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Journal of Arid Land Studies

Photovoltaic Energy System in Arid Land

Koichi YAMADA and Keiichi OKAJIMA

Energy pay-back times (EPTs) and costs were evaluated for large scale photovoltaic energy systems using polycrystalline silicon cells whose production rate was 100GW/yr. For the construction site, Gibson desert in Australia was selected. Pb-batteries and sodium-sulfur (NaS) batteries were used for back-up systems. The EPT and the electricity cost of the system using Pb-batteries were calculated to be 1.7 years and ¥101/kWh. These values were reduced to 1.1 years and ¥32/kWh by sabstitution of NaS-batteries for the Pb-batteries.

Key Words : Energy Evaluation, Economic Evaluation, Solar Energy, Photovoltaic Power System, Energy Pay-back Time

1. Introduction

The development of solar energy system is very important for long term measures to solve energy resource and global environmental problems. An economic revenue over a short term is the most important thing to realize such systems. However, the evaluation results of energy consumption and environmental impact should also be taken into account for a long term plan of the system. Standard photovoltaic (PV) energy systems were evaluated in terms of energy ,economics and CO_2 emissions elsewhere[1)~3)]. Based on these results, large scale PV energy systems in a desert are evaluated herein in terms of energy and economics. For energy evaluation, EPT (Energy Pay-back Time) defined by Eq. (1) is used. The electricity cost is basically calculated using the annual expenditure which is 15% of the investment cost.

$$EPT = Ite / Oe \qquad (1)$$

where, Ite is total energy input to produce PV energy system and Oe is energy generated by PV energy system.

2. System evaluation

2.1. Outline A large scale power generation plant is constructed in a desert. For the evaluation of the system, the production and transportation of PV cell panels, batteries and inverters, the construction of power plant including transformers and transmission wires, and plantation are considered. Energy consumption data for the PV cell modules reported elesewhere[1)] are used for this work.

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2.2. Plant scale and site Gibson desert (400km × 840km) in Australia where the insolation energy is 2,100kwh / m2, 1.8 times higher than was Tokyo, is selected for the power plant site. The electric power generated is transmitted 1,000 km to Perth. Batteries were installed for a stable power supply. Basic data used for the evaluation are shown in Table 1.

Table 1 Calculation basis of PV systems

Photovoltaic cell	Poly-Si(20years Life)
Efficiency of cells	20%
Cell production scale	100GW/year
Transmission	1000kVUHV efficiency 96%
Maximum power	145GW
Efficiency of systems	90%
Area	860km^2

2.3. Module production and transportation PV cell modules (surface area : 4.72×10^8m^2, weight : 2.86×10^6t) are used for the system. We assumed that the modules produced in Japan were transported by a 50,000t ship to Australia for 7,000km and then by 20t trucks inland for 1,000km.

2.4. Energy input and investment cost of BOS Energy input data for the production and construction of BOS (Balance Of System) such as supporting racks, inverters, construction, electricity collectors, transmission towers, transmission wires and transformers were calculated and are shown in Table 2.

Table 2. Total annual energy input in terms of electricity(ITe) and EPT for PV systems using poly-Si solar cells

Maximum output	145 GW		
Electricity output	1.10×10^{11} kWh/y		
	ITe[kWh/y]	EPT[y]	Rate
Supporting rack	2.61×10^{10}	0.24	14%
Inverter	2.25×10^9	0.02	1%
Construction	3.96×10^9	0.04	2%
Electricity collecting	1.01×10^8	0.00	0%
Transmission tower	1.41×10^9	0.01	1%
Transmission	8.58×10^7	0.00	0%
First transformer	1.54×10^9	0.01	1%
Final transformer	1.62×10^9	0.01	1%
Module	6.95×10^{10}	0.63	37%
Module transportation	7.57×10^8	0.01	0%
Battery	7.80×10^{10}	0.71	42%
Total	1.85×10^{11}	1.7	

The unit cost of inverter was assumed to be ¥500 / kg and that of the construction to be ¥1,000 / m^2 based on the labor cost of ¥10,000 / man • day. Inverters having the unit capacity of 18,000kW were used and their unit cost was calculated to be ¥123,000,000 using 0.8 power rule from the unit cost of 3kW inverter. Investment costs for transmission towers and transformers were calculated from the reported values in Japan[4]. A plantation was established around the power plant with 100m zone for a wind and sand break. Its cost was assumed to be ¥10,000 / ha. The calculated costs are shown in Tab.3.

Table 3 Investment and electricity cost for PV systems using poly-Si solar cells

	Investment[1000¥]	Cost[¥/kWh]	Rate
Supporting rack	3.27×10^{9}	4.4	4%
Inverter	1.18×10^{9}	1.6	2%
First transformer	5.48×10^{8}	0.7	1%
Transportation	6.33×10^{6}	0.0	0%
Module	8.75×10^{9}	11.8	12%
Battery	5.91×10^{10}	80.5	80%
Transmission tower	5.00×10^{8}	0.7	1%
·Final transformer	5.74×10^{8}	0.8	1%
Forestation	4.34×10^{4}	0.0	0%
Total	7.39×10^{10}	101	

2.5. Battery system A power storage system is required to supply stable electric power from the centralized PV power plant . Here, a lead battery system was used. Electric power generated by the PV power plant was supplied through the battery system whose charge-discharge efficiency was assumed to be 0.87. The storage capacity of the system was assumed to be the power generated for 2 days considering weather conditions. The number of batteries needed was calculated based on 70% of maximum capacity. The unit weight of 2V-8,000Ah battery without electrolyte was 498kg. The life time of battery was assumed to be 10 years and its cost, ¥2,120,000 / unit.

3. Results and discussions

The EPT was calculated to be 1.7 years and the electricity cost to be ¥101 / kWh. As shown in Tables 2 and 3, the transportation, transmission, civil construction and plantation did not strongly affect both EPT and cost of the total system. The module, supporting rack and battery systems were the main cost factors. The battery system cost was as high as 80% of the total cost. In order to reduce costs, a sodium-sulfur (NaS) battery system instead of the lead battery system was investigated hereafter. The NaS battery system has a high energy utilization capacity of 100% of the maximum capacity and a high charge-discharge efficiency of 0.95. For the evaluation, the life time of 20 years and the cost of ¥200,000 / kW which was a target cost in Japan were used. As shown in Figs. 1 and 2, the EPT and electricity cost were reduced to 1.1 years from 1.7 years and to ¥32 / kWh from ¥101 / kWh.

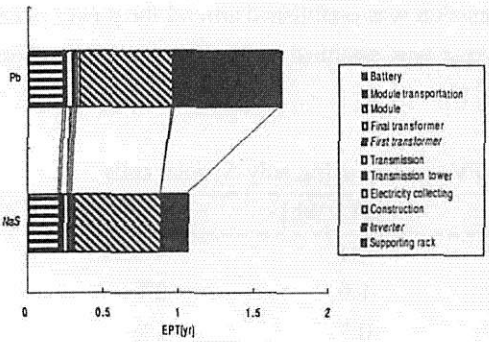

Fig.1 EPTs of PV systems using Pb and NaS batteries

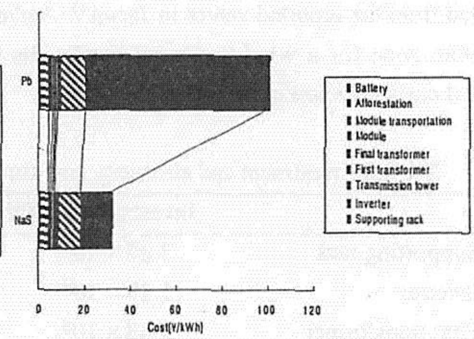

Fig.2 Costs of PV systems using Pb and NaS batteries

4. Conclusion

The EPT value of 1.7 years using the lead battery system is low enough for the realization. However, the electricity cost of ¥101 / kWh is 5 to 10 times higher than a present cost from a fossil fuel burning plant in Japan. This high cost is caused by the use of the lead battery system. The future system of NaS battery can reduce the electricity cost and EPT remarkably, however, this reduction of the cost is not enough to compete with a current power generation system.

Further R&D works on both PV cells and energy storage systems are necessary to realize a large scale utilization of PV energy system, .

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Solar Desalination Technology for Deserts: An State-of-art Utilization of Wind Speed to Create Low Pressure and Regenerative Effect

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Abstract - The proposed solar distillation system is compact, sufficiently simple and gives a high thermal performance. Air regenerative effect, passive condensor and wind-induced low pressure in deserts are integrated in its design. Analytical expressions are derived using the energy balance equations for each component of the system and results are compared with the other systems.

Key Words: Air regenerative, Passive condenser and Solar distillation

1. Introduction

A number of design modifications have been incorporated in passive as well as active solar stills to improve efficiency and yield (Malik et al., 1982). Though, solar distillation systems are yet to be accepted commercially. Water regenerative effect has been considered in past as one of the most effective way to increase yield from solar stills. It has double advantage in active systems (Zaki et al., 1983). It utilizes the latent heat of vapourization as well as keeps the glass temperature low, thereby increasing the basin water and glass temperature difference. Performance of the conventional active solar still can further be improved by replacing collector with concentrator. But, regenerative effect produced with saline water has practical difficulties and shortcomings ie., additional equipment is needed for this arrangement extinction of solar radiation, corrosion etc. and in case of feeding, basin water temperature and efficiency decreases while, in non-feeding, thermal energy stored in the flowing water is wasted. This makes it unsuitable for desert areas where even brackish water is scarce. Whereas, in deserts, windy condition can be integrated with the system to produce regenerative effect with better performance and without any additional arrangement.

A considerable improvement in production of distilled water can be obtained by reducing the still pressure and continuous removal of water vapour from the still. For this purpose, passive surface condenser can be connected to the still in the shaded zone of a single sloped still. It acts as an additional effective heat and mass sink. The hot water vapour will tend to move from the still to the condenser due to one or more of the following mass transfer modes: (a) 'diffusion' from high vapour concentration to low concentration, (b) 'purging' due to relative pressure difference of water vapour and (c) 'natural circulation' due to air density difference. Creating low pressure as well as using wind energy for active regenerative effect can be effectively combined to address these shortcomings especially in deserts where one usually has windy conditions. In this presentation, one such model is put forth, modelled and analyzed. The analysis based on the energy balance equations of different components in the forced circulation mode has been carried out in terms of design and climatic parameters. Performance of the system is compared with other latest models in terms of daily yield and instantaneous efficiency. The optimum condition for higher yield from the proposed system has also been discussed analytically. For large scale exploitation, there exists tremendous potential for the proposed system.

1.1 Working principle of the proposed solar still The single slope solar still of $1 m^2$ of basin area is coupled with non- tracking cylindrical parabolic concentrator (CPC) through an electric pump. The block diagram of the system is shown in Fig.1. Cold water from the basin is fed by pump to the receiver tube of the concentrator and hot water at the outlet of the receiver tube is fed to the basin. The operating temperature of the still becomes higher in the active mode, therefore, higher yield is expected. But at the same time, higher evaporation makes the glass cover hot and in turn, the temperature difference between the glass cover

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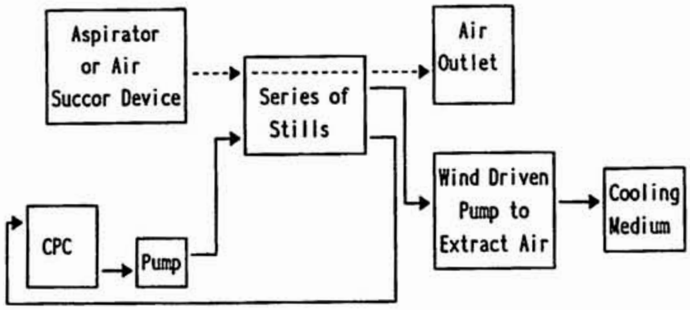

Fig.1 Block Diagram of proposed system

and basin water reduces. This decreases yield. To reduce the glass temperature, ambient air which has relatively lower temperature is made to flow over the glass cover with the help of wind succor device such as aspirator. Basically, it is an apparatus commonly used in mechanised farming for drawing a stream of air or gas through a tube. Different versions are used for seed processing as well as for crop drying. Aspirator has moving ducts/fans designed to suck in air at higher heights taking advantage of increase in wind velocity with height. This air passes through the hollow pipe on which it is mounted. Their height varies between 6m to 10m depending upon wind velocity distribution of the region. Again the single basin still is designed in such a way to have wind-induced low pressure inside it. The passive surface condenser may be placed in the shaded zone of the single sloped still which acts as an additional effective heat and mass sink. The hot water vapour moves from the still to the condenser by different mass transfer modes. Due to low pressure inside the still, a considerable improvement in the production of distillate can be expected.

1.2 Wind Induced Low Pressure Desalination Passive condensors are appropriate only for single still. For large scale desalination, vapours from the stills can be removed using an air succor device or a pump. Wind driven pumps can be easily integrated in the systems for the above purpose. These vapours, in turn, can be condensed in relatively cooler environment such as underground tanks. Since, condensation of these vapours in underground tanks will create low pressure at the other side, the efficiency of the air succor device or pump will be high.

2. Thermal Modelling

2.1 Passive Air Regenerative Solar Still Following Sinha and Kumar (1994), energy balance equation for flowing air over the glass cover, lower glass cover and water mass are respectively, as follows,

$$h_1(T_g - T_{af})\, b\, dx = \dot{m}_{af} C_{af} (dT_{af}/dx)\, dx + h' (T_{af} - T_a)\, b\, dx. \qquad (1)$$

$$h_1(T_w - T_g) = h'_1 (T_g - T_{af}). \qquad (2)$$

$$(\alpha\tau)_{eff} I(t) A_b = M_w C_w (dT_w)/dt + U_s (T_w - T_a) A_b. \qquad (3)$$

Where, A_b, b, M_w, m_{af}, C_{af}, C_w, dx, T_w, T_g and T_{af} are the still area, glass width, watermass of basin, flowing rate of mass of air, specific heat of air and water, an incremental element along the flow direction, basin water temperature, glass temperature and flowing air temperature respectively. h_1, h', h'_1 and U_s are, total heat transfer coefficient from basin water to glass cover, from glass cover to ambient air, from glass cover to flowing air, and overall heat transfer coefficient of still respectively. I(t), T_a and $(\alpha\tau)_{eff}$ are solar intensity, ambient air temperature and fraction of solar intensity absorbed by basin water. Now, using Eqs. (1) and (2), one gets,

$$T_{af} = [b(h' T_a + h_{11} T_w)/H \dot{m}_{af} C_{af}](1 - e^{-Hx}) + T_{afi} e^{-Hx}. \qquad (4)$$

Thus,the rate of energy carried away by air regenerative effect,

$$\dot{Q}_{uf} = \dot{m}_{af}C_{af}(T_{afo} - T_{afi}), \quad (5)$$

Where, T_{afo} and T_{afi} are outlet and inlet temperature of flowing air and

$$H = b(h'+h_{11})/m_{af}\ C_{af}, \qquad h_{11} = h_1\ h'_1/(h_1+h'_1)$$

<u>2.2 Active Air Regenerative Solar Still (Concentrator assisted)</u>: In this case, additional energy, $\dot{Q}_c$ will be supplied to the water mass of the still from CPC. The energy balance for water mass will be modified as,

$$(\alpha\tau)_{eff}I(t)A_b + \dot{Q}_c = M_wC_w(dT_w)/dt + U_s(T_w - T_a)A_b, \quad (7)$$

Following Duffie and Beckman (1980), the useful energy obtained from CPC concentrator, $\dot{Q}_c$ is,

$$\dot{Q}_c = F_RA_a[(\alpha\tau)_cI(t) - U_L(T_w\ \ T_a)/C]. \quad (9)$$

Where, $C = A_a/A_r$, $A_r = \pi\ d_oL_r$, $F_R = F'F''$ & $F'' = m_wC_w\ \{1\text{-}\exp(-A_rU_LF'/m_wC_w)\}/A_rU_LF'$,

$F'U_L = 6.542 + 0.0277\ (T_w - T_a)$ and A_a and A_r are aperture and receiver area of concentrator while, m_w is mass flow rate of water in the receiver tube. Eq.(6) can now be expressed as,

$$dT_w/dt + a_1T_w = f_1(t) \quad (10)$$

Using boundary conditions,

$$T_w = \overline{f_1(t)}/a_1\,(1 - e^{-a_1t}) + T_{wo}e^{\ a_1t}. \quad (11)$$

Where, $a_1 = [F_RA_rU_L + U_s\ A_b]/M_wC_w$ and $f_1(t)= [\{(\alpha\tau)_{eff})A_b+(\alpha\tau)_cA_aF_R\}I)t)+T_a\ \ \{F_RA_rU_L+U_sA_b]/M_wC_w$

<u>2.3 Modified hourly yield for passive surface condenser</u> In the conventional system, the hourly yield is a function of water and glass temperature. When a passive surface condenser is attached to the still, part of the vapour will transfer to and condense on the condenser surface. Modes of water vapour transfer are considered to be in one or more of the following ways:

Diffusion: Water vapour will diffuse from the highly concentrated still to low concentrated condenser as,

$$\dot{m}_d = D * (A/x) * (\rho_s - \rho_c) \quad (12)$$

Where, D ($=0.256cm^2/sec$) is water vapour diffusion coefficient and ρ_s, ρ_c are water vapour pressure inside still and condenser.

