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VEGETATION TYPES IN THE FORELAND OF THE QIRA OASIS: PRESENT DISTRIBUTION AND CHANGES DURING THE LAST DECADES

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1 INTRODUCTION

The indigenous vegetation surrounding the river oases on the southern rim of the Taklimakan Desert has drastically diminished due to overexploitation as a source of fodder, timber and fuel for the human population. Within the framework of the Chinese-German research project on the development of sustainable management strategies to combat this desertification detailed vegetation analysis was conducted at the Qira Oasis on the southern rim of the Tarim Basin (Hotan Province, Xinjiang Uighur Autonomous Region, P.R. China). It is the aim of this contribution to give an overview on the spatial extent of the vegetation types occurring today in the foreland of the Qira Oasis and to describe how the foreland landscape has changed in the last 50 years.

2 METHODS

A vegetation map was prepared by a ground survey performed in the summers of 1999 and 2000 using four-wheel drive vehicles and camels. The base of the map was a SPOT 4 satellite scene (Satellite Pour l’Observation de la Terre, No. 209-276 26/09/98, with center coordinates of N 36°51’30”N, E 80°44’28”E and dating September 1998). The image was projected into the UTM grid (44 S) and transferred into a GIS (ArcView 3.1). Vegetation reference plots were established in the western and northern periphery of Qira and vegetation type borders in this foreland section were mapped with GPS in the ground survey. In particular, all locations having remnants of *Populus euphratica* stands were noted. Such places can be unequivocally recognized by parts of trunks with bark and layers of dead leaves covered by sand. In the following, this situation is referred to as the state in 2000.

The situation in 1956 was assessed using aerial b/w photographs, dated 18/10/1956 (series K-7-18X56). An exact georeferencing of the photographs turned out to be impossible because no feature that corresponded to objects present today could be detected. Therefore, only road bends on some major traffic routes provided a rough georeference ± 100 m. Six overlapping photographs were combined in ArcView (K-7-18X56 no. 20, 22, 24 and 39, 41, 43). Using a stereoscopic microscope, trees, river courses and fields were delineated on the GIS map.

