中国科学院新疆生态与地理研究所

Xinjiang Institute Of Ecology And Geography Chinese Academy Of Sciences

International Symposium on Ecological Restoration and Management of the Aral Sea

Bioresource of Central Asia and its utilization on ecological restoration of damaged desert ecosystems

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Professor and Director of EGI

Topics covered

Part 1. Bilogical resources in Central Asia

Part 2. Utilization of the bioresources for the ecological restoration

Part 3. Some successful utilization from EGI Experiences

Part 4. Green Aral Sea Megascience Initiative

Part 1.

Biological resources in Central Asia

Central Asian countries and Xinjiang region

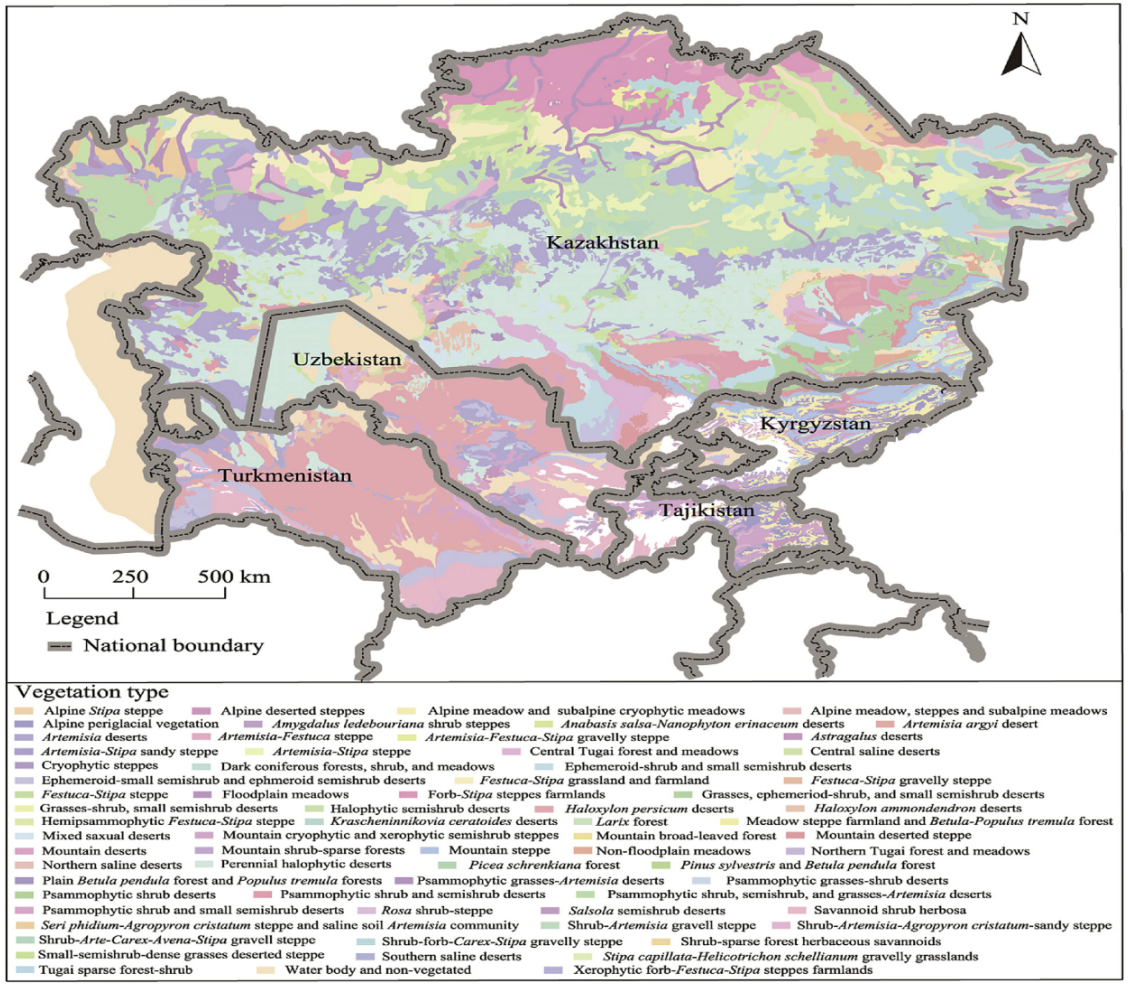
- Unique biogeographic units
- Key area of biodiversity
- Abundant types of biological resources
- Origin and differentiation center of many plants

Main types of ecosystems and vegetation

Predominant types: Deserts, semi-deserts, and steppes, plains and hills cover nearly 75%

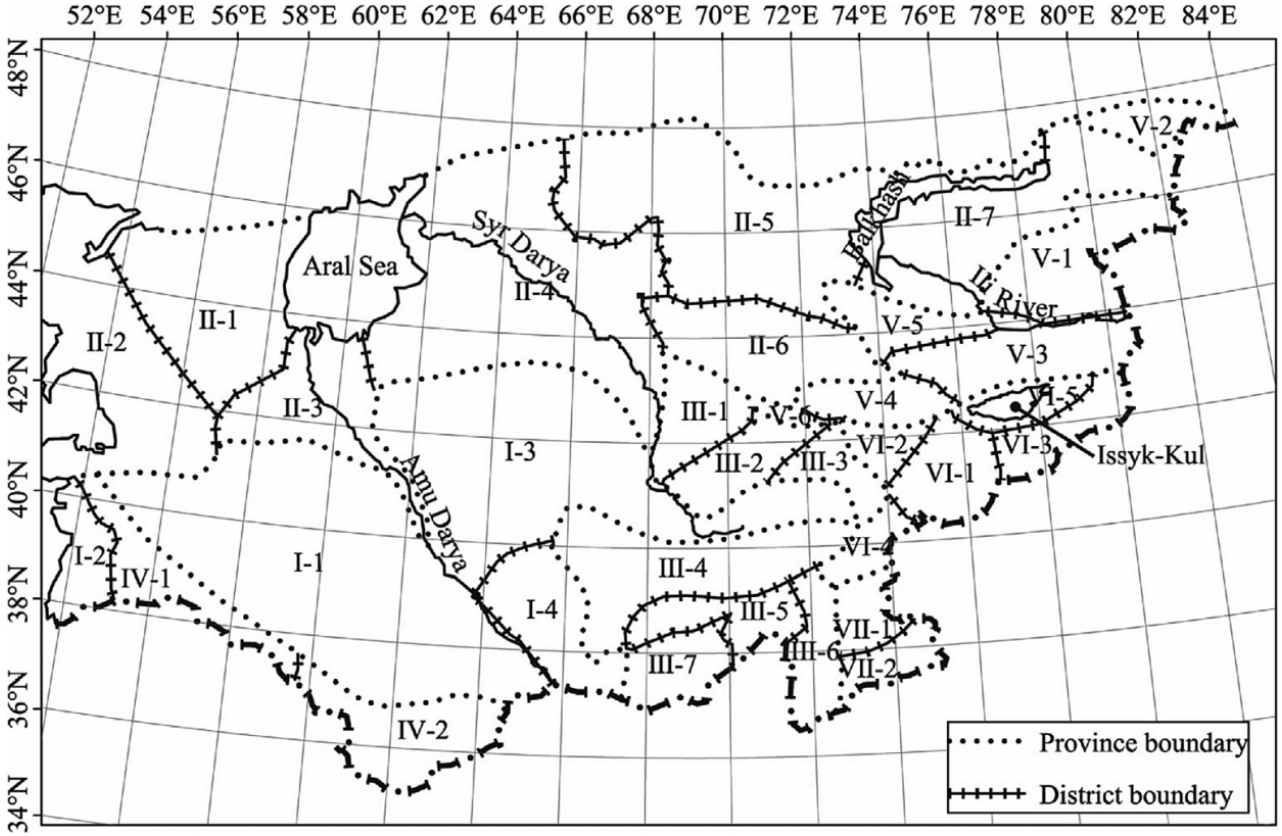
Some highest mountain ranges: the Tian Shan and the Pamir

Altitudinal gradient: desert, mountain shrubland, deciduous broad-leaved forest, dark coniferous forest, subalpine, alpine meadows and alpine cushion vegetation