Purging: It takes place due to higher still pressure to the condenser. Neglecting temperature difference,

$$\dot{m}_p = [V_c/(V_s + V_c)] \quad (13)$$

Where, V_s and V_c are volume of water inside still and condenser respectively.

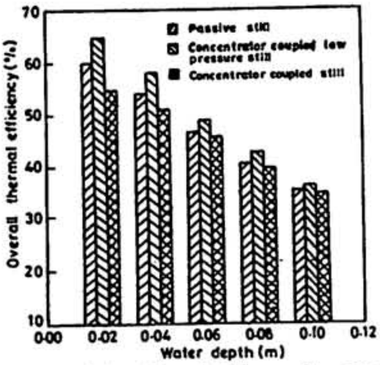

Fig. 3 Variation of thermal efficiency with water depth in different modes

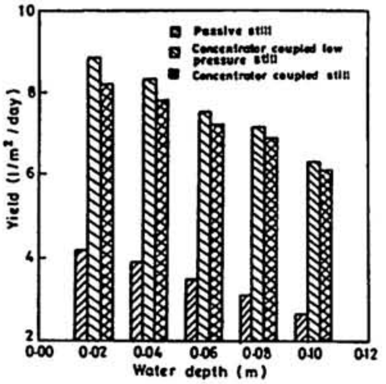

Fig-2 Variation of daily yield with water depth

Natural circulation: It is due to relative density difference between still and the condenser. Saturated hot air inside the still moves upward, while saturated cold air inside the condenser tends to move downward. The rate at which air circulates between the still and the condenser is obtained by equating the driving change of pressure generated by the buoyancy force and the resisting pressure drop caused by flow resistance as,

$$\dot{m}_a = (\rho_c - \rho_s) * g * Z/[KE/(\rho * A_N^2)]^{1/2} \quad (14)$$

Where, $KE = 1/(2 * C_d^2)$. C^d is coefficient of discharge and Z is condenser height. Therefore, in the proposed system, the hourly yield will be a function of water vapour pressure at water surface (P_w) and glass cover (P_g) 1986 as.

$$\dot{m}_{em} = h_{ew}(P_w - P_g)/\mathcal{L}. \quad (15)$$

2.4 Thermal efficiency (η) The thermal efficiency of the system for $I(t) = I_c(t)$ is given under active mode of operation.

$$\eta = [\{m'_{em} \times L \times 3600\}/\Sigma(A_a + A_b)I(t)] \times 100.$$

Where. L = latent heat of vapourization $= 2.5 \times 10^6$ J/Kg.

3. Numerical Results and Discussion

To compare the results of the proposed system with that of Sinha and Kumar (1994). the design and climatic parameters have been taken the same. The daily yield obtained from the system shows its performanc. In Fig.2. the yield per m^2 of the still area per day is shown at different water depth of the basin. Because of low pressure inside the still due to passive surface condenser. the yield of the proposed system is very high. It is important to note that the concentrator coupled still with passive surface condenser has maximum output compared to other systems. The overall thermal efficiency of the proposed system (Fig. 3) is higher as compared to that of Sinha and Kumar. 1994. This is because of reduced heat loss in the concentrator. While. the thermal effciency in the active regenerative mode of operation is lower than that in passive regenerative mode because of higher operating temperature range.

4. Conclusion

It may be concluded on the basis of above analysis that air is a better alternative for creating regenerative effect and low pressure inside a solar still. Therefore. high wind speed in deserts can be used effectively to obtain better yield especially in high temperature distillation system such as concentrator assisted conventional system. These systems will be economical due to better yield and higher efficiency as compared to conventional systems.

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Biodiversity & Afforestation

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Contents

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Bilogical-ecological basis for plant adaptation to the conditions of arid zone of Uzbekistan.

Tura RAKHIMOVA

The resistance of the species to the extreme environmental factors may either be formed by functional, structural or by other biological adaptation. This brought us to the necessity of systematic analysis of the basis of research methodology.

The object of this analysis is to determine of the complex of adaptation features of plants of arid zone to the xerothermic conditions and the adaptation community systems to characterize ecological groups.

It was discovered, that representatives of hyperxerophyts: Haloxylon aphyllum (Minkv.) Jljin, Halothamnus psammophilus Botsch.sp.nov., Anabasis eriopoda (Schrenk) Benth., Salsola orientalis S.Y.Gmel., Climacophtera lanata (Pall.) Botsch., Salsola Sclerantha C.A.Mey., Girgensohnia dintera Bgl. and others are the most adaptative to the xerothermic conditions.

The water regime of hyperxerophytes by all of the studied qualities is well balanced. The high water-retaining quality determines stable hydration and low water deficiency. It was demonstrated that the highest coefficient of correlation (0.7-0.9) was between the water-retaining quality and other characteristics of water regime. The water - retaining capability of the hyperxerophytes is the determining factor in the regulation of the water regime. The correlation of the characteristics of water-regime (not less than 0.6) shows its well balancing.

Hyperxerophytes are destinguished by their high heattolerance ability (59.5-62.8°C). Considerable adaptation property of this group is that, the root of young plants is of prime impotance. It grows into the soil quicker than it dries up. The leaves of the majority of hyperxerophyts in the arid zone of Uzbekistan (Haloxylon aphyllum, Salsola orientalis, Halothamnus psamminophilus, Anabasis eriopoda, Salsola paulsenii, Climacoptera lanata and others) are reduced.

The centric type of the mesophyll is observed that is adaptative to the arid condition. The lower number of stomatas on the leaf square 1 mm^2 is normal. A specialized water parenhyma with a thin wall, a large cell epiderm and hypoderm is promoting the water-retaining property of leaves (Butnik, 1977).

Hyperxerophytes are characterized by steady relatively even daily and seasonal cycle of photosynthesis and maximum degree of attainment of their potential. A high resistance of respiratory system to the extreme temperature was determined: the limiting temperature of respiration is 51-57°C (Alekseev, 1983). The plants of this group are characterized by deep and versatile adaptation to the existing in the conditions for the lack of moisture and high temperature.

The water regime of the representatives of the euxerophytes is more lebile, than the hyperxerophytes. Transpiration intensity is considerably higher, and hydration of assimilated sprouts is lower, than the hyperxerophytes. Beginning from spring up to summer the hydration of seedlings sharply decreases, but the osmotic pressure increases. Low expenditure of water at the mesothermic period is due to the low water-retaining ability, than by that of hyperxerophytes.

Water balance of euxerophytes are closely correlated with water content osmotic pressure, and transpiration of intensivity. These characteristics have coefficient of 0.7 to 0.9 and determine the ways of regulation of water balance. The adaptation of this group is due to the rise of osmotic pressure and the decreasing of intensivity of transpiration under reducing of watering.

Heat tolerance of euxerophites is higher than the hyperxerophytes (59°C). Depression of seedlings growth and defoliation of some leaves was observed in summer. The leaves of the representatives of this group is a platelike with hyperxerophytes.

Unlike the transpiration intensivity, the photosynthesis activities of Kochia prostrata and Ceratoides eversmanniana are higher than the plants of hypexerophyts group (Zakhyarants and others, 1971).

Phosphorus exchange of these species in the dry period is less. Also a decrease in nucleic acid is present (Negmatov, 1983). The temperature limit of respiration is almost as high (50-55°C) as the hyperxerophyts (Alekseeva, 1983).

Artemisia species of Seriphidium group are widely represented in the deserts and semi-deserts of Uzbekistan, which we consider to be in the group of teroiremoxerophytes that are dormant in the summer. Structurally and functionally, they are less adaptated to the xerothermic conditions, than species of hyper- and euxerophytes group. Their great adaptatility under arid conditions are defined mainly to the features of the seasonal behaviour and the specific morphological structure of the vegetative organs. The adaptation is less by the conservative anatomical and functional peculiarities.

The leaves of Artemisia species are small, cleaved, trimmed, but anathomically are less xeromorphologic than those preceding groups: mesophyll with insignificant number of hydrated cells situated around the veins (Alimuhamedova, 1974).

The water regime of Artemisia species is more lebile, than those of euxerophytes. Transpiration intensity in the spring is very high and in summer decreases six times. Hidration of assimilated shoots decreases twice in summer. Water-retaining capability is lower than that of the representative hyper- and euxerophytes, when assimilation proceses are minimum. Preservation of water balance period is possible due to large reduction of transpiration, and increase in osmotic indexes and also to a decrease of surface evaporation by means of defoliation of leaves (70-100% of leaves fall down). In summer the depression of the growing processes is clearly observed.

Maximum heat tolerance level (52-56°C) is lower in compare with hyper and euxerophytes. Photosynthetic activity of Artemisia species at the mesothermical period of the year is active. However in summer as well as water exchange it is reduced. Adaptation of photosynthesis to high temperature and lighting is limited: light saturation is observed in the scope of 40-50 thousand lk., but the temperature zone of photosynthesis optimum is within the 12-37°C. Critical respiration temperature is 47-50°C, that is a little lower, than those of all the previously above mentioned plants (Zakhyarants, 1971).

For the representatives of this group, the decrease in functional and biological activities at the xerothermic period is typical. This looks like as "escaping" or "avoiding" the unfavourable conditions.

Xerophyts are, the plants with very deep searching root system (20-30 m.) penetrating in to the horizons. The most widespread species in the arid zone are the representatives of the phreatophits Alhagi pseudalhagi, Capparis spinoza and Glycyrrohiza. We classified them as gemixerophytes as they are resistant to aerid, but not soil drought. They are characterized by high transpiration. Intensity of transpiration in summer period increases, which is not characteristic to the representatives of other ecological groups of xerophyls type. Hydration of the assimilated shoots during the vegetation season is reduced, osmotic pressure and water deficit slightly increases in summer. The plants of these group have relatively stable water regime. They differ from hyperxerophytes having high transpiration, stable watering and osmotic pressure are ensured by the deep root system, reaching the level of the subsoil waters. They vegetate from spring to late autumn keeping its high metabolic activity during the whole summer period.

Xerophyll structural type are characteristics include sclerophycation of the main vein of the leaf, centric organs and prickles and development of water-safety tissue with high quantity of starch. Photosynthetic efficiency of the representatives of the hemixerophyts are higher than those previously mentioned groups. Maximum heat tolerance is 60°C. Analysis of representatives of the xerophyte type - that is hyperxerophytes, euxerophytes, teroiremoxerophytes, hemixerophytes are not equal to the complex of the adaptative characteristics determining their resistance to the arid conditions.

In conclusion because of the diversity of adaptative features of different species of plants to drought and the absence of integral indicators of drought-resistance, it is impossible to look at only one of them. Instead we must take into concideration all complex properties. This will allow us to determine more precisely the character of this or that combination of biomorphological and functional peculiarities of this or another ecological groups.

The developed ecological classification of the fodder plants is a scientific basis for their distribution in districts in phytoamelioration. The representatives of ecological groups are not equal in their degree of adaptation to xerothermic factors. Plants with stable (hyperxerophytes) and average stable (euxerophyts) water regime, having limited water-supplying may be widely distributed in the arid zone. Teroiremoxerophytes exists where annual precipitation is more than 200 mm.

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Role of Exotic Plant Species In Biodiversity of Great Basin Deserts

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Abstract - The truly arid portions of the Great Basin of western North America are known as salt deserts because of halomorphic soils. During the last century, a number of accidentally introduced species, most originating from Central Asia, have invaded these deserts. Depending on the specific plant community and soil where the alien plants have become established, the influence on biodiversity has ranged from readily apparent to very subtle.

Key Words: Temperate Deserts, *Halogeton*, *Salsola*, Granivores, Grazing.

1. Introduction

The region in western North America between the Sierra-Cascade Mountains on the west and the Rocky Mountains on the east is known as the Intermountain Area. In the southern portion of the Intermountain Area, crustal spreading has produced typical basin-and-range topography. This Great Basin has no drainage to the ocean. The Great Basin is composed of a series of sub-basins separated by towering fault block mountains. Some of the higher basins contained pluvial lakes that spilled over their lips during the Pleistocene and drained either to the northeast or northwest to form inland seas. In the northeast was pluvial Lake Bonneville, of which the present Great Salt Lake of Utah is a remnant. The area where we will focus our attention is the basin of pluvial Lake Lahontan in northwestern Nevada.

Early in the Holocene the pluvial lakes abruptly dried and apparently for a prolonged period there was near complete desiccation of the basins. This dry period must have been accompanied by wind deflation of the fine-textured sediments exposed as the lakes disappeared. From woody ancestral members of the chenopod family a flora evolved to vegetate the exposed lake sediments. This is a very harsh environment to colonize because of the atmospheric drought combined with osmotic drought induced by the salt content of the sediments (Billings, 1949). The halomorphic soils has led to the common name of salt deserts (West, 1983). These deserts constitute about 16.9 x 10^6 ha in the western United States (Kuchler, 1970). A little more than a century ago there began the accidental introduction of alien plant species to these salt desert environments. Most of these species originated in Central Asia under similar temperate desert environmental conditions. Our purpose is to describe the sequence and consequences of this invasion and interpret the impact on biological diversity.

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2. Environmental Setting

2.1 Types of Habitats The four major subdivisions of habitats in the salt desert are based on the location of the ground water table and include: 1) uplands dominated by xerohalohytes where the ground water table never reaches the rooting zone of the shrubs, 2) low lands areas dominated by hydrohalophytes where the water table, for at least a portion of the year, is within the rooting zone of shrubs, 3) transitory marshes dominated by emergent rushes and sedges, and 4) playa surfaces which occasionally can be flooded and normally are without vegetative cover. Playa surfaces are synonymous with salt-pans, Iranian *kavirs*, North African *shotts*, and Russian *tahyr*, and occur in the lowest or in interrupted portions of drainages. In northern Nevada, playas constitute about 1 million ha or 6% of the landscape, which is about twice the arable, irrigated cropland.

2.2 Shrub Mounds On the lake plains and in the uplands, the chenopod shrubs almost always occur on soil mounds. These mounds vary among sites from a few centimeters to several meters in height. The mounds result from saltation and subaerial deposition of particles that become trapped under shrub canopies. The subcanopies shelter limited areas of litter accumulation and cryptograms. This subcanopy mound is the only site of nutrient cycling in this type of vegetation (Charley and West, 1976).

