies to a great extent, causing a wide variety of saline soil types: marshy solonchaks, crusty and puffy solonchaks, solonchaks slightly covered by sand, degraded coastal solonchaks, takyr solonchaks and takyr soils, sandy soils.

On sandy or sandy loamy soils deflation of soil particles takes place. Barchans or complexes of barchans and salt deserts develop. They are widespread on the east coast. Since the middle of the 1980s, open salt deserts have developed on a large scale. Some plant populations have decreased according to the salt desert formation. The fast increase of the salt desert areas, the changing of soil texture and increase in salt content of the soils has caused the absolute dominance of halophytes as pioneer plants, mainly species from the Chenopodiaceae, to the exclusion of most other life forms.

Succession

The development of vegetation units is different on sandy and loamy or even clay soils. Some typical examples will be mentioned.

Succession on Loamy Soils (Fig. 2)

On marsh solonchaks at the present coast line (stage I), dominant plant communities are found with the following species: *Salicornia europaea*, *Suaeda crassifolia* and *Tripolium vulgare (Aster tripolium)*. These are pioneer plants that directly follow the retreating sea water level. During the vegetation period, this area is often flooded, creating ecological conditions favourable for the development of annuals (Colour Plate 4). The plants normally are only 30–50 cm high. Figure 3 illustrates the development of the *Salicornia* unit on the marsh solonchaks from year to year on the Bajan transect on the east coast. The density of the plant population varies tremendously from year to year. When the water level sinks, the pioneer plants die and the coastal solonchaks develop (stage II). The crusty and puffy coastal solonchaks are formed when the groundwater level goes down to about 1–2 m and no further inundations occur. The strong capillary upwards movement of water leads to an extremely strong salinization of the upper most soil surface and the formation of a salt crust, containing up to 16–20% of salt. The ecological conditions for colonization and establishment of plant species are then very severe in comparison with marsh solonchaks.

Only few species are able to colonize such stands. These are the pioneer plants of the second generation (Colour Plate 5). colonizing the dry sea floor (*Climacoptera aralensis*, *Petrosimonia triandra*, *Bassia hyss*opifolia) or developing successional salt deserts. Those successional deserts can be defined as stands, where for lack of a seed bank, colonization by plants has not yet taken place. Thus, during further succession salt deserts are often formed, and can exist for 10–20 years and more. They are the main area and source of the salt dust output from the dry sea floor. The third stage of succession is a loose mixture of annuals and perennials like *Halocnemum strobilaceum*, *Halostachys caspica* etc. on degraded solonchaks.

