RANGELAND ASSESSMENT OF THE WAKHAN CORRIDOR STUDY AREAS

Results from the 2007 Field Season

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Introduction

The major rangeland assessment effort occurred in the Wakhan Corridor. The rangelands of the Wakhan Corridor evaluated during 2007 consisted of areas in both the Big Pamir and Little Pamir. My primary objective was to describe the different rangeland sites and plant communities, to determine productivity (above ground standing crop), and to determine methodology for classifying rangeland degradation. I have chosen to use a rapid reconnaissance methodology to see as much of the area as possible to help ensure that I have observed most of the rangeland types. I believe it is important to observe most of the area to evaluate areas important for pastoralists and areas where there may be competition for forage between livestock and wild ungulates. These rangelands are the basic resource for the livestock and wildlife that have used the Wakhan Corridor for centuries. There is no doubt that livestock grazing has impacted these rangelands and in many areas overuse by livestock has decreased site productivity associated with soil erosion and changes in plant composition. Other human use has also impacted rangelands by removing shrubs for fuel (in some areas minor use of trees was observed), cutting of hay, use of "peat" from *Carex* meadows, irrigation ditches, and (in a few areas) ditches for draining or diverting wetlands. A number of plant species appear to be "disturbance" species and appear to be rarely used by livestock.

I have separated the section on Wakhan rangelands into four major sections. Initially, I provide a brief discussion of training of the rangeland assessment team. Second, I provide a general overview of our routes and some notes on general observations. Third, is a major section on the rangelands of the Wakhan Corridor concentrating on the upper Wakhan. In this section I discuss plant cover/community types, provide results of rangeland mapping using vegetation indices and supervised classification, and discuss rangeland degradation in separate subsections. The finals section is a brief summary and goals for future work.

Rangeland Field Training

The training involved working with three Afghan students (recently graduates of Kabul University) and two Wakhi young men. The major training for the three Kabul University students consisted of the development of skills with a compass (determination of aspect, slope and direction), in the use of a global positioning system (GPS) to locate sites (elevation and geographic coordinates and to be able to return to the sites), establishment of transects (including photo methods), plant identification skills, quantification of plant community attributes (cover, above-ground biomass) and discussion of rangeland degradation attributes. The Wakhi trainees participated in the above activities but were not required to use a GPS or measuring transects (they did help with establishing transects). The Wakhi concentrated on measuring biomass by clipping plant material by species. One Kabul student, Mr. Mohammad Ayoub Wafi, continued to work as a rangeland technician from September to March in helping with data transfer to electronic format, summarizing data and in some analyses of the data.

General Description of Routes and Rangeland Reconnaissance

Our reconnaissance allowed us to view rangelands and their use by pastoralists and to some extent by wildlife[1]. Because our team concentrated on vegetation aspects, our observation of wildlife may have been rather random (we likely missed many more animals then we observed); however, we did observe a number of Marco Polo sheep, Ibex, wolves, foxes and hares, and we observed more wildlife in areas of better vegetation conditions and less human impacts. Our first rconnaissance[2] began at Sharhad-e Broghil, traveling north toward Lake Zorkul, and then again continued east along the lake to the Tajik border. We then followed our trail back to Lake Zorkul, but continued west toward Alisu, and eventually southwest through Sargez Pass to

[1] Our sightings of wildlife are "random observations" mostly as we were traveling or in camp. Our crew was relatively large, often with 10 to 12 pack animals, 6 to 8 porters and 3 to 6 rangeland technicians so most of my sightings were when I was either ahead of the crew or when we were in camp. A number of small mammals and birds were observed but I will only mention the larger species such as wolves, foxes, ibex and Marco Polo sheep.

[2] The rangeland team during this first trip consisted of one student (M. Ayoub Wafi Nahrabi), a Wakhi guide and cook, and approximately 6 porters. I had planned on the three trained technicians from our 2006 work to work during summer 2007 but they were not allowed to leave their current positions. We therefore had a very small team.

Sargez (Fig 1). Our second reconnaissance was in the Little Pamir area with the objective to observe rangelands of the main valley of the Little Pamir in the Chaqamatin Lake area to Tegermensu. Our second route also began at Sharhad-e-Broghil and finished at the same point (Figure 1).

Field notes of these reconnaissance trips, photos (see Figure 2), and transect data have been included in a rangeland GIS and is not detailed in this section. During these reconnaissance trips we established 134 transects with spatial coordinates and photos to be used as potential permanent photo points and for establishing plant community information. We also measured standing crop (kg/ha) on most of these sites to allow for an estimation of forage production and thus a general guide to grazing capacity for future analyses. The detailed transect information will be presented and discussed in the section "Plant Community Analysis and Description". The following is an overview of the rangeland assessment team's route to describe to other researchers areas visited.

First Reconnaissance. As stated above we began at Sharhad e-Broghil on 25 June and traveled up a trail through Matak Chapdara valley. Approximately 0.3 km south of a small Wakhi camp (Uween-e-ben) at 37.05372N; 73.45873E we observed a group of Ibex. I counted 5 females, but some of the porters said they observed about 20 individuals before I returned to our camp following plant collection. This location was just below an unnamed pass dominated by alpine vegetation. Steep slopes and rocky conditions force livestock into narrow steep valleys, making grazing and productivity quite low. We continued up the valley toward a Wakhi camp called Past Tasaman in upper Matak Capdara and toward Spreg Shir Uween pass (approximately 4732 m). After the pass we traveled northeast to the Ptukh Shur stream valley and Chapdara Valley.

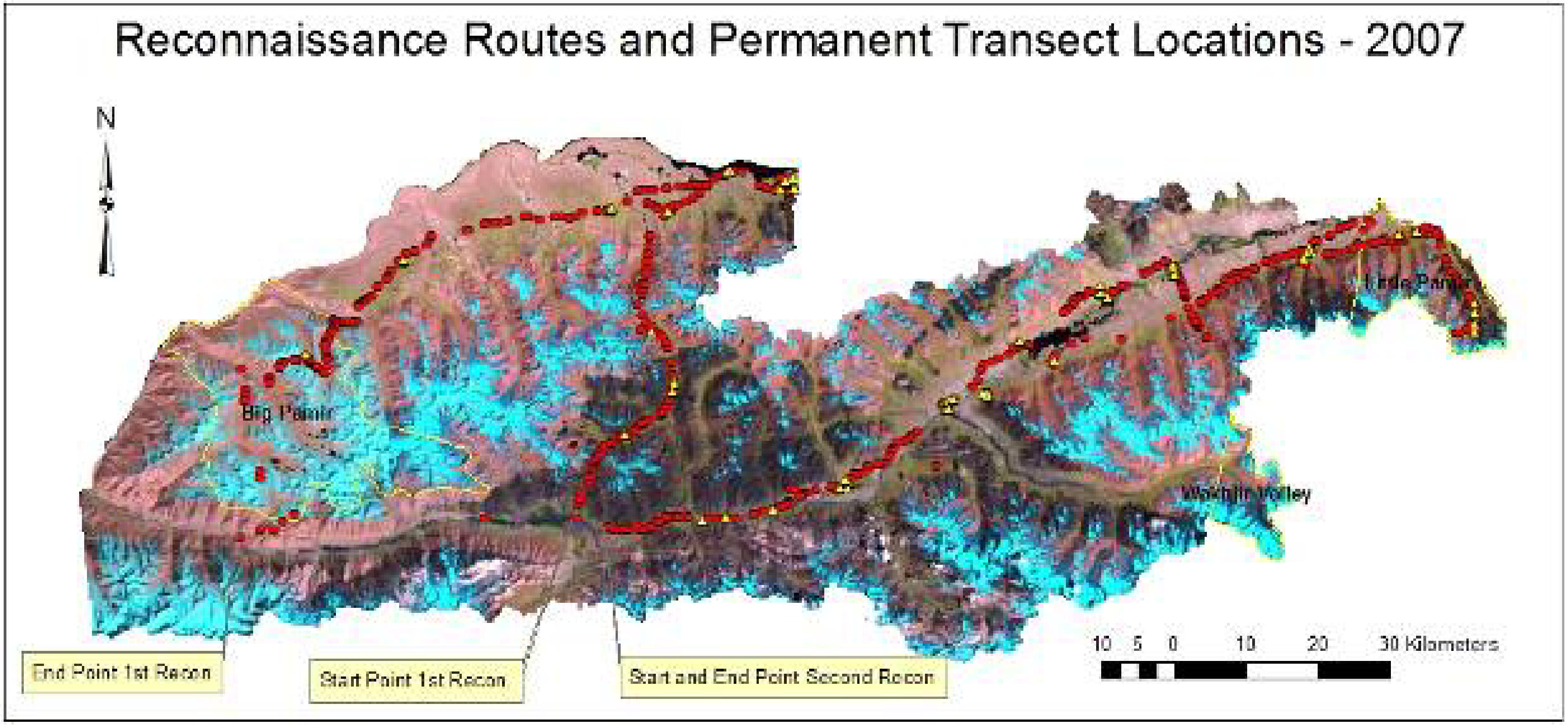

Figure 1. . Reconnaissance routes (individual points shown in red) and permanent transect locations (points shown in yellow) for first and second rangeland reconnaissance trips in 2007. All points with photographs are hyperlinked in the rangeland GIS. Base image is Landsat ETM+ image with 5,4,3 band combinations for red, green and blue respectively. Snow and glaciers appear turquoise, clouds white, and vegetation green.

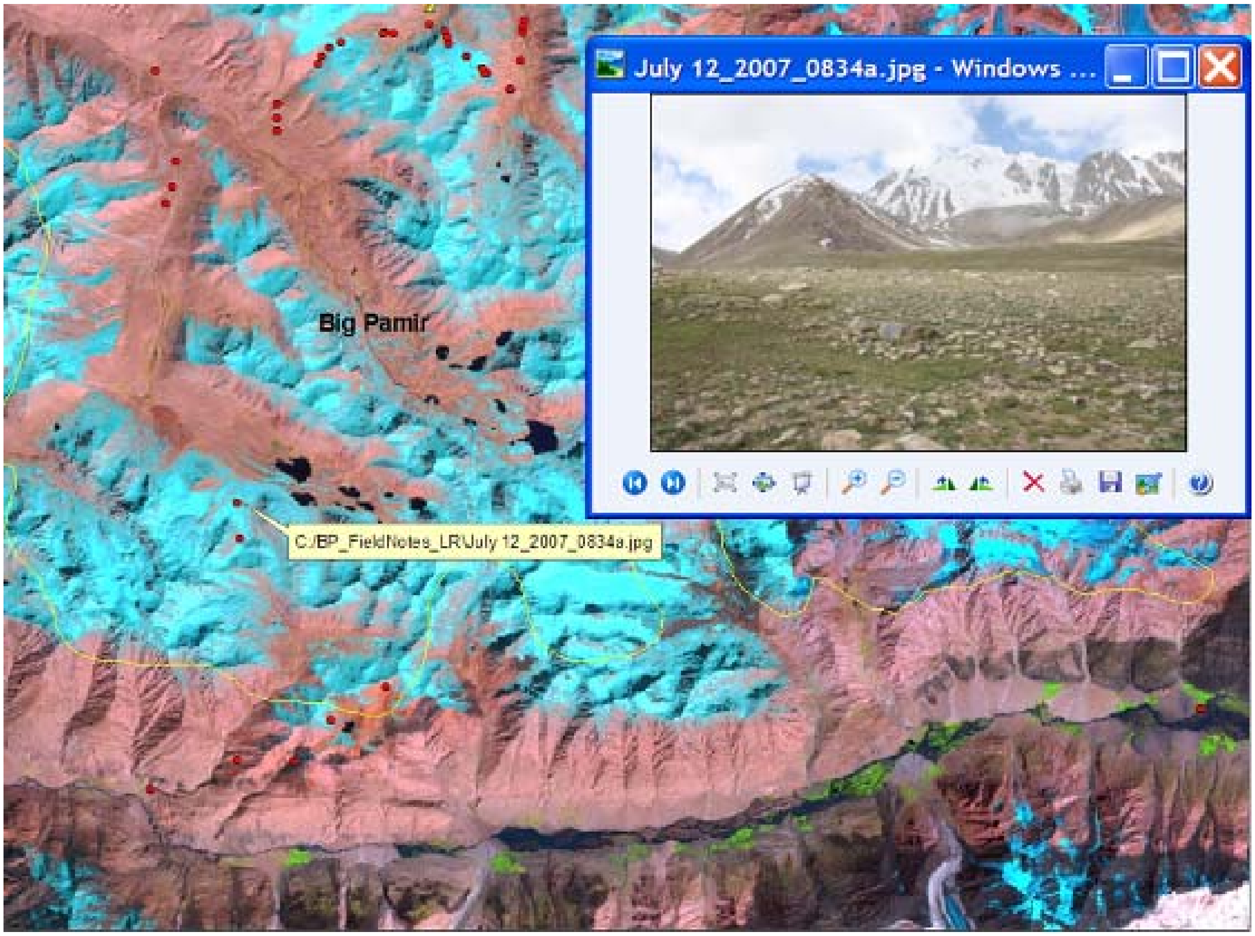

Figure 2. A close-up of figure 1 depicting a hyperlink between field note points and photos. Data regarding field notes and transect information are included in the rangeland GIS.