2.3 Shrub Species The chenopod shrubs of the salt deserts constitute eight genera of which three are endemic to North America and one or two are monospecific. The other genera are shared with Central Asia, or in the case of *Atriplex*, arid areas through out the world. According to West (1983)., about 20% of the chenopod shrubs communities in the salt deserts are nearly monospecific. Widely occurring *Krascheninnikovia lanata* communities are an example of soil controlled, single species dominance. This limited species diversity may be due to the few species adapted to such harsh environmental conditions and/or the limited geologic time scale over which colonization of these habitats has occurred.

2.4 Herbaceous Vegetation In upland areas where aridity is more of an environmental limiting factor than salt affected soils, a fair diversity of perennial herbaceous species is present. In the lower areas where hydrohalophytes predominate, the expression of perennial herbaceous is often virtually restricted to clonal *Distichlis spicata*. The salt deserts do not have the diversity or occasional super abundance of annuals species so characteristic of the Mojave and Sonoran Deserts of western North America.

3. Sequence of Introduction

The annual herb, *Erodium cicutarium* was apparently introduced to the Great Basin before the arrival of Europeans because this alien was given a name in the language of the local Shoshone Indians (Steward, 1938). Probably, it was brought across the mountains to the Great Basin from 18th century Spanish settlements in California by Indian traders.

3.1 *Salsola* *Salsola australis* was the first alien plant to widely colonize salt desert plant communities (Young, 1988). It was established in the Great Basin by 1900. This herbaceous weed combines wind blown tumbling of the hemispherical canopy after maturity with tremendous seed production (as many as 250,000 seeds per plant). This system helps to assure dispersal of seeds to adapted habitat. This weed is only adapted to areas without competition from established native species such as roadsides, abandoned cropland, or severely over grazed rangelands. Even in very high condition salt desert rangelands there are natural disturbance areas, such as blowing sand or rodent burrows, where *S. australis* is adapted. When established, it changes the ecology of these limited areas and provides a seed source for colonization of any natural or artificial more extensively disturbed areas.

Salsola paulsenii became widely distributed in the Great Basin by 1970. Very similar in appearance to *S. australis,* this new introduction has subtle, but significant differences in reproductive ecology. *S. australis* plants must tumble for the seeds to be freed from axillary bracts. *S. paulsenii* plants do tumble with the wind, but some seeds disperse from the plant as soon as they are mature. This makes the second introduction a much more persistent colonizer.

There are many perennial species of *Salsola* native to Asia, but only *S. vermiculata* has been introduced to the United States. This perennial has spread on the arid hills west of the San Joaquin Valley in California, but the source introduced is not winter hardy in the Great Basin.

3.2 *Halogeton* *Halogeton glomeratus* was first collected in North America near Wells, Nevada in 1934. A fleshy annual weed, it superficially looks like a *Salsola* species during early growth stages. A relatively rare species from Central Asia it was very difficult to obtain the correct identification of this new introduction. In 1942 it was determined the weed was highly toxic to sheep and could occasionally poison cattle.

Halogeton shares many seed ecology characteristics with the *Salsola* species. Large to huge numbers of simple seeds are produced by individual plants. *Halogeton* plants do not tumble, but the papery bracts that surround the seeds make short-distance seed dispersal by winds very effective. *Halogeton* seeds have the potential for almost instant germination over a wide range of environmental conditions, including reduced osmotic potentials. The plants are phenotypically very plastic and this plasticity extends to seed production. The production of black seeds that germinate nearly instantly, and brown seeds that can remain dormant in the soil for 10 years is controlled by day length. Like many extreme halophytes, *Halogeton* herbaceous litter is highly enriched with salts. Over several generations, the salt accumulation on the soil surface under *Halogeton* stands can be sufficient to inhibit germination of seeds of other plant species.

3.3 Other Introductions The *Salsola* species and *Halogeton* are obviously herbaceous annuals that were accidentally introduced and rapidly spread in near empty ecological sites. They have various levels of interference with seedlings of native perennial species depending on the site and precipitation levels. However, they are not competitive with established native perennials.

The creeping rooted perennial *Lepidium latifolium* has been introduced to wetlands and riparian areas throughout the Great Basin. It is highly competitive with native species and colonization results in large areas of near mono-cultures. The woody perennial *Tamarix ramosissima/ T. chinensis* has colonized large areas of wetlands. It also forms near mono-cultures. A perennial introduction capable of characterizing landscapes in the more arid, upland parts of the salt deserts has not become established.

4. Conclusion: Influence On Biodiversity

Vast expanses of the salt deserts are largely dominated by alien herbaceous annuals. These species dominate because the native vegetation was largely destroyed by excessive grazing. Once native perennial species are restored, the alien annuals are suppressed. The influence of this transitory alien annual dominance is difficult to assess. The seeds of some of these species enter into the diet of native granivores which in turn influence the seed ecology of native perennial plants. The introduced perennials, *Lepidium latifolium* and *Tamarix ramosissima*, have a very negative influence on biodiversity.

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Biodiversity and Desertification in The Drylands of China

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Abstract - There is 2.976 million km^2 of drylands in northern China and 334,000 km^2 of them has suffered from desertification. Due to influence of both desertification and adverse human activities, such as over-collection fuelwood, over-cultivation and over-grazing etc., the plant and animal communities have greatly changed. Consequently,biodiversity has lost during this process.

Key Words: Biodiversity, Desertification, Drylands, China.

1.Distribution and Bioclimatic Features of Drylands in China

1.1 Distribution The drylands are widely distributed in northern China. The area covers 2.976 million km^2, or 31% of the land mass.The drylands cover over 80% of the agricultural land of Heilongjing Province, Ningxia Autonomous Region, Liaoning Province and Jiling Province, 70-78% of Inner Mongolia, Gansu Province, Qinhai Province, Shaxi Province, and Shaanxi Province, 46% of Hebei Province, 38% of Shandong Province, 54% of Henan Province, 20% of Beijing, 29% of Tiangjing, and 7% of Xinjiang Autonomous Region (Cheng C.,1993).

The northern drylands can be divided into three belts based on rainfall and aridity index as shown in Table 1. The aridity index refers to the ratio of potential evapotranspiration to average annual rainfall.

Table 1. Bioclimatic belts and its features in the northern drylands of China

Bioclimatic Belt	Annual Rainfall(mm)	Aridity Index
hyperarid and arid	<250	>3.5
semiarid	250-400	3.5-1.5
dry subhumid	400-900	1.5-1.0

1.2 Bioclimatic Features Dry climate is the most salient feature of bioclimate in drylands (Li K. R.,1990) and also main nature factor affecting biodiversity distribution and desertification.

1.2.1 Rainfall The annual rainfall in the large parts of drylands of China is less than 200-300mm. About 70% of rainfall occurs during June to August in the eastern part, and 40%-60% in the western region. The monthly variability of rainfall is 30% to 40%, and could be 50% or higher.

1.2.2 Wind Velocity Daily average wind velocity of 5 m/s or higher occurs more than 50 d/yr in most parts of northern China, and more than 80 days in the northern Inner Mongolia.In the western parts of Mongolia, where the most serious erosion occur, this can be more than 100-200 d/yr and even over 200 days.

1.2.3 Relative Humidity The mean annual relative humidity of arid lands is generally below 50%. In northern Gansu Province, western Inner Mongolia, and the Tarim and Turpan Basin, it is less than 40%, less than 30% in the Qaidam Basin. It is usually 50% to 60% in semiarid area.Relative humidity is higher in the Winter than in Spring or Summer.

2.Biodiversity

Coniferous and broadleaf mixed forest, deciduous broadleaf forest, and temperate pasture are present in the major parts of drylands of China.

2.1 Plant Species Diversity There are 200 families, 1000 genera and 3500 species of angiosperm in the dry subhumid area, 125 families, 760 genera and 3600 species in the semiarid area, and 130 families, 817 genera, 3900 species in the arid area (Cheng, 1993). Cultivated food crops are wheat, corn, soybean, sorghum, millet. also, cotton, peanut, sesame, sugar beet are cultivated in the drylands of China.

Species, genetic, and ecosystem diversities are related to climate and pedology. In addition,the abuse of the dryland can affect such diversities. There are 107 families, 654 genera and 2409 species in Xinjiang

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Autonomous Region, which is one-sixth of the area of China, and 120 families , 650 genera and almost 3000 species in Inner Mongolia, which is one-ninth of the area of China. The plant species diversity in Xinjing is less than that in Inner Mongolia. But cultivated plants in Xinjing are quite abundant while medical plants, such as *Lycium chinense*, *Codonopsis pilosula* and *Cistanche deserticolo* etc. are quite abundant in Inner Mongolia. Xinjiang is near the center of the origin of wheat, so there are 10 genera and 82 varieties and subspecies of wheat allied plants. Xinjiang is considered to be one of the regions where cultivated fruit tree originated. There are 23 genera and 69 varieties of wild fruit trees, which include wild common apple, wild apricot, wild walnut , and wild almond as well as wild plum.

2.2 Animal Species Diversity There are 500 species of mammalia, 1200 species of ares, 380 species of reptilia, and 280 Species of amphibian as well as 2800 species of pisces in China (CAS,1979). The number of insect is not clear. No detail data on animal species diversity are available for the drylands, data show that some of survivor, such as *Eguus przewalskii*, *Asinus hemionus* and *Camelus bactrianus* as well as *Cervus albirostris* etc., are found in the Northern China (Cheng L.,1993). In addition, 144 species of mammalia, 500 species of ares, 23 species of amphibian and 47 species of reptilia and 80 species of pieces in Gansu Province are present. Of these 54 species are protected by government law.

3. Desertification

3.1 Extent Desertification in northern China is primarily the result of human activities. Desert-like landscape, such as shifting sand sheet, coasemed farmland and shifting sand dune is mainly distributed in patches in densely populated region, especially agropastoral region of northern China. Desertification covers about 334,000 km^2, of which 30.7% is located in arid area, 65.4% in semiarid area, and 3.9% in dry subhumid area. Also, another 535,000 km^2 of arable land are at risk or susceptible to desertification.

Data obtained from analysis of aerial photographs, TM imagery, and field investigation show that desertification increased from 110,000km^2 in the mid-1970's to 127,000 km^2 in the mid-1980's in agropastoral region, while desertification increased from 13,200cm^2 in the mid-1970's to 29,200 km^2 in the mid-1980's in other parts of northern China (Table 2).

Table 2. The Developmental Trends of Desertification in Northern China (Zhu et al.,1994)

Region	Area of Region km^2	Desertification in Mid-1970's		Desertification in Mid-1980's		Annual Growth		Duration
		Area	%	Area	%	Area	%	
Horqin in Jirem	59765	21566.6	43.4	23800	47.8	186.2	0.82	1975-1987
Horqin in Chifeng	34680	7404.6	21.4	9050.5	26.1	137.2	1.7	1975-1987
Bashang in Hebei	17659.4	2612.8	14.8	4514.5	25.6	158.5	4.7	1975-1987
Houshan in Inner Mongolia	48533	13769.8	28.4	23000	47.4	769.2	4.4	1975-1987
Mu Us in Ih Ju	49112.4	43407	88.3	45973	93.6	256.6	0.6	1977-1987
Qahar	12769.2	3668.9	28.7	5540.9	43.4	156.0	3.5	1975-1987
Yanchi	6761.2	1368.9	20.2	1845.5	27.3	47.7	3.0	1975-1987
Yulin	21528.9	1530.5	71.1	13219.1	61.4	-232.1	-1.6	1977-1987
Xilin Gol	51780	13194.1	25.5	16408.5	31.7	267.9	1.0	1975-1987
Western Alxa	16200	3480	21.5	5955	36.8	225	5.0	1975-1986
Centre Alxa	1573	1171.6	74.5	1308.4	83.3	13.7	1.1	1974-1984
Qaidam	7920	4400	55.6	5573	70.4	117.3	2.4	1976-1987

Although no up-to-date data are available, the study from some case studies does show that desertification expanded in rainfed farmland from 9.1% in 1983 to 14.7% in 1993, and was reduced in irrigated farmland from 11.3% in 1983 to 4.5% in 1993 in southern Duolun of Inner Mongolia and Fengning of northern Hebei Province. These parts represent the typical agropastoral region.

3.2 Causes Bare surface with loose sandy deposits and temporal synchronism of the dry season and windy season are the main natural factors causing desertification. However, 28.5% of the desertification in northern China is caused by overgrazing, 25.4% by over cultivation, 31.8% by over collection of fuelwood, 8.3% by abuse of water resources, and 0.7% by technogenic factors, and only 5.5% by sand dunes movement. Therefore, human activities are considered the major cause of desertification. Among the various elements, over-population is an important one. For example, in order to meet the need of over increasing population, 80% of steppe was reclaimed from the mid-1960's to the middle of 1970's in Naiman Banner of Inner mongolia. Consequently, severe desertified land expanded from 8.56% of arable land in the 1970's to 11.67% in 1980's.

4.Impacts of Desertification on Biodiversity

Vegetation change is one of the most remarkable environmental effects occuring during the process of desertfication. This change does not only include vegetation cover, but also includes plant community and species composition. For example, the species composition in Horqin steppe has changed from 23 in slightly desertified land to 5 in severely impacted land (Table 3).Moreover, there are at least 22 rare and endangered plants and 31 rare and endangered wild animals at risk in the drylands of China due to influence of both desertification and human activities

Table 3. The Influence of Desertification on Distribution of Dominant Plant Species in Horqin Steppe(Zhao et al.,1994)

Plant Species	Degree of Desertification			
	Most Severe	Severe	Moderate	Slight
Artemisia halodendron	+	+	+	+
Caragana microphylla	+	+	+	+
Setaria viridis	+	+	+	+
Cynanchum thesioides	+	+	+	+
Agriophyllum squarrosum	+	+	+	+
Pnramites communis		+	+	+
Xanthium sibiricum		+	+	+
Pennisetum flaccidum		+	+	+
Corispermum dilutum		+	+	+
Salsola collina		+	+	+
Echinops gmelinii		+	+	+
Euphorbia esula			+	+
Aneurolopidium dasystachys			+	+
Bassia dasyphylla			+	+
Ixeris gracilis			+	+
. *Euphorbia humifusa*			+	+
Lespedeza dahurica			+	+
Digitaria ciliaris			+	+
Eragrostis pilosa				+
Convolvulus arvensis				+
Pocockia ruthenica				+
Chlcris virgata				+
Delphinium granadiflorum				+

\+ refers to the existence of species

5.Conclusion

.Desertification has led to the loss of biodiversity in the drylands of China.Unless adequate measures are taken to arrest or reverse the process of desertification, we will not be able to keep food security in the future.

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Assessment of Land Degradation using Remote Sensing and GIS A Study from Local to Global Level

Krishna PAHARI* and Shunji MURAI*

Abstract - This paper is based on a study of land degradation, first at the local level, in a mountain watershed in the Nepalese Himalaya with an area of only 279 Km^2, and then some highlights of the ongoing research on global land degradation assessment being carried out by the authors is given. In both cases, the aim is to develop an operational application of remote sensing and GIS for land degradation assessment.

Key Words: Remote Sensing, GIS, DTM, Land degradation.

1. Introduction

Land degradation is one of the most serious environmental problems in the world today. This is a global problem which has to be addressed at both the global as well as local level. Accordingly, it is necessary to develop methods to assess the state of land degradation at various levels from local to global. The global assessment is important to have an overall picture of the problem while the local assessment is necessary to make detailed analysis and thus adopt appropriate management strategy at the local level. This is in line with the famous motto "think globally, act locally".

Remotely sensed data of varying spectral, spatial and temporal resolution have emerged as powerful sources of information to address various environmental problems. Also GIS have proved to be very powerful tools for handling spatial information and for performing spatial modelling of environmental phenomena such as land degradation.

2. Assessment at the Local Level

2.1 The study area and the conceptual framework The area for the local level study was a river watershed called the Andhikhola watershed in the middle mountainous zone of Nepal covering 279 square kilometers, roughly equal to one pixel area if we compare with the 16 km resolution GVI data normally used for global studies.