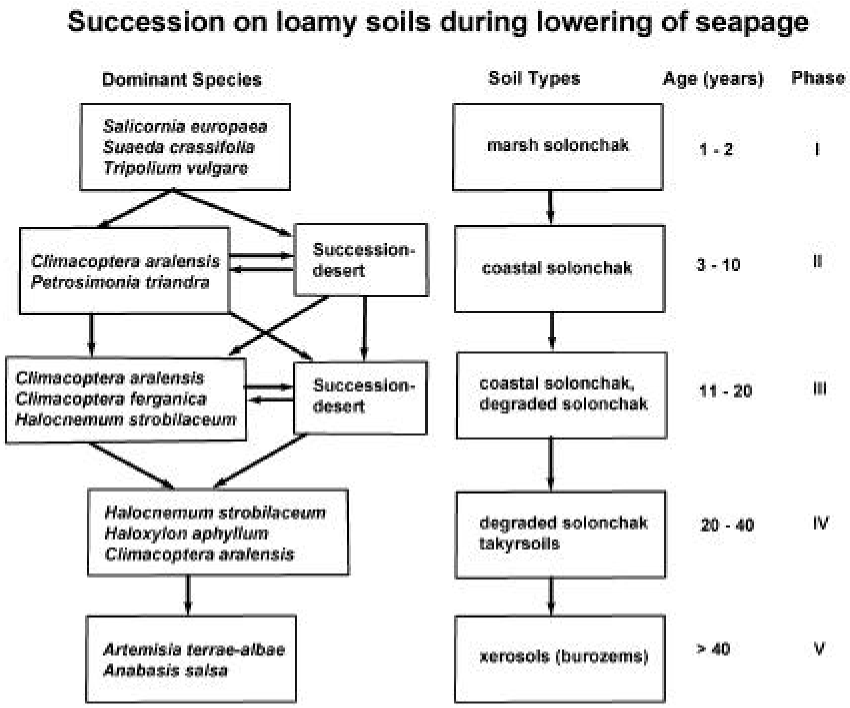

Fig. 2. The main direction of succession on loamy soils

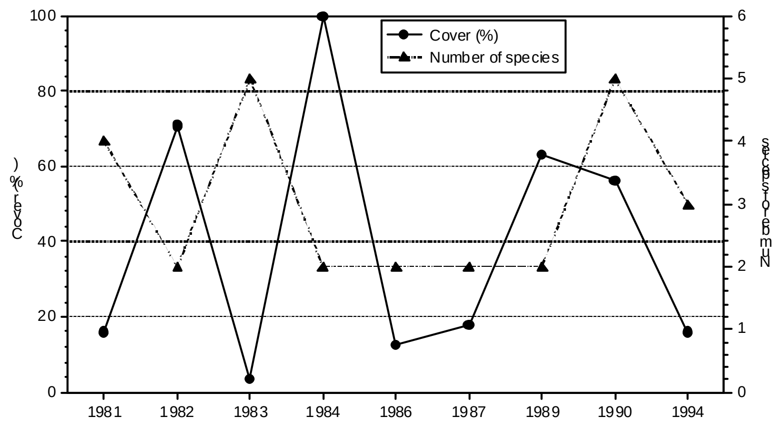

Fig. 3. Development of *Salicornia europaea* community on the marshy solonchaks from year to year (transect Bayan)

Degraded coastal solonchaks develop from coastal solonchaks by further lowering of the groundwater table and thus drying of the surface. The capillary threads no longer reach the surface, but end below the surface at a depth of about 10–30 cm. With time communities with a cover percentage up to 20% and more are formed (stage IV). On the Kaskakulan transect, permanent communities of *Halocnemum strobilac*eum and *Haloxylon aphyllum* are widespread throughout the east coast (Fig. 4).

Fig. 4. Permanent communities of *Haloxylon aphyllum* with some *Halocnemum strobilaceum* (stage IV) on the dry sea floor at the east coast of the Aral Sea

Succession on Sandy Soils (Fig. 5)

The psammoseries of vegetation are most perfectly developed around the islands of Barsa–Kelmes and on the southeast coast of the Aral Sea. The soil profile is sandy up to at least 2 m in depth. The succession is influenced also by the sinking groundwater level as well as by the desalinization by means of a good water percolation along the soil profile. On the marsh solonchaks (stage I) the floristic composition is slightly different. Together with *Salicornia europaea, Suaeda acuminata* and *Atriplex fominii* form pioneer units. On the coastal solonchaks (stage II) the species compositions and the vegetation units are richer and more variable. Already during this stage deflation events start. The nanorelief with small hills (5–10 cm high) is already distinct. Plants accumulate sand around them and the small hills increase (15–20 cm high). These stands are optimal for the development of *Atriplex fominii* units. Further decrease of the groundwater table to 1.2–1.7 m and desalinization of the top soil (down to 50 –60 cm depth) is the precondition for the first colonization with perennial psammophytes (stage III, Fig. 6) an. With time psammophyte communities with *Stipagrostis pennata*, *Calligonum* and *Astragalus* species thus develop on the sandy soils.