3 RESULTS

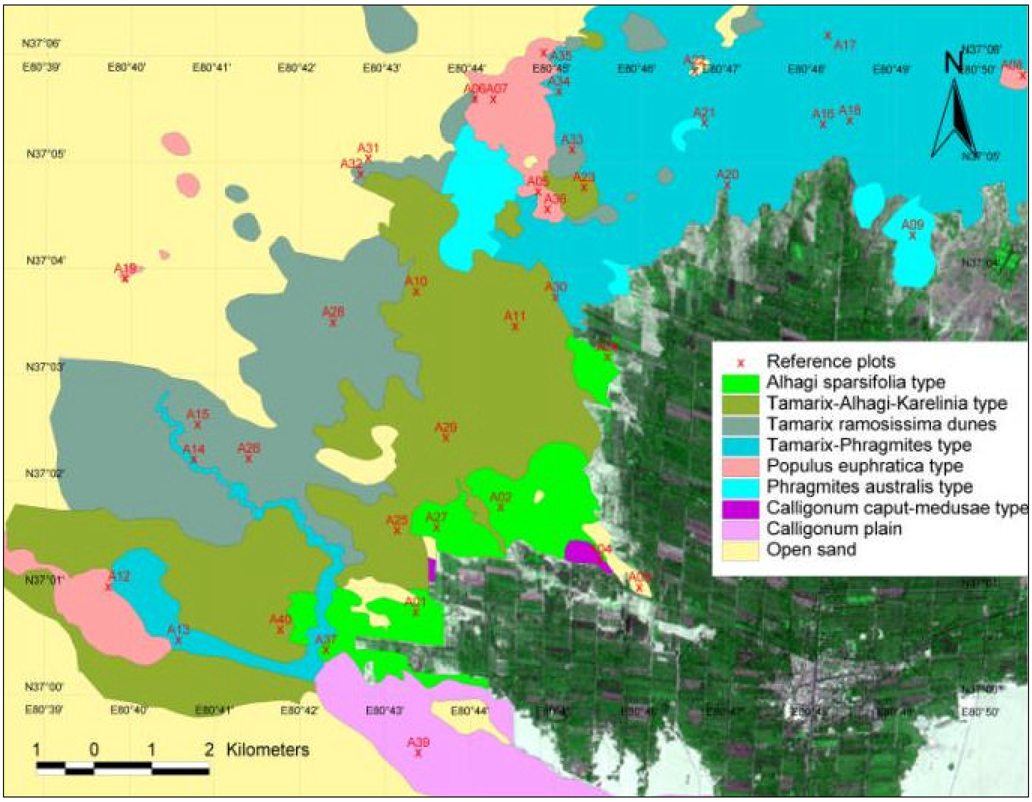

Fig. 1: Vegetation map of the Qira Oasis foreland. Location of the ground reference plots is given in red numbers. Please note that plot A38 is outside the shown map section.

Figure 1 shows the vegetation map of the northern and western sector of the Qira Oasis foreland. In total, nine vegetation types or types of land cover could be distinguished. The vegetation is arranged in belts around the oasis with eight main vegetation types that are characterized by only five dominant species: *Alhagi sparsifolia* Shap., *Populus euphratica* Oliv., *Tamarix ramosissima* Ledeb., *Calligonum caput-medusae* Schrenk and *Phragmites australis* (Cav.) Trin. The by far most abundant vegetation type are stands of *Tamarix ramosissima*, which cover more than 90% of the area in the oasis' surroundings. *Tamarix* forms not only dominance stands but also grows in codominance with *Phragmites* and with *Alhagi* and *Karelinia caspica* (Pall.) Less. *Phragmites* forms dominant stands mainly in the north of the oasis (east of E 80°48'). *Calligonum caput-medusae* stands grow only at two locations where they had been planted for wind and sand protection in direct contact to the edge of the oasis. Another species of *Calligonum* (*C. mongolicum* Turcz.) grows in the river valleys. In the ground survey special effort was put into mapping of the remaining stands of *Populus euphratica* trees. At present, *P. euphratica* forms two main stands north and southwest of the Qira Oasis.

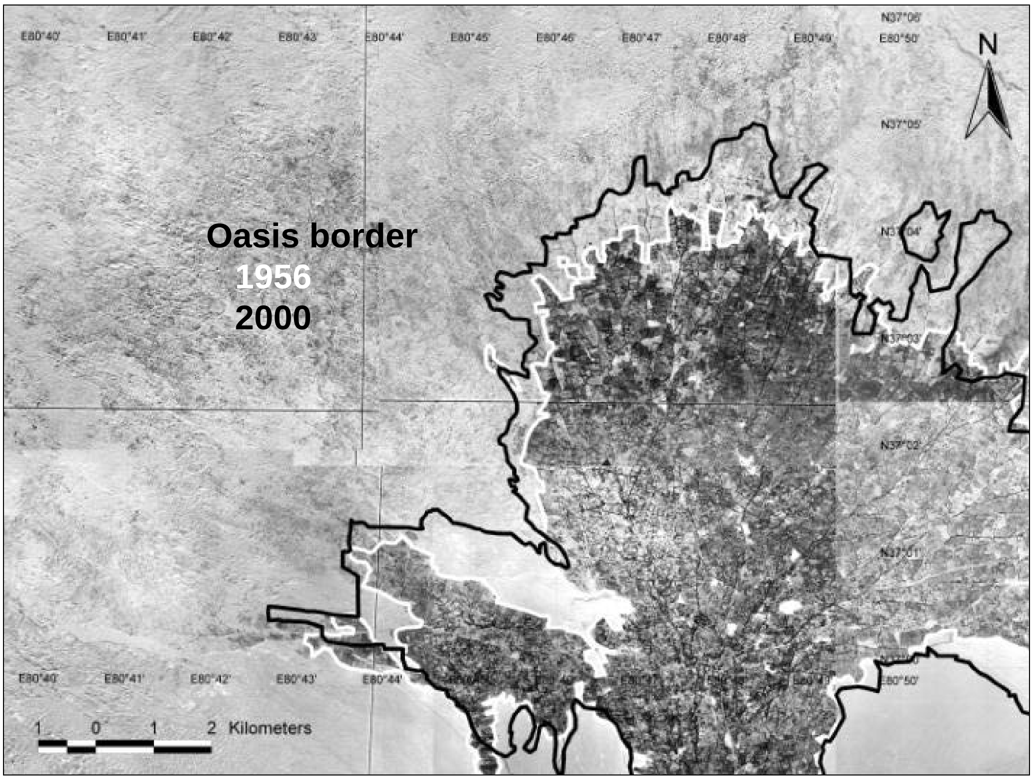

Fig. 2: Aerial photographs from 1956 with the oasis border in 1956 in white and in 2000 in black.