By using the Universal Soil Loss Equation (USLE) with the revised equation for the topographic factor as the conceptual basis, attempt was made to quantify the rate of soil erosion due to flowing water. According to the USLE (Wischmeier and Smith 1978), the annual soil erosion in tonnes per hectare is given by the following equation:

$$E = RKLSCP$$

R, K, C and P, which are the factors for rainfall, soil erodibility, land cover/management and conservation practice respectively, were calculated based on the original USLE. However, since the topographic factor from the original USLE was found to have large errors in case of steep mountain slopes, this was calculated based on the following revised equation (Moore and Wilson 1992)

$$LS = (L/22)^m (10.8 \sin\beta + 0.03) \text{ for slopes} < 9.0\%, \text{ and}$$

$$LS = (L/22)^m (16.8 \sin\beta - 0.50) \text{ for slopes} \geq 9.0\%,$$

where, β = slope gradient in degrees,

$m = F/(1+F)$, and

$F = (\sin\beta/0.0896)/(3\sin^{0.8}\beta+0.56)$

where, L = length of slope in meters,and

S = angle of slope in degrees.

2.2 General methodology Remote sensing, Geographic Informations Systems (GIS) and Digital Terrain Modelling (DTM) were the three vital tools used for the spatial and temporal analysis of soil erosion.

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Remote sensing was used to make spatial and temporal analysis of land use. Digital image processing was done by using maximum likelihood classification on the SPOT HRV data (path/row 221/294) acquired on 15 March 1991 to make land use classification of the study area. Also, a comparison was made with the land use obtained from the interpretation of aerial photographs of 1978 for the temporal analysis of land use. Digital Terrain Modelling was used for representing the complex watershed topography and subsequently for calculating the topographic factor required for computation of soil erosion. The DTM was based on the existing topographic map at a scale of 1:50,000 (contour interval = 100 feet). Finally, GIS was used for creating various thematic maps representing the factor values such as K, LS, C, etc and then for making spatial and temporal modelling for soil erosion.

2.3 Results and discussion

The followings were the main findings of this research

i). High resolution satellite data was found to be very effective in making spatial and temporal analysis of land use. The classification of remotely sensed data showed that more than 55% of the area is under agriculture and only 31% under forest, thus proving the intense human pressure on this watershed. However, special considerations were necessary for the shading effect in the satellite data due to mountainous terrain, during classification. Due to the very heterogeneous land use conditions, only high resolution satellite data were found to be effective. A multitemporal analysis for the thirteen year period from 1978 to 1991 showed that more than one fourth of the original dense forest was converted to degraded forest due to human pressure.

ii). DTM was found to be very effective in analyzing the complex terrain conditions of the watershed. It showed that more than 60% of the area is having slopes more than 20% and only 20% with slopes less than 10%.

iii). The rate of soil erosion was found to be generally very high ranging from less than 5 tonnes/ha/yr at the flat river valleys up to more than 200 tonnes/ha/yr in the steep degraded rangelands (Figure 1). More than 50% of the area was found to have soil loss value greater than 20 tonnes/ha/yr, thus demonstrating the critical watershed condition. Topography and land use were the factors most dominant in determining the soil loss value, compared to other factors. It was found that agricultural land was the land use contributing to almost two third of the total soil loss.

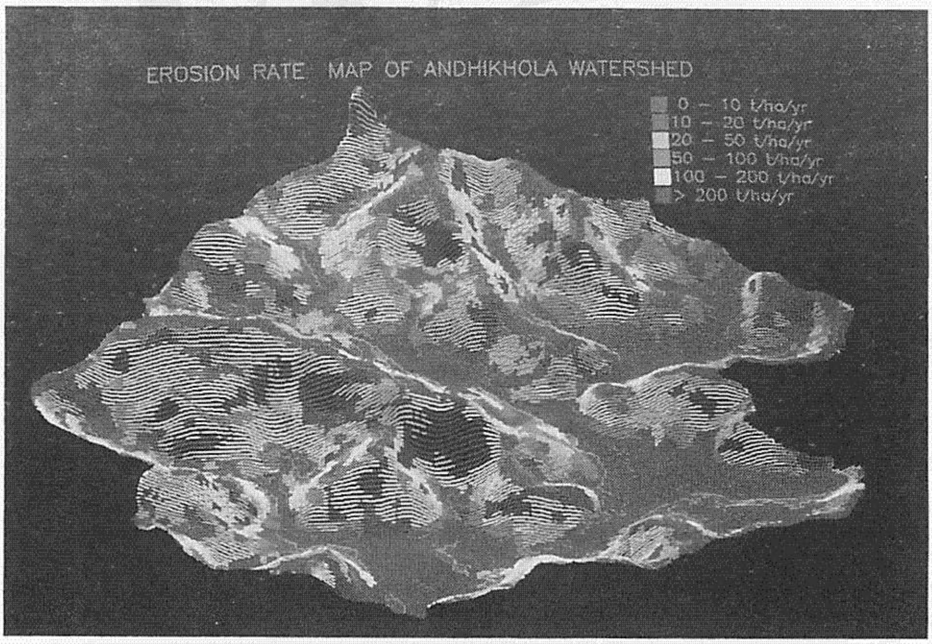

Fig. 1 Soil erosion rate map of Andhikhola watershed draped with topographic relief

iv). It was observed that the USLE with the revised equation for the topographic factor gives relatvely better estimates of soil loss in the mountainous terrains. Under such conditions, the results from the old equation for topographic factor were far from realistic.

v). A modeling for alternative land use based on sustainable level of soil erosion (assumed as 20 tonnes/ha/yr) showed that more than one third of the agricultural land needs to be converted into other land use, either forest or tree crops.

3. Assessment at the Global Level

3.1 Conceptual Framework Based on the definition given by UNEP(1992) and works by other authors, in this study, land degradation is taken as the reduction of land resource potential in general, and desertification is considered as the land degradation in the arid, semiarid and dry subhumid areas. Soil degradation by water, wind or chemical agents and the degradation of vegetation are the main factors leading to desertification.

While we analyze high resolution data by considering a physical process model with greater spatial details for local studies, the global assessment of land degradation involves data with very coarse resolution, data from various sources and under different formats and different levels of accuracy.

3.2 General methodology The study for global land degradation is being done by the authors by using remotely sensed data and other relevant data with the help of global GIS. For this purpose, we need to use some conceptual models which can be classified into two broad categories, climatic model and the physical and bio-process model.

3.2.1 Climatic model In this approach, various kinds of moisture and aridity indices are calculated based on the rainfall and temperature data, and these are used as indicators of the desertification. Some of such indices are following:

i. Moisture Index This index is calculated by:

Moisture Index = Annual Rainfall/PET

where, PET is the potential evapotranspiration, which can be estimated by Thornthwaite method or other methos.

ii. Aridity Index The Martonne's ariduty index is given by:

$AI = P/(T+10)$;

where, P = annual precipitation (mm),

T = sum of monthly mean temperature of those months with monthly mean temperature greater than 0, divided by 12.

3.2.2 Physical and bio process model In this category, various models related to physical processes of land degradation such as water erosion, wind erosion and net primary productivity can be considered. Since land use/cover is a major factor contributing to such processes, the remotely sensed data, particularly, NOAA GVI data, can be specially useful for such studies.

i. Water erosion Water erosion is a function of land use/cover, rainfall, topography and soil characteristics. However, due to the scale factor, it is necessary to make some generalizations in case of global study. For example, to relate the topography for land degradation, instead of calculating the slope in absolute values, some topographic roughness factor may be more appropriate.

ii. Wind erosion Wind erosion is a function of speed and direction of wind, land use/cover and the soil properties. This analysis is more complicated compared to water erosion, and depends upon the availability of appropriate data.

iii. Net primary productivity It has been observed that NOAA GVI data have correlationship with the primary productivity as shown by Box and Bai (1993). The net primary productivity can also be taken as an indicator of the land degradation.

3.3 Results and Discussion The preliminary results of the aridity zoning based on the Martonne's Index are given in Table 1 and Figure 2. Compared to the actual land use classification of the world based on remotely sensed data done by various authors (such as Murai and Honda 1991), the area under forest is more and that under deserts or semi-deserts is less from this model. This is considered as an indication of the change in land cover due to human intervention from the natural land use conditions, that can exist under the given climatic conditions.

Table 1 Aridity indices and areas under different zones

Class	AI	Percent area
Desert	<=5	7.34
Semi-desert	5-10	5.94
Grass land	10-30	31.47
Forest	>30	41.96
Cold	---	13.29

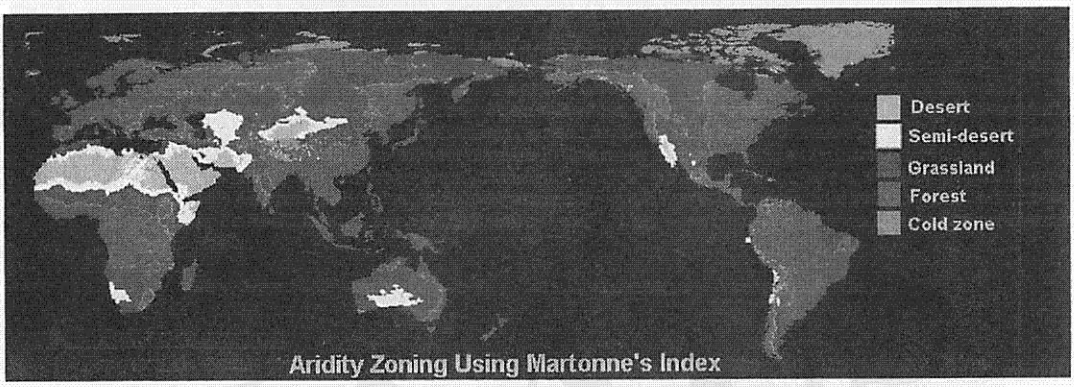

Figure 2: Aridity zoning based on the Martonne's Index

4. Conclusion

Remote sensing and GIS can be successfully used for making spatial and temporal analysis of land degradation, both at the local level as well as global level. The applicability at the local level is already demonstrated by the authors and that at the global level is under progress.

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Nitrogen Enrichment-Immobilization to Control Succession In Arid Land Plant Communities

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Abstract - Water is the ultimate limiting factor governing plant growth in most arid environments. Inorganic nitrogen is the catalyst that often governs the efficiency of water use in arid plant communities. In Pleistocene age sands of the Great Basin in the western U. S., we determined that enriching or immobilizing available nitrogen dramatically influenced secondary succession. Alien annual weed species were enhanced in density and biomass with nitrogen enrichment. The growth of these weeds eliminated seedling establishment of perennial species. Immobilization of nitrogen favored seedling establishment of the native perennial *Achnatherum hymenoides*.

Key Words: Annual weeds, soil moisture, competition.

1. Introduction

In arid ecosystems, competition for moisture is usually the paramount factor in determining species composition of plant communities. Inorganic nitrogen availability is often the catalyst that governs this competition. For the temperate deserts of western North America, the average total nitrogen stored in soils is 0.604 kg N/m^3 (Peterjohn and Schlesinger, 1990). Disturbance by excessive grazing, wildfires, and accelerated erosion enhances mineralization of nitrogen. In the shrub dominated temperate deserts, there is considerable spatial variation in total and inorganic nitrogen. Shrub sub-canopy areas are greatly enriched compared to interspace areas (Charley and West, 1975).

Disturbance of temperate desert plant communities by excessive grazing and recurrent wildfires leads to accelerated erosion and accelerated mineralization of nitrogen. Following wildfires the surface 5 cm of soil beneath shrub canopies have a significant loss of nitrate nitrogen, but the organic fraction is predisposed to rapid mineralization and subsequent high levels of ammonium-nitrogen (Blank et al., 1994 a and b).

We hypothesized that introduced annual weeds use nitrogen enrichment associated with disturbance to out-compete the seedlings of native perennial species for moisture. This results in truncating secondary succession.

2. Experimental Procedures

2.1 Environment of Experimental Site The experimental plots were located near the ghost town of Flanigan, Nevada about 50 km northeast of Reno.

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The site is topographically situated near the floor of an embayment of pluvial Lake Lahontan. Since the close of the Pleistocene, sands from deltas of glacial fed streams that discharged into Lake Lahontan have been driven across the deep water portions of the embayment and up the eastern bordering mountain escarpment by prevailing winds. The sand fields where the experiment is located were stabilized by the shrub *Artemisia tridentata* and the perennial bunchgrass *Achnatherum hymenoides*. The woody perennial vegetation was destroyed by a wildfire in 1985. Since the wildfire there has been a very dynamic seedling establishment of the perennial grass *Achnatherum hymenoides* associated with parallel dynamics in the populations of vertebrate granivores (Longland 1995). The alien annual species *Bromus tectorum* and *Salsola paulsenii* have also increased following the wildfire. *Bromus tectorum* invaded the heavily grazed site before the wildfire and provided the fuel that allowed the spread of the wildfire among the native shrubs. Severe wind erosion following the wildfire destroyed the *Bromus tectorum* seedbank allowing the initial *Achnatherum* dynamics to proceed without competition. Annual precipitation averages near 125 mm, but is highly variable from near 0 to 225 mm and largely occurs during the cold winter months.

2.2 Treatments The sand substrate was tilled before initiating the experiment. Because the pre-existing vegetation was destroyed by tillage the dynamic seedling response observed in relation to treatments had to be from seedling establishment from soil borne seeds. A randomized block design with four replications was used. The treatments were: 1) control, 2) calcium nitrate 30 kg-N/ha, 3) urea 30 kg-N/ha, 4) ammonium sulfate 30 kg-N/ha, 5) sucrose at 580 kg/ha, 6) nitrapyrin 2.2 kg/ha, 7) sucrose 58 g/m^2 plus nitrapyrin 2.2 kg/ha, and 8) ammonium sulfate 30 kg-N/ha plus nitrapyrin 2.2 kg/ha. The initial application was in September 1993 before the first effective rainfall, and applications were repeated at the same rates in December 1993, and February 1994. The treatments were repeated in September and December 1994, and February 1995 both on the original plots and on new areas at the same location.

2.2 Sampling We sampled species density with four subplots 400 cm^2 in area that were randomly located in each treatment. Sampling was conducted from February through July 1994 and the repeated treatments were sampled in the spring of 1995.

3. Results

3.1 Growing Conditions The winter of 1993-94 was very dry with only 82.5 mm precipitation recorded on the site over the winter months. Seedling emergence began in March and considerable seedling mortality occurred in the nitrogen enrichment treatments (Table 1).

3.2 Differential Emergence It is well known that nitrate nitrogen enrichment enhances the germination of dormant seeds in seedbanks (e.g. Mayer and Poljakoff-Mayber, 1989). The bulk of

Table 1. Species density per m^2 by life form for March and September 1994 in nitrogen enrichment-immobilization experiments located at

Flanigan, Nevada, USA. Seedlings of both life forms emerged in March. In September annuals were counted that had successfully produced seeds and perennials that appeared to be alive and therefore successfully established.

Treatment	Date and life form			
	March		September	
	Annual	Perennial	Annual	Perennial
	---------- density/m^2	----------	----------	----------
Control	710bc	30b	400b	0c
Ammonium sulfate	840b	20b	540a	0c
Urea	890b	20b	600a	0c
Calcium nitrate	1,140a	0b	540b	0c
Carbon	40d	200a	10c	40ab
Nitrapyrin	10d	180a	10c	60a
Carbon + nitrapyrin	10d	210a	0c	20bc
Ammonium sulfate + nitrapyrin	210d	40b	90c	10c

*Means within columns followed by the same letter are not significantly different at the 0.05 level of probability as determined by Duncan's Multiple Range test.

the annual species that were recorded in the March 1994 samples were *Bromus tectorum* and *Salsola paulsenii* whose seeds are known to respond to nitrate enrichment (Young et al., 1969, Young and Evans, 1979). It is surprising that reducing nitrogen in the seedbed by either immobilization (carbon enrichment) or through inhibition of nitrification significantly ($P \leq 0.05$) enhanced the emergence of *Achnatherum hymenoides*. Seedbanks of this native grass become quite large in the desert sands (Young et al., 1983). The dormancy of seeds in these seedbanks is known to be very complex with both interference with water transfer through the caryopsis coverings and embryo dormancy present (McDonald, 1987). Dormant seeds of *A. hymenoides* do not respond to enrichment of the germination substrate with nitrate nitrogen.