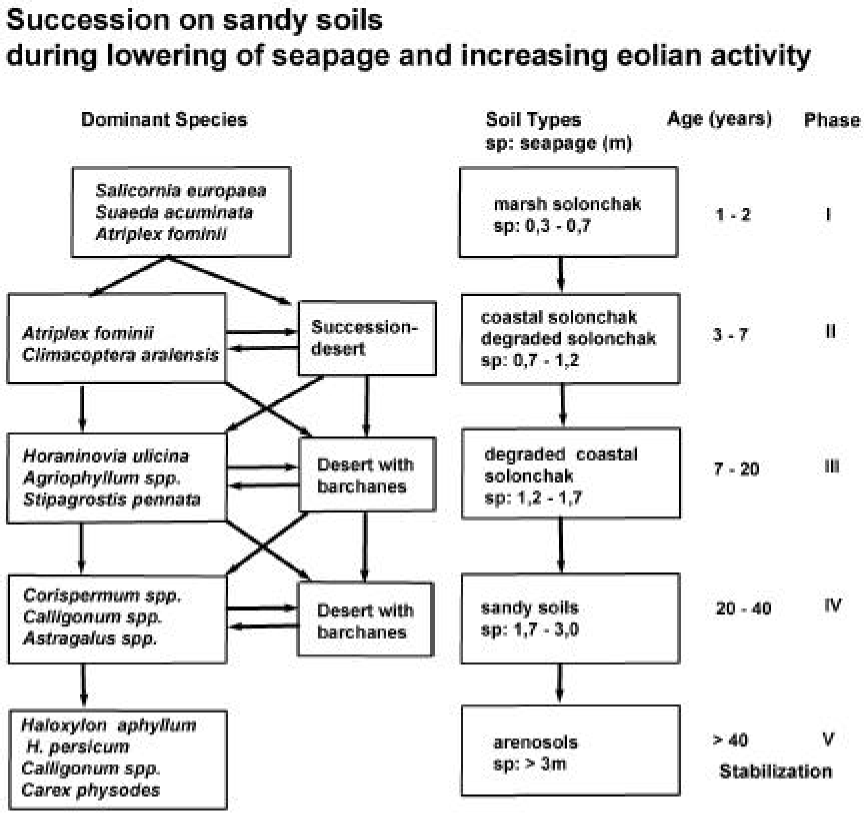

Fig. 5. The main directions of succession on sandy soils

On average, the succession on loamy stands can be described by two to four stages, and on sandy soils by three to five stages. The existence of a distinct stage is a matter of the ecological conditions and their lability or stability, and thus might vary between 2 to 30 years. In the course of further drying out, ecosystems with new characteristics arise: the granulometric composition, salt content and microrelief may be different. Particularly striking is the contrast between the dry areas of the 1960s and 1970s and those of the 1980s and 1990s. Accordingly, the temporal change of the vegetation and of the soils do not match the spatial position of plant societies.

Fig. 6. Beginning of first colonization with perennial psammophytes of *Stipagrostis pennata* on sandy soils (stage III)

Fragments of the Vegetation Development around the Small Aral Sea

In 1998 the dry sea floor around the Small Aral Sea (12 transects) was surveyed. The new hydrological situation, in contrast to that of the Great Aral Sea, has influenced the colonization of the dry sea floor in two ways. The therophytic vegetation with *Salicornia europaea* and *Suaeda* species was inundated and is almost lacking now on most parts of the present coastline because of the rapid rise of the water level. On some coastal parts also perennial and woody vegetation was inundated. First observations show that the resistance of the various species to inundation varies greatly.

The Pioneer-Species

Pioneer species like *Salicornia europaea*, *Suaeda crassifolia*, *Suaeda salsa* and *Suaeda acuminata*, which form plant associations close to the coast line, entered a new ecological situation. With the rise of the water level the therophytic belt also drifts backwards to the older former coastline. The rise of the water level occurs so rapidly that some pioneer species from the first colonization wave simply disappear. The distribution of the pioneer species around the Small Aral Sea is very interesting (Table 1) .

Table 1. Distribution of the pioneer species around the Small Aral Sea arranged according to successional sequence of localities

Locality/ Species	1	2	3	4	5	6	7	8	9	10	11	12
Salicornia europaea	++	++	++	++	++	++	++	+				
Suaeda acuminata	++	++	++	+	-	+	-	+				
Suaeda crassifolia	+	+	+	++	+	+	+	+				
Suaeda salsa				+	-	-	-	-				
Petrosimonia triandra					-	+	+		+	+	+	+
Climacoptera aralensis									+	++	-	+
Atriplex fominii									-	+	+	+
Phragmites australis									+	-	+	-

++ dominant species; + sparse; - missing

The small bights (Butakov, Dzhideli, Table 1: 1–4), where wave activity is low and salinization slightly enhanced, exhibit a well-developed plant cover with typical pioneer species like *Salicornia europaea*. Around the larger, more open bights (Shevchenko, Table 1: 5–8) the typical pioneer species are only subdominant or members in other plant associations. The third group (Table 1: 9–12) are the open coast lines, where the halosucculent therophytes, like *Salicornia* and *Suaeda* species have disappeared and are replaced by pioneers from the second generation (*Climacoptera* and *Petrosimonia* species). On the remaining dry sea floor of the Small Aral Sea conditions are favourable for a second flush of therophytes (with several *Climacoptera*, *Salsola* and *Petrosimonia* species) as well as for some woody species from the tugai vegetation. The overlapping of the ecological amplitudes of several species seems to have become wider. This may result in future in more stochastic processes during formation of vegetation units and a higher interspecific competition.