We crossed Run Zherav near where these streams joined. At just north of the junction of Run Zherav and Wutsir Zherav, there is a large pile of rocks that is certainly a human construct (Figure 3). Nearby (approximately 200 m north) is a rock outcrop with many pictographs. Some of these pictographs are the usual style showing animals and humans, but there were several pictographs with unknown writings (Figure 4 and several cataloged in my photograph collections) and others with musical instruments and various other scenes. Other pictographs were observed along the trail in this area, and it seemed to be rich in past human use. I also observed pictographs at about 3 km down the valley as we continued north up the Wutsir Zherav stream (37.16315N, 73.58523, 4122 m) although these were not as clear and only on a few rocks in the area.

Figure 3 Photo of "rock pile" almost 2 m high.

Location (37.13192N, 73.57150E; 4013 m) about 200 m off of trail (photo catalog June 28_2007_ 0956.jpg).

The upper reaches of Wutsir Zherav had numerous sites of productive *Carex* meadows. In a few sites there were low *Salix* types. At 37.21463N, 73.57770E; 4217 m there is a side valley to the east. A couple of our Wakhi porters said they had observed a small number (7-9) of Marco Polo sheep in this east-west valley. At a second east-west valley in the upper watershed of Wutsir Zherav, I found a Marco Polo horn sheath (37.23522N, 73.53442E; 4470m). Although this horn could have been transported by humans into this area, it seems to collaborate the porters statements of Marco Polo being in the area.

We continued north and crossed Kotali Shavr Pass (4890 m) where the horses had great difficulty because of the soft snow. We continued north into Kyrgyz territory and along Shaur stream. At Sar Maqur we met with the Kyrgyz leader of the area and changed porters. From this point we traveled to Lake Zorkul and east to the Tajik border. Our trail mostly followed the lake, but wetlands and to some extent insects, kept us mostly about 1 km south of the lake. It should be noted that there were several Kyrgyz camps in the valleys south of the lake that are not shown on the current settlement GIS shape file.

Figure 4. Photo of pictographs on large rock outcrop (37.13340N, 73.57205N; 4080 m) showing writing.
(Photo catalog id. June 28_2007_1007b).

From here we traveled almost due west crossing the Sharu valley again, then the Beshkunak, Ilgonak, Tila Bai, and Bai Tibat Valleys. East of Tila Bai (37.35657, 73.26300; 4414 m) I observed a single Marco Polo skull on an *Artemisia* steppe north facing slope. At Bai Tibat we left Kyrgyz settlements and traveled southeast to Jermasirt Valley (Buqbun Wakhi seasonal settlement), crossed Kotali Agh Pass (4400 m), and descended into the Alisu Valley to the hotsprings and then west southwest to Abakhan-gash (a Wakhi seasonal settlement). From here we decided to travel up the Abakhan valley in mostly a southern direction as this trail was not marked on maps and the head of the valley is known to have Marco Polo. There are several Wakhi seasonal camps in this valley not shown in the current settlement layer. We traveled south south west across Abakhan by an unnamed pass (37.18138N, 73.02993E; 4765 m) to the upper reaches of Manjulak watershed. After crossing the pass we came into some productive Carex meadows and alpine meadows. At approximately 37.18833N, 73.01783E (4685m) I observed approximately 30 Marco Polo sheep on 10 July along the snowfields to the south. By the time I observed the sheep, they were moving across the snow fields. At this point there were 30 yak grazing in the Carex meadow.

From the upper watershed of Manjulak we traveled west toward Shikargah Valley. At 37.18793N, 72.97838E on 11 July I observed about 50 Marco Polo sheep in a snowfield area. I believe the sheep were ewes, but I did not have a spotting scope to make an accurate observation of the group. I crossed an unnamed pass (37.18658, 72.97422; 4821 m) and continued toward Shikargah Valley. At 37.16953N, 72.95572E (4389m) I observed a lone wolf. For the most part I was not on a trail but eventually descended to Darah Big, a seasonal Wakhi settlement, in mid Shikargah Valley. We then traveled mostly north down the Istimoch Zherav to the junction of Kand-a-Thur Zherav where we traveled south southwest toward Sargez, crossing Sargez pass (4800 m) and down to Sargez village on 12 July.

Second Reconnaissance. Our second reconnaissance was in the Little Pamir area. My objective was to observe rangelands of the main valley of the Little Pamir in the Chaqamatin Lake area to Tegermensu. We left Sharhad e-Broghil on 11 August and returned to the starting point on 15 September. During this time we established 99 transects and measured standing crop on all but 4 of these sites.

Our route was the Kasch Goz River route to Bozai Gumbaz (4 days). At approximately 3.3 km east of Bozai Gumbaz, we crossed the upper Wakhan River and visited a hot springs area up the stream Aq Arqar (37.16187N, 74.07553E; 4064 m). We traveled mostly east crossing some large wetlands and streams until arriving at Rashid Khan's summer camp (16 August) on the Qara Jilga (stream) (37.26276N, 74.39566E; 4240 m). As can be shown in our route map we mostly followed an existing trail (along the base of the mountains), but we sometimes left the trail to observe some areas closer to Lake Chaqmaqtin. From Rashid Khan's camp we continued to travel east toward Tegermansu Valley mostly along the trail at the “toe”of the mountains. At one point I continued toward Aqsu River and saw a lone wolf at 37.37817N, 74.64928E (3985 m). At this time our porters and my crew were south along a small trail near the base of the main mountain valleys. We arrived at Tegermansu on 22 August.

Tegermansu is a north-south valley draining to the north. The valley is wider than all other valleys south of Chaqmaqtin Lake until the Wakjhir Valley. Terermansu also has a number of side valleys to the southwest that were not explored. No settlements are shown in the valley and no recent signs of significant human habitation were seen although there are some old rock corrals and other structures that show pastoralists have used the area in the recent past. In this valley I observed several herds of Marco Polo and several foxes. On the evening of 22 August just above our camp (37.27903N, 74.83910E; 4498 m) we observed 22 Marco Polo sheep moving across a scree slope. On the morning of 23 August I observed 34 Marco Sheep (all ewes or young) at the same location moving along the scree slope to the south. I moved to within 100 m of these sheep and counted 29 ewes and 5 lambs (Figure 5). I continued to see Marco Polo sheep as I walked south up this valley but likely I was observing the same sheep. The animals were feeding in *Carex* meadows and *Festuca/Poa* grasslands near the base of the valley. Once disturbed these sheep moved into the steep scree slopes on the east side of the valley, but did not appear to be overly concerned with my presence. On 24 August I observed 58 Marco Polo sheep in mid morning in *Carex* meadows at approximately 37.30490N; 74.81608E (4455 m). This was a group of ewes, but I was not close enough to determine how many lambs were in this herd. As before, when these animals were disturbed they went across scree slopes and moved away slowly. Tegermansu is an area that I believe needs additional research on vegetation communities as it seemed to be an area of high wildlife value. The area was ungrazed by domestic livestock and was quite productive compared to many areas visited. I believe this area should receive protection as it is an area of relatively high density of Marco Polo sheep and one of the few areas of the Wakhan Corridor not currently grazed by livestock.

Figure 5. . Photo of Marco Polo ewe/lamb group.
Location approximately 400m west of 37.27903N, 74.83910E; 4544 m.

We left Tegermansu on 24 August and traveled back to Rashid Khan's camp on the same trail. From Rashid Khan's camp we traveled almost due north along the Qara Jilga. We crossed Aqsu and intersected a trail and tank track back toward Chaqmaqtin Lake. We camped at two sites near the lake and then traveled back to Kashch Goz area. From this point we were on the Kashch Goz River trail and back on the same trail to Sharhad e-Broghil, arriving 5 September.

Rangelands of the Wakhan Corridor

The rangelands of the Wakhan have formed over time under the influence of the geology, soils, climate, and animals that use these rangelands. The mountain landscape is one of high elevation plateaus, steep slopes (with scree slopes prevalent), alluvial fans, both broad and narrow, and some relatively large valleys. With the dynamic nature of the environment, rangelands are continually changing and the plant communities of the Wakhan vary both in time and space. The climate is cold and relatively dry so that these rangelands are dominated by a cold, semi-desert type at mid and lower elevations and alpine and cushion plant communities at higher elevations below the nival (rock and ice) zone[3] where ice formation and frost heaving of soils may impact plant communities. "Green strips" and meadows form where there is additional water from melting glaciers, along streams, and sub-irrigated areas. Soils are generally poorly developed, and as associated with the mountain building processes, are relatively young soils with little horizon development.

No weather stations exist so estimations of annual precipitation have been based on surrounding stations in Pakistan, Tajikistan, and Afghanistan. Frietag (1971) provides precipitation map for Afghanistan which shows the Wakhan with precipitation belts of 200 mm to 400 mm (western lower portion and low elevation areas), 600-1000mm for high mountains, 400-600mm for most of Little Pamir, and 200-400 in low areas of corridor. It is likely that the lower valley may receive as little as 100mm based on vegetation type. It is my belief that the precipitation "belts" suggested by Frietag (1971) are on the high side. It is also likely that some of the wide "upper valley floors" are impacted by "rain shadows" and likely receive less than 200 mm of precipitation. In the higher mountains precipitation may approach the 600-1000 mm precipitation zone as shown by Frietag, but most of this precipitation occurs in snow/ice zones with little vegetation. The majority of the precipitation occurs in winter and spring with summer drought. It is likely that much of the snow in lower areas sublimates, compounding semi-arid conditions.

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[3] Breckle (1971) describes the nival zone as occurring at 4900 m on northern exposed slopes and 5300 to 5400 m for southern exposed slopes in northern Afghanisan. This seems to be accurate for much of the Wakhan.

Altitude is an important factor in plant community development for a number of reasons. In higher altitudes the growing season is shorter and thus frosts more common, solar radiation is more severe, and snow and total precipitation are greater. Aspect (sun angle) and degree of slope interact with elevation to influence vegetation with south and west aspects being warmer/dryer with lower vegetation cover and production. Also, at the higher vegetated elevations in the Wakhan, human use is less as these areas are more difficult for human habitation because of colder weather. In general these areas are less impacted by livestock, but in certain areas livestock use is significant to the nival zone. The influence of soil frosts can be seen as "frost heave" and thus lower plant cover, especially in the upper alpine region between 4500 to 5000 m.