Nitrogen enrichment did not significantly depress *A. hymenoides* emergence compared to the control plot, but emergence was much higher on the plots where nitrate nitrogen was reduced. Perhaps the differential emergence is a function of competition for available moisture in these arid seedbeds. The greatest stand of annuals (calcium nitrate enrichment) had no perennial grass seedling emergence.

3.3 Seedling Establishment There was considerable seedling mortality among both the annual and perennial seedlings during the 1994 growing season (Table 1). No *Achnatherum hymenoides* seedlings established in the nitrogen enriched treatments. Above 40% of the annual seedlings died without producing seeds in the nitrogen enriched treatments, but sufficient plants produced seeds to maintain seedbanks. The density of *Achnatherum* seedlings that were apparently alive at the end of the summer (10 to 60/m^2) was much greater than the potential of the site can support (Young et al., 1994).

3.4 1995 Results The winter of 1994-95 was above average in precipitation with 208 mm received by April 1995. Although we have not completed collecting data at the time of manuscript preparation, with more moisture the differences between nitrogen enrichment and immobilization are more striking than during the previous dry year. The nitrogen immobilization or nitrification inhibition treatments a virtually free of annual seedlings.

4. Conclusion

The environment where these studies was conducted is so variable in precipitation among years it is obviously necessary to repeat this experiment over a broader spectrum of precipitation years, but the preliminary results appear very promising that nitrogen immobilization may be a method of directing secondary succession in arid plant communities.

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THE STRATEGY FOR ADAPTATION OF GENERATIVE ORGANS OF KOCHIA IN THE ARID DESERT CONDITIONS.

K.N.Toderich, T.E.Matyunina and A.R.Rabbimov.[1]

ABSTRACT - The formation of reproductive organs of the species Kochia prostrata L. Shrad is submitted to the influence of herothermal factors of desert stipulating high adaptation of main cytoembryological structures at the all the stages of ontogenesis. The strategy of their adaptation leads to the reduction of the elements of a flower and the surface of leaves The increase of receptive surface of stigma, the decrease of number of anther and ovule in ovary. The formation of a great number of pollen grains, their small sizes, dryness and capability to fly over long distances are connected with processes of pollination in this plants. The well coordinated mechanism of dehiscence of anther owing to specifical strusture of endothecium and connective cells. The variation in the somatic chromosomes number is being found in species Kochia. The most perspective for selection of Kochia prostrata L.are polyploids forms.

Key words: tapetum, endothecium, pollen grain, karyotype, Kochia prostrata (L.) Schrad.

1. Itroduction.

Succefull selection of arid crop plants have be based on the revealition of more adaptive and productive genotypes to the extreme desert conditions. It is known that the creation of new sorts of cultivated plants for a long time based on the use of distant hybrydization, polyplodization, gene transfer, tissue and cells culture, gamete and zygote selection and other methods. However these methods have not been used for the selection of arid plants yet.

Kochia prostrata (L.) Schrad -perennal, polymorphical semishrubs of the Chenopodiaceae - one of the most interesting objects for explanation of adaptive potential of arid plants. There are many publications about the morphologico-anatomical structural changes of seedling,leave, root and stem of this plants(Butnik,1984), growing in sand desert conditions in the Uzbek part of Kizilkum. The interspecies systematical position of Kochia is very contradictory. The objective of this study is to explain the strategy of adaptation of generative organs and their processes as well, as the possibility of using the cytoembryological indexes for selection of more adaptive ecotype and forms.

The cytological research was carried out on various populations of Kochia prostrata (L. Shrad of different origin, growing in the Karnab's station of our Institute.

2. Morphometric and Cytoembryological Studies of flower, Microsporogenesis, Pollen quality and Karyotype.

2.1. The morphology of flower organs, microsporogenesis and pollen quality.

The study of interdependent development of male and female generative structures showed several sexual types correlate with different manner of

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pollination (auto-cross and the pollination within one brush). The Kochia flower has typical aneumophylious adaptation: long, flexibe and shaking sthamen threads: explosive, portional release of pollen: morning mass blossoming of flowers, the increased receptive surface of stigma: the formation of great number of pollen grains (39,5-46,0 thousand in one anther). Consequently their great concentration around the brush, well coordinated mecanism of dehiscence of anther owing to well developed fifrous thickening in endothecium and connective cells. The presence of thick layer of cuticule on the epidermis, perhaps, defends pollen grains from the influence of high temperatures. Specific changes have been noticed in the structure of tapetum cells, their division rate, the level of polyploidization of nuclei and the dinamic of degeneration cells after postmeiotical stage.

The studied populations differ by the peculiarities of meiosis, morphology, fertility and viability of pollen grains. The greatest anomalies of meiosis are found at hybrid populations of the 5-th (9,16%) and 16-th (11,02%) samplles. The variation coefficient of this index as seen from the table 1 makes 26,5-80,5%.

Table 1. The variation of some cytoembryological indexes of pollen grains in Kochia species

The Studied populations	Meiotical index (%)	Diameter of pollen grains (%)	Fertility of polen (%)
Kochia sand ecotype	0,5-3,8 cv=39,8	24,1-28,4 cv=15,3	63,2-89,3 cv=28,3
Kochia clay ecotype	0,9-3,2 cv=80,5	20,7-23,2 cv=19,7	79,2-95,6 cv=64,8
Kochia stone ecotype	2,8-9,0 cv=57,1	21,4-26,7 cv=15,6	57,9-82,2 cv=18,7
N 3(F2 sandX stone ecotypes)	1,9-8,1 cv=46,7	19,7-29,4 cv=17,5	55,3-79,0 cv=15,9
N 5 (F2 clay ecotype from Stavropol X clay ecotype from Kirgizia)	2,7-9,61 cv=26,5	18,2-30,2 cv=10,7	40,21-71,08 cv=14,0
N 16 (F2 clay X sand ecotypes	5,4-11,02 cv=30,9	19,3-27,0 cv=12,4	44,7-68,4 cv=14,3
N 6 (F2 clay X stone ecotypes)	1,6-7,1 cv=40,1	28,4-31,4 cv=9,02	62,4-93,8 cv=12,0

The differences are marked also in forms and sizes of pollen grains, thickness of exine and quantity of pores on its surface. The sizes of pollen grains of the studied populations variy from 18,2 up to 31,4 mk. The population of samples N 3,5 and 16 are characterized by the small sizes of pollen grains (40,1-68,4%). The essential superiority of sizes is noticed at polyploid selection sample N 6 (28,4-31,4 mk). The diameter of pollen grain at 2,9-7,5 mk larger.

Due to the level of fertility of pollen populations can be divided into 3 groups: low-samples 3,5,16; medium- Kochia ecotypes growing in the stone soil and high- the local Samarkand population of clay ecotype and the plants of the samples N 6. The viabilility of pollen of studied population ranges from 44,52 to 78,6%.

2.2. THE VARIABILITY OF CHROMOSOMS IN THE POPULATION OF KOCHIA.

The study of number of chromosoms in the apex of the root of seedlings of various populations of Kochia showed their great variability. Our result on the polyploid raw in tribe Kochia coicides with data of Shahanov,1989. The predominant number of chromosoms is 2n=18 (the sand ecotype of Kochia). The population of clay ecotype of Kochia has both 2n=18 and 2n=36 sets of chromosom. The hybrid sample N 6 (2n=54) is likely to be easier for polyploidization. Aneuploids (2n=35 or 37 chromosoms) and mixoploids plants were found in 5,16 samples. The average number of these cases appeared to be very small (0,05%).

Thus the future study of number and morphology of chromosoms will be useful for explanation of some systematical and adaptive charactetistics in tribe Kochia.

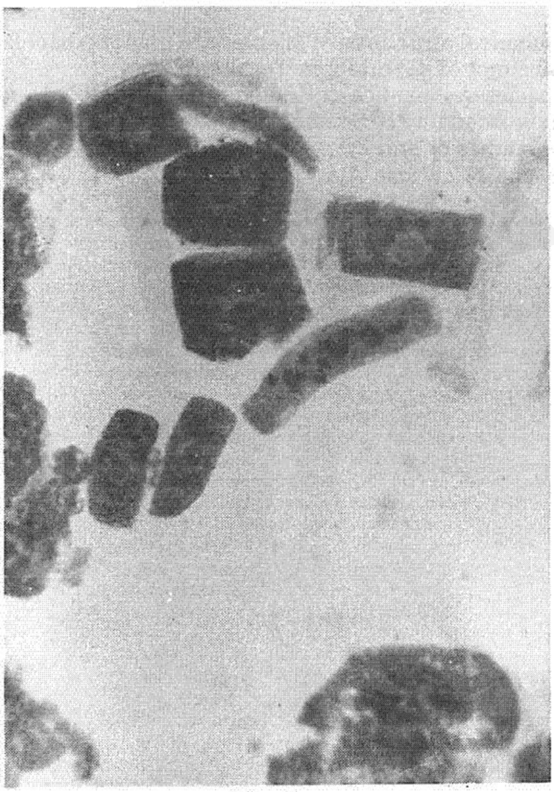

Fig.1

Fig.2

Fig 1 The diploid set of chromosoms in Kochia prostrata (L.) Schrad sand ecotype (2n=18 X 4500

Fig.2. The hexaploid set of chromosoms in hybrid form of Kochia N 6 (2n=36).

3. Conclusion. The polymorphysm of reproductive organs of Kochia species and their structure discovered by us stipulate its high ecological plasticity and successiful adaptation for growing in arid conditions. The karyological results confirm the interspecies systematics of Kochia prostrata L. Schrad, which was worked out earlier by Pratov (1971).

Meiotical index, the morphology, fertility and viability of pollen grains, as well as the differences of the dinamics of growth of pollen tube could be used as diagnostical indicators for the productivity of introductional and selectional forms of arid plants.The hybrid form N 6 raised by us can serve as the initial material for selection. Thus, the polyploidization and interecotypic hybridization may give the best results for selection of Kochia prostrata L. Schrad.

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Control and Development of Desertification Land in Yulin, China

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Abstract - This paper mainly describes the evoluation process of desertification land in Yulin, which is located in the temperate, dry steppe zone, and achievements in control and development of desertification land as well as technical measures taken in the past 40 years.

Key Words: Yulin, Desertification land, Control and development

Yulin, in the temperate, dry steppe zone, is located in the northern Shaanxi Province of the northwestern part of China, and is one of the arid and semi-arid desertification area. The desertification land in Yulin belongs to a part of Maowusu Desert and covers 24,400 km^2. South boundary is approximately the old Great Wall and on the south of it is the Loess Plateau area.

1. The Natural Characteristics of the Desertification land

1.1 Geomorphology The wind erosion is the main cause to the formation of modern geomorphology with flat surface, elevation of 1100 - 1300 m and relative elevation difference of 30 - 50 m. The surface component mainly consists of loose sandy sediments of the Quaternary Period, and its surface configuration is the mosaic of moving dune, semi-fixed dune and fixed dune with lakes and grasses. Ground water is high with water table of 0.6 - 5.3 m.

1.2 Climate It has typical continental climate. Annual precipitation is 316.4 - 445.0 mm with big annual range and 60 - 80% precipitation concentrates on the period of between July and September. Annual mean temperature is 7.6 - 8.6°C. Mean monthly minimum temperature (January) is -8.8 - -10°C, and mean monthly maximum temperature (July) is 22.2 - 23.4°C. Active accumulated temperature (≥10°C) is 2847.2 - 3307.5°C. Frost-free period is 134 - 169 days. Annual mean wind velocity is 2.4 - 3.3 m/s, and there are a great number of wind and most of them are strong in spring which is also dry season.

2. Evolution Process of Desertification Land

2.1 Natural factors of formation of desertification land The wide spread loose sandy sediment of the Quarterary Period is the base for the formation of desertification land. The frequent change in climate, especially both dry season and strong windy season occurring in the same period, is the external power for the formation of the desertification land.

2.2 Historic evolution process of desertification land 5000 years ago, desertification land had already existed and had proceeded both normal and inverse evolution process of a series of moving dune, semi-fixed dune and fixed dune. At that time, the evolution process was mainly affected by natural factors. Since eleven centuries, especially 500 years ago, with the increase of population and more frequent human activities, vegetation has been severely damaged, and it had a very little ability in natural recovering. These had accelerated the land desertification and given rise to continuously increasing of desertification land area, which resulted in the formation of modern desertification land pattern. The landscape possesses the features of intermingling of large- or small-scale moving dune with semi-fixed, fixed dune, desertification farm land and steppe.

In the dynamic view, the desertification has been undergoing both growth and decline in the past 40 years. That is, there is, on one side, the development and acceleration of desertification, and at the same time, there is some control of it, too. The surface changes showed that there are not only formation of new desertification land or moving dune, but there also appeared more vegetation coverage

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that helps control and utilization of moving dune, semi-fixed dune and fixed dune. The trend of desertification development was showed in two ways. On one side, there was increase of sand land range. By the end of 1950s, there was 2,246,150 ha sand land, while there was 3,018,020 ha at present. The borders of sand land have extended both south and east 5 - 30 km. For increase of sand land area, see Table 1.

Table 1. Change of desertification land area unit: km^2

Year	Area Surveyed	Moving Dune	Fixed Dune	Semi-Fixed Dune	Total
End of 50s	19020	5773	1933	2667	10373
End of 80s	18017	3063.8	5408.5	2939.6	11411.9
Increase/Decrease	-1003	-2709.2	+3475.5	+2726	+10389

Besides potential natural factors, factors, such as irrational over-reclaiming, over-grazing, felling, construction of plant, mine industry and transportation, were the major causes to the development of desertification land.

In the past 40 years, 412,840 ha of desertification and potential desertification land was controlled and developed. The most supereminent of it is that 270,920 ha of moving dune was controlled and developed. The annual average decrease rate of moving dune was 1.92%.

The situation of dsertification land by the end of 80s is given in Table 2.

Table 2. Classification of desertification land types unit: ha

Total area in region	Desertification land						Potential deserti-fication land
	Total	Moving Dune	Semi-fixed dune	Fixed dune	flat dune	Alkali-saline soil	
2,440,000	1,195,500	306,380	293,960	540,850	33,470	20,840	124,660

3. control and Development of Desertification Land in the past 40 years

3.1 The basic principles in control and development Integrating of control and development of desertification land with economic construction would help establish the system that will not only prevent and control desertificatin land, but also promote the natural ecological recover and natural economic coordinating for agricultural, forestry and animal husbandry development.

In the control of desertification land, biological measures should be major ones with combination of engineering measures. The establishment of protection forest shelterbelt system should lay the base, with full utilization of available land and water resources, and establishment of stable pasture and basic irrigation land. At the same time, both the construction and development of factory, transportation and city/town and control of desertification land would be secured.

In the ways of controlling and developing, establishment of regional sand controlling system should be the target and large protection forest shelterbelt will be the main frame with combination of wind-and-sand break and farmland and pasture protection forest system to control sand move. The land should be intensively used and appropriate timber and economic stand should be established.

The key target in control should concentrate on the moving dune, and in the selection of species, shrub should dominate. On other types of sand land, consolidation and establishment of stable vegetation community should be objective. Measures are taken according to local real situation and arbor, shrub and grass species should be integrated to increase sand land production.