The evaluation of the 1956 photographs documented a drastic and profound transformation of the oasis that, according to inquiries, had occurred in 1983. As a consequence, the course of canals, location and size of fields and the road system were completely different in 1956 compared to 2000 (see Graefe et al., this volume). Figure 2 shows that the agricultural land increased in area, from 76 km^2 in 1956 to 90 km^2 in 2000. The expansion of farmland occurred mainly north of the oasis, in the area of sand dune intrusion west of the center and on the shoulder of the gravel plain in the east. There was also a loss of some area in the southwest due to water erosion by the Qira River. It is noteworthy that this gain in farmland area was still detectable despite the reported trend of large losses of arable land in the 1980s (Zhou 1993; Zhang et al. 2001; Zhang et al., this volume). This loss has not yet counterbalanced the increase in agricultural area that must have occurred between 1956 and 1980 (see Figure 3 of Zhang et al., this volume; please note that the larger total area in arable land in their figure results from the fact that they refer to the entire Qira County, and not only to an oasis section).

The shifting dune west of the center covered almost 3.5 km^2 in 1956 but was almost completely fixed in 2000 (Fig. 3), most likely due to desert reclamation efforts in the 1980s (Zhang 1993). In contrast, the open sand approached closer to the northwestern outer foreland perimeter in 2000 by a distance of about 1 km. Since the oasis expanded by approximately 0.5 km, the width of the vegetation belt in the northwestern foreland decreased from 7.5 km in 1956 to 6 km in 2000.

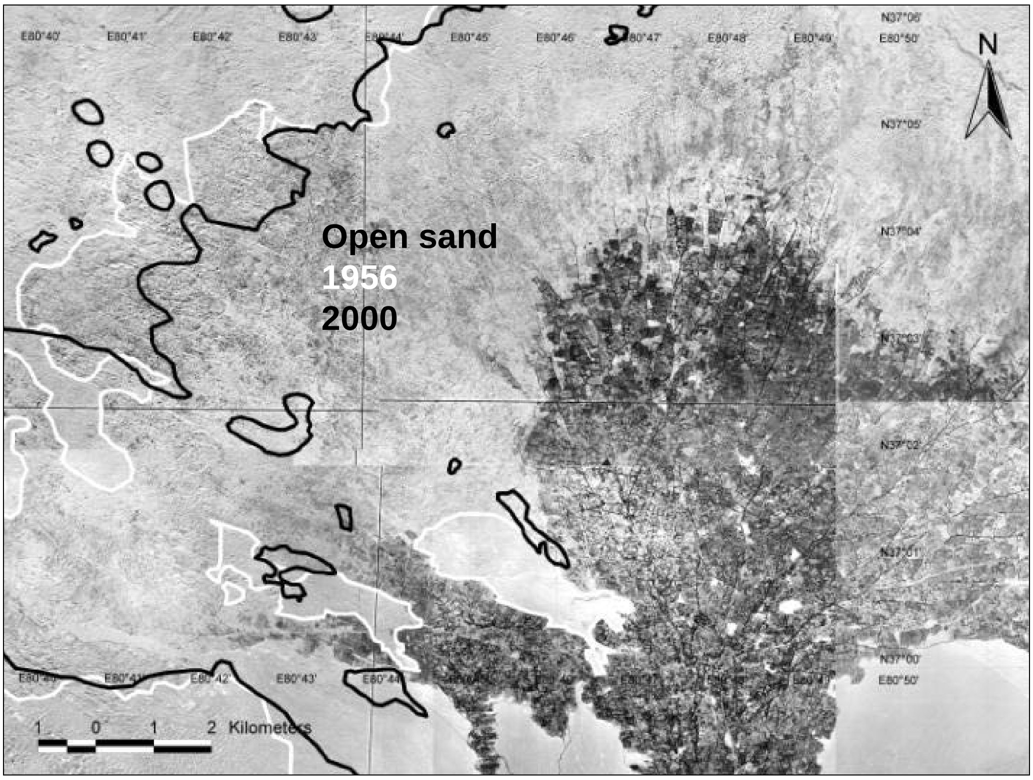

Fig. 3: Aerial photographs from 1956 with areas covered by open sand in 1956 outlined in white and in 2000 in black.