As stated above, the rangelands of the Wakhan have formed over time under the influence of the geology, soils, climate, and animals that use these rangelands. The potential value of different rangelands is largely associated with their plant communities and as such different rangeland types are characterized/named associated with physical site characteristics (soils, precipitation, geographic area, etc.) and/or plant communities. Petocz (1975) classified the rangelands to the Big Pamir and Little Pamir into 5 alpine types based on either vegetation or site characteristics. These were a Sedge Meadow, Steppe, Rubble Slopes and Scree, and Heaths and Gulleys. In the following section entitled "Vegetation Cover and Community Types," I have delineated a number of major plant cover types using predominately vegetation characteristics (plant communities) to allow for a better understanding of the value of these sites for livestock and wildlife. I also discuss mapping of some broad vegetation cover types and productivity in the section "Vegetation Indices and Land Classification" and end with a brief section on rangeland degradation.

Vegetation Cover and Community Types

A major objective of the rangeland analysis of the Wakhan in 2007 was to improve data on plant community types to help discern habitat types or ecological sites (potential natural plant communities or climax communities) for the Wakhan area. During our field work we established 134 point intercept/line intercept transects that varied in elevation from 3465 m to 4690 meters. At each site we measured elevation, slope, aspect, starting point direction, and coordinates of the starting and ending points of transects. All sites were photographed by taking landscape and close-up photos along each transect. Plant cover (as canopy cover, foliar cover or basal cover) or ground cover (litter, rock, or bare ground) was recorded using a point technique at each meter mark. Plant cover was also determined using the line-intercept method to provide additional information on species coverage and composition as many sites were over 85% soil/rock. In *Carex* meadows and for some other communities in which individual plants were not easy to discern, only the point sampling procedure was used. In general, we used two transects to characterize site conditions. Transects were generally 50 m long and were spaced 10 m apart. For most sites we also measured current standing crop by species to provide an estimate of forage production and productivity of these communities on a dry weight basis. In addition to the monitoring plots, a rapid reconnaissance methodology was used to estimate soil and vegetation cover and a description of rangeland type for mapping of community types was created using remote sensed data (Landsat ETM+) and is part of the rangeland GIS.

In this report I have named cover types (vegetation types) according to the dominant overstory specie or species and the dominant understory specie or species. As such, a "type" may consist of several communities associated with site differences and grazing use or other disturbances. I also identified community types where sufficient data allowed for a “finer” classification. The main cover types designated in 2007 are an *Artemisia*-Steppe cover type with two community types (an *Artemisia/Festuca-Stipa* community type and an *Artemisia/Acantholimon* community type), a Low *Artemisia* Shrub cover type, a *Krascheninnikovia* cover type, a Salt Grass cover type, a Sedge Wetland Meadow cover type, a *Juniper/Stipa* cover type, and a Birch/Willow cover type. Some photos are included in the discussion below and photos of all transects are included in the rangeland GIS. A number of “miscellaneous” types were not included in the following discussion as there were too few transects to delineate a cover type or more often no cover type was apparent. These were sites often dominated by forbs which were associated with high grazing pressure. For all sites in which biomass was determined, standing crop varied from 24 kg/ha to 1986 kg/ha with a mean of 414 kg/ha (Appendix 1). Scree slopes, saline flats, steep slopes (especially south facing) and shallow soils have low natural productivity. *Carex* meadows have the greatest productivity and are critical as areas for livestock. Petocz (1978b) stresses their importance to Marco Polo sheep. The *Artemisia* steppe produces an intermediate level of forage, but the large area makes it a critical resource for livestock and wildlife.

I have chosen not to provide a discussion of the different cover measurements for each of the vegetation types (canopy cover, foliar cover, and basal cover) although all transect data is summarized as Appendices 2 and 3 and all data is included in the rangeland GIS. In table 1 I provide a summary of all transects for canopy cover, foliar cover, and basal cover by vegetation growth form. As would be expected canopy cover is highest and basal cover the lowest of the cover measurements. Basal cover varied from 0 to 40% with 31% of the transects with 2% or less cover. Foliar cover, a measure of the ability of the vegetation to protect the soil surface from raindrop impact varied from 0 to 96% (the high value a productive sedge meadow and also an outlier as the next highest value was 69%) with 51% of the transects with 10% or less foliar cover.

Plant identification to species was problematic as no plant keys exist for this area. Therefore, plant voucher specimens were collected (approximately 150) and will be verified to species where possible later in 2008. Petocz (1978) and Huss (1979) provide some community type descriptions of the Wakhan. Also, Freitag (1971) provides a description of the natural vegetation of Afghanistan and Breckle (1971) provides a more in-depth discussion of alpine flora of Afghanistan. An initial plant list is included as Appendix 4.

Table 1. Comparison of canopy cover, foliar cover and basal cover across all transects (standard errors).

Cover Variable	Canopy Cover %	Foliar Cover %	Basal Cover %
Shrubs	5.8 (0.58)	3.0 (0.38)	1.2 (0.20)
Sub-shrubs	1.2 (0.20)	1.0 (0.18)	0.8 (0.16)
Forbs	7.1 (1.01)	4.2 (0.70)	2.1 (0.38)
Carexdl[1]	2.3 (0.48)	0.4 (0.13)	0.0 (0.03)
Carex wl	8.6 (1.76)	2.6 (1.01)	1.1 (0.45)
Grass	12.6 (1.3)	4.3 (0.55)	2.1 (0.27)
Tree	1.3 (0.66)	1.1 (0.62)	0.2 (0.07)
Total	36.8 (2.0)	16.5 (1.38)	7.4 (0.69)

[1] Carexdl and Carex wl are abbreviations for dry land sedges (Carexdl) and wetland sedges (Carex wl). Carex wl also includes rushes (*Juncus* sp.) although rushes were not commonly found on these transects.

Artemisia/Steppe Cover Type

The most widely distributed cover type measured in 2007 was an *Artemisia*-Steppe cover type found on mountain slopes and wide valleys. This type is dominated by medium high (25-75 cm tall) *Artemisia* shrubs, predominately A*rtemisia rutaefolia* and *Artemisia persica*. During

2007, 31% of all transects had at least 2% canopy cover of these two *Artemisia* species. The *Artemisia*/Steppe is important because it is widely distributed, and the *Artemisia* species are the most important fuel source for most pastoralists and the type is moderately productive in regards to forage production for livestock and wild ungulates. At this time I have categorized two community types within the Artemisia/Steppe cover type: (1) an *Artemisia/Festuca-/Stipa* community type and (2) an *Artemisia/Acantholimon* community type. Soils of these sites are medium textured (silt loams, silty-clay loams, clay loams and of medium depth).

***Artemisia/Festuca-Stipa* Community Type.** The *Artemisia/Festuca-Stipa* community type-phase includes several communities in which the dominant grass species differ by cover and productivity. As such, this community type may be grouped into other community types with further data collection. I hypothesize that there is an *Artemisia/Stipa* community type, but with the current limited data I have grouped the *Artemisia/Festuca* and *Artemisia/Stipa* community types into a *Artemisia/Festuca-Stipa* community type-phase. A summary of site characteristics and plant cover is presented in (Table 2). The dominant *Artemisia* is *A. rutaefolia*. A total of 20 transects were classified into the *Artemisia/Festuca-Stipa* community type. The most productive sites in this community type are found on cooler aspects (north and east) below the alpine communities where species of *Festuca* and *Poa* are dominant grasses. *Koeleria cristata* is also a common species but of low coverage. *Stipa* becomes more common on warmer (south and west) aspects and productivity decreases. A comparison of this community type with the *Artemisia/Acantholimon* community type shows that this community type has higher grass and forb cover and less *Carex* and sub-shrubs. The *Artemisia/Festuca-/Stipa* community type showed significant grazing use and often high cover of unpalatable forbs such as *Potentilla* sp., *Neptea* sp., and *Astragalus* sp. The grazing pressure had also reduced the grass cover as these sites should be naturally more productive than the *Artemisia/Acantholimon* community type community type. Total standing crop averaged 475 kg/ha. Total shrub, total forb, and total grass standing crop averaged 228 kg/ha, 150 kg/ha, and 120 kg/ha, respectively. Potential grass productivity of these sites is hypothesized at approximately 450 kg/ha and the low average standing crop was considered an influence of high livestock grazing pressure. Livestock grazing increases "mat-forming" forbs, forbs with high anti-herbivory compounds, sub-shrubs, and bare ground.

Table 2. Site characteristics of major community and cover types measured in 2007.

Site Variable	*Artemisia/ Aconthilimon* community type	*Artemisia/Festuca-Stipa* community type	Low *Artemisia* Shrub cover type	*Krascheninnikovia lanata* cover type	Salt Grass cover type	*Carex* Meadow cover type	*Festuca* community type
Elevation	4149 (53)[1]	4169 (47)	4059 (17)	3996 (31)	4006 (75)	4138 (196)	4155[2]
Slope	8 (3)	9 (1)	7 (2)	10(2)	2 (1)	2 (3)	16
Total CC[3]	34 (3)	39 (5)	17 (3)	15 (5)	52 (18)	83 (9)	40
Grass CC	6 (2)	13 (2)	6 (2)	6(4)	49 (20)	3 (3)	29
Sedge CC	7 (3)	2 (1)	2 (1)	0	0	74 (12)	2
Forb CC	4 (2)	14 (5)	1(1)	< 1	3 (2)	6 (5)	6
Shrub CC	11 (2)	9 (3)	8 (2)	7 (3)	<1	< 1	2
Sub-shrub CC	6 (1)	<1	<1	1(1)	0	0	1
Total Foliar Cover	18 (3)	22 (4)	6 (1)	4 (2)	15(14)	39 (21)	29
Litter Cover	12 (3)	14 (4)	2 (1)	4 (2)	34 (21)	50 (21)	12
Basal Cover	10 (2)	11 (3)	3 (1)	1 (2)	15 (16)	30 (21)	6
Rock Cover	13 (4)	17 (6)	13 (4)	10 (4)	4 (4)	2 (3)	4
Soil Cover	65	58	82	85	47	17	78

[1] Standard error.
[2] No standard error presented as only 4 transects for this community type.
[3] CC is canopy cover.

It has been speculated that high *Artemisia* shrub cover may be associated with livestock grazing in the Wakhan. I hypothesize that *Artemisia* shrubs are likely the natural dominant plant cover in this community type (and associated habitat types), although with heavy livestock grazing, there may be an increase in density and cover of the *Artemisia*. On sites near villages where there is a natural *Artemisia* community type, the lack of *Artemisia* is associated with the use of the shrubs for fuel. These shrubs protect sites by reducing wind flowing across the site, reducing soil loss, catching/holding snow, and increasing soil protection and moisture. And often, within shrub bases, grasses are protected from intensive grazing and thus provide a seed source for revegetating sites that are more intensively grazed. As such, conservative use of shrubs for fuel is important and removal of all shrubs for a particular area or site should be avoided.

***Artemisia/Acantholimon* Community Type.** An *Artemisia/Acantholimon* community type was similar to the *Artemisia*/*Festuca-Stipa* community type but several sub-shrubs or cushion-like plants were present in the understory. These sub-shrubs were predominantly *Acantholimon* sp. (*Acantholimon erythraeum, Acantholimon gili, and Acantholimon pamiricum*) with some low *Ephedra sp*. A total of 15 transects had at least 3% canopy cover of sub-shrubs. Like the *Artemisia*/ *Festuca-Stipa* community type the dominant *Artemisia* is *A. rutaefolia*. A summary of site characteristics and plant cover is presented in Table 2. Grasses were dominated by *Stipa* and *Festuca* at almost equal mean cover and representing 90% of total grass cover. Mean total standing crop was 207 kg/ha, which did not include the thorny sub-shrubs, mainly *Acantholimon*. Shrub, forb, dryland sedge, and grass standing crop were 119 kg/ha, 29 kg/ha, 8 kg/ha and 50 kg/ha, respectively. Sub-shrub standing crop was estimated at 80 kg/ha. As such, these sites produce low forage and browse resource for ungulates. It is also likely that the *Artemisia/Festuca-Stipa* community type could regress to a site with high sub-shrubs and thus these two community types could be easily confused. I propose that a more "natural" *Artemisia*/*Acantholimon* community type exists where there is greater rock coverage, coarser soils, and as such the sites are more xeric.