Land Use

On the northeast coast of the Butakov bight (Table 1, transects 3, 8) the small village of Tastjubek and the camel farm Akkuduk are located. The camel flock consists of 50 animals. Along this coast line the inhabitants are using the dry sea floor as grazing area and for hay production. The annual *Atriplex* and *Suaeda* species are ideal, monotonous salty meadows. The salinization of the upper soil surface, grazing mowing are prevent the perennial species from spreading out.

Ecological Peculiarities of the Plant Colonization of the Dry Sea Floor

Flora

The dry sea floor and the coastline of the Aral Sea are one of the centres of diversity for Chenopodiaceae and Polygonaceae (Calligonum) in Central Asia.

The Chenopodiaceae are a cosmopolitan plant family. They play a special role in the arid areas of Europe and Asia. This family determines the appearance of the vegetation cover in the Central Asiatic deserts and on the dry sea floor. At present, about 75 species of Chenopodiaceae and about 30 species of *Calligonum* are recorded from the dry sea floor (Wucherer, in this volume).

Expansion of Plant Species

Hundreds of species had the opportunity to fill out or expand their distributional area. The primary seed bank is on the Aral terraces at the former coastline. The second seed bank is being formed today on the dry sea floor. By nivellements, with the help of bathymetric maps and GPS measurements, we were able to determine relative precisely the age of the relevant dry sea floor stand and thus the speed of colonization by various species. The fastest are the halosucculent therophytes which directly follow the retreating coast line, at a speed of about 70 km within 30 years.

Unique Plant Communities and Ecosystems

There are many examples of unique composition by various species. We will discuss a few examples from the psammophytic, halophytic and hygrophytic units. On the sandy substrate around the island Barsa–Kelmes and at the south-eastern coast a plant unit either with *Stipagrostis pennata* and *Halocnemum strobilaceum* or *Stipagrostis pennata* and *Phragmites australis* (Colour Plate 6) can often be found. Such a combination is peculiar and needs explanation. The sandy coastal solonchaks first are colonized by *Halocnemum strobilaceum*. With the further decrease of the ground-water table, the upper sandy layer over 8–10 years becomes slowly desalinized down to about 1 m depth. The main active roots of *Halocnemum strobilaceum* are at a depth of 1–2 m. *Stipagrostis pennata*, however, has main roots in the upper sandy soil. This vegetation unit is an intermediate vegetation type. With the stabilization of the sea water level, it might be possible for such vegetation unit to become rather permanent.

Development of Monotonous Widespread Vegetation Units

The dry sea floor of the Aral Sea is a huge open flat plane. This is a perfect condition for wide-ranging plant dispersal. The therophytes may cover hundreds of km^2 within a very short period of less than 2 or 3 years. *Petrosimonia triandra* is a very typical anemochorous plant; it is cut off at the base by wind and then the whole plant is dispersed like the steppe runners by wind. Very dense stands were formed by *Petrosimonia triandra* in 1998 on the northeast coast; *Atriplex fominii* was extremely dense in 1994 on the southwest coast. As a rule, those units are often poor in species and over vast distances only three to seven species are found. The perennials can also form uniform, monotonous stands. *Halocnemum strobilaceum*, as a succulent chamaephyte, forms extensive stands along the east coast of the Aral Sea. Such units are ideal for studies on the genetic and biological variability of these plant populations.