In contrast to expectations, the forest area covered by *Populus euphratica* was not larger 44 years ago than today (Fig. 4). Even when stands of trees adjacent to the outer border of the oasis, which could not be distinguished from planted poplars (*P. nigra*, *P. alba* and hybrids) in the aerial photograph, are taken into account, the area was smaller in 1956 (1.5 km^2) than in 2000 (5.5 km^2). Surprisingly, in the main area of *P. euphratica* stands in the north (between E 80°44' and E 80°45') no tree could be found in 1956. Today this area is covered with a large *P. euphratica* forest (Fig. 1). There is much information available about this particular stand because it was one of the project areas (see other contributions at this workshop). According to tree ring analysis the forest grew up in 1977 (Gries et al., submitted). Inhabitants of that part of the oasis said that the trees started growing after an occurrence of exceptional intensive flooding (Zhang Henian, pers. comm.). Interestingly, the trees show clear signs of clonal growth by forming clusters of two to five stems. DNA fingerprinting with AFLP technique confirmed that all (but one) trees within an sampling area of 4 ha belonged to one genet (see Bruelheide et al., this volume). A clone of this size must have developed over centuries. This large time span corresponds to radiocarbon data of dune development (Jäkel 1991). Therefore, it can be concluded that some time in the past, i.e. before 1956, a large forest area had been cleared and that at this site the present forest grew up since 1956. The complete lack of trees in this area in 1956 is explained by the fact that only trees above a certain height could be identified on the aerial photograph. Resprouting trunks of limited size would not be distinguishable from other shrubs in the photograph.