Festuca Community Type

A *Festuca* community type was identified on north facing slopes of the upper Little Pamir. This type is apparently a transition from the *Artemisia/Festuca-Stipa* community type-phase and the alpine grassland found at higher elevations. I believe there are a number of *Festuca* species which may include *Festuca alaica, Festuca pamirica, Festuca rubra, and/or Festuca valesiaca*. I also observed that this community would transition to a *Festuca/Stipa* phase and then into a *Stipa* community type with more xeric conditions (lower elevations or south or west aspects). We had relatively few transects on this type (n=4) and further data is needed to better document this type, but it was observed on moderate slopes in several areas of the Little Pamir. These sites had high canopy cover averaging 40 % with grasses averaging 72.5% of the total canopy cover. Total standing crop averaged 330 kg/ha with grasses averaging 321 kg/ha. Mean elevation was 4155 m and a summary of site characteristics are shown in Table 2. The moderate productivity of these sites would make them important sites for livestock and wild ungulate grazing although the palatability of these *Festuca* species may be low to moderate for many grazers. Other more palatable grasses (*Poa* sp., *Elymus nutans,* and *Koeleria cristata*) were common on many of these sites. Figure 6 is a photo of a Festuca community on a north facing slope just west of the mouth of Tegermansu Valley.

Stipa Community Type

As stated above there is likely a *Stipa* Community type that is found on more xeric sites than the *Festuca* community type. At times these two communities can be adjacent to each other and separated by only an aspect change; however, in many cases the *Stipa* community transitions to shrub types. The major species are *Stipa caucasica* and *Stipa trichoides* with a grass *Pipthatherum* sp. often present. I only measured two sites that I designated as a *Stipa* community so the limited data does not allow for statistical analyses. For these sites total standing crop was 177 kg/ha. Figure 7 is photo of a *Stipa* community located in the upper Little Pamir. I suggest that with heavy grazing these sites likely regress to a Low *Artemisia/Stipa* type.

Figure 6. Festuca community type on north facing slope.
Note high litter on this site which showed no recent livestock grazing use.
Photo August 21_2007_1740b.

Figure 7. Stipa community on southeast aspect.
This site was adjacent to Festuca community type on north facing aspect. Photo August 25_2007_0800a.

Low Artemisia Cover Type

A Low *Artemisia* cover type is a common cold-desert shrub type throughout much of the Little Pamir. The dominant *Artemisia* species are *A. leucotricha* and *A. vachanica*. Both of these species are less than 35 cm tall and appear grey or white. A total of 25 transects (19%) had canopy cover of at least 2% of these two *Artemisia* species. On 22 transects low *Artemisia* was the dominant shrub canopy with a mean canopy cover of 7% with a maximum cover of 14%. On these 22 transects mean elevation was 4059 m and some summary site characteristics and different cover summaries are presented in Table 2. *Stipa* was the dominant grass comprising 83% of the grass cover. *Hordeum* and *Leymus* were common but at very low coverage. A dryland sedge was also common on some of these areas but again at low coverage. Figure 8 is a photo of a Low Artemisia cover type. These sites were often in the valley bottoms as shown here.

**Figure 8. A Low *Artemisia* cover type in the upper little Pamir.
Photo August 27_2007_1630.**

The Low *Artemisia* cover type is common in valleys along the Wakhan River and Aksu River in the Little Pamir and at some locations it is the dominant community type across relatively large areas. Soils are shallow, fine-textured, generally with a hardpan. Signs of salts are common but apparently are not as saline as the *Krascheninnikovia* community type. These sites are droughty and as shown above have very low plant cover. Total standing crop averaged 202 kg/ha with 131 kg/ha of shrubs, predominately the low sagebrush, but an occasional *Krascheninnikovia lanata* or taller *Artemisia* species. Total grass, total forb and a dry-land sedge standing crop averaged 54 kg/ha, 7 kg/ha, and 11 kg/ha, respectively. Because of the low community cover and low productivity, these areas are prone to erosion. It is unknown if these areas should have greater *Krascheninnikovia lanata* and other forage species than currently present; however, on many of the measured sites the areas appeared to suffer from both erosion and grazing/browsing as shown by pedastalled plants and rocks. I believe there is little doubt that these sites are naturally of low productivity but also have been impacted by livestock grazing which has increased soil loss and decreased forage and browse production. Natural productivity is hypothesized at 300 kg/ha, but some sites will naturally have productivity nearer to 200 kg/ha.

Kraschenіnnikovia Cover Type

Krascheninnikovia lanata occurred with at least 2% canopy cover on 39 of the 132 transects (30%) measured in 2007, and on 20 transects *Krascheninnikovia* was the dominant or co-dominant shrub species. *Krascheninnikovia lanata* is often seen near marmot dens and other areas of "fertility" such as herders' camps. It can also be found on dry slopes, areas with higher soil salt levels (flats and "badlands"), and as a co-dominant species adjacent to *Artemisia* and salt grass types forming transition communities. Areas where *Krascheninnikovia lanata* was the dominant shrub were restricted to relatively small areas (less than a few ha), and I observed no large areas where *Krascheninnikovia lanata* was the dominant shrub species. This was unexpected as this is a common cold desert type in many areas of Central Asia. Soils are generally fine-textured, but rock content can be high on some sites. Signs of salts are common and salinity level is important in influencing different communities within this cover type. I have grouped all sites where *Krascheninnikovia* was dominant or co-dominant shrub to designate a *Krascheninnikovia* cover type; however, with further data collection I hypothesize that *Krascheninnikovia*/*Leymus* and *Krascheninnikovia*/*Stipa* community types could be designated as major community types.

A summary of site characteristics and plant coverage summaries are presented in Table 2 for the *Krascheninnikovia* cover type. For these transects *Krascheninnikovia* averaged 6% canopy cover (maximum 14%) and as some transects were close to herding camps there is little doubt that coverage of *Krascheninnikovia* had been reduced by livestock browsing. *Leymus* was the dominant grass and *Stipa* was the only other common grass (frequency of 20%) and forbs were of low coverage. Total standing crop averaged 189 kg/ha with shrub and grass standing crop averaging 153 kg/ha and 35 kg/ha, respectively. These sites, although not very productive, supply a valuable browse resource in that *Krascheninnikovia lanata* is a palatable and nutritious shrub. However, the low cover of vegetation results in high potential of erosion. Since *Krascheninnikovia lanata* is a palatable shrub, its coverage has likely decreased from browsing and also possibly from harvesting for fuel. Without exclosures it is impossible to state if this community type has been significantly decreased by human impacts.

Salt Grass Cover Type

Areas of high salinity are common throughout the Little Pamir and Big Pamir. Often these sites are located where water has evaporated leaving high salt concentration. Productivity and species composition are associated with the salinity levels and presence of water. For these sites we categorized one cover type as the Salt Grass cover type. The dominant plant cover is comprised of the grasses *Puccinellia*, *Leymus*, and *Hordeum*. Forbs and shrubs were uncommon but when present Chenopods were dominant. On some sites the productive and tall grass *Achnatherum splendens* was also present and formed small but productive sites (Figure 9). I classified 8 transects as salt grass type. Mean site characteristics are presented in Table 2. On four sites *Leymus* was the dominant grass, on two sites *Pucinnellia* was dominant, and for two sites there were approximately equal dominance by *Leymus* and *Hordeum*. *Puccinellia* occurred where there was additional water or "ponded" water for a portion of the growing season and salinity levels were high (Figure 10). Forbs, subshrubs, shrubs were not identified in these transects although trace amounts were present in the plot area.

The Salt Grass cover type averaged 836 kg/ha total standing crop but varied from 98 kg/ha to 1690 kg/ha on the four sites where biomass was measured. As stated previously, the high variability is associated with salt concentration and soil water availability. Some sites have "extra" water associated with "water ponding" whereas other sites have some sub-irrigation, but evaporative demands lead to accumulated salt conditions near the soil surface. The relatively high productivity of these sites is somewhat offset by the relatively low palatability of many of the species occurring on these sights. In many areas there are small salt flats that are practically unvegetated.

There is also a *Saline* meadow community (no transect data at this time) where high water levels result in high productivity. *Pucinnellia* and *Hordeum* are common, but as these sites are very wet other grasses and *Juncus* and Carices are common.

Figure 9. A *Leymus* community, one of the more productive types, in the Salt Grass type. This area had been heavily grazed. Note in the background a small area of the productive grass *Achnatherum splendens*. September 02_2007_1544b.

**Figure 10. A photo of *Pucinnellia* community type designated as a common community in the Salt Grass cover type.
Photo August 20_2007_1552c**.

Sedge Wetland Meadow Cover Type

The most productive rangeland type is the Sedge (*Carex sp.* and *Kobresia* spp) Meadow/Wetland Type. These sites are located in subirrigated and wetland areas along springs, streams, and other sites with high water tables on relatively flat areas. Often these sites are “boggy” and have a high organic layer (peat) that is often collected and burned by pastoralists. A second sedge type exists on relatively steep mountain slopes at higher elevations where there is additional water from snow melt. These sites are often relatively narrow bands but supply a valuable and productive grazing resource. In 2007, we classified 10 transects as sedge meadow wetland cover type. Summary site characteristics and vegetation cover variables are presented in Table 2. The predominant cover is over 90% sedges, but the sites do have significant diversity but low coverage of other species. The sedges (mainly *Carex* and *Kobresia*) are difficult taxonomic groups and no doubt there are several community types within this cover type. Mean total standing crop was 1226 kg/ha with 46 kg/ha of grass and 52 kg/ha of forbs. In 2006, we measured one site with standing crop of 3600 kg/ha so I would hypothesize that many of these sites will produce over 2000 kg/ha of biomass per year. Some sites where there is a mixture of sedges and grasses were used as hay production areas (Figure 11). Several of the 2007 transects were not in the most productive sedge meadow types as four transects had the major grass cover as *Puccinellia distans*, a species found in higher salinity areas. Two sedge meadows had *Salix,* but the plants were no higher than the sedges as they were severely browsed.

The Sedge Meadow cover type is a major type found throughout the upper elevations of the Wakhan Corridor. In general, sedge meadows are limited in area, but are widely distributed and no doubt supply significant amounts of forage for livestock and Marco Polo sheep.

Figure 11. Hay production on wetland sedge/grass community near Chaqmaqtin Lake. Photo August 30_2007_1152.

Juniper Community Type

We measured two juniper (*Juniperus semiglobosa*) sites. The first of these sites was along a cut-bank about 20 m above the Wakhan River (Figure12). Elevation was 3450 m, aspect 160 degrees but only a 1% slope. Juniper cover averaged 17% and total plant canopy cover was 37%. Basal area was 7% and rock and litter averaged 44 and 24%, respectively. A second “mountain side” juniper community was measured at an elevation of 3712 m (Figure 13). This site was on a slope of 40 % and an aspect of 208 degrees. Juniper was widely scattered and more shrub-like than tree-like. Canopy cover of juniper averaged only 1% cover and total plant canopy cover was only 13%. Basal area of all plants averaged 2% and rock and litter cover were 57% and 2%, respectively. There were signs that juniper had been cut along the main trail in this area, but very few juniper stumps were found so it did not appear that juniper had been a significant component of this area’s vegetation during recent times. It is more difficult to determine if the juniper had been more prevalent in the last few hundred years and perhaps removed over time. One would hypothesize that if juniper had been recently cut (within last 15 years one should be able to see remnants (stumps), but this was not the case. As reproduction of juniper on these sites appears to be very low (seedlings or small shrubs rare), one must assume that if humans even took a few juniper per hectare the community would digress. It is obvious that the juniper is unique in this area, provides a special habitat not found in large areas of the Wakhan, and should be protected. In some areas along the trail, fires were started at the base of junipers which will certainly lead to death of the tree (photo August 12_2007_0916). Above these sites at a very rocky outcrop, juniper was more prevalent and perhaps "seeded" these sites. *Juniper* can be seen from approximately Daliz Pass (3973 m) to just west of Langar along these predominately south facing slopes and occasionally along benches on the north side of the Wakhan River down to an elevation of about 3525 m.