3.2 Scope of control and development of desertification land Large-scale control and development started after mid-70s, and by the end of 80s, the total controlling and developed area was 874,990 ha (see Table 3.), accounting for 35.9% of the total regional area. In the period of 1989 - 1993, control of 271,000 ha moving dune was carried out. 108,400 ha area was afforested by either trees or grasses, controlling 186,000 ha moving dune, and 85,000 ha moving dune was controlled by trees and grasses grown from airsown seed. In the meantime, 13,000 ha of farm land was built from either controlled sand land or improved sandy farmland.

Table 3. Classification of control and development of desertification land unit: ha

Year	Total area	Remaining Afforested area		Area planted by grassed			Improvement of low-yield land	used by factory, transportation and town
		Plantation	Air sowing	Planting	Air sowing	Improvement of pasture		
End of 50s	323,396	289,773	---	14,676	---	---	15,594	8,002
End of 80s	874,990	626,531	11,670	77,679	29,219	11,613	61,038	58,513

3.3 Construction of protection forest system By the end of 80s, the total protection forest area was 626,531 ha. The protection forests accounted for 90.5% of total area of all forest types, and shrub stands accounted for 77.5% of total forest area (see Table 4). The forest coverage increased to 23.3% from the previous 1.8% in 50s, and standing stock is 2,428,800 m^3. Four large protection forest shelterbelts formed with a total length of 1,5000 km and afforestation area of 117,000 ha.

Table 4. Construction of protection forest system by the end of 80s unit: ha

Species	Total Area	All types of protection forests				Timber Forest	Economic forests	Forest for special purpose
		Wind-sand Break	Soil-and water conservation forest	Farmland Shelter-belt	Other protection forests			
Arbor	139,847	32,537	7,936	20,504	19,176	50,980	5,568	3,146
Shrub	486,684	404,824	80,843	----	1,017	----	---	---
Grass	626,531	437,361	88,779	20,504	20,193	50,980	5,568	3,146

4. Technical Measures in Control and Development of desertification land

4.1 Control of moving dune by trees and grasses from arsine seed Achievements on afforestation and grasses established from arsine seed have been made through many years' studies. After 1981, it has become one of the main technical measures for the control of moving dune in Yulin. After the moving dune was afforested once by mean of airsowing, the vegetation coverage could reach 28.8 - 46.9%, and 4 - 8 years late after airsowing, it will increase to 45.8 - 75.5%. Plant species suitable for airsowing in the moving dune area are *Hedysarum monolicum*, *H. scoparium*, *Artenmisia ordosica*, *Astragalus adsurgens*, *Caragana korshinskii*, *Melilotus officinalis*. All the species can fix dune, which are anti-wind-erosion, fast growing, self-productive and adaptable to moving dune.

When vegetation coverage is 25.4% after airsowing afforestation on moving dune, it will reduce wind velocity by 27.4% and when the coverage is 40.7%, it will reduce by 63.7%. Five years after airsowing, thickness of crusting on the forest floor was 0.4 - 1.8 cm, organic material content rose to 0.6% from 0.13%, particles (<0.05 mm) increased to 13.2%, and grass yield per hectare was 3,236 kg.

4.2 Setting up sand barrier to help control moving dune Wind erosion has severe influence on trees and grass planted, and plants will suffers a lot from it. Hence, barriers on moving dune were built to change wind and sand flowing and provide better living condition for plant growth. The barriers can be divided into plant barrier and mechanical barrier.

In plant barrier, plants adaptable to sand land were used. On the facing slop, dense row planting (interplant distance is 10 - 20 cm) was applied and row distance was 2 - 3 m to form "live" plant barrier. Its features are: forming dense plant community to resist wind erosion; maintaining individual plant life and development; and controlling move of moving dune and providing better niche for planting trees as well.

Mechanical barrier is to build "dead" barrier on the dune from non-biological materials of all kinds, and the patterns of barrier are of row or grid. The features of this barrier are: no season limitation in building; more power but shorter period in control of wind erosion and dune movement; no competition for water and nutrients between plants grown and barrier itself; and normal growth of plants grown after setup of the barrier.

4.3 Only planting used in control moving dune in the area with less wind erosion
In the low part between two dunes, arbor trees and shrub were planted to stop the advance of dune. On the lower 1/3 part of the facing slope, shrubs with strong sand-fixing power were planted to hold sandy slope surface, and the area above lower 1/3 facing slope was moved forward by wind to gradually flatten dune year after year and to form stands.

Or Plants were grown on every other dune to let unfixed dune advance to expand lower area between dunes and to grow trees each year to form stands.

4.4 Artificial afforestation on non-moving dune Because there is slight wind erosion and stable surface, and water and nutrients are the main limiting factors affecting tree development in those areas, those factors could be used as key factors in classifying site types. Accordingly, tree species were selected and then different afforestation technical measures were considered. In the light of selection from many years, the following arbor species may be selected: *Populus opera, P. simonii, P. alba var. bolleana, P. hopeiensis, Salix matsudana, Ulmus pumila, Pinus tabulaeformis, P. sylvestris var. mongolia, Prunus armeniaca var. ansu*, etc. the following shrub species may be selected: *Sabina vulgaris, Salix psammophila, Amorpha fruticosa, Hedysarum monolicum, H. scoparium, Tamarix chinensis, Hippophae rhamnoides, Caragana intermedia, Lycium barbarum*, etc.

4.5 Establishment of farmland forest shelterbelt The pattern of farmland forest shelterbelt with "narrow strip and small grid" was adopted. Main strip was 2 - 3 rows and auxiliary strip was 1 - 2 rows. The distance between main strips was 150 - 200 m, and distance between auxiliary strips was 500 m, which protected the area of 8 - 10 ha. The strip structure was wind-venting and venting coefficient was 0.5 - 0.7 with a little occupation of farmland. Popular species were dominant ones with high growth, and at the distance of 3 - 11 times of tree height, wind velocity was reduced by 49.4%, compared with that in the open area without strips.

4.5 Engineering measures in the control of desertification land Engineering measures could be used on the desertification land of any kind. It mainly refers to the measures applied in building farmland, development of water surface, and desertification land utilization by construction of factory, mine, transportation and town. The methods used in building farmland were: transportation of sand by water; Mechanically flattening dune, etc. The most popular was transportation of sand by water, which used hydraulic power from river, lake, reservoir, or natural flowing water, pumping water to wash flat dune. Meanwhile, agro-forest network, irrigation and drainage, and electrical power line facilities were added.

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Eco-physiological approach to the arid-land afforestation

Yoshitaka KAKUBARI and Naoko ODAKA

Abstract- The possibilities of afforestation at the level of 100x100 km[2] on deserts against the greatly increased CO_2 fixation are discussed by use of eco-physiological approaches. The methodological study by use of *Sorghum bicolor*, which is expected to lead the research to be conducted by use of the eco-physiological model, which varies according to changes in photosynthetic rate, ambient air temperature, radiation and soil water contents. The differences of daily photosynthesis on three different water levels are shown clearly by use of eco-physiological simulation model.

Key Words: Afforestation, CO_2 gain, Transpiration, Simulation model, Arid land

1. Introduction

Afforestation of arid and semi-arid lands, which is characterized by high temperature conditions, water scarcity and high salinity, may be one of the feasible measures of CO_2 fixation, because one third of the land surface biosphere has a large potential to fix carbon and change in land use management is expected to be acceptable locally and globally.

For more than three years a project to asses the possibilities of afforestation at the level of 100x100 km[2] on deserts has been conducted under the sponsorship of RITE (Research Institute of Innovative Technology for the Earth) and The Japan Gas Association (Ozawa et al. 1994, Matuda et al. 1994).

Plants and plant communities have multiple purposes and functions, and are hence superior in function to other materials, and are also able to increase quantitatively through natural regeneration. In another respect, forests can achieve sustainable development following afforestation. The planting system herein shall be described from an eco-physiological approarch, which makes it possible to clearly elucidate the life of plants on arid land. We need to calculate the water balance and information about eco-physiological characteristics of plants.

We try to introduce the simulation techniques to the estimation of CO_2 and H_2O balance of plants as a basic informations of afforestation on arid and semi-arid lands against the greatly increased CO_2 fixation .

2. Material and methods

Plant material was used a pot-grown *Sorghum* (*Sorghum bicolor*) instead of woody plants, which are cultivated on dry land regions as world-wide crops, and was grown during 30 days under sand culture at first, and cultivated under water culture condition during 20 days before photosynthesis measurements. The photosynthetic rates of *Sorghum* were

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measured under different four degrees of water stress;i.e. 0, 364, 389 and 432 Kpa. Water stress was made with a solution of polyethylene glycol (PEG, molecular weight of 6000). The root system of material was immersed in the solution at fixed time. Photosynthesis and respiration rates were measured with a Koito intelligent porometer system (KIP-8510 system, KOITO Co.,Ltd, Tokyo, Japan) at 400 micromole $m^{-2}.s^{-1}$ under artificial light conditions. The water potential measurement of PEG solution was used with the WESCOR HR-33T system (Wescor Co.,Ltd, Utah, U.S.A.). Radiation and air temperature data were taken in the experimental station of the University of Shizuoka at Hamaoka, Shizuoka Pref. and soil moisture contents data were taken from the station of Al-Oha agricultural experimental station of the Univ. of United Arab Emirates, in Al-Ain, U.A.E..

3. Data processing and modelling

Data concerning photosynthetic rates, plant transpiration, water potential, evaporation from ground surface, and soil moisture contents will be collected through a field work and used to determine the relationship between plant life and ambient conditions on arid-land ecosystems, and to analyze the mechanism of plant productivity that has dropped because of a lack of soil moisture contents (Larcher, 1995). It is important to investigate the relationship between physiological response of plant and field conditions of climate and soil. We are able to explain the water use efficiency of crop among three different soil moisture contents by use of a simulation model (Kakubari, 1994). An eco-physiological model are established with the external factors of air temperature (AT), solar radiation (RAD), soil moisture contents (SMC), and photosynthetic rate is also influenced with AT and RAD as shown in Figure 1. The amounts of photosynthesis can be estimated with a computer simulation model, which varies according to changes in SMC (Fig. 2).

4 Results and Discussions

The balance between H_2O and CO_2 in plant depends directly on not only the water content of tissues but also soil moisture contents. If soil moisture contents stay at or below the drought level during the growing season, the net amount of photosynthesis becomes to zero. Figure 2 shows the relationship between soil moisture contents (pF in Fig. 2) and the relative vales of photosynthetic rate in *Sorghum bicolor* comparing with the rate of photosynthesis under available conditions. The rate of photosynthesis remains constant in relation to field moisture capacity (pF1.8, 6.19KPa), although it decreases with soil moisture contents, particularly between the point at which capillary water flow stops (pF2.7, 49.2KPa) and the point of where wilting begins (pF4.2, 1554KPa). Therefore, the irrigation plan shall be designed with considering relationship between soil moisture contents and water use of plants.

The daily amount of photosynthesis can be estimated with a computer simulation model, which varies according to changes in soil moisture contents. We estimate amount of dry matter gain and transpiration at different soil moisture levels; 165.4, 155.8 and 54.8 mg CO_2 $dm^{-2}.day^{-1}$ at soil moisture contents of 6.1, 49.1 and 618.8KPa, respectively.

Total amount of water loss to dry matter gain can be estimated with a rate of molecular weight (18/44), and compared with soil moisture contents taken data in the United Arab

Emirates, and shown in Table 1.

Table 1 Total amount of dry matter, transpiration , and water demand of *Sorghum*

S.M	TDM	DM	RT	TRS	TRSU
6.1	165.4	67.7	1.00	13.5	67.7
49.1	155.8	63.7	0.94	12.7	63.7
618.8	54.8	22.4	0.33	4.5	22.5

S.M.: soil moisture content(KPa), TDM: Total amount of dry matter (CO_2 $dm^{-2}.day^{-1}$),DM: water use required in photochemical process level,RT:Relative rate,TRS:Transpiration per hectare estimated with a ratio of 200 times to DM level($tH_2O.ha^{-1}$),TRSU:Mean transpiration on individual levels in case study of the United Arab Emirates(litre, total amount of transpiration /220 ind.).

In this case study, we used as a material *Sohrgum* samples, which belongs to C_4 groupe of photosynthesis type, and demand water estimated may be too much comparing the normal C_3 woody plants. After Larcher(1995), transpiration rates of C_3 woody plats is one third comparing with that of C_4 tropical grass species. Therefore, it's transpiration may be to estimate around 7 litre at water content level of 618.8KPa. In general irrigation water in U.A.E. is used from 20 to 30 litre a tree, and it's too much comparing the result of this simulation. On the other hand, too much irrigated water conserve planting trees from salinity accumulated on ground surface, and we need to evaluate effects of leaching by irrigation water. It is very hard to distinguish irrigation water for a irrigation and/or for a leaching, and also establish the optimum irrigation system. Photosynthesis rates, transpiration, water potential of leaves, evaporation from ground surface, and soil moisture contents shall be collected through a field work and used to determine the relationship between water economy of plant life and ambient conditions in arid-land ecosystems, and to analyze the mechanism of plant productivity.

5.Conclusion

The methodology of the afforestation on the problem on an arid and semi-arid regions was presented, which is expected to lead to the direction of the research to be conducted by use of the eco-physiological computer simulation model, which varies according to changes in photosynthetic rate, ambient air temperature, radiation, and soil moisture contents.

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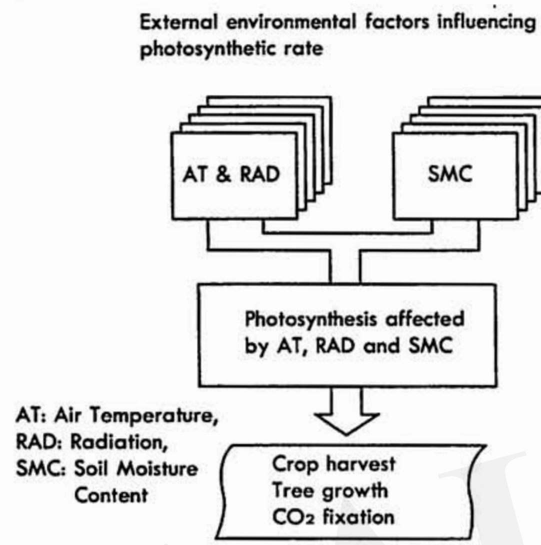

Figure 1. General structure of eco-physiological computer simulation model

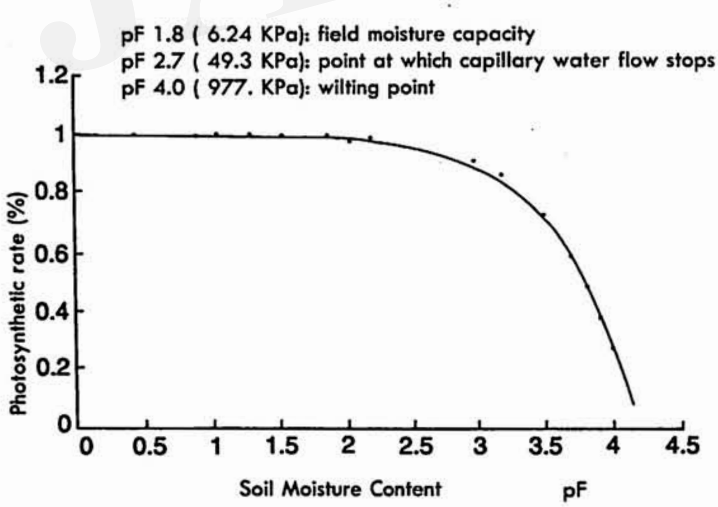

Figure 2. The relationship between soil moisture content and attenuation in the photosynthetic rate of *Sorghum bicolor*

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Adapting Strategies Of Woody & Semiwoody Plants In The Arid Environment (Xerophyllization Problem)

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Abstract - The status of the problem of xerophyllization is examined. The strategies in the adaptation of assimilating organs in the ontogeny of the woody and semiwoody biomorphs of gypsiferous Kizilkum desert are described. It is noted the variety of mesophylls types as the main feature of xerophytes.