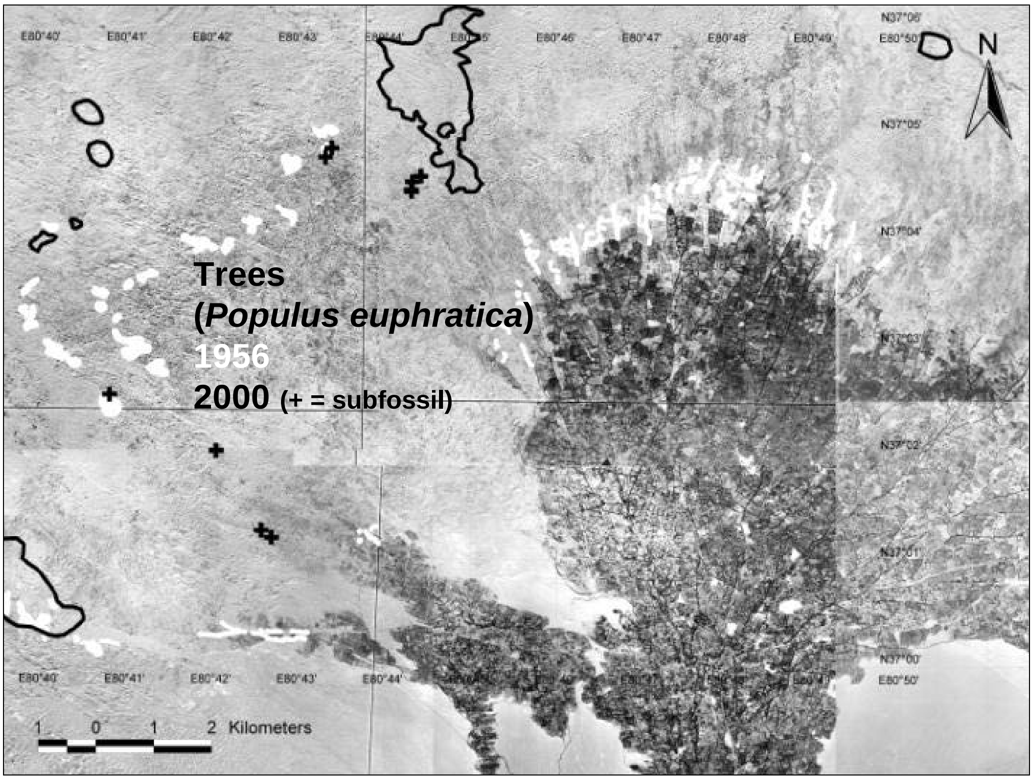

Fig. 4: Aerial photographs from 1956 with occurrences of tree vegetation in 1956 marked in white and in 2000 in black. The black crosses indicate locations where subfossil records of *Populus euphratica* were found in 1999 and 2000.

In contrast to the forest reestablishment in the north, many scattered patches in the west that were probably covered with trees in 1956 are treeless today. Our field work revealed several sites where sand-covered layers of subfossil *Populus* leaves and chunks of wood were encountered, also in areas where not a single *Populus* tree is found at present. The remnants of trunks showed clear signs of chopping indicating that trees had been felled. These patches partly correspond to places where remnants of former *Populus* stands were found (Fig. 4). At least three of these sites had already been deforested in 1956, in particular the locations near to the oasis border.

Figure 5 shows that the main Qira River changed its channel considerably. In 1986, a furcation occurred at N 37°00’30”, E 80°42’10”, and part of the river flowed northward. This event was also responsible for the interruption of the old desert path between Qira and the neighbour oasis Lop. The old river bed moved northward by a distance of about 400 m. This northward shift was also responsible for the loss of farmland in the southwestern part of the oasis (Fig. 2).

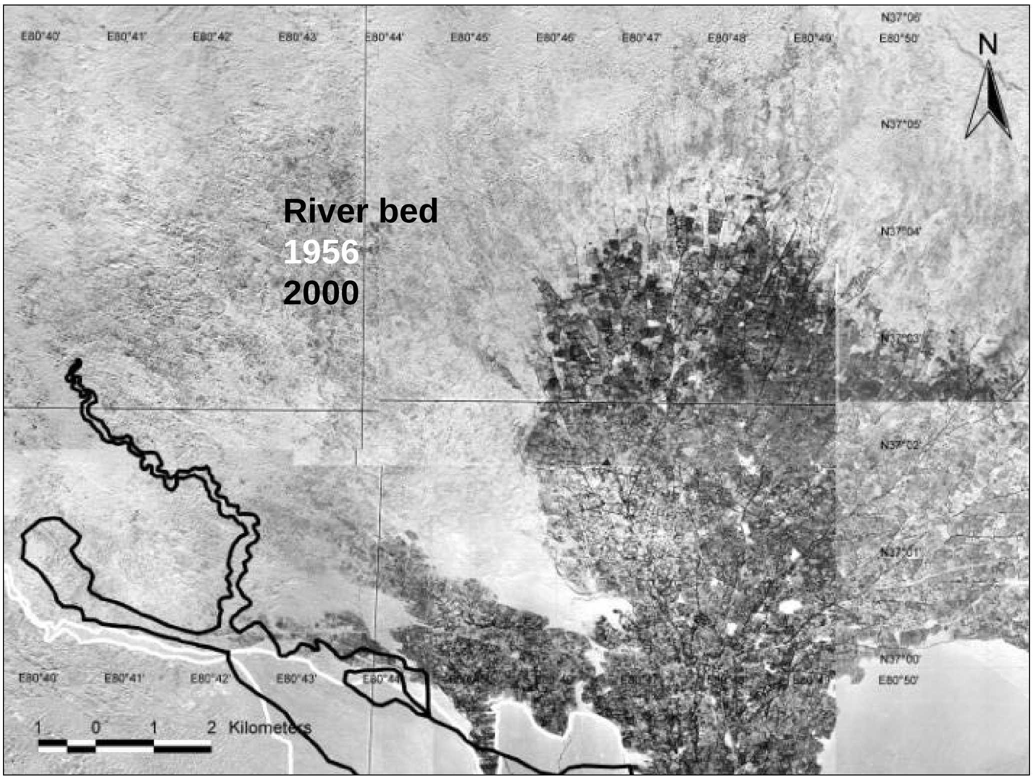

Fig. 5: Aerial photographs from 1956 with the river bed of the Qira River in 1956 outlined in white and in 2000 in black.