Figure 12. *Juniper* transect site on cut slope above Wakhan River. Photo September 04 _2007_0715b.

In both of the sites where transects were established, *Ephedra* and *Artemisia* were common. Other shrubs (*Rosa, Amygdalus,* and *Lonicera*) are often present and can be common on some Juniper sites. Standing crop was 499 kg/ha on the river juniper site with shrubs and sub-shrubs (including *Ephedra*) averaging 361 kg/ha and 132 kg/ha, respectively. The second site had a total standing crop of only 54 kg/ha with the majority the standing crop of sub-shrubs and

Ephedra. *Stipa* is the dominant grass, but grass cover and production are low on juniper sites that were measured and where others were observed. In general, these sites produce little forage for domestic livestock; however, the communities are unique because of the juniper and likely provide habitat for a number of wild species and should be protected.

Figure 13. Juniper with damage from harvesting wood and burning the base of the tree. Photo August 12_2007_0916. Approximate location 37.00499; 73.5999.

Birch/Willow Forest Community Type

A Birch/Willow Forest type (*Betula chitralica*, *Salix schugnanica* and *Salix* sp.) exists as small, narrow and isolated riverine forest types along several streams (especially streams entering into the Wakhan River) from east of Sharhad-e-Broghil to Langar. These Birch/Willow communities are also common around seeps on north facing hillsides south of the Wakhan River in this area. We established only one transect pair in one of these communities so we do not have sufficient data to describe these communities. Many of these sites have a diverse plant community, provide significant cover and shade, and have water available. Often these sites show significant impacts of livestock and human use. The major overstory dominants are *Betula* and *Salix*. A shrub understory is generally present with species of *Rosa, Salix, Ribes, Myricaria, and Lonicera.* In some areas *Juniperus* was an associated tree on adjacent drier slopes. Common grasses included *Calamagrostis, Elymus, Deschampsia, Poa* species. Some harvesting of birch was in evidence (cut stumps used for building material and fuel wood) as well as willow (apparently for fire wood). The Birch/Willow Forest site measured was at 3491 m in a relatively deep draw and no birch/*Salix* forest cover types occur east of Langar. The site was very rocky and little understory vegetation was present as grazing was very severe. Canopy cover of birch and willow was 42% and 27%, respectively (Figure 14).

Figure 14. Birch-*Salix* transect site in creek valley.
This is very minor but very unique type in the Wakhan. These sites are often in narrow stream valleys. Photo September 04_2007_1104b.

Alpine Grassland Cover Type

An Alpine Grassland Cover Type was identified in 2006 and we measured an additional 4 transects in this important type in 2007. This is a diverse and productive type with relatively high herbaceous cover. This type has a variety of forbs and grasses including species of *Trisetum*, *Agrostis*, *Poa*, *Festuca*, *Phleum, Aloepecurus, Ranunculus*, *Delphinium*, *Anemone,* *Potentilla, Pedicularis, Oxytropis, Gentiana, Primula, Allium, Waldhemia, Taraxacum, Polygonum*, *Papaver*, *Nepeta*, *Sedum, Primula, Saxifraga, Geranium* and several Asteraceae and Brassicaceae. High landscape diversity is associated with a mix of types such as the Sedge-Wetland types. There is no doubt that these areas are often critical for a number of wild species, but are also used by livestock. Several of the sites measured in 2007 were grazed very heavily by livestock and as such the transect data showed very high variability and no community type was designated. Most of these sites had large cover of forbs, especially *Neptea sp., Potentilla* sp., and other species in the mint family. As stated above, these alpine sites are considered grassland sites but can regress to forb type. Additional data is needed to determine cover/community types. Potential forage production is hypothesized at 600 kg/ha.

Vegetation Indices and Land Classification

A key aspect determining pastoral production is the productivity of the rangelands and the diversity of those rangelands to supply different types of forage and browse throughout the year. Productivity of the Wakhan rangelands are limited by water, cold temperatures and soil depth as much of the area is dominated by steep rocky areas, snow, ice and glacial moraines. As our work was concentrated in Kirghiz areas in 2007, I initiated image classifications using both standard vegetation indices and then a supervised classification to determine landscape types and productivity. All analyses were performed using Imagine software (Leica Geosystems) and ArcGIS software. The following section discusses productivity of the Kirghiz areas of the Big Pamir and Little Pamir regions and summarizes some of the image analysis. This work is ongoing and in 2008 I will revisit these areas to determine the accuracy of the supervised classification and modify site classification to improve accuracy. The low productivity (and resultant low vegetation cover and high bare ground), high topographic diversity (resulting in shady areas in narrow valleys and high variability in aspect), and problems with mixed pixels associated with high variability in soils all limit the accuracy of image classification.

To limit the analysis I used a shape file showing the different ethnic areas[4] of the Wakhan. The Kirghiz area is shown as two separate areas. I will refer to these areas as the Big Pamir Kirghiz area and the Little Pamir Kirghiz area. The Big Pamir area includes Bai Tibat,

[4] The shape file was provided by WCS GIS staff and previously drawn on paper maps by the Community conservation team.

Tila Bai, Ilgonak, Beshkunak, Shaur, and Shaur Maqur watershed and all watersheds south of Lake Zorkol (including the streams Qara Jilga, Istiq, Maqur Qara Jilga, and several smaller streams). The total area of the Big Pamir Kirghiz area was 147,595 ha. The Little Pamir Kirghiz area includes those areas east of Warm Zherav and Bai Qara watersheds. This area includes 296,677 ha and the entire Little Pamir upper watershed.

In 2007 our site biomass measurements ranged from 24 kg/ha to 1986 kg/ha (mean of 414 kg/ha) and mean basal vegetation cover ranged from 1 to 30%. The low values of both basal cover and biomass production illustrate the low productivity/high bare ground of these rangelands. The low productivity of the rangelands is also shown in the vegetation indices[5] and is probably best illustrated using a NDVI (Normalized Difference Vegetation Index) transformation. In this index all pixel values are transformed using algorithms that produce values between -1.0 and +1.0. NDVI values below 0.1 are generally considered barren areas, values between 0.2 and 0.3 correspond to grassland and shrubland types, and values greater than 0.6 often correspond to forest types. I used two available Landsat images to compute NDVIs[6]. The images were a July 26th (early summer with relatively high snow at higher elevations) and an August 15th image (late summer). From these images 79% and 78% of the total area had negative NDVIs. Figures 15 and 16 are the resulting images for the 15 August 1999 for the Big Pamir and Little Pamir areas, respectively. As such, one can conclude that approximately 80 percent of the total area was no longer producing forage (perhaps an earlier spring image would have shown greater positive pixel values at lower elevations) although I believe that basically the majority of the area is "barren" with production of approximately 25-250 kg/ha). Obviously, rocky mountain slopes, glaciers, snow fields, and water are ungrazeable, and these areas were found to comprise 211,429 ha or 47.6% of the total area using a supervised classification (Figures 17 and 18). Moderate NDVI values (> 0.3) made up only 0.4% and 1.2 % of the total pixel values for the July 26 and August 15 images, respectively. NDVI values between 0.2 and

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[5] I initially completed several vegetation indices using Imagine software. Vegetation indices generally include the use of the "red" band (highly absorbed by green plants) and the NIR (Near infrared) band (highly reflected by green plants). For the Landsat ETM+ and TM images these bands correspond to bands 3 and 4, respectively. Vegetation indices were done using two images, one was a July 26th image and the second was an August 15th image. Vegetation indices included NDVI, square root of the IR/R bands, TNDVI (square root (band 4-band 3/band 4+band 3) + 0.5), and a band 4-band 3 subtraction.

[6] It is planned to examine the use of a vegetation index by MODIS (Moderate Resolution Imaging Spectroradiometer) to "track" vegetation as this sensor has much greater temporal information. The main reason for initially using the Landsat images was for determination of vegetation types.

0.3 averaged 2.2% and 1.9% for the July 26th and August 15th images respectively (Figures 15 and 16).

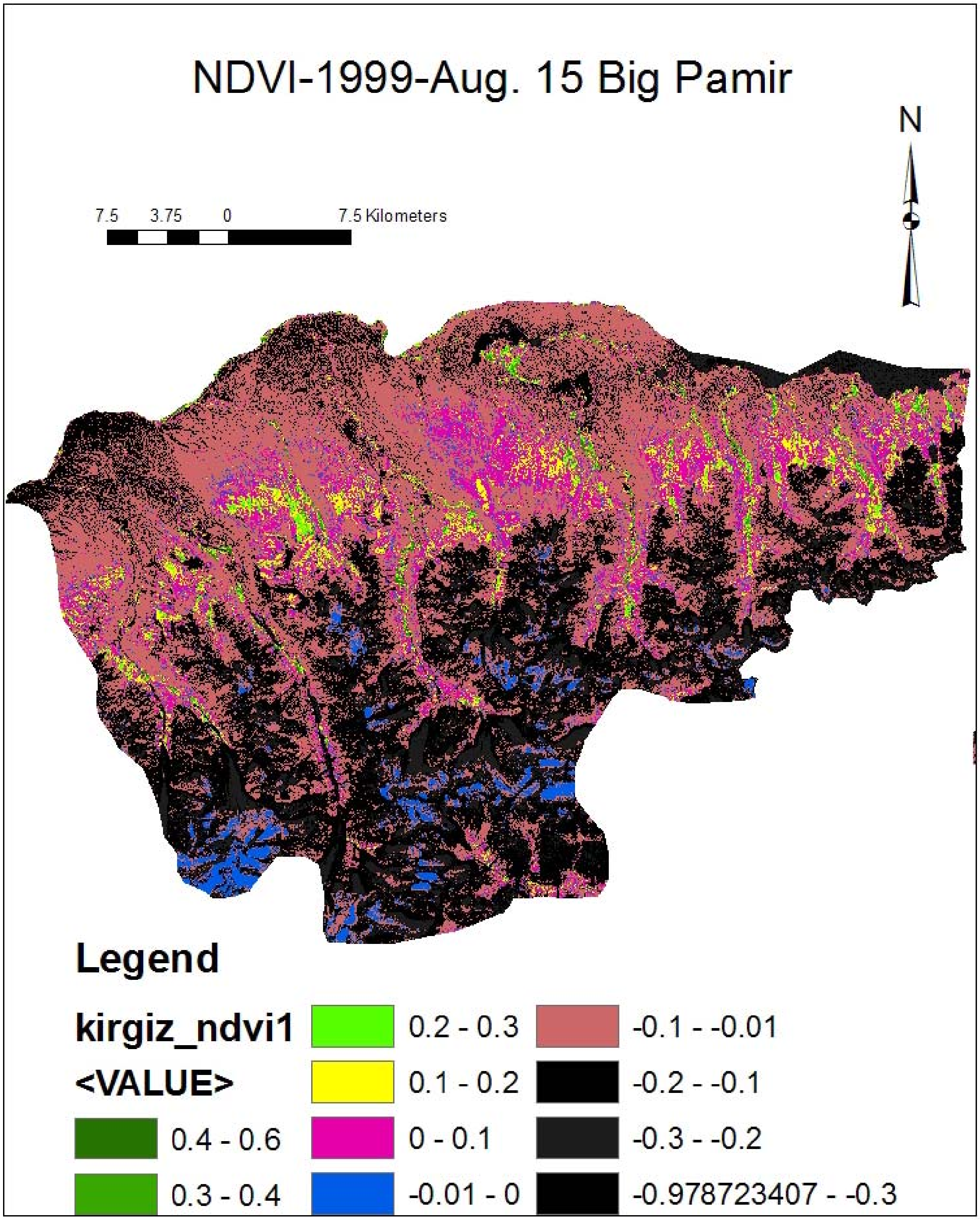

Figure 15. NDVI (Normalized Difference Vegetation Index) for the Big Pamir Kirghiz area.