Plant geographical divisions and components

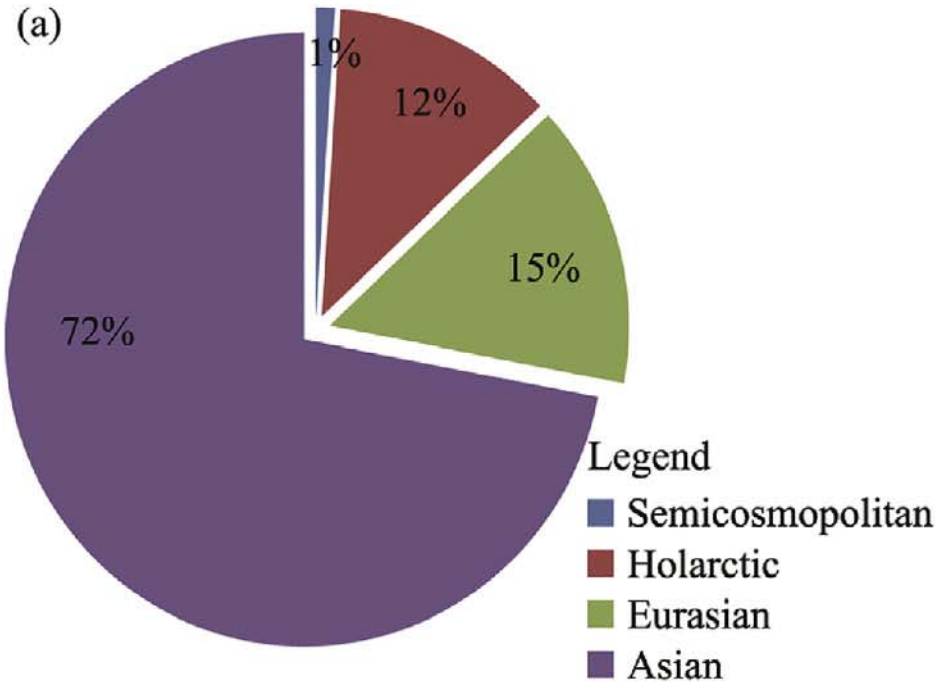
Five provinces and 33 districts

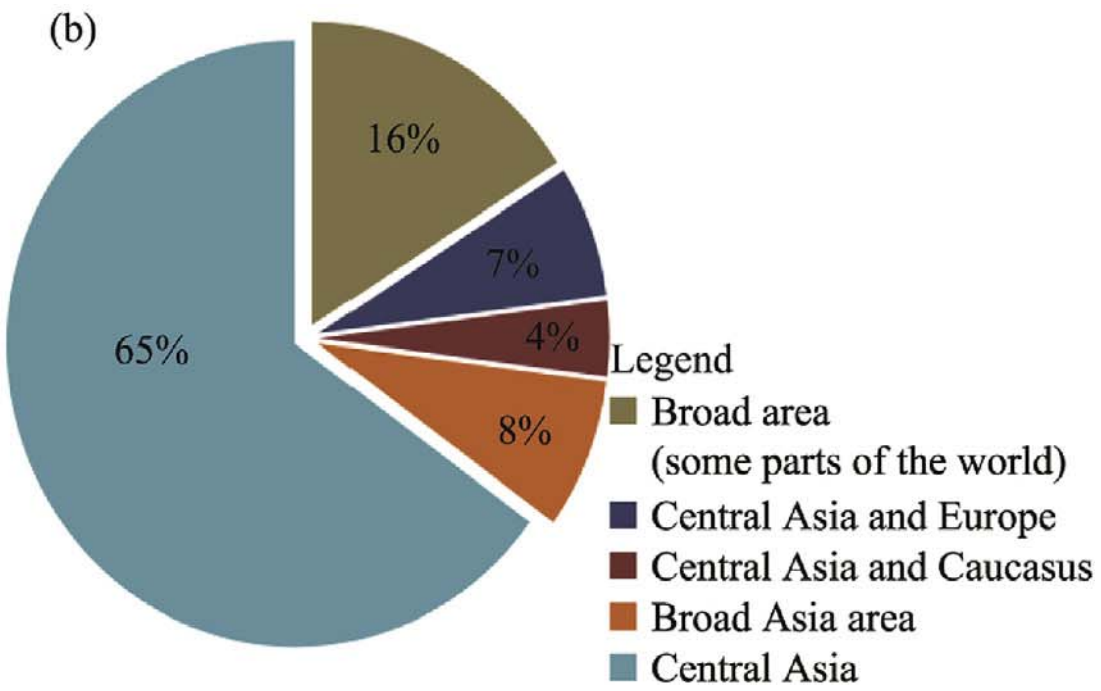


- Between Irano-Turanean and Central-Asiatic
- Almost the whole region is situated in the Tethian (Ancient Mediterranean) subkingdom
- In the north it includes the Altai-Sayan province of the circumboreal region of the Boreal subkingdom (Takhtajan, 1978)

- Kamelin (1998) suggested that the flora of Dzungar Alatau is rich by boreal species that are more typical for the boreal Siberian flora

Plant geographical divisions and components





- 65% have a Central Asian distribution
- Eurasia and Holarctic species represent 12% and 15%, respectively
- 16% are broadly distributed in more than three continents
- 7% of the species are distributed in both Central Asia and Europe
- 4% are distributed in both Central Asia and Caucasus

Biodiversity:

Biodiversity hotpot, Mountain of Central Asia

- 7000 vascular species in the mountainous area, accounting for over 75% in the region
- Ancestors of domestic fruits and nuts: apricots, plums, cherries, apples, pears, cherry plums, grapes, pistachios, almonds, walnuts, and pomegranates
- Reservoir of crop diversity, wild crop relatives: wheat, barley, rhubarb, sorrel, anise, oats, onion, garlic, and tulips
- Centers of ephemeral plants: *Allium*, *Tulipa, Gagea, Juno*, *Ferula* and *Hedysarum*

Biodiversity: species and herbarium

Country & region	Flora & Checklist & Red Data book	Species Count	Reference
Central Asia	Conspectus florae Asiae Mediae, 1-11	9341	Kovalevskaya, 1968–1971, Bondarenko and Nabiev, 1972, Pakhomova, 1974–1976, Kamelin et al., 1981, Adylov, 1983, 1987; Nabiev, 1986, Adylov and Zuckerwanik, 1993; Khassanov, 2015
	Plant resources and utilization in Central Asia	9346	Zhang et al., 2013
	Checklist of vascular plants of Central Asia	9520	Li et al., Unpublished
Kazakhstan	Flora Kazakhstana, 1-9	5631	Pavlov, 1956-1966
	Checklist of vascular plants of Kazakhstan	5658	Abdulina, 1999
	Red Data Book of Kazakhstan,Volume 2: Plant	387	Baitulin, 2014
Kyrgyzstan	Flora Kirgizskoj SSR, 1-11, supplementary 1-2	3576	Shishkin and Vvedensky, 1950–1962
	Checklist of vascular plants of Kyrgyzstan	3927	Lazkov and Sultanova, 2014
	The Red Book of the Kyrgyz Republic	87	Shukurov, 2006
Tajikistan	Flora Tadzikskoj SSR, 1-10	4445	Ovchinnikov, 1957–1991
	The Red Data Book of the Republic of Tajikistan, Volume 1	267	Rahimi et al., 2017
Turkmenistan	Flora Turkmenii, 1-7	2607	Fedtschenko et al., 1932–1960
	Manual of vascular plants of Turkmenistan	2800	Nikitin and Geldykhanov, 1988
	The Red Data Book of Turkmenistan Volume 1: Plants and Fungi Ed. 3rd	115	Annabayramov, 2011
Uzbekistan	Flora Uzbekistanica, 1-6	4148	Schreder and Vvedenskyi, 1941–1962
	Flora of Uzbekistan, 1-3	375	Sennikov et al., 2016–2019
	Red Data Book of Uzbekistan 1. Plants.	324	Khassanov and Pratov, 2009
Xinjiang, China	Flora Xinjiangensis, 1-6	3875	Florae Xinjiangensis, 1992–2011

Key floras in Central Asia countries

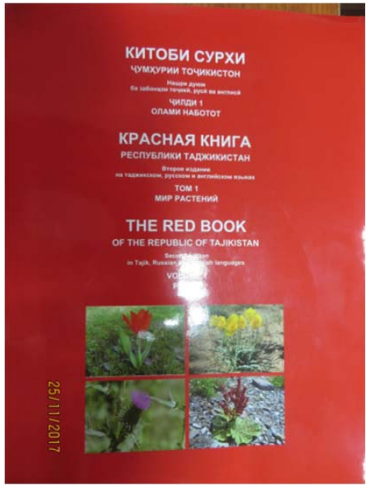
Country	Herbarium Code	Institution	Location	specimens
Kazakhstan	AA	The Institute of Botany and Phytointroduction, Ministry of Science, Academy of Sciences	Alma-Ata, Kazakhstan	300,000
	PPIU	M. Utemisov Western Kazakhstanian State University	Uralsk, Kazakhstan	340,000
	KG	International Phytochemistry Research and Production Institute	Alma-Ata, Kazakhstan	28,000
	KSPI	Kostanay State Pedagogical Institute	Kostanay, Kazakhstan	25,000
Kyrgyzstan	FRU	Institute for Biology and Soil, National Academy of Science, Kyrgyzstan	Bishkek, Kyrgyzstan	400,000
Tajikistan	TAD	Institute of Botany, Plant Physiology and Genetics, Academy of Sciences, Republic of Tajikistan	Dushanbe, Tajikistan	200,000
	KHOR	Pamir Biological Institute	Khorog, Tajikistan	30,000
Turkmenistan	ASH	National Institute of Deserts, Flora and Fauna of the Ministry of Nature Protection of Turkmenistan	Ashkhabad, Turkmenistan	135,000
Uzbekistan	TASH	Institute of Botany, Academy of Science, Uzbekistan	Tashkent, Uzbekistan	1,500,000

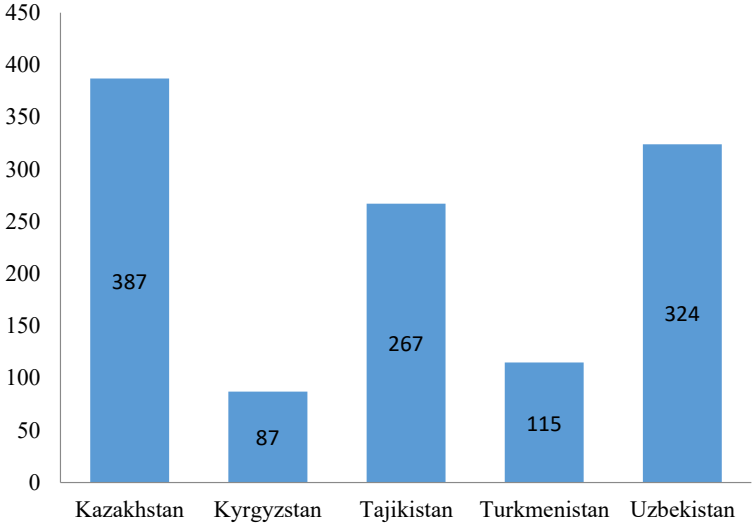
Key herbaria in Central Asia countries

- About 9520 species of higher plants, 20% of which are endemic species, belonging to 138 families and 1176 genera
- All this preliminary work and data, i.e. explorations and floristic data, flora books, monographs, papers and specimens, constitutes a solid foundation for botanical research in Central Asia

Rare and endangered species

- 1010 species (87 families and 384 genera) were listed in Red Data Book of five countries
- Many rare and endangered species are also sources of economically valuable medicines, ornamentals, food, fruit, livestock fodder, etc.
- Principal threats: human activities (excessive pasturage and plowing, collection for use as medicines, food, firewood, and ornamentals).