4 DISCUSSION

The belt structure of the natural vegetation reflects two environmental gradients in the oasis foreland: a gradient of decreasing distance to ground water from south to north, indicated by an increasing dominance of *Phragmites*, and a second gradient of increasing influence of drifting sand from the oasis center towards Northwest, indicated by decreasing ground cover of plants. All vegetation types have important functions in the oasis ecosystem: on the one hand, they are protection belts that prevent moving dunes from intruding into the arable fields (Zhang 1993; Zhang et al. 2001); on the other hand, they are a source of fuel wood, timber and winter fodder, and not least, they are important rangelands.

The results give evidence of profound landscape changes within half a century. The increase in the oasis' size corresponds to the demographic growth trend in the human population. Between 1973 and 1988 the Qira population increased from 87 000 to 112 000 (Zhang et al. 2001) and was estimated to be 130 000 in 1998. If there was a temporary loss in farmland area in the 1980s (Zhang 1993), it has been overcompensated since then. The growth in the cultivated land area corresponds to the 'oasification' trend in Xinjiang observed in the last four decades (Tian and Song 1997).

The study revealed that the idea of the existence of an extensive forest belt in the Qira area half a century ago has to be revised. If this belt had ever existed, it had already been reduced to patches 44 years ago. The clonal regrowth of the *Populus* stand in the north is proof that it had previously been destroyed, signifying that considerable deforestation had already taken place by 1956. It is not surprising that the oasis' inhabitants have always had a considerable impact on the forest area, but it is alarming that the remaining area of *Populus* forests of the 1950s has been further reduced by about 50% in the entire Tarim Basin to date (Tian and Song 1997).

The perspectives for the future of the Qira Oasis are even more alarming. If no effective countermeasures are taken against the overuse and degeneration of the foreland vegetation, it can be expected that the front of the open desert will move further inwards in the next few decades, and ultimately reach the oasis border. The local authorities in Qira have recognized this threat and have forbidden the extraction of winter forage (mainly *Alhagi*) and fuel wood (mainly *Populus* and *Tamarix*) from a zone of 3 km around the oasis. However, since grazing is not affected by this legislation, it might prove ineffectual. Once destroyed, the foreland vegetation can only be re-established with great difficulty. Regeneration experiments have shown that the natural regeneration of all dominant species by seeds, with the exception of *Tamarix ramosissima*, is an extremely rare event (Bruelheide et al., unpubl.). Especially *Populus euphratica* has difficulties regenerating itself.

When natural regeneration from seeds was observed, this always occurred on the river plains after flooding (Bruelheide, pers. observation). This fact emphasizes the importance of river dynamics for the maintenance of viable plant populations of all species. However, the dynamics observed over the last 44 years in this study have been probably much smaller than in former times, due to the increasing water demands of the expanding oases that allow ever decreasing amounts of water to flow into the desert (Zhou 1993). This trend is obvious in the number of reservoirs built in the last decades. At present, there are 466 reservoirs in the whole of Xinjiang with a storage capacity of 5.93 x 10^9 m^3 (Tian and Song 1997), which almost corresponds to the magnitude of the annual discharge of the Tarim River (Cheng 1997). The oases in Xinjiang account for 4.3% of the total area but consume 55.5% of the surface runoff and take up 72% of the actually diverted discharge (Tian and Song 1997).

It can be predicted that the construction of new reservoirs in the upper reaches of the Qira River will drastically reduce the distance the rivers intrude into the desert, the area of river flood plains, and finally, the area of potential regeneration sites for all plant species. Another, poorly investigated aspect of reducing the discharge by reservoirs and oasis water consumption is to which degree the recharging of ground water is affected. Since all dominant plant species in the foreland are phreatophytes (see Thomas, this volume; Gries et al., submitted), a decreasing water table in the foreland might have dramatic effects with a total die-off of plants at the landscape level. Such effects have already been observed in the lower reaches of the Tarim River where the ground water level dropped by 6 to 8 m in the last decades (Zhou 1993). If the foreland vegetation vanishes, there will be nothing left to stop the sand encroachment of the oases.

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