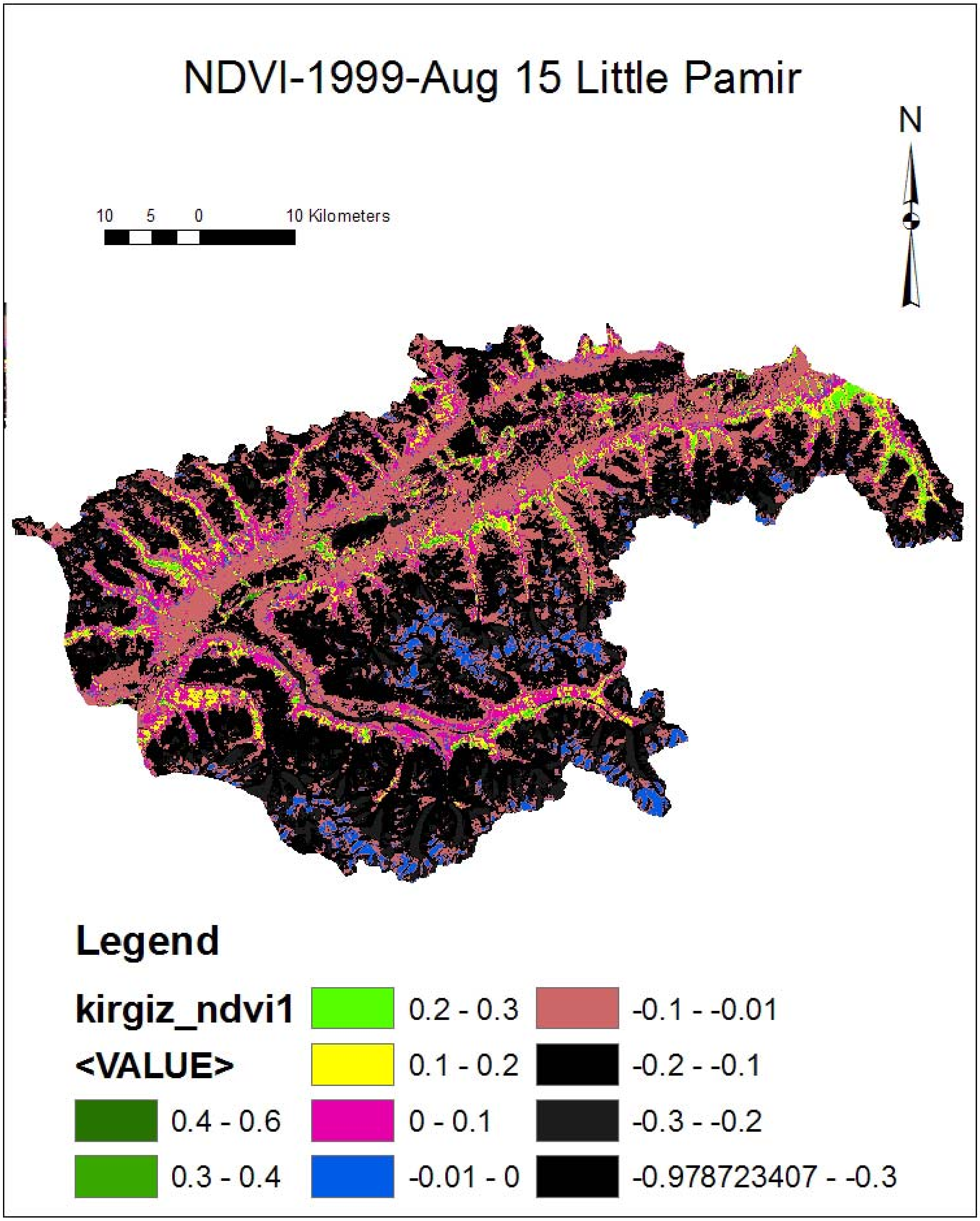

Figure 16. NDVI (Normalized Difference Vegetation Index) for the Little Pamir Kirghiz area.

Examination of NDVI, false color composite images and site data revealed that the sedge meadows were the major "green" areas across the landscape and had relatively high productivity. The sedge meadows are widely distributed across the landscape and occur where "extra" water is available from snow melt and/or as subirrigated conditions. Although these sedge meadows provide relatively high amounts of forage, the diversity of forage types is relatively low (high sedge biomass but low biomass of browse and forbs). Petocz (1978), however, considered the sedge meadows as critical areas for Marco Polo sheep, especially the rams, and these areas also receive heavy use by livestock and some are used for making hay. Therefore, these areas need conservative management, and we need a better understanding of how to conserve these areas for future generations. Generally the sedge meadows are relatively easy to discern on the Landsat images used for vegetation analyses and are shown as the deep green type on figures 15-18. An initial supervised classification showed a total of 75,010 ha of sedge meadow/alpine high productivity sites or 9% of the total area (Table 3). A second Sedge Meadow type with moderate productivity was combined with a moderate productivity grassland type as sites were often of mixed pixels. This type comprised about 7% of the total area. The sagebrush steppe and cold desert low shrub averaged 16.7% and 16.5%. A *salt Salt flat* type comprised only 0.2% of the area. This seems somewhat low but large areas of the *Cold desert low shrub* type would also have high salt content and certainly there is overlap between these types. Further work is needed to determine the accuracy of these vegetation type values and to further separate community types. Using a moderate to high resolution digital elevation model (currently not available) could allow for better separation of alpine meadows from the sedge meadows and also help in vegetation type differentiation.

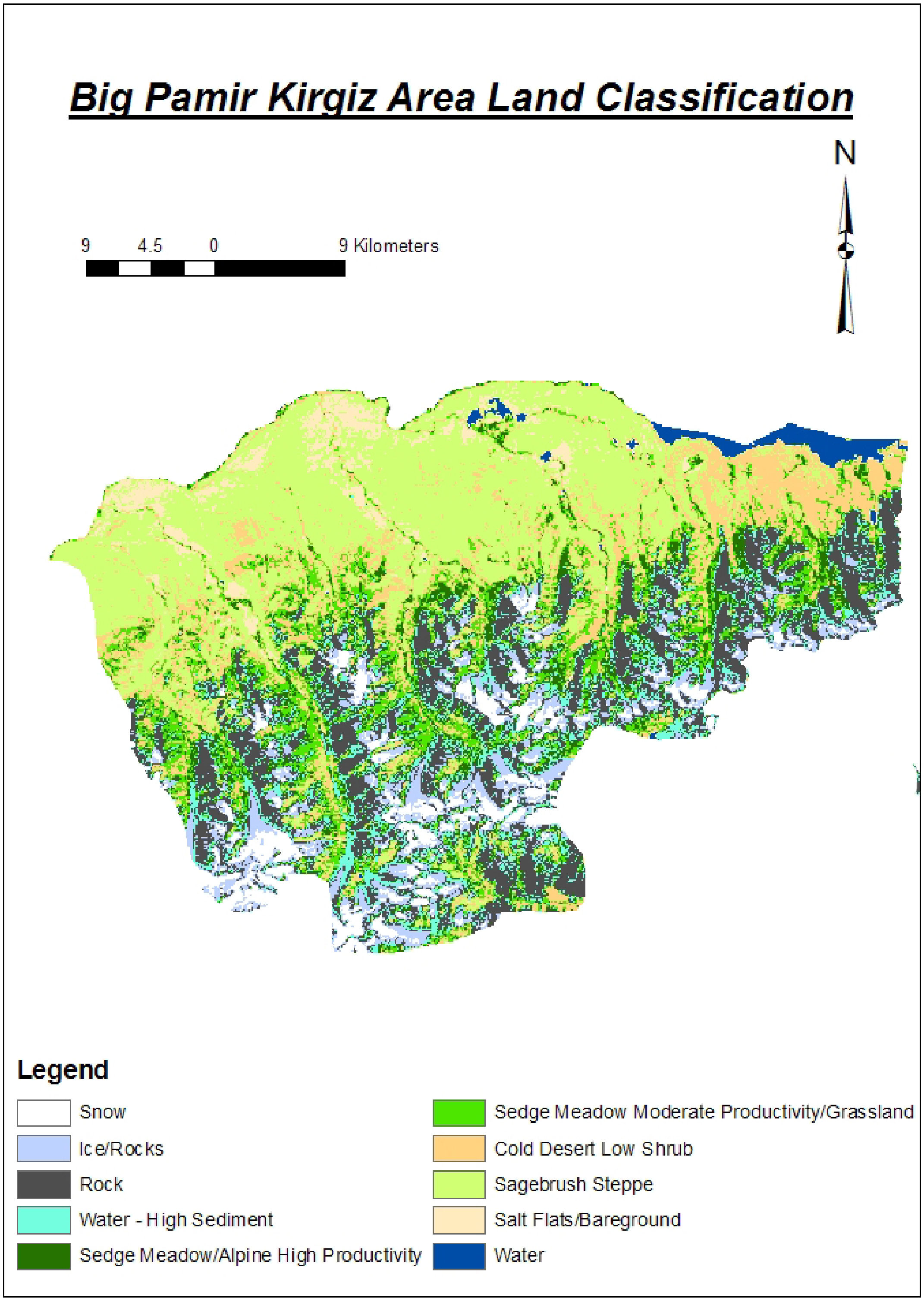

**Figure 17. Land cover types delineated using a Landsat ETM+ (August 15, 1999, Path 150, r34) for the Big Pamir Kirghiz area.
The supervised classification system used transect data and IMAGINE software.**