Number of species in Red Data book

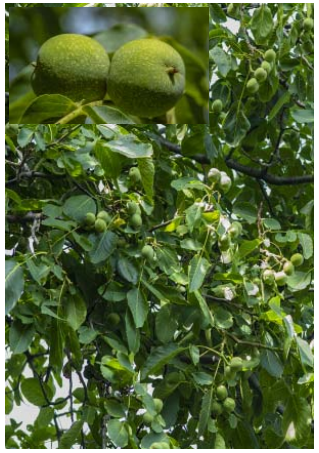
Ferula Tadshikorum

Classification and utilization of plant resources

- According to a classification system proposed by Wu et al. (1983), plant resources of Central Asia can be grouped into 5 categories and 31 subcategories

➢ Edible plant resources

103 species of wild fruit trees, more than 200 species of large edible fungi, more than 50 species of vitamin plants, nearly 100 species of oil plants, and more than 500 species of plants that provide nectar and pollen for honeybees



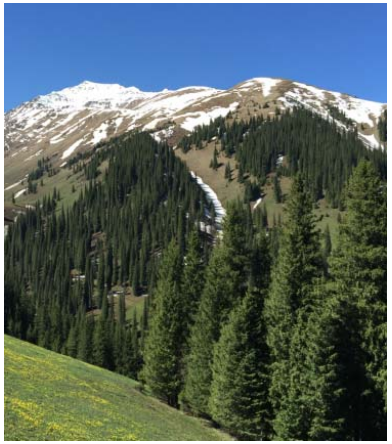
➢ Medicinal plant resources

2014 species of medicinal plants, of which 1451 are wild species and more than 120 are used in the manufacture of pesticides

Classification and utilization of plant resources

- Industry use

100–150 species of timber tree, and over 380 species of fiber plants. More than 200 species yield tannin, spices, fat, gum and dyes for industrial use.



- Environmental protection and landscape construction plant resources

more than 80 species of shelterbelt tree species, more than 100 species of sand-fixing plants, and more than 300 species of ornamental plants.

Classification and utilization of plant resources

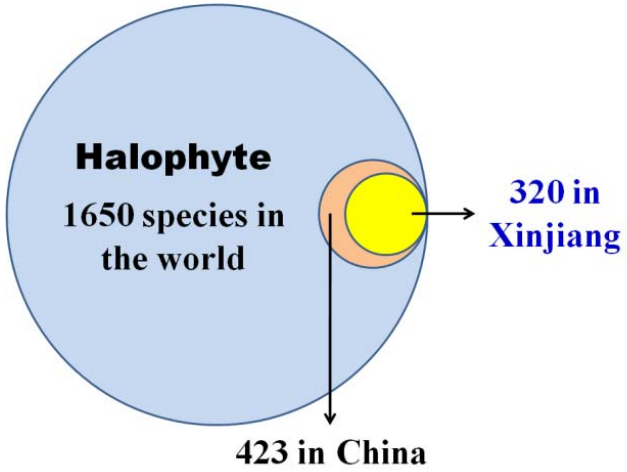
- Plant germplasm resources
  - 87 species of wild cereal crops and 70 species of wild fruit trees
  - salt-tolerant, drought-resistant, and disease-resistant

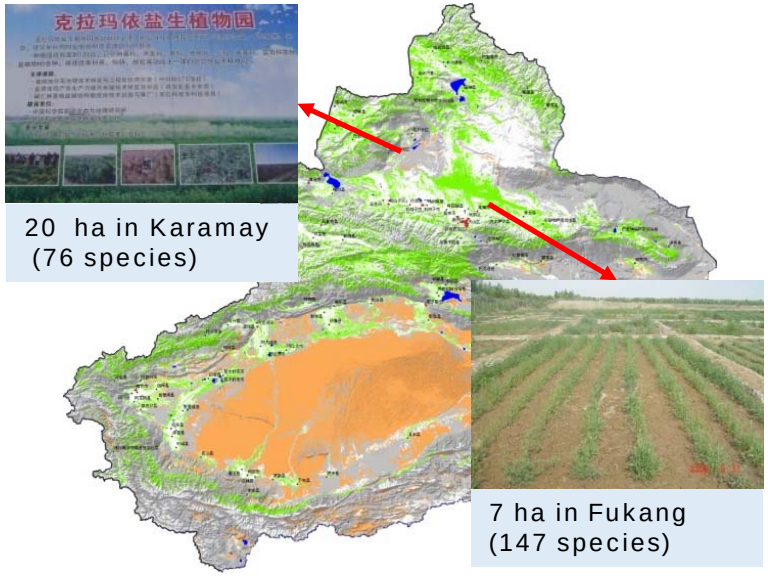





Classification and utilization of plant resources

➢ halophyte resources



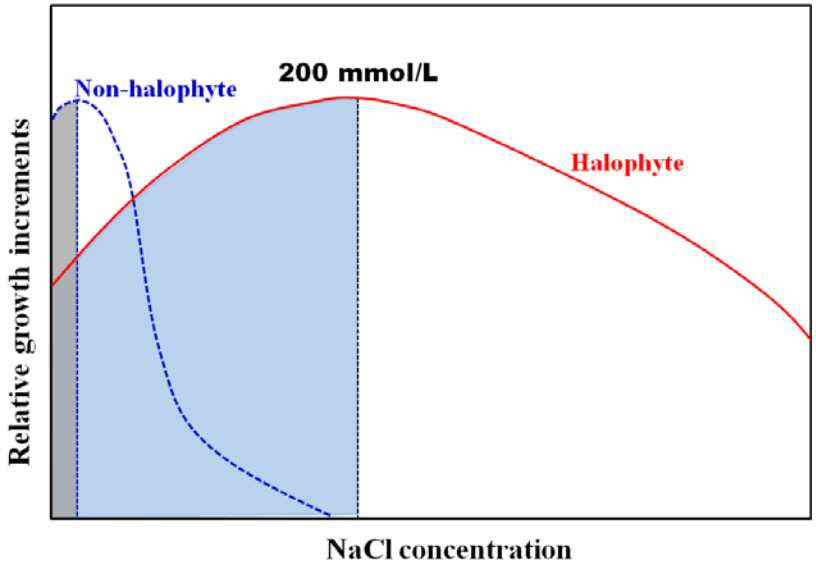


❶ Investigation of halophyte resources ❷ Our book : Halophytes in Xinjiang ❸2 halophyte plantations

Salt tolerance evaluation

Beet

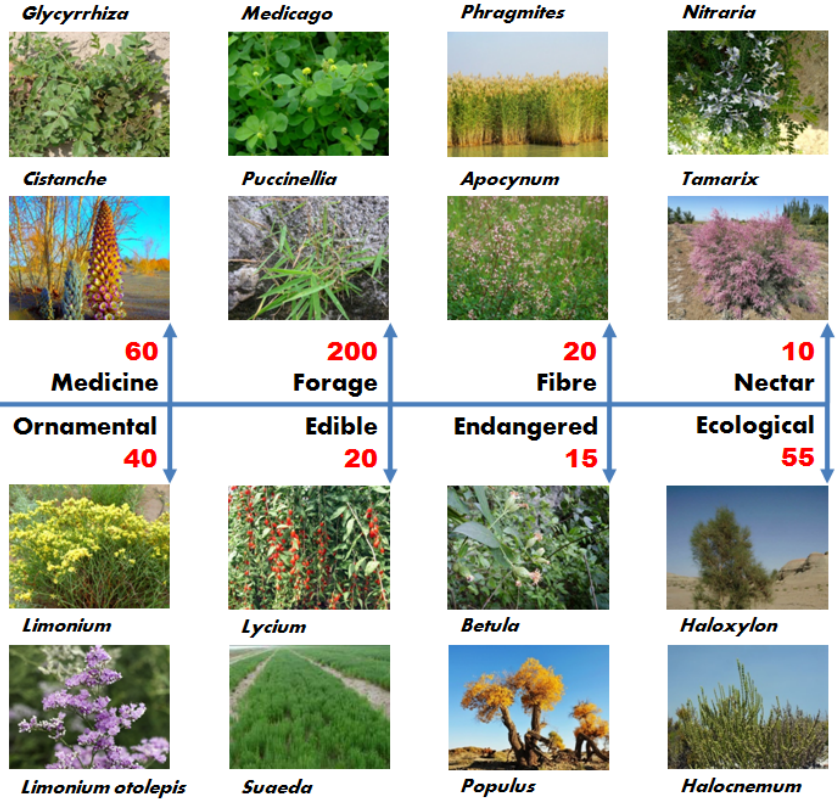
Suaeda salsa



Evaluation on the utilization value of Halophytes in Xinjiang

Application classification of halophytes

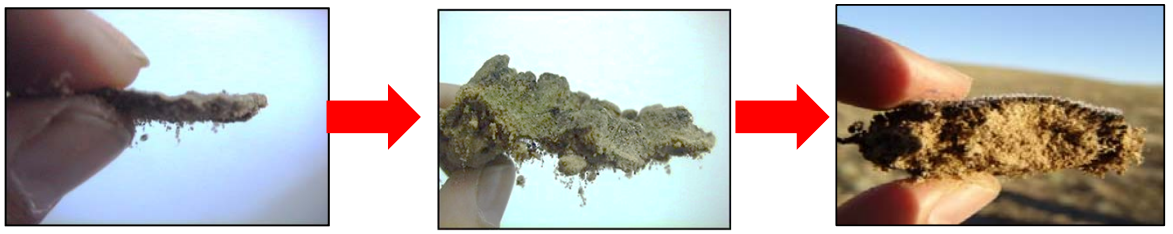
Halophytes in Xinjiang

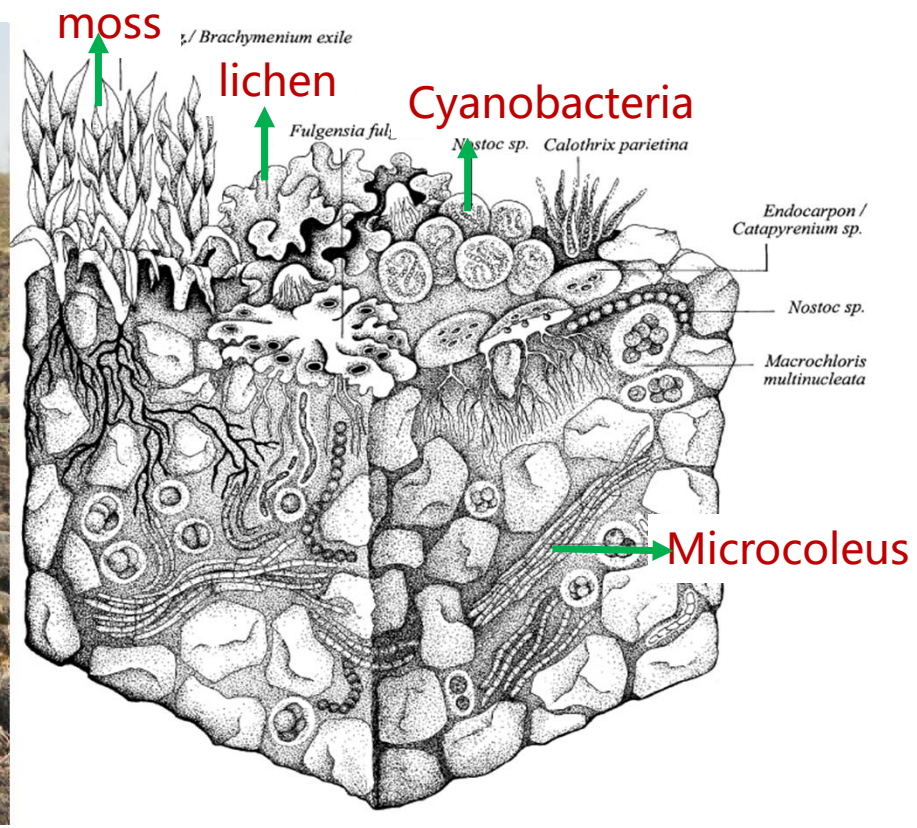


➢ Biological soil crusts

Species composition in North Xinjiang

- Algae species: 23 families,56 genera,148 species
- Lichen species: 17 families,17 genera,17 species
- Moss species: 2 families,4 genera;6 species