Development of New Ecological Attributes of the Species

The variability of the stands on the dry sea floor is, in comparison with the adjacent mainland, much higher. There are various sandy, loamy and clayey soils, also with rather varying horizontation. The salt content varies over a wide range between 0.3 and 20% of dry matter. The groundwater table lies between 1 and 5 m depth. Atypical ecological conditions may force plant species to specific adaptations. As an example, the annual *Salicornia* species normally develop a root system not deeper than 30–40 cm. The ecological conditions of the marsh solonchaks of the dry sea floor may change very fast. During early spring the tiny seeds of *Salicornia* germinate rather close to the water level or in standing water, especially after a rainy day. The groundwater level is less than 20 cm deep. However, during the vegetation period it may recede rapidly and the groundwater level may go down to about 2–2.5 m depth at these stands and, accordingly, the water availability in the top soil decreases. Since the density of plants is extremely high, there is a water deficiency quite soon. The reaction of the strongest individuals of *Salicornia* is, accordingly, to produce roots which follow the capillary availability of water down to 1 m. The maximum root length found was about to be 1.06 m.

Because of the variability of stands with extreme conditions, the dry sea floor is an ecological challenge even for halophytes. Due to such habitat variability and rapid changes it is possible to see and to become familiar with the ecological amplitudes and the overlapping of species adaptations as well as the ecological limits of distinct species in a better way.

Unexpected Combinations and Interrelationships

Species which under natural conditions cannot be found together with other species despite an apparently similar ecological behaviour, here form new vegetation units. As an example, *Climacoptera aralensis* occurs on crusty and puffy solonchaks as well as on secondary solochaks in fields in the Kzyl–Orda district. It forms isolated, monotonous units, sometimes together with a few salt meadow halophytes. *Petrosimonia triandra* is distributed very locally only and prefers moderate marsh conditions or slightly saline meadows. Both species do not occur together at the same localities. However, on the dry sea floor they meet and form extensive stands. *Petrosimonia triandra* is dispersed faster and colonizes the coastal solonchaks first. One to two years later, *Climacoptera aralensis* follows. Due to the winged fruits the latter species has a high potential for wide range dispersal, but in comparison with *Petrosimonia* remains always only subdominant. Both species form mixed stands with a high cover percentage of about 60–80%. If salinity of the top soil increases, then *Petrosimonia* frequency decreases, but *Climacoptera* remains. The ecological range of both species apparently overlapps broadly, but some of their life strategies are different. *Petrosimonia triandra* has a more rapid dispersal ability, *Climacoptera aralensis* is more salt-resistant.

Contrasting Fluctuating Dynamics

The great annual variability in cover percentages of spring annuals in deserts is well known. In most cases in the Aral Sea floor we have halophytic therophytes which have a life cycle of about 6–8 months. Again, their density varies tremendously from year to year. The greatest contrast could be observed between the years 1981 and 1982 and 1998 and 1999. The first case is described from the north coast of the Aral Sea (transect Karabulak) and was mapped by Wucherer and Galieva (1985). The second case will be illustrated by an example from the transect Bayan. In 1998 along the transect therophyte units were developed with a percentage cover of about 80–100% with many species, mainly *Suaeda acuminata, Suaeda crassifolia, Petrosimonia triandra, Climacoptera aralensis* etc. One year later on the very same areas an absolutely barren salt desert could be found without any plants. The soil surface, however, was covered by an incredible amount of seeds, which had no chance to germinate. About 30–450 seeds per 100 cm^2 on the surface of the soil below dead *Suaeda acuminata* plants from the previous year could be counted. The reasons for such a regressive dynamics are mainly too dry spring months and too warm winters, poor in snow.

Conclusions

The successional processes on the dry sea floor are diverse and peculiar. The geomorphological, sedimentological and pedological factors determine the vegetation and succession patterns. The biological characteristics (plant strategy) of the plants are also very important for colonization of the dry sea floor. By the start of the succession, especially in the first 5 years, abiotical factors control the development of vegetation. Later, biotical factors intervene. The importance of facilitation and inhibition in early succession is only generally known. To what degree is physical amelioration required for invasion? The ecological situation on the dry sea floor is very changeable and the dry sea floor is a large dynamic ecosystem complex. The development of vegetation in the area of the Small Aral Sea is different from the Great Aral Sea. The actual trend in dry sea floor characteristics is the formation of salt deserts and spreading of halophyte vegetation. Long-term studies on vegetation development on the dry sea floor will contribute greatly to our understanding of primary succession and ecosystem dynamics in Central Asia.

Acknowledgements. This research is funded by the German Federal Ministry for Education and Research (BMBF grant 0339714).

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