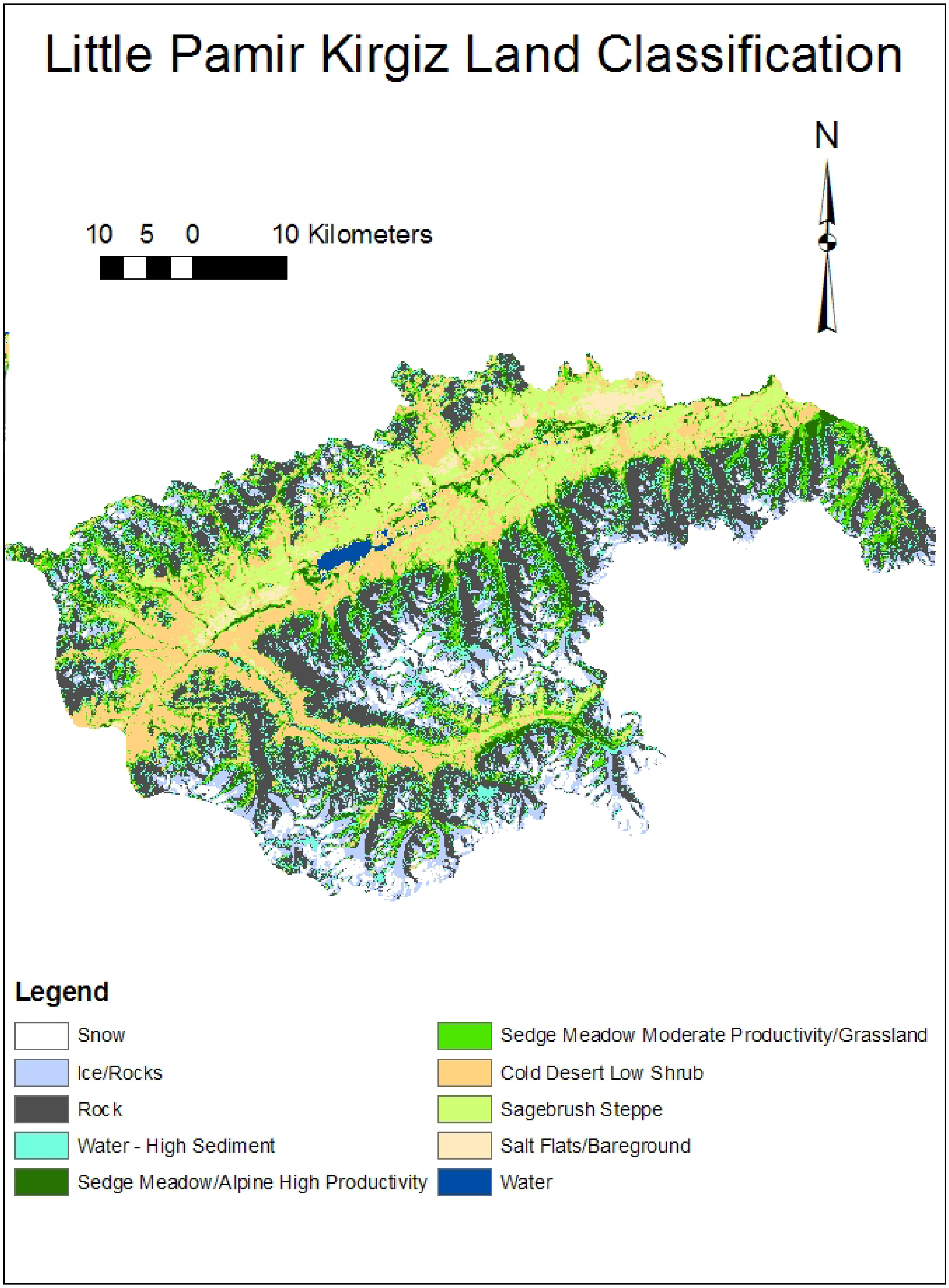

Figure 18. **Land cover types delineated using a Landsat ETM+ (August 15, 1999, Path 150, r34) for the Little Pamir Kirghiz area.**
The supervised classification system used transect data and IMAGINE software.

Table 3. Land/vegetation types, area (ha) and description of types from initial supervised classification.

LAND/VEGETATION TYPE	AREA (HA)	DESCRIPTION
Snow/Glacier	36141	Areas of "clean" snow and ice.
Glacier Ice/Till	42491	Areas of snow/rock mix.
Rock	108644	Scree slopes, rock cliffs, unvegetated mountain sides.
Water (High sediment)	19073	Mostly streams and some small ponds with high sediment. Melting snow and ice around glaciers for August image also show in this class.
Carex Meadow/Alpine Meadow High Productivity	41453	Areas of highest productivity. Difficult to discern some types as often mixed. Carex meadows most common where site receives additional water.
Carex and Grassland Moderate Productivity	33557	Areas of moderate productivity. Difficult to discern as some types are often mixed.
Cold Desert Low Shrub	73549	Difficult to discern as mostly bare ground and low biomass.
Sagebrush steppe	74351	Includes a number of "tall" *Artemisia* types.
Salt flats	9937	Areas of high salts with low vegetation cover.
Water	5080	Water. Predominately of lakes.
Total	444,272	

Rangeland Degradation

The potential value of different rangelands is largely associated with their plant communities and productivity. Rangeland degradation will decrease both productivity and natural values (including water quality and quantity, aesthetics, wildlife, carbon sequestration, air quality, etc.) of these sites for wild ungulates and human use. Each ecological site and the various plant communities within an ecological site will vary in the response to overgrazing and/or type of overgrazing and other human impacts. There is little doubt that rangelands of the Wakhan area have degraded associated with overgrazing and other human impacts. However, it is often very difficult to separate natural arid conditions from overgrazing. These rangelands have been grazed for centuries if not millennia by livestock and longer by wildlife. Current concentrated livestock use around "villages," more preferred sites, and possibly long grazing periods (from almost "green-up" to fall) has resulted in localized rangeland degradation, and I believe rangeland degradation caused by overgrazing across the general landscape is moderate to high. Other direct human impacts on rangelands include shrub harvesting for fuel, use of medicinal plants, hay cutting, use of peat from sedge meadows for fuel, ditching/irrigation practices, but certainly livestock grazing has much widely distributed impacts across the landscape.

For much of the upper Wakhan Corridor (sites studied), the major grazers/browsers are sheep and goats, yak, and to a lesser extent horses and camels. Goats and camels are considered browsers (consume predominately shrubs), sheep are intermediate feeders (consume a diet high in forbs/grasses and some browse), and horses and yak are grazers (consume diets high in grasses). The use of complementary grazing (more than one type of livestock) results in the potential of greater use of all types of forage/browse (grasses, forbs, and shrubs) and thus reduces selectivity and a specific advantage of one "type" compared to another. However, there are many plant species with high anti-herbivory compounds or structures that increase with livestock grazing that can be observed in the study area. Structural elements include thorns as found on some *Acantholimon*, *Cirsium*, *Cousinia*, *Lagochilus*, and *Astraglus* species, to name a few, that were commonly observed in the Wakhan. Plants with chemical compounds that may reduce herbivory include poisons and oils and tannin. *Peganum harmela* and *Halogeton glomerata* are known poisonous species and *Artemisia, Potentilla,* and many mints (Laminaceae) such as *Nepetea* and *Ziziphora* contain aromatic oils making them unpalatable. Other disturbance species, often annuals, and species that respond to increased fertility associated with bedding/corral areas include annual Chenopods and to a lesser extent annual grasses. Rarely observed grazed species include *Neptea* sp. (and also most Laminaceae), *Potentilla* sp., *Descurainia sophia*, *Lepidium* sp., *Sisymbrium* sp., *Arenaria* sp., *Silene* sp., *Cousinia* sp., *Saussurea* sp., *Cynoglossum glochidiatum*, and *Lindeofia macrostyl* and *Peganum harmela* and *Halogeton glomerata* (known very poisonous species) to name a few. Interestingly, I rarely observed sites where one or only a few disturbance species dominated a site. Some exceptions were near camps/bedding areas where large amounts of annual Chenopods thrived in the disturbed, fertile soils and on some sites where dense "mats" of a low growing *Astragalus* species and Laminaceae formed "a carpet" of low height plants, but of high cover.

I suggest that one of the initial/intermediate signs of overgrazing impacts on many of the communities of intermediate productivity (alpine, *Fescue*, *Stipa*, and *Artemisia* grasslands) is the reduction in size (height and basal area) of tufted grasses. The reduction in size is not initially observed as a decrease in cover or density (number/area) of tufted grasses, but grass productivity is decreased. This impact was observed as transects were measured nearer to herder camps. In these areas there is also an increase in species with lower palatability, especially mints (Laminaceae) and *Potentilla* sp. Additional data collection and analyses is needed to better define these relationships. We are just now verifying species and improving plant species lists (see Appendix 4), and I will work to classify species to grazing response in the next report. For example, some species are highly palatable and are almost always seen as severely grazed/browsed or grazed. A few examples are *Amygdallus* sp., *Lonicera* sp., *Kochia prostrate* (all shrubs) and the grasses *Phleum alpinum* and most *Poa* sp. With higher levels of degradation the site becomes dominated by low growing species with low palatability. Grasses are lost from overgrazing and with removal of shrubs.

In dryer types, Low *Artemisia* communities and *Krascheninnikovia lanata* communities, there is currently little vegetation cover which is likely a natural condition of these sites. However, heavy browsing of *Krascheninnikovia lanata* and wind erosion evidence ("pedastalling" of plants and rocks) is common on these sites and likely decreasing site productivity. On these sites the general lack of vegetation cover, especially a loss of tufted grass species (*Stipa* sp.) is the most obvious degradation characteristic.

Another obvious negative influence of livestock grazing is trailing. The trails obviously become compacted and bare increasing erosion and allowing disturbance species to invade along the edges of trails. Over time larger areas are impacted. These trails are more obvious on steeper slopes and near main trails, but trailing is quite wide-spread likely associated with relatively narrow stock movement areas along the valleys.

There are a number of other direct human impacts on rangeland degradation. Two of these are fuel wood (shrubs predominately) harvest and irrigation/ditching of areas. Almost all fuel used by families in the Wakhan is from shrubs and manure. Shrubs are used for cooking and manure mainly for heating. Harvest of shrubs for fuel is likely a significant impact around villages, but people were observed harvesting shrubs at least 2 km from camps. At this time I have no data on the level of shrub removal, if any conflicts exist in regards to areas of shrub collection, and if the harvest is sustainable. But shrub use is high (Figure 19). Information is needed on preferred species for fuel and level of harvest. I did notice that the taller *Artemisia* species were most often collected, but at times I saw significant *Krascheninnikovia lanata*, a palatable browse species, collected. I was also told by a Kirghiz herder that they collected fewer shrubs as they realized these plants were important as a food source for their livestock. The conservative use of fuel shrubs is important to insure that there are mature shrubs to reseed harvested sites and to protect the site from wind and water erosion. Shrubs will reduce wind speed across the soil, hold snow and blowing soil, reduce soil temperature fluctuations compared to bare soil,, and increase site productivity as well as provide some cover and browse for wild species. I will also stress that shrubs facilitate grasses (protect some grasses from continual livestock grazing), allowing for a seed source for the grasses to reproduce and revegetate disturbed sites. Removal of all shrubs will likely decrease grass vigor and production.

Figure 19. Photo of *Artemisia* collected for fuel.
At this summer village each family had a collection approximately this size. At winter camps there were larger collections. Photo July 09_2007_0708.

Ditching (possibly to drain wetlands) and irrigation "canals" are evident in many areas. Herders irrigate areas for growing hay (although most sites I observed where hay was harvested were in natural wet meadows). Many of the irrigation ditches appear quite old (perhaps from Soviet times) although newer ditches were also evident. Sites in which irrigation water is removed can result in a change in hydrology and drying of the site. This apparently occurred in several small sedge meadows observed in the Big and Little Pamir. The drying of these meadows is a concern because of their high natural productivity. Another concern with irrigation is the potential of elevated salinity levels on certain sites. At this time, irrigation is seen as causing only localized problems with rangeland degradation (both salinity problems and drying of certain sites), but is a potential problem that should receive additional monitoring.

There is no doubt that rangeland degradation is a significant concern in the Wakhan Corridor. I believe the level of rangeland degradation is moderate to high for most of the area. A major difficulty in defining the level and/or types of rangeland degradation is that few sites exist where grazing is not significant. There are also no plant guides or site information for these rangeland types. We have now developed a significant plant list, established site characteristics for major plant communities and will develop methodology for ecological site determination and rangeland degradation during 2008.

Summary and Concluding Statements

During 2007 we established 134 transect for the collection of plant community information. Transects measured in 2006 and 2007 will be the basis of ecological site information that will aid in determining the values of different ecological sites and plant communities for livestock and wildlife and for determining rangeland degradation attributes. We have now developed a comprehensive plant list although the list will continually be updated as new information is gained.