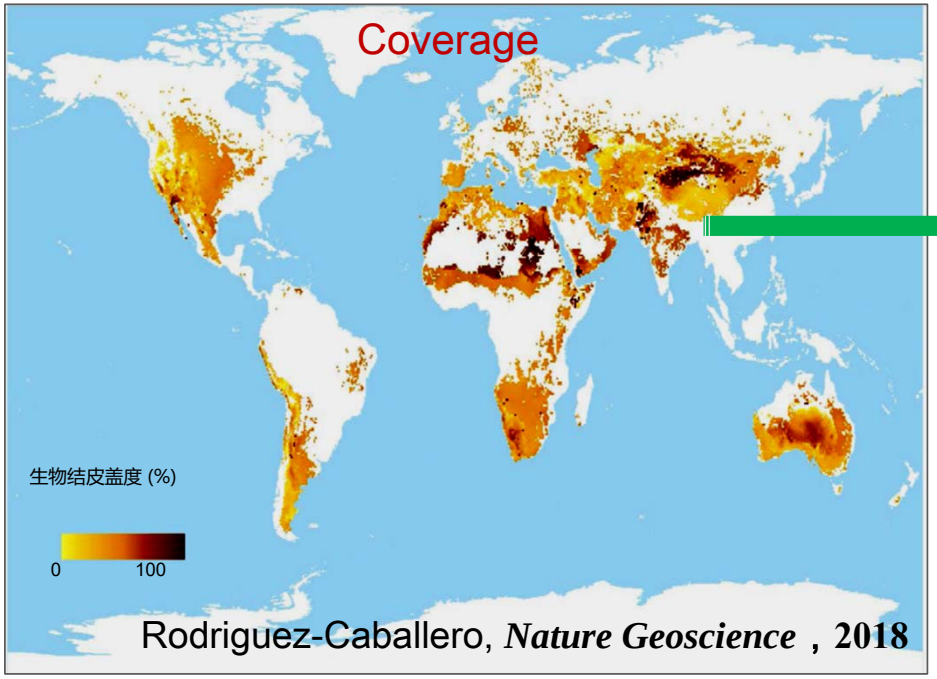


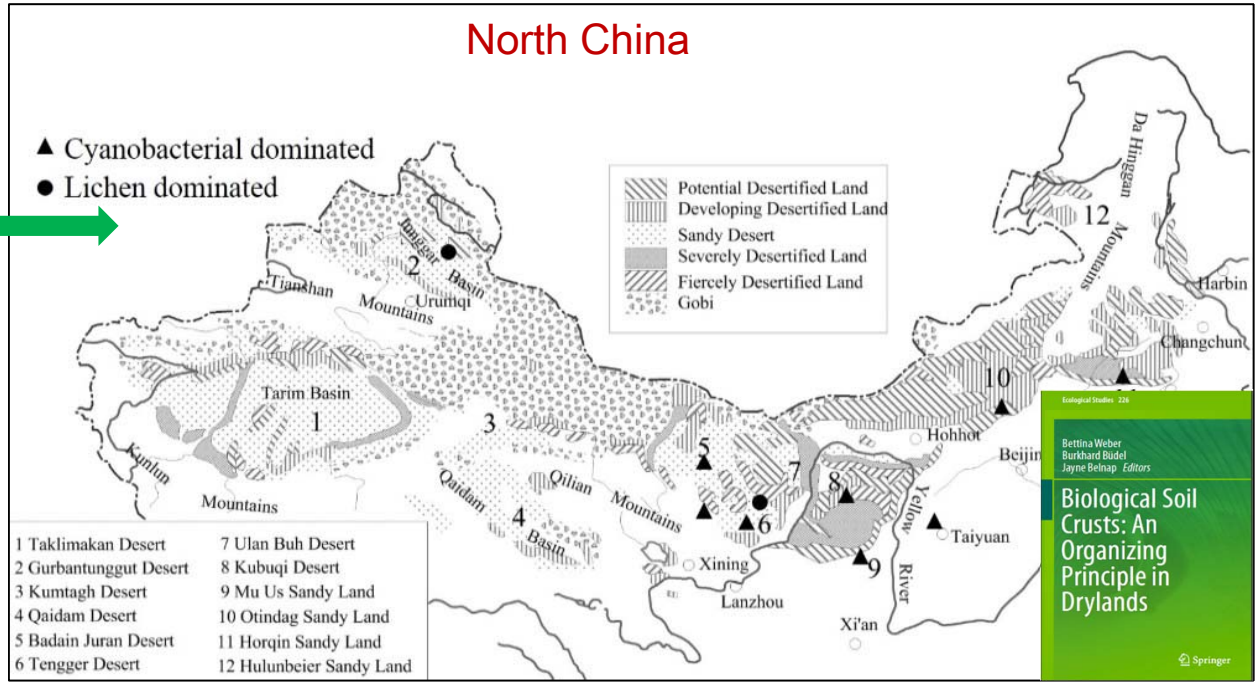
Distribution

An organizing Principle in Drylands

Global： covering 12% of Earth's terrestrial surface, mainly in drylands, northern part of Africa with the Sahel region and the large deserts in Asia host about 66% of the world

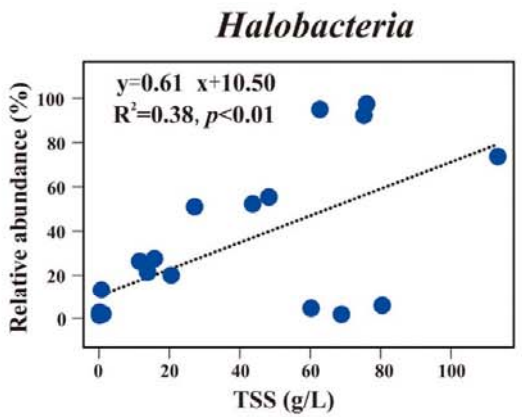
◆ carbon and nitrogen cycle ◆ Surface stability ◆ Hydrological process ◆ Biodiversity

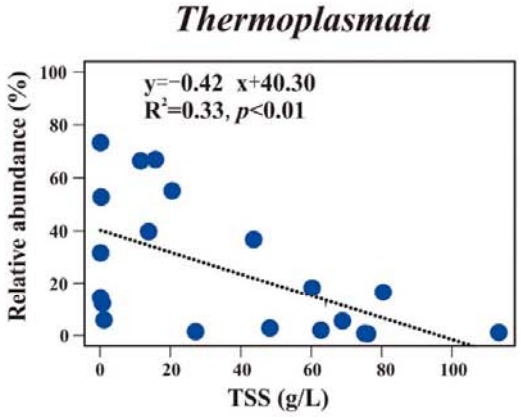




Microbial Diversity in Aral Sea

(a) Archaea



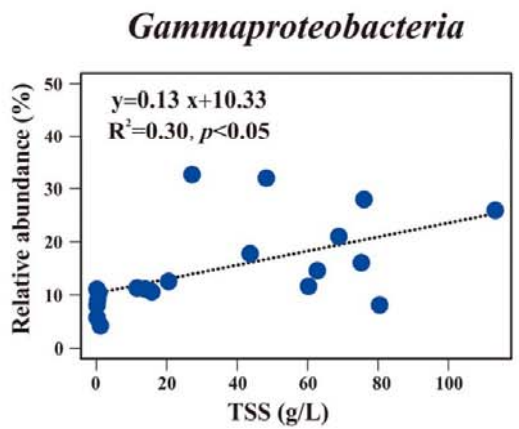


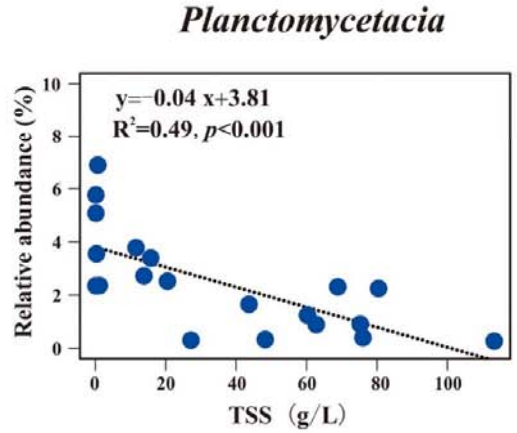
ELSEVIER
Science of The Total Environment
Available online 5 October 2020, 142675
In Press, Corrected Proof

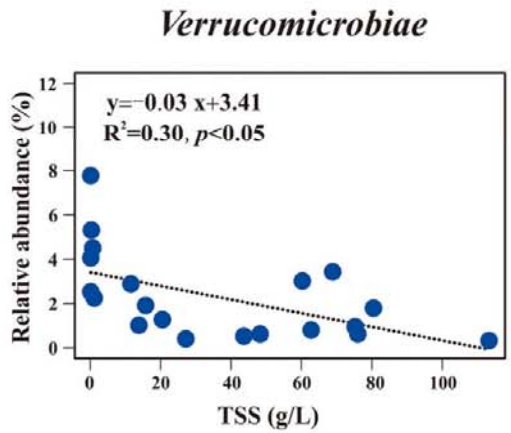
Onshore soil microbes and endophytes respond differently to geochemical and mineralogical changes in the Aral Sea

Hongchen Jiang PhD [a, b, 1], Jianrong Huang MS [c, 1], Li Li PhD [b, 1], Liuqin Huang PhD [c], Mehvish Manzoor [c], Jian Yang PhD [c], Geng Wu PhD [c], Xiaoxi Sun MS [c], Beichen Wang MS [c], Dilfuza Egamberdieva PhD [b, d, e], Hovik Panosyan PhD [f], Nils-Kåre Birkeland PhD [g], Zihua Zhu PhD [h], Wenjun Li PhD [b, i]

(b) Bacteria







archaeal OTUs :902 OTUs; bacterial OTUs :8753 OTUs

TTS: total soluble salts

Part 2.