Key words: Cotyledon, leaf, biomorph, adaptation, xerophyte.

1. Introduction

The xerophyllization problem is very real. It is an extension and intensification of desert territories. About 45% of a world and 80% of the Uzbekistan is under desertification. Studies of xerophillization will allow us to clarify some questions about plant evolution, to preserve exceptional xerophyte genofund, to identify drought resistance. The drought resistance and xerophyllization are asimilar conceptions. The drought resistance and salt resistance are first reactions of organisms to the environmental conditions, the phenotypic reactions. The xerophytism as halophytism are historical and evolutionary processes, which change plant genotypes and is accompanied by changes in structure and function. Therefore arid factor and halo factor are becoming necessary for plant life and their are including in the reaction norm. Xerophyllization is very complicated process. The adaptation of plants is for survival and reproduction. Plants have adapted to the extreme environment in a variety of ways. Xerophytic plants have followed a different scheme compared to the other species. The original discovery by Kortshak et al. (1965) that sugar cane possesses an alternative highly efficient pathway of carbon dioxide fixation and its connection with kranz tissue in the leaves permits to revise the evolution of assimilating organs in many taxons from a new point of view (Welkie, Caldwell, 1970).

2. Material and region.

We studied anatomical structures of assimilating organs of 40 species of woody and semiwoody biomorphs from 11 families in the process of ontogenesis plants: Ephedraceae Wettst.(1 sp.), Chenopodiceae Vent. (18), Polygonaceae Juss. (5), Tamaricaceae Link. (1), Fabaceae Lind. (5), Zygophyllaceae R.Rz. (2), Nitrariaceae Lind. (1), Solanaceae Juss. (1), Convolvulaceae Juss. (3), Scrophullariaceae Juss. (1), Asteraceae Dum. (2).

Materials were collected in the Kizilkum desert located 40°45' north latitude and 65°45' east long·itude, 350 meters above sea level. The south western Kizilkum is in the Turian province of Irano -Turian Region (Takhtajan, 1978). The study region is characterized by low precipitation (80-100mm per year), the high summer temperatures (to +45°C), low winter (to -30°C) and strong winds. Various soil types are present in this region: sandy, saline, loamy, stony, gypsiferous. Studies were conducted at the experimental station in Kizilkum desert.

3. Types of assimilate organs.

About 900 species are described in Kizilkum: trees - 3% of species, shrubs -

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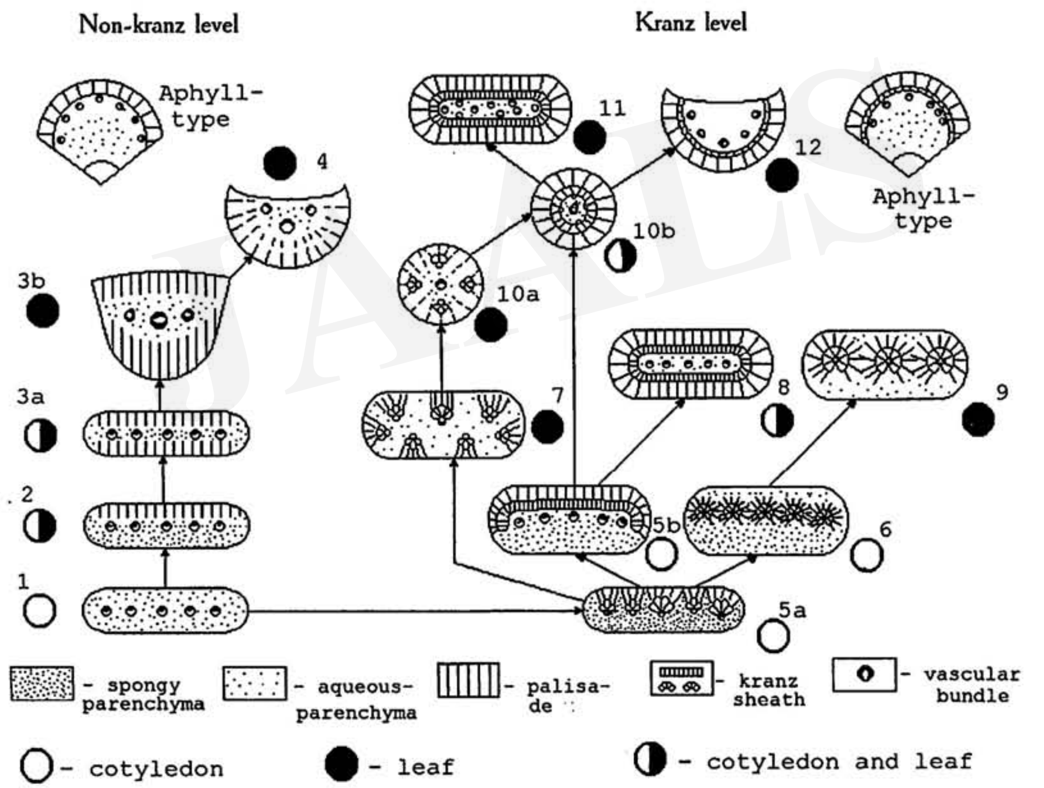
12%, semishrubs - 5%, perennial grasses - 35%, annual grasses - 45% (Granitov,1964). Although woody and semiwoody biomorphs are not numerous, they are the dominant desert vegetation. R.Carolin at al.(1975), V.Vasilevskaya, A.Butnik (1981), J.Gamaley (1988) have described 12 types and 6 subtypes of mesophylls in only Chenopodiaceae (Scheme 1). Nine types were discovered in cotyledons and leaves woody and semiwoody plants from them. From the Scheme 1, we observed, that the evolution of mesophyll types in two structural levels: non-kranz and kranz. Kranz arrangement, kranz type, kranz syndrom, kranz cells - those are all the titles of anatomical structure connected with C_4 and CAM types carbon dioxide fixation. The wide adaptive radius of the leaf structures, especially kranz types, is characteristic for xerophytes. Kranz group mesophyll types is more evolutionary young. Kranz tissue and C_4 and CAM types of photosynthesis permit the desert plants to grow in the wide temperatural range, low precipitation and to occupy various ecological niches. Non-kranz and kranz evolutionary lines finish by aphyll types.

Scheme 1. The mesophyll types and the possible ways of their evolution (for example Chenopodiaceae).



The mesophyll types presence at the cotyledons (the first figure in brackets, % from the all species) and leaves (the second figure) woody and semiwoody plants are in the next forms: non-kranz - 1. Isolateral - spongy (5%; 0), 2. dorsiventral (30; 0), 3a - isolateral - palisade (0,10), 3b. isolateral-palisade (scleromorphy) (0;10), 4. ventro - dorsal (0; 2.5); kranz - 5a. kranz - dorsiventral (interrupted) (2.5; 0), 5b. kranz - dorsiventral (continuous) (5; 0), 6. dorsiventral - rosettelike (0; 0),

7. kranz - isopalisade (0; 2:5), 8. kranz - isopalisade (circular) (7.5; 0), 9. kranz - rosettelike (0; 5), 10a. kranz - centric (interrrupted) (0; 5), 10b. kranz - centric (continuous) (10; 32.5), 11. laminate - centric (0; 0), 12. kranz - ventro - dorsal (0; 5).

We observed that the cotyledons of 55 % species and leaves of more 80% species are xeromorphic and 25 % cotyledons and 40 % leaves have the kranz tissue.

4. Conclusion

All varieties of leaf structures may be grouped into four structure-functional strategies of adaptation: picnophylls (microphyllous dense tissue xerophytes), succulents, sclerophylls and aphylls. (Scheme 2).

Scheme 2. The adaptive strategies of the leaf xerophytes

Vector of specialization (↑)

The adaptive strategies		The radical-feature of the structure	Ecology (soil factor)
A P H Y L L S	Kranz type	The assimilating cortex of shoots, reduction of leaves.	The taxon-specific ecological specialization
	Non-kranz type		
S U C C U L E N T S	Kranz type	The abundant aqueous parenchyma.	Halophylic-factor
	Non-kranz type		
S C L E R O P H Y L L S	Kranz type	The abundant sclerenchyma of the bundles arising from procambium.	Petrophylic-factor
	Non-kranz type		
P I C N O P H Y L L S	Non-kranz type	The compacted tissues, universal type of adaptation.	The wide ecological range.

The ***picnophylls*** are addapted to the transpiration because of reduction of evaporating surface and the development of protective feature (pubescence, thick celluar wall). The main criterion of the ***sclerophylls*** are the mestome sheathes of the veins, developed from the procambium. Oxalate calcium crystals are located around sheathes. The ***succulents*** are adapted to xeric environment as a result of water accumulation in the tissues. The succilents predominate in Kizilkum because of the saline soiles and because it is possible that certain taxons have littoral origin.The reducing process of leaf ***aphylls*** was accompanied by a change of cell divisions in the growing point and formation of primary assimilating cortex.

Every adaptive strategies have their radical feature and ecological specialization. The vector of adaptive strategies trends on the reduction of the size organs and cells and complication their structure.

The degree of specialization of leaf structures defines the variability of species at different factor and perspective their cultivate . at wide or narrow ecological ranges.

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Resources, urban, sand & wind

R1: Chaired by A. Williams & T. Yamaguchi
R2: Chaired by M. Matthews & T. Nagahama

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Mechanical Classification of Wind–Sand Engineering and Its General Design Principles

Liu Xianwan*

Abstract–Mechanical Classification of wind–sand engineering is a scientific method. Two basic models of the wind–sand engineering are put forward as the circuitous flow on movable and fixed beds, and the binary flat–plate flow on a semi–infinite plane. According to functions of the wind–sand engineering, they are included in the following 6 categories: sealing, fixing, blocking, transporting, redirecting and dispersing. Design principles of wind–sand engineering are summed up as the permanent control principle, the comprehensive control principle, the counteracting principle, and the preventing first and controlling second principle.

Key words: Wind–sand engineering, mechanical classification, basic model, design principle

The classification of wind–sand engineering is a prerequisite for correct understanding and application of wind–sand engineering. The measures to prevent and control wind–sand harm have long been classified into biological, mechanical and chemical ways according to the materials used (Wu Zheng, 1987). The sand fences as one of the mechanical measures can be further divided into high–upright, upright and semi–buried sand–fences based on their vertical height. In addition, the function of wind–sand engineering can be summed up as four words, i.e. fixing, blocking, transporting and diverting (Zhu Zhenda et.al.,1979). These can be reflected by reduced wind–speed, weakened intensity of wind–sand flow, fixed sand surfaces, and controlled wind erosion (Wu Zheng, 1987).

However, it is not satisfactory to classify wind–sand engineering, solely on the materials used or on the vertical height. Even the same materials, when set in different ways, can produce quite different effects. The function of various sand–fences with the same height is quite different. Therefore, it is more acceptable to classify wind–sand engineering based on mechanical principles.

Wind–sand damage in nature generally results from both wind–sand flow and forward movement of sand dunes, and thus our discussion about the wind–sand engineering classification will be confined to these aspects. Other damage such as dust storms, dry–hot winds and soil salinization will not be included in this classification.

According to historical material [1,2] and our research results [3], the functions of wind–sand engineering are summarized as follows: 1) control sand movement; 2) protect sand surfaces from wind erosion; 3) keep and speed up movement of wind–sand flow; 4) force sand grains in the wind–sand flow to deposit; 5) alter the direction of wind–sand flow; 6) halt forward movement of sand dune; and 7) make the sand dune move forward in the way of scattered wind–sand flow rather than the whole dune body. Therefore, in accordance with the

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mechanical functions, the wind–sand engineering can be divided into: 1) cut off contact between gas and solid phases of the wind–sand flow; 2) inhibit interactions of the gas and solid phases of the wind–sand flow at the interface; 3) increase motion drag of the wind–sand flow; 4) reduce advancing resistance of the wind–sand flow; 5) change the wind–sand flow direction; 6) impede sand dune movement; and 7) decrease geometrical resistance of sand dune. In conclusion, this classification is shown in Table 1. From this table we see that there are more than 20 engineering measures against wind–sand damage, but they can only be included in two mechanical models, namely, the circuitous flow on the fixing or movable bed,

Table 1. Mechanical classification of wind–sand engineering

Mechanical models		Types	Usages	Functions	Examples
Shear circuitous flow on movable and fixed beds		Sealing	Seal active sand surface and alter its features	Cut off contact between gas and solid phases on the interface; and alter dynamic characteristics of sand surface	Spray asphalt emulsion; cover the surface with clay,and open holes
		Fixing	Fix active sand surface,and change movable bed into fixed or semi–fixed bed	Eliminate or weaken interfere of the gas and solid phases each other on the interface	Spray crude oil and salt solution; cover sand surface with coarse gravel; closure and planting; and straw and clay sand–barrier
Binary shear flat–plate flow of body on semi–infinite plane and camber	Binary plane and fence	Blocking or intercepting	Hinder or block the passing wind–sand flow and the dune movement	Increase movement drag to make sand grain deposit; slow down dune movement	Paling fence; forest belt; sand–blocking wall; semi–buried sand–barrier; sand–blocking ditch
	Binary plane or camber and plate	Transporting or diverting	Enhance or speed up the wind–sand flow to pass through protected area	Overcome or reduce friction drag and formdrag on surface	Top and bottom–sand–transporting bridge; zero deposition cross section
	Binary plane and winged bar	Redirecting	Redirect wind sand flow	Increase upwind resistance and force the wind–sand flow to move laterally	Single–line lateral–leading sand plate; feather–like fences
	Binary plant and semi–ellipsoid body	Dispersing or scattering	Make sand dune move forward in a turbulent wind sand flow	Decrease formdrag of dune, increase moving wind speed of grain above dune surface	Sand–bolwing dam; under–leading sand plate; drawing sand by wind force

and the binary flat–plate flow of body on the semi–and the binary flat–plate flow of body on the esmi–infinite plane. Their functions can be put briefly as six words: transporting (diverting), redirecting, and dispersing (scattering). Its mechanical principles lie in separating or weakening the interaction of the gas and solid phases of wind–sand flow on the interface; increasing or reducing the resistance of the wind–sand flow along the advancing path; and decreasing or eliminating the geometrical resistance.

1. Permanent Control Principle

Wind–sand engineering is a large scale, technical, long term measure. Commonly struc–

tures are built in harsh, dry environmeructures are built in harsh, dry environments where the availability of labar is law. The target is to prevent wind erosion, to encourage sand deposition and accumulation, and to prevent sand dunes from forward movement to keep the protected area from being buried. The most important principle of wind–sand engineering is to control wind–sand permanently.

1.1 Separating: In order to cut off contact between the gas and solid phases of the wind–sand flow and alter dynamic characteristics of sand surfaces, i.e. increase their elasticity. The thickness of the sealing layer should be adequate. The sealing materals should have good elasticity, aging–resistance, and endurance to striking and abrasion. They should not become soft under the scorching sun or become brittle or crack under cold winter canditions. Most important, they should be cheap.

1.2 Fixing(stabalizing): In such cases, the gas and solid phases contact each other, which creates favourable conditions for plants to grow. When spraying crude oil or salt solution, enough permeating depth is required. When laying straw or clay sand–barriers, they should not be spread over the whole surface. Before closure and planting, a straw sand–barrier should be spread first to create a favorable microenvironment to guarantee plant protection.

1.3 Blocking or intercepting: According to the permanent control principle, the aim here is to make the sand grains in the wind–sand flow deposit and stop dune movement. Hence, we should pinpoint the goals of protection to decide the specification and air permeability of fencings or forest belts. Otherwise, if the fencings are designed improperly or the forest belts have no irrigation, sand could accumulate in the front of the fence, and thus it is impossible to control wind–sand permanently. As for sand–blocking ditches, they should be combined with other measures because of its low sand–blocking amount and effects. For instance it will not be possible to protect railways from wind–sand damage only by sand–blocking ditches.