Utilization of the bioresources for the ecological restoration

Eco-environmental Issues

Grassland Degradation

Soil Salinization

Sand Encroachment

Aeolian Desertification

- Lake Dry-up
- Desertification
- Salinization
- Pasture Degradation
- Biodiversity Lose

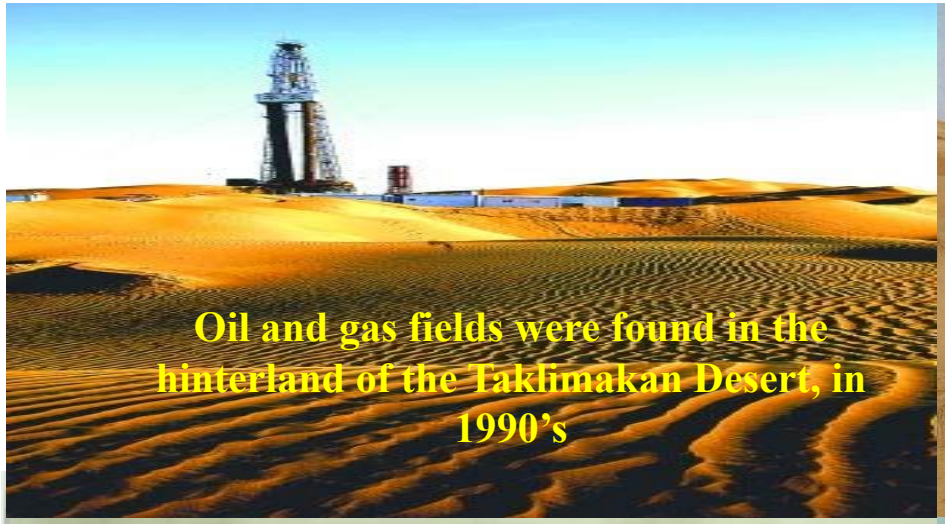
Dried Lop Nur

Wind-break and sand fixation: plant species selection

- Rich species for ecological restoration

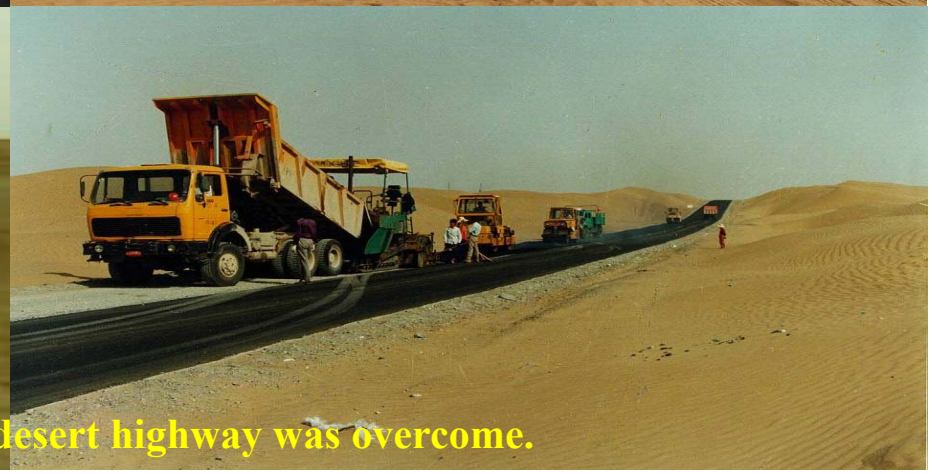
- Species lived in fixed and semi-fixed sanddune: *Haloxylon ammodendron*, *Eremosparton songoricum*, *Tamarix*, *Calligonum mongolicum*, *Artemisia desertorum*, *Capparis spinosa*, *Alhagi sparsifolia*
- Nearly 1000 species can use for wind-break and sand fixation

Saline Groundwater Usage in the Taklimakan Sand Sea to Combat Desertification



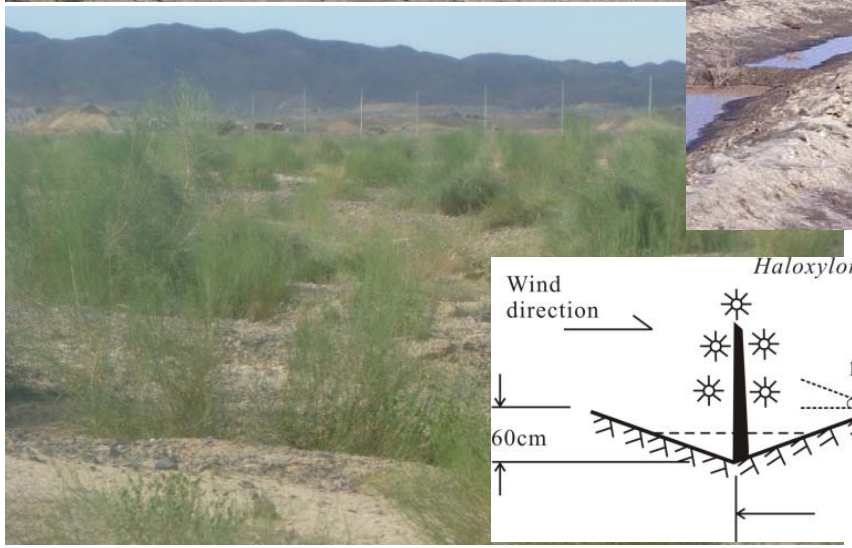
Oil and gas fields were found in the hinterland of the Taklimakan Desert, in 1990's

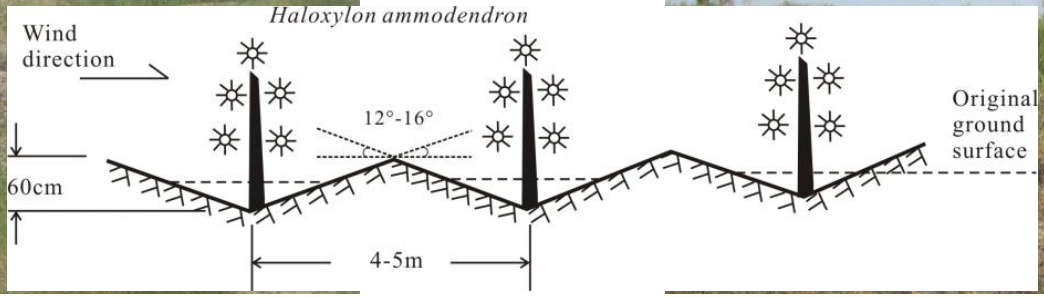
The transportation in the desert is very difficult

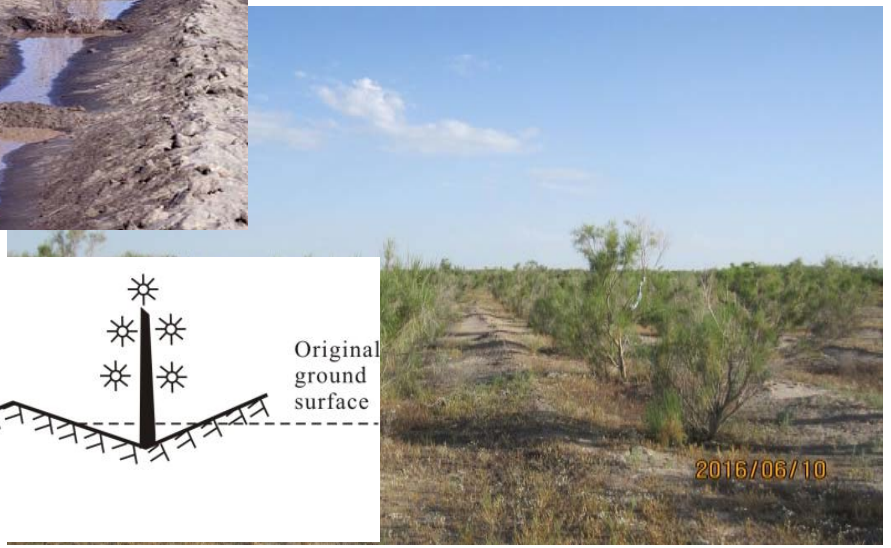


The technology of the mobile desert highway was overcome.

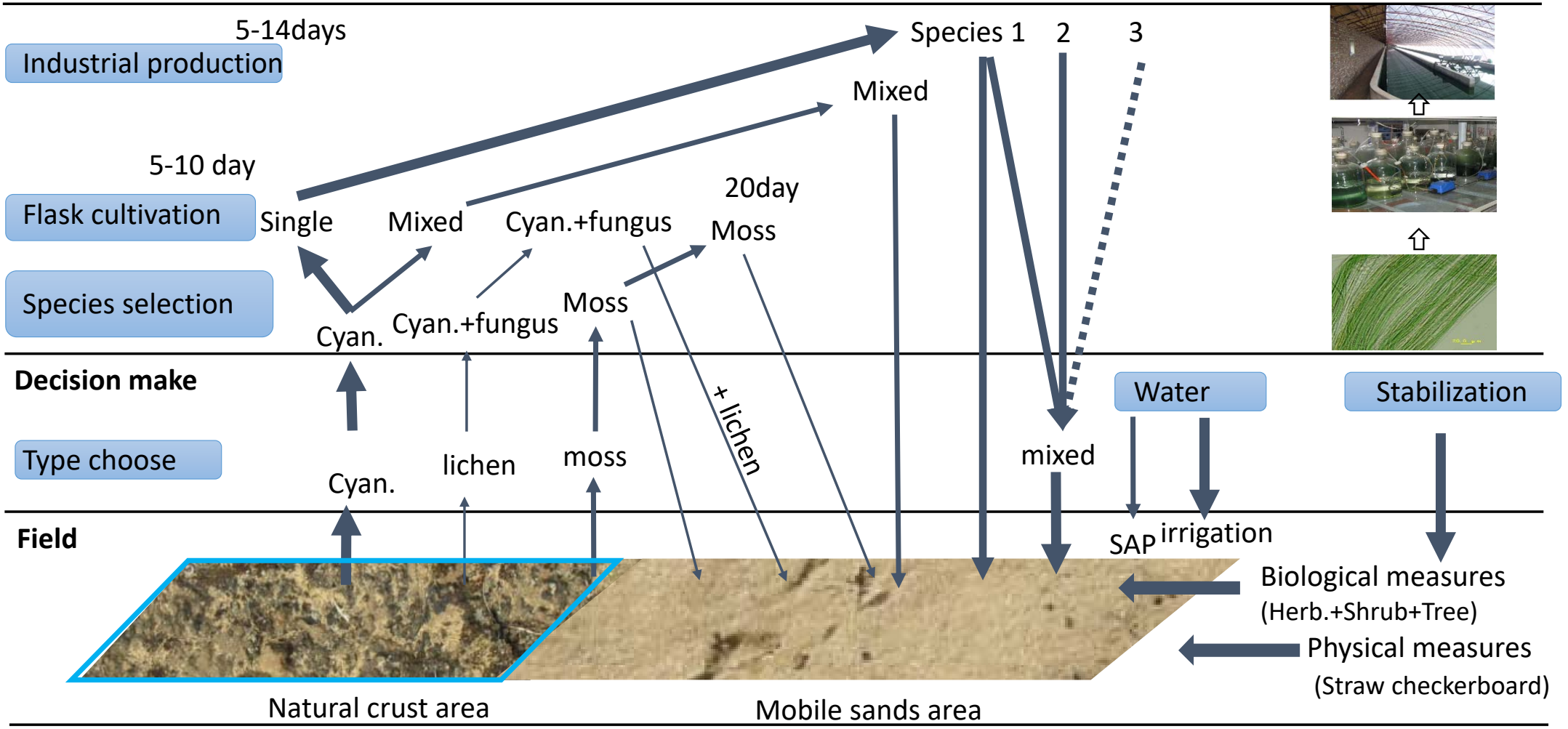
No (low) irrigation or Water harvesting afforestation technology in the Gobi Desert







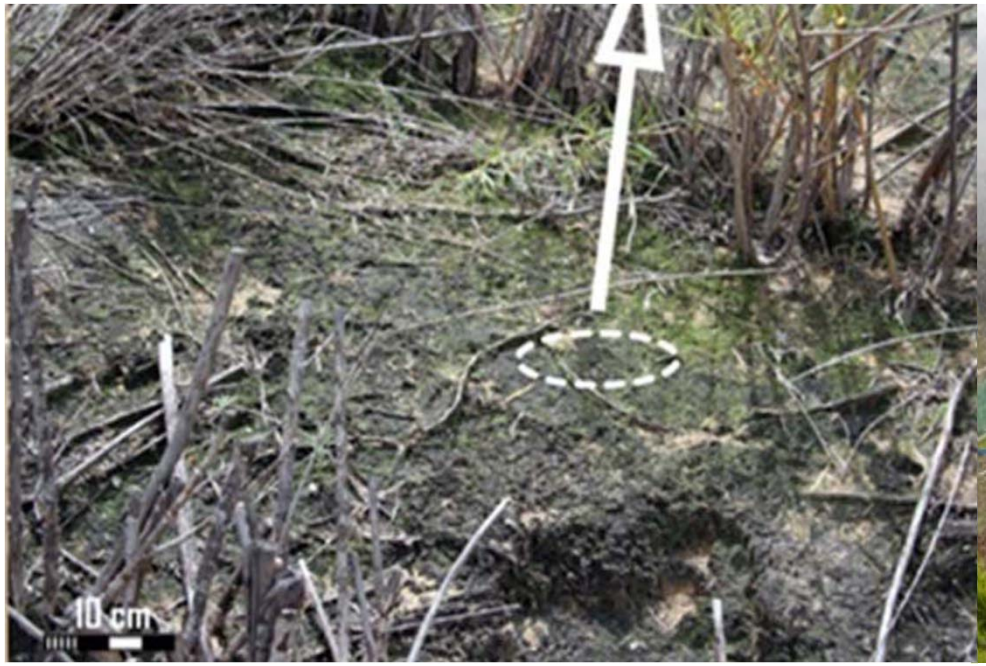
Wind-break and sand fixation: Biological soil crust rehabilitation in China



Zhou, X., et al. (2020). Restoration Ecology **28**(S2): S45-S55.

Artificial biological soil crust

Algal crust in Kubqi Desert



200 ha

Moss crust in Loess Plateau

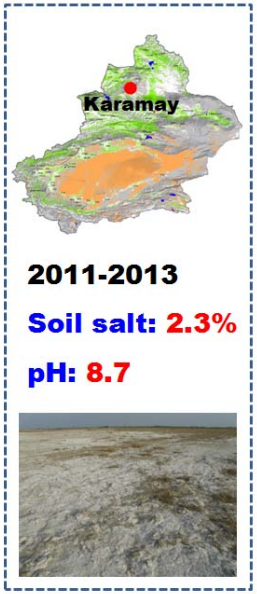
Improvement of heavy saline alkali soil: Halophytes planting

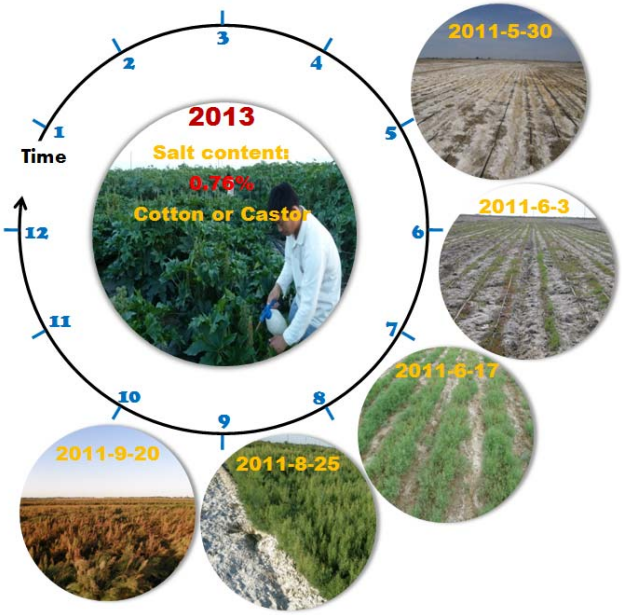
Drip irrigation → Increase the emergence of seedlings

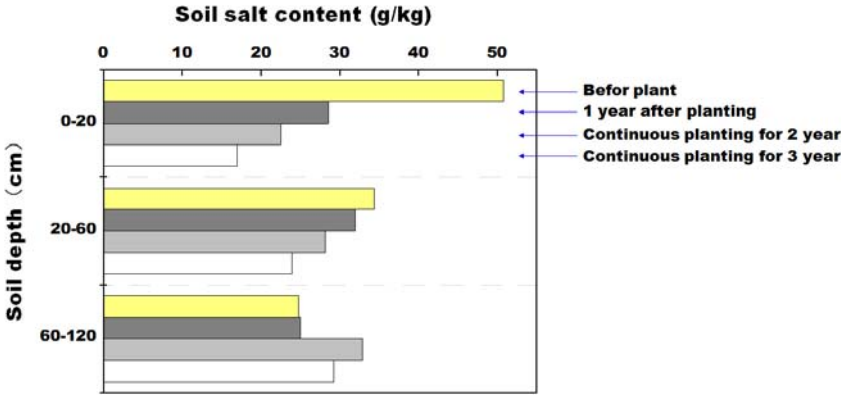
Halophyte → Absorption of soil salt → Desalination

Salt tolerant leguminous plants → Biological nitrogen fixation → Fertilization

Rapid improvement and sustainable utilization of salinized soil







- **Suaeda salsa planting can take 4800 kg salt per hectare per year**
- **The improvement of saline alkali soil in 2-3 years**

Part 3.

Some successful utilization from EGI experiences

Case 1: green corridor crosses the Taklimakan Desert

Typical sand control project

- The green corridor crosses the Taklimakan Desert was China's top ten science and technology news in 2006
- Won the Second Prize of National Science and Technology Progress in 2008
- Made China’s top ten environmental friendly projects in 2008

Desert ecological industry technology

The technique of *Cistanche* artificial cultivation had been solved

200 hectares of Cistanche production base in desert

International application

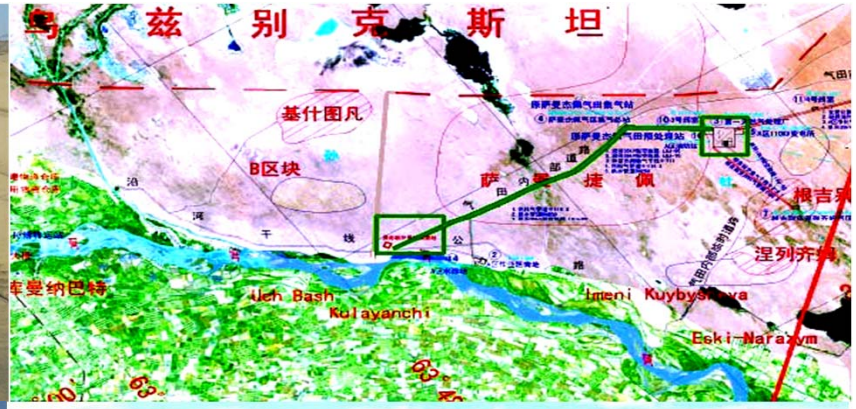
The technology have been extended to the Sahara desert