1.4 Transporting or diverting: The principle of transporting is to speed up wind–sand flow, to lift ground surfaces, or to narrow passing sectional areas, and to increase surface elasticity gradually. Diverting is only to make the wind–sand flow pass regardless of what happens later on. Therefore, to guarantee the wind–sand passes through the protected area permanently and thoroughly, we should combine the transporting method with the diverting method in wind–sand engineering.

1.5 Redirecting: It is an energy–consuming process to make the wind–sand flow transmit laterally. In order to force the wind–sand flow to transmit at a fixed angle, influences of sand accumulation along the advancing path should be taken into account. If the influences are small, a cheaper and open type of feather–like fence should be adopted; if the influences are great, an enclosed type of feather–like fence should be adopted. When one set of fences does not meet with the requirement, other sets of fences are used to keep the appropriate angle.

1.6 Dispersing and scattering: Whether the dispersing or scattering engineering succeeds or not depends on the construction of sand–blowing dams. The dam height, and cross sections must be adequate. Enough height is a prerequisite to increase wind force, but if the dam is too high it will suffer from wind erosion. So dams should be covered properly with coarse gravel. The vertical and cross sections of the dam are of vital importance to its sand–blowing effects and stability. The steep vertical section, for instance, with minor axis of ellipsoidal base, is beneficial to reduce the amount of work and slow down the dispersion of dunes. However, if the slope of the dam is too steep, there could be deposition at the foot of upwind and leeward slopes, and wind erosion of the dam of body. Therefore, it is not possible to build an effective sand–blowing dam of local materials unless its stability and effectiveness are maintained through constantrepair.

2. Comprehensive Control Principle

In order to control wind–sand damage permanently, a comprehensive control principle is essential. This requires a combination of various wind–sand control engineering designs, and each project also requires proper protection, and maintenance. For example, if there is abundant sand resources, these should be taken into consideration and the remote wind–sand flow should be hindered or redirected. Sand dunes within the protected area should be leveled, and the wind–sand flow outside the protected area should be made to move forward smoothly. should be hindered or redirected. sand dunes within the protected area should be leveled, and the wind–sand flow outside the protected area should be made to move fornard smoothly. Only by the rough and appropriate design can we achieve the goals of wind–sand damage controlled engineering bodies themselves from wind erosion, and maintenance to protect the bodies from falling and being buried, and to keep fences at the correct height. In addition, it is necessary to pay attention to protecting the front part of the feather–like fence, and covering wind eroded sections of sand–blowing dams.

3. Counteracting Principle

The design of wind–sand engineering should put a premium on what it causes as well as its functions. The reason for this is that unlike ice or snow deposition, the sand deposition is a long–term process. Once a tract of sand accumulates, the fixed bed will turn into a movable bed, and thus the engineering will lose its effect, or even do some damage. For instance, the width of the under–leading sand plate should be designed to avoid the accumulation at its front and off–front mouths. The plate should be smaller and have a larger front mouth. The angle between the plate and the inflow should be less than 90° or more than 180° in the opposite direction. Taking another example, the single–line lateral–leading sand plate should be designed in accordance with the thickness of the local wind–sand flow layer, and its breadth should be in accordance with the non–accumulating length. This is the reason why we use a set of feather–like fences instead of the single–line lateral–leading plate. Several sets of the fences can transport the sand by relay away from the protection area.

4. Preventing first and Controlling second Principle

Wind–sand damage and its engineering control measures must be incorporated in the overall plan and design of factory and traffic constructions, and mining project etc. This is a very important principle, and should be included in the policy of environmental protection. Because wind–sand engineering requires a lot of investment, labor power, materials and funds, only by adopting the above–mentioned principles can we get an ideal, cost effective design plan for wind–sand engineering.

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Experimental Projects in Desert Architecture - Israel

Y. Etzion *

Abstract - The paper describes a few projects executed during the last few years by the Desert Architecture Unit in the Israeli Negev, in which a special attention was paid to desert environmental conditions.

Key Words: Desert Architecture, Thermal Comfort, Energy

The southern half of the land area of the State of Israel is the Negev desert, but only 7% of the Israeli population lives there. This is probably the main reason why Israeli housing authorities have till now paid only little attention to the development of appropriate desert architecture and building technology. Most of the current construction in the Israeli Negev, as well as that of the last few years, has been of designs popular in the northern part of the country. Sometimes buildings in the Negev are slightly better insulated to conform with the Israeli standard for the thermal insulation of buildings[1] , but this is the degree to which buildings are modified to fit the desert conditions. In public buildings, often air-conditioning is provided, in residences the air conditioning system has in most cases to be installed by the owner. Other aspects of desert environment are not addressed at all.

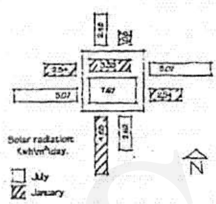

Fig. 1 - Sede-Boker - yearly radiation - horizontal, east, west, north, south.

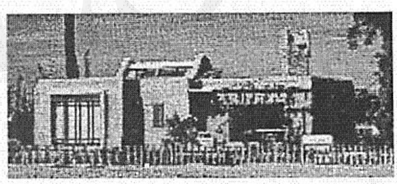

Fig. 2 - Sede-Boker - The "Adobe" house, view from the south.

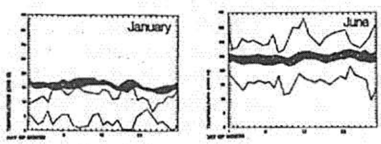

Fig. 3 - Sede-Boker - The "Adobe" house, internal and ambient temperatures, January 82 (left), June 82 (right)

During the last twelve years, the Desert Architecture Unit of the J. Blaustein Institute for Desert Research (Ben-Gurion University of the Negev) has been deeply involved in research, experimentation and design appropriate for the desert conditions of the Negev. This article describes only a few of the recent design-research projects that have been executed by the Unit. Most of the projects are located in Sede-Boker, at the Ben-Gurion University campus, but some are in other locations in the Negev, such as Netivot and Yotvata.

Sede-Boker is located at the heart of the Negev highland at an altitude of 500 m above sea level. Its climate derives directly from its geographical location: very intense solar radiation both in summer and winter (fig. 1), and albedo of 0.3 that amplifies the affect of the solar radiation even more. Temperatures during the summer will reach a daily average maximum of about 33°C, but will drop during the night to as low as 16 or 18°C. This very large temperature swing provides for an efficient night time convective cooling of buildings, given they are well designed to take advantage of this phenomena. Winter temperature may drop occasionally to just below freezing, the average daily temperature in the winter is 9°C. The large number of clear sky days, combined with the strong solar radiation make solar space heating a very attractive and pretty reliable technique.

The first major project of the Unit was the "Adobe House" [2] designed and built in the late 1970's (fig. 2). This was a joint project of two research units of the J. Blaustein Institute for Desert Research: the Desert Architecture Unit was in charge of the design, the building material and the construction of the building; the Applied Solar Calculations Unit took care of the energy aspects. This project was the first major introduction of solar design to Israel, and also an attempt to introduce the old-new technology of earth construction. While failing, to date, to jump-start a serious tendency towards earth construction, the building was a noted success in thermal and energy performance. It proved to provide

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very satisfactory internal thermal conditions both in summer and winter (fig. 3) with only an insignificant amount of fossil energy needed for back-up during the winter. Comparison studies with other houses showed that the building is over 90% energy independent: In 1982, which was the harshest winter since its completion, the house required about $22 of back-up heating, compared to an average of about $500 needed for other similar size houses in Sede-Boker. In the summer the building heavily relies on night ventilation, assisted by a ventilation tower which increases the rate of air flow in the building. Of particular interest in this building is the rotating prism wall that was developed by the Applied Solar Calculation Unit, and which is installed at the south facade of the house's bedroom.

The second research-design project of the Unit was an earth-bermed dome structure [3], which was intended to be a test facility for earth-sheltered construction (fig. 4). This structure of about 70 m^2 consists of two domes. The north one is completely earth bermed, with the exception of two small windows which are used for day lighting and convective cooling during summer nights. The south dome is opened to the south, from where it gets all the needed solar radiation for heating during the winter. This opening is kept widely open during summer nights to assist in the convective cooling of the building. The structure has been monitored intensively under various patterns of usage, and showed that during the winter it was possible to maintain its southern dome at 20°C with as little as 0.8 Kwatt*hr*day-1 of supplementary energy. The northern dome required somewhat more energy - about 1.5 Kwatt*hr*day-1. During the summer the temperature inside both domes were maintained at the comfort zone solely by keeping an appropriate pattern of closing the building during the day and opening it up for ventilation at night.

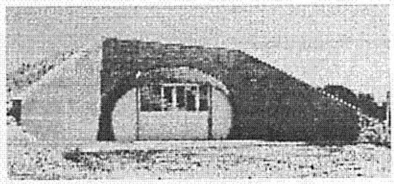

Fig. 4 - Sede-Boker - The experimental earth bermed structure.

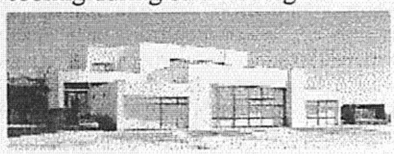

Fig. 5 - Sede-Boker - The Zukerman Community Center - summer mode

Fig. 6 - Sede-Boker - The Zukerman Community Center - winter mode

A much larger project was the Zuckerman Community center that was built adjacent to the local high-school (figs. 5,6). The building's 700 m^2 floor area is supposed to provide the students of the school with spaces for their afternoon curricula: It holds 4 youth clubs, a small "cafe" sitting area, a darkroom, a pottery room a music room and administration space. In order to minimize the effect of solar radiation in the summer and to decrease to a minimum the heat losses through openings during the winter, the building's east and west elevations do not have any significant openings, except of a few rest room windows. The large glazed area to the north, which is bringing in daylight, is built of glass bricks, whose thermal conductivity is low compared to regular glazing. Most of the south facade of the building is glazed, to take advantage of solar radiation during the winter. Special effort was made to design the south facing openings as "smart" ones, so that full advantage can be taken of both the energy aspect and the connection of the yard with the internal spaces. A series of small openings, a fan installed in each of them, provides additional forced ventilation to the building during the summer nights. Not being completely finished, this particular building has not been monitored yet.

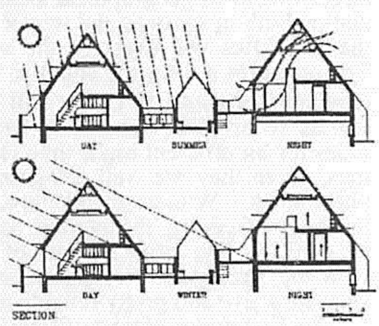

Fig. 7 - Sede-Boker - The experimental Student dormitory building - summer and winter modes.

The students dormitory in Sede-Boker [4,5] is a project still to be built, but its design incorporates some of the most important basics of desert design. The leading objectives in the design of this building were the reduction of the ratio between volume and external surface area as well as the optimization of the solar exposure of the elevations in both summer (minimum) and winter (maximum) (fig. 7). The triangular section of the building reduces the roof area, which is the most susceptible component of the building to heat transfer into the building during the summer, and out of it during the winter. Light shading devices were added on the tilted walls in order to shade the walls from the summer sun.

The largest and most sophisticated project yet done by the Desert Architecture Unit is the International Center for Desert Studies, built for the Desert Research Institute in Sede-Boker [6]. This 1000 m^2 building is the center of activity of the international programs of the Institute, and includes two large apartments and six smaller rooms for accommodating visiting scientists and scholars, a cafeteria and a lounge, the main library of the Institute, a few teaching classes, a teaching laboratory and (of course...) - administration space (fig. 8). The building is builtaround a sunken atrium of about 500m^2, whose floor is about 4m below the surrounding grade. From the outside, the building is bermed with earth up to the height of the second floor windows. The atrium is covered by a special "selective" sheet of polycarbonate, which reflects most of the direct solar radiation incident to the sheet within the range of +/-9° to the normal, but allows penetration of most such radiation incident at greater angles. The geometry of the roof was determined so that during the hot hours of the summer most radiation is reflected off the roof, while during the winter most of it is admitted. Provisions were made to completely close the atrium in winter, so that solar heating will be maximized, and fully open it during the summer, so that maximum flow of air will occur and reduce heating.

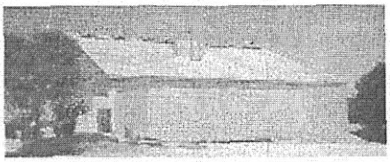

Fig. 8- Sede-Boker - The International Center for Desert Studies, view from the south

The need for heating in this building is significantly reduced by the earth sheltering and the berming of earth on the outside walls. It is reduced even further since the exposed walls of the building face the interior of the atrium, in which the temperature are higher than the outside temperatures due to the affect of the solar radiation . The little heating needed, is provided by extracting hot air from the highest part of the atrium into the internal spaces of the building (Fig. 9). In the summer a very large evaporative cooling tower provides cool air to the atrium. This tower is supplying the courtyard with app. 25,000 m^3 of pre-cooled outside air, yielding up to 120 kw of cooling in the hottest hours of the summer (fig. 10) The floor level of the atrium was designed in such a way as to store most of the cooled air at the most used area.

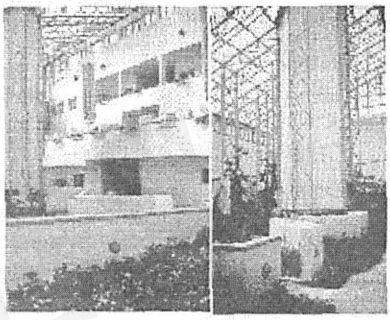

Fig. 9 - (left) Sede-Boker - The International Center for Desert Studies, view of the internal courtyard.

Fig. 10 - (right) Sede-Boker - The International Center for Desert Studies, view of the large cooling

The Etzion residence [7] is the private house of the author of this article. The house was designed to provide maximum thermal comfort with the least use of fossil energy as possible. The floor area of the house is 250m^2, and it was designed to be as "heavy" as possible under economical constraints, in order to increase its thermal storage and inertia. The structure of the house is made of concrete, the walls are in-fill of silica blocks. The house is heavily insulated with 5 cm of polystyrene on the walls, and 10 cm on its inverted concrete roof. Most of the openings are due south, and there are no opening facing west and east, except for relatively small openings in the eastern side of the living room, that could not be avoided given the beautiful view seen from them (fig. 11). The north facing windows are small, and include a device which converts the shutter into a wind deflector to enhance the northwestern air flow through the house during the summer nights. In the upper floor rooms, which face north, there are south facing clerestory windows which bring in solar radiation during the winter days. All windows are shuttered with extruded aluminum sections filled with polyurethane to provide protection from summer solar radiation and increase the openings thermal resistance when they are closed, while allowing the maximum solar interception in winter for space heating (fig. 12,13). The main spaces of the house - the living room, the kitchen and the master bedroom - are open to a north facing courtyard, which is always almost fully shaded by the upper floor, to provide exterior space for summer use.

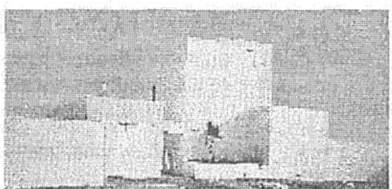

Fig. 11 - Sede-Boker - The Etzion residence, west elevation. Notice the absence of openings.

The Etzion house is part of the first solar neighborhood designed and built in Israel. This 78 housing units neighborhood was designed by the Desert Architecture Unit under a commission from the Ministry of Housing [8]. Special attention was given during the design to the solar rights of the individual houses, as well as to their appropriate potential for natural ventilation (fig. 14). The