Libya expedition

Technological training

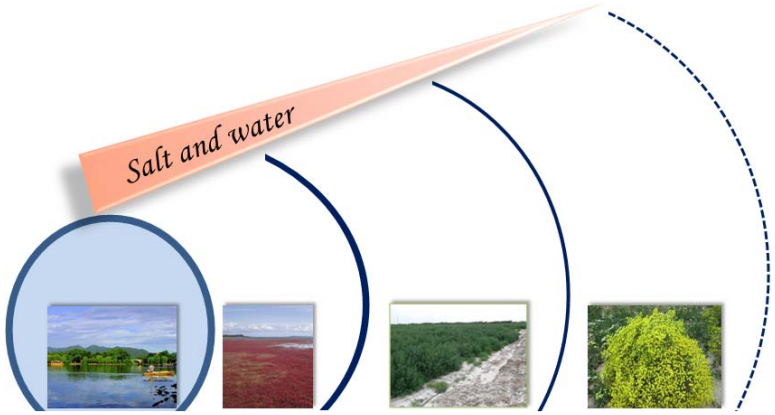
International application

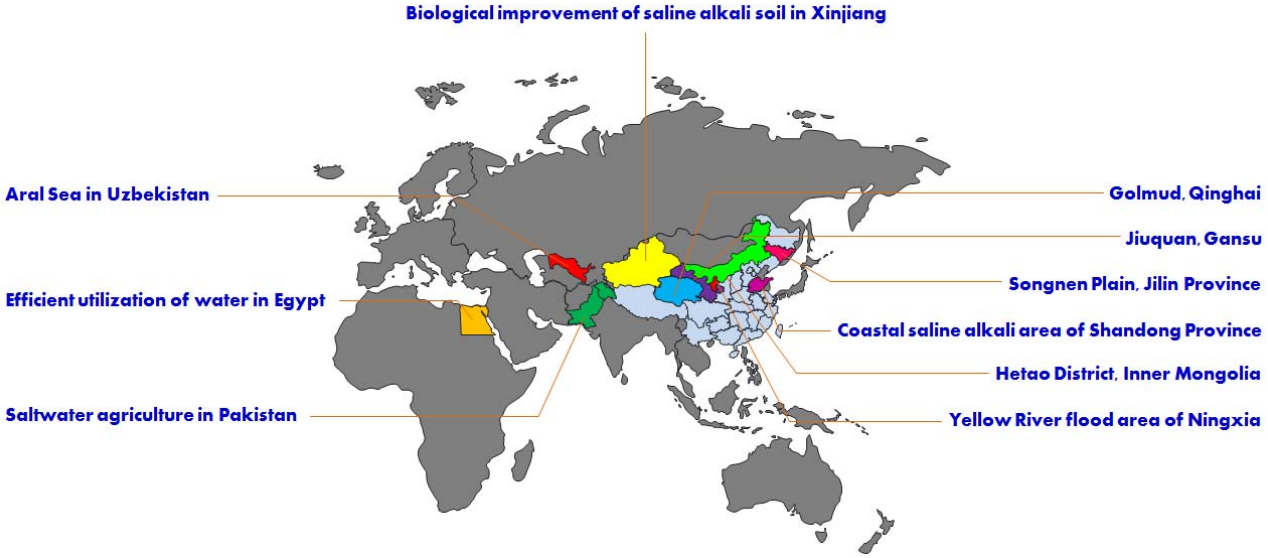
The technology have been extended to Amu Darya oil and gas field in Turkmenistan, Kazakhstan, Pakistan, Mongolian



- Life camp protection and greening
- Production plant protection and greening
- Nursery and greenhouse construction
- Gas field highway protection and greening

Case 2: Ecological construction by Halophytes in severe saline alkali soil





Halophytes in the ecological management of the Aral Sea

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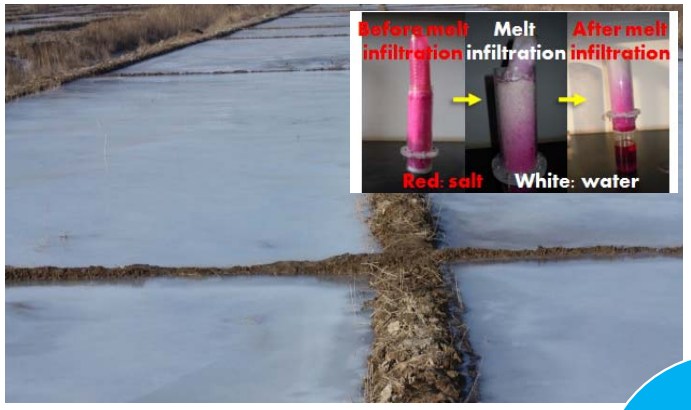

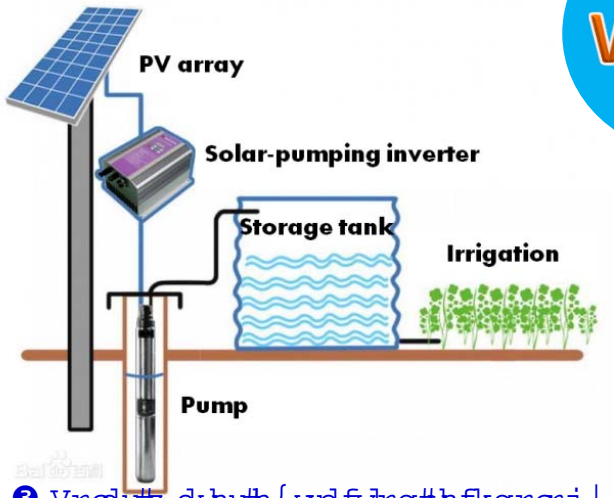

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Water

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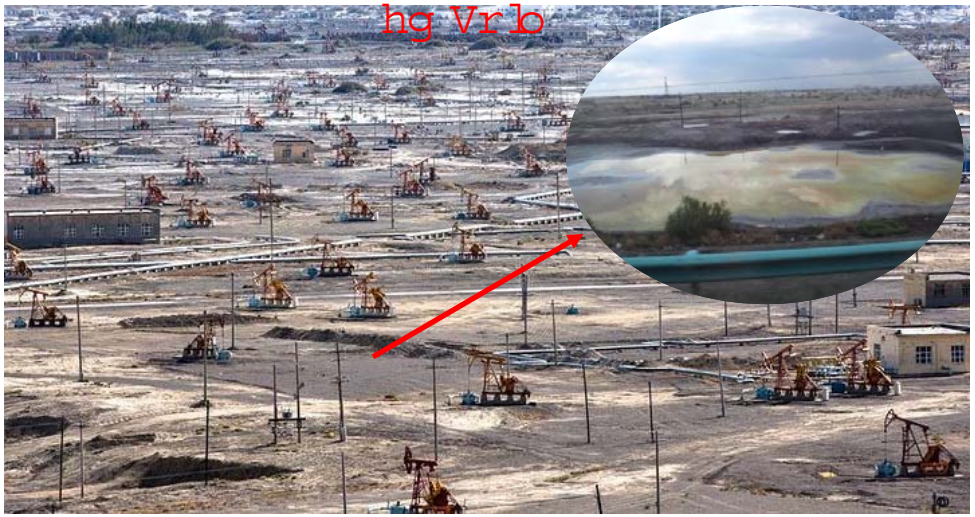
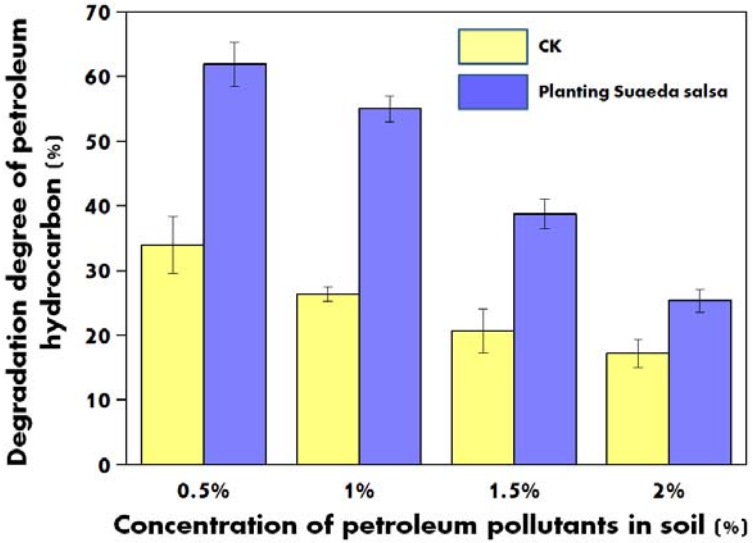
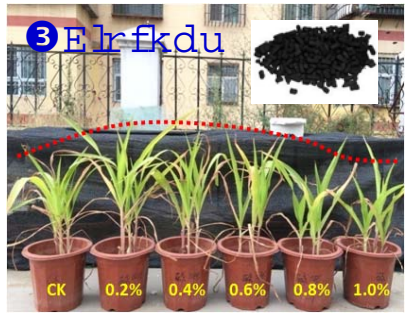
Halophytes for environmental restoration

Uhp hgldwlrq riShwurdhxp Frqwdp lqdw hg Vrlo





Utilization of halophytes



❹Irudjh#iru#hdyhvwrfn

- 5 suitable Halophytes
- 60 t per hectare
- Best harvest time
- Nutritional value
- Appropriate ratio
- Suitable time
- Safe as forage
- Improve the quality of meat

Halophytes	Crude protein	Nitrogen free extract	Crude ash	Crude fat
Chenopodium rubrum %	14.81	43.94	25.65	1.27
Atriplex aucheri %	13.63	44.87	19.34	1.20
Suaeda salsa %	10.75	41.18	31.51	1.25
Salicus salicera %	10.70	31.60	43.09	1.10
Suaeda altissima %	9.44	45.91	24.86	1.53
Alfalfa %	15.13	57.34	9.51	1.93

Case 3: Ecological restoration of abandoned mining area

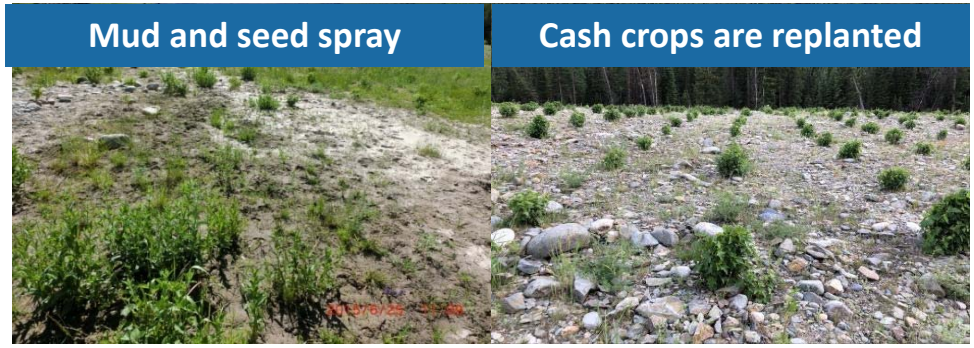
- Water - saving and irrigation free by Microtopographic reconstruction
- Rapid collection of soil seed Banks and field activation techniques to improve biodiversity
- Forest and grass interact to fix the slope and reduce the risk of geological disaster

Damage

Increased topographic relief;Soil loss, bare gravel;The surface vegetation has almost disappeared.

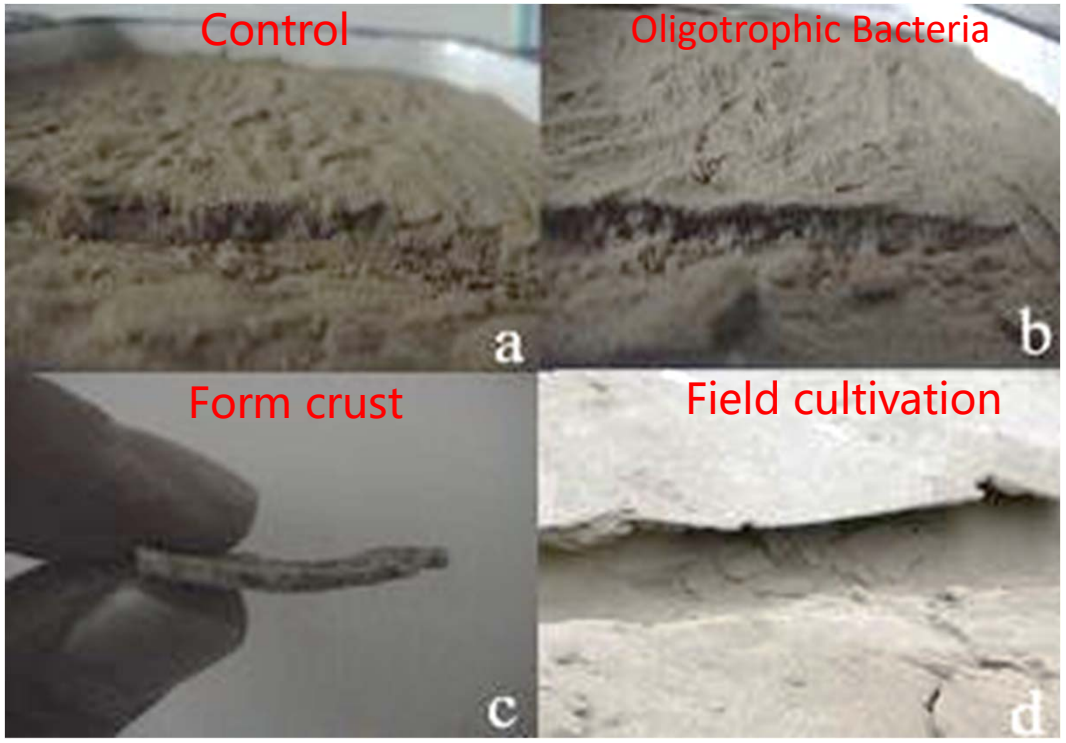
Repair effect

After 8 years of restoration, the coverage of the treatment area increased 20-60 times, and the similarity reached 40-60%.



Case 4: Biological soil crust restoration in degraded area

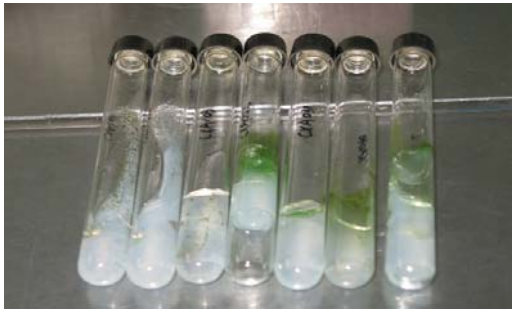
Oligotrophic bacteria cultivation

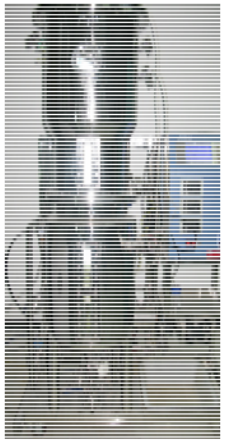


Two months later: 6mm crust (Wu *et al*. 2010， ALRM)

Cyanobacterial cultivation and field inoculum

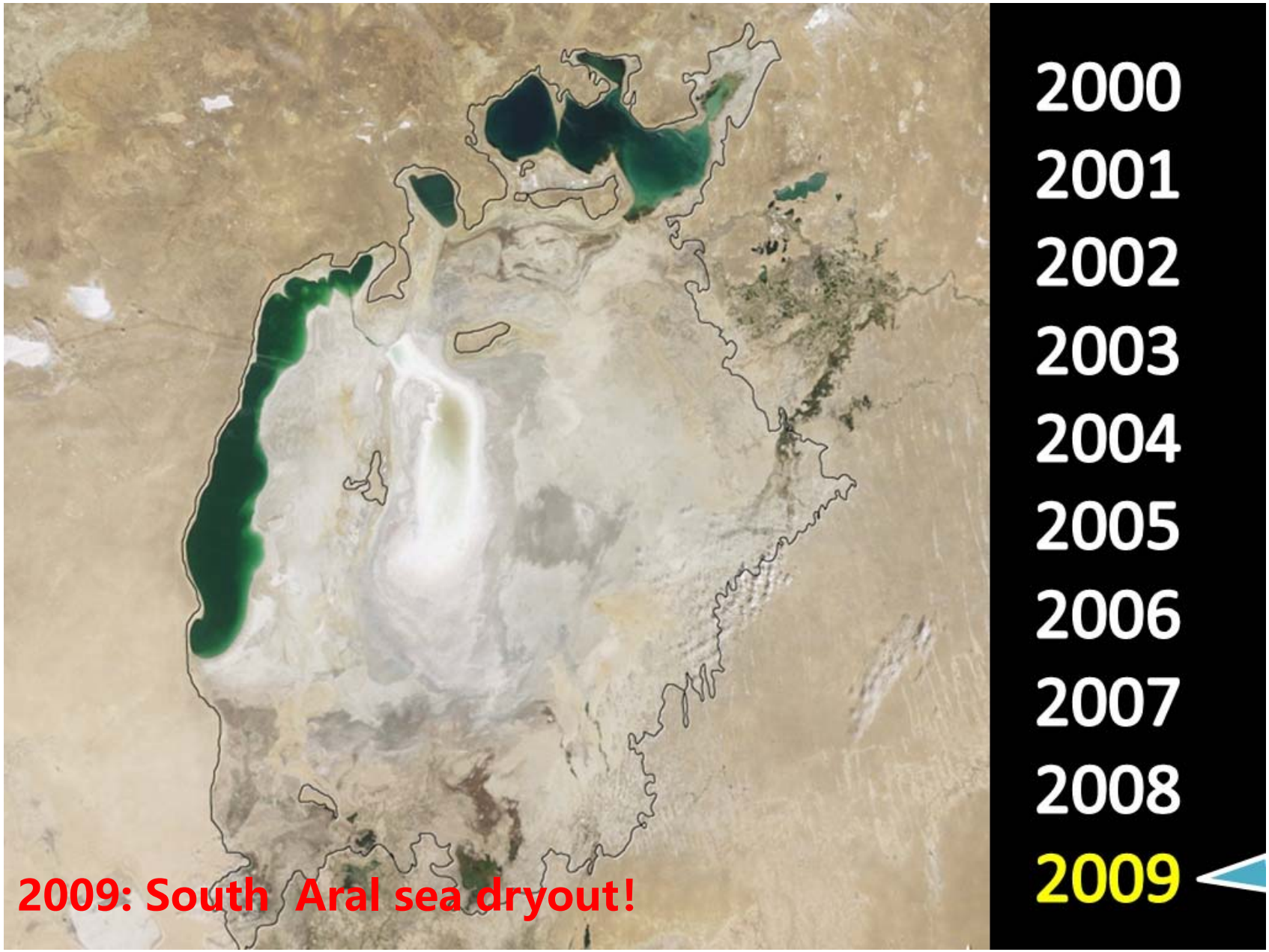
species → Mass cultivation → Field inoculum





Part 4.

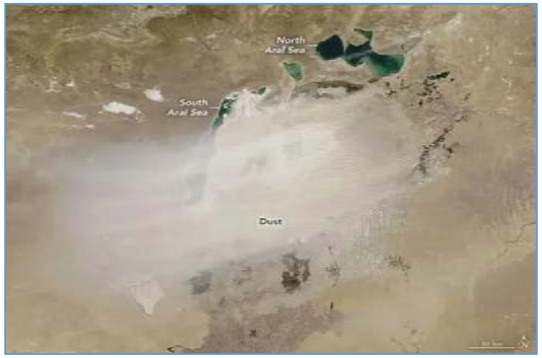
Green Aral Sea Megascience Initiative


2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2009: South Aral sea dryout!

Ecological degradation

◆ Increasing desertification, huge desert landscape—3,000,000 ha Aralkum Desert (Aral desert)

◆ Sources of sand (salt) storm– intensive soil salinization, affecting surrounding area



Green Aral Sea Megascience Initiative

China

Uzbekistan

United Nations

Kazakhstan

ANSO

Priority area

Succession of Aral sea ecosystem and sustainable development

Demonstration of green technique

Research and system technique integration in comprehensive management of Aral sea

Capacity improvement

Example: Joint Uzbek-China Key Lab of Ecobiomes in Arid Land


Thank you for your attention!