A rangeland geographic system (GIS) with all transects data, photo-points, and reconnaissance information has been developed. The GIS system will allow other researchers to revisit transect sites and have access to all rangeland data to determine change with time. We have also initiated several vegetation indices and supervised classification to determine if we can improve rangeland site classification with imagery. In 2008 we plan to revisit some sites to attempt to improve the site classification. We also hope to get better digital elevation models (DEMs) which will allow for some site differentiation that is now difficult. The rangelands of the Wakhan Corridor are quite variable spatially and the low productivity, high topographic variation, and high natural and human (livestock) disturbance make classifications using the available imagery (Landsat ETM and TM images) difficult. However, because of the large area and difficulty of accessing the area (only by foot or animal) we will continue to use remote sensed data for rangeland analyses. In time we will provide site classification and rangeland degradation information in the GIS.

I believe rangeland degradation in much of the Wakhan is mostly moderate to high. In general, the most impacted sites are the *Artemisia* Steppe where there is potentially moderate forage production but presently most of these sites are dominated by unpalatable forbs and thus producing low forage amounts. Rangeland degradation not only occurs associated with livestock grazing but from other human impacts such as shrub harvests for fuel, especially in the *Artemisia* Steppe.

My observations regarding wildlife is limited to almost random observations; however, I stress that where I have observed the most wildlife (Marco Polo sheep, wolves, foxes, bear signs, etc.) human impacts (less livestock and no nearby camps) appeared to be much lower than surrounding areas. This was obvious in Tegermansu Valley where Marco Polo sheep were easily observed and did not appear overly fearful of humans and also in the upper Wakhjir (visited in 2006). Tegermansu was quite productive and impressive although I only had time to visit the main valley as we were short on food.

In 2008 I plan to initiate interviews of pastoralists to determine their views on rangeland values, important species for livestock and or wildlife, medicinal plants, rangeland degradation and fuel woods. We will also attempt to determine rangeland/livestock problems as viewed by pastoralists. During the previous field seasons I have mostly collected data on rangelands and I believe interviews with pastoralists will provide valuable information on traditional ecological knowledge.

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Appendices

Appendix 1. Summary of transect data for shrub, forb, Carexdl, grass, "half-shrubs, and total standing crop (kg/ha) for transects sorted by initial cover or community type[1].

DATE	TIME	INITIAL COVER OR COMMUNITY TYPE	ELEVATION (m)	ASPECT (degrees)	SLOPE (%)	SHRUBS KG/HA	FORBS T KG/HA	CAREXDL KG/HA	CARICES KG/HA	GRASS KG/HA	HALF-SHRUBS KG/HA	TOTAL KG/HA
06/07/2007	2	Artgrn /Astmatty	4409	2	7	552	143	0	0	90	0	785
06/07/2007	2	Artgrn Astmatty	4407	0	8	334	92	0	0	110	0	536
06/07/2007	3	Artgrn /Astmatty	4409	0	8	141	58	0	0	33	0	233
06/07/2007	3	Artgrn /Astmatty	4391	16	8	372	32	0	0	39	0	443
06/07/2007	4	Artgrn/Astmatty	4373	40	9	334	164	0	0	162	0	660
06/07/2007	4	Artgrn/Astmatty	4373	40	9	126	314	0	0	146	0	587
06/07/2007	5	Artgrn/Astmatty	4373	40	9	320	190	0	0	49	0	559
06/07/2007	5	Artgrn/Astmatty	4382	40	10	350	185	0	0	105	0	639
08/07/2007	1	Artgrn/Astmatty	4190	326	3	57	0	0	0	60	0	117
08/07/2007	2	Artgrn/Astmatty	4214	326	2	196	0	0	0	66	0	262
08/07/2007	1	Artgrn/Fescue	4419	50	4	176	132	0	0	101	0	410
08/07/2007	1	Artgrn/Neptea	4410	50	4	285	366	0	0	68	0	719
27/08/2007	1445	Artarb/	4063	162	3	151	0	0	0	179	0	330
27/08/2007	1600	Artarb/	4039	329	0	214	0	0	0	5	0	219
28/08/2007	830	Artarb/	4033	322	15	71	0	0	0	12	0	83
30/08/2007	1420	Artarb/	4073	160	8	259	0	0	0	0	74	332
16/08/2007	715	Artarb/Carexdl	4062	141	11	116	0	57	0	158	0	331
20/08/2007	1400	Artarb/Carexdl	4044	324	13	16	10	73	0	26	10	124
28/08/2007	920	Artarb/Cerlan-Stipa	4040	350	11	159	2	0	0	39	0	198
1/9/2007	1030	Artarb/Leygig	3948	154	8	43	0	0	0	148	0	191
28/08/2007	1015	Artarb/Stipa	4037	342	9	32	1	0	0	15	0	47
28/08/2007	1100	Artarb/Stipa	4056	350	12	65	1	0	0	19	0	84
28/08/2007	1130	Artarb/Stipa	4056	10	11	80	0	0	0	80	0	160
29/08/2007	430	Artarb/Stipa	4152	142	18	180	0	22	0	17	0	218
30/08/2007	1520	Artarb/Stipa	4094	160	4	405	0	0	0	31	0	436
30/08/2007	1620	Artarb/Stipa	4087	320	0	44	0	1	0	27	0	72
4/9/2007	800	Artarb/Stipa	3465	161	1	361	0	0	0	6	132	499
03/07/2007	1	Artemisia	4186	311	2	92	13	17	0	6	0	128
04/07/2007	2	Artemisia	4154	238	3	73	0	24	0	18	0	115
15/08/2007	1520	Artgrn/Fescue	4082	322	6	11	260	0	0	429	102	543
20/08/2007	1610	Artgrn/Hordeum	4096	341	3	28	0	0	0	120	0	148
15/08/2007	1340	Artgrn/Stipa	4064	42	1	15	31	0	0	121	11	147
31/08/2007	330	Artgrn/Stipa	3970	166	12	89	0	0	0	87	0	176
04/07/2007	1	Carex	4170	360	2	0	0	0	808	0	0	808
23/08/2007	1610	Carex Meadow	4608	120	10	0	35	39	1940	0	7	1986
28/08/2007	215	Carex Meadow	4019	0	0	0	27	0	896	181	39	1115
28/08/2007	320	Carex Meadow	4030	0	0	0	196	0	690	48	8	746

2/09/2007	430	Carex Meadow	3882	0	0	0	0	0	1475	0	0	1475
05/07/2007	1	Cerlan	4140	1	1	183	0	0	0	5	0	188
1/9/2007	840	Cerlan/Leygig	3972	152	13	165	0	0	0	4	0	169
1/9/2007	910	Cerlan/Leygig	3963	156	12	171	0	0	0	64	2	237
1/9/2007	800	Cerlan/Stipa	3960	142	14	253	0	0	0	36	0	290
1/9/2007	1115	Cerlan/Stipa	3936	15	12	141	0	0	0	1	0	143
16/08/2007	1525	Cerlan-Artgrni/Fescue	4060	330	10	63	18	0	0	169	1	233
4/09/2007	130	Ephedra/Acontholimon	3712	208	40	0	0	0	0	0	54	54
02/07/2007	1	Fes/Astmat	4453	300	10	0	695	0	0	203	0	897
20/08/2007	1710	Fescue	4146	340	11	0	17	0	0	302	0	302
25/08/2007	810	Fescue	4164	0	20	0	77	0	0	339	19	359
3/9/2007	800	Fescue Potentilla	3945	342	25	0	64	0	0	235	106	341
23/08/2007	1420	Fescue/Poa	4690	29	12	0	75	0	0	393	5	398
24/08/2007	915	Fescue/Poa	4503	40	22	0	101	0	133	386	24	543
04/07/2007	3	Poa/Artgem	4137	md	md	0	159	0	0	240	0	398
03/07/2007	2	Poa/Potentilla	4206	322	8	16	348	0	0	290	0	653
29/08/2007	140	Saline Flat	4037	168	3	0	0	0	0	297	4	301
29/08/2007	245	Saline Flat	4063	162	3	7	9	0	0	88	3	98
01/09/2007	945	Saline Flat	3958	136	11	7	33	0	0	99	0	107
20/08/2007	1500	Saline Meadow	4075	338	3	0	0	0	0	1690	0	1690
2/9/2007	315	Saline Meadow	3850	186	1	0	63	0	0	1232	21	1253
24/08/2007	800	Sedge/Grass	4490	24	6	0	100	25	118	140	75	357
25/08/2007	710	Stipa	4164	180	14	1	34	12	0	263	0	276
31/08/2007	410	Stipa	4006	166	10	7	0	0	0	38	0	44
03/9/2007	915	Stipa	3887	0	0	0	0	0	0	24	0	24
03/9/2007	1030	Stipa	3923	155	1	0	0	0	0	31	14	44

[1] Carexdl is a summation of *Carex* species considered upland sedges, "half-shrubs" are suffrutescents with woody bases but mostly herbaceous tops. Initial cover type or community type was designated in the field.

Appendix 2. Summary of site characteristics and plant cover (%) attributes for all transects established in 2007.

DATE	TIME	ELEVATION (m)	ASPPECT	SLOPE (%)	TOTAL CANOPY COVER	TOTAL FOLIAR COVER	TOTAL LITTER COVER	TOTAL SOIL COVER	TOTAL BASAL COVER	ROCK COVER	CC[1] GRASS	CC CAREXDL	CCL SEDGES	CC FORBS	CC SUBSHRUBS	CC SHRUB	CC JUNIPER	CC BIRCH	CC SALIX	COVER TYPE/ COMMUNITY TYPE [2]
7_27_2007	730	4352	344	22	34	28	20	68	18	14	2	0	0	32	0	0	0	0	0	ALP
7_27_2007	1000	4356	344	24	46	30	20	76	14	10	10	0	10	26	0	0	0	0	0	ALP
6_27_2007	1730	4172	8	10	46	28	22	46	10	4	6	0	8	32	0	0	0	0	0	ALLIUM
6_29_2007	800	4131	224	14	28	20	8	68	4	28	0	0	0	4	0	24	0	0	0	ART-GRS
6_29_2007	1000	4142	md	18	30	18	12	94	4	2	6	0	0	2	0	22	0	0	0	ART-GRS
6_29_2007	1400	4133	240	14	36	28	2	41	12	6	14	0	0	4	0	20	0	0	0	ART-GRS
6_29_2007	1500	4121	270	md	16	10	4	82	4	14	10	0	2	4	0	0	0	0	0	OVGRZ
6_29_2007	1600	4121	md	8	18	12	4	68	2	30	8	0	0	10	0	0	0	0	0	OVGRZ
6_30_2007	635	4109	267	16	28	22	0	48	16	36	16	0	0	12	0	0	0	0	0	OVGRZ
6_30_2007	730	4102	270	12	20	18	0	50	10	36	14	0	0	6	0	0	0	0	0	OVGRZ
6_30_2007	830	4108	260	8	32	8	4	74	6	20	8	14	14	10	0	0	0	0	0	OVGRZ
6_30_2007	900	4108	260	8	30	12	0	72	2	26	8	14	16	6	0	0	0	0	0	OVGRZ
6_30_2007	md	4402	md	md	md	md	md	md	md	md	md	md	md	md	md	md	md	md	md	SED/ ALP
7_2_2007	1610	4453	300	10	58	46	34	68	18	18	26	0	0	32	0	0	0	0	0	NEP/ ACAN
7_3_2007	1530	4185	311	0	34	22	20	84	4	12	0	12	12	2	4	16	0	0	0	ART/ SBSRB
7_3_2007	1600	4187	311	3	30	20	30	84	10	6	0	8	8	0	10	12	0	0	0	ART/ SBSRB
7_3_2007	1640	4205	322	7	48	24	38	92	4	4	22	0	0	26	0	0	0	0	0	ASTMA
7_3_2007	1745	4206	322	9	58	32	40	88	12	0	32	10	10	12	0	4	0	0	0	ART-GRS
7_4_2007	730	4166	360	2	88	60	74	76	24	0	2	0	86	0	0	0	0	0	0	WL
7_4_2007	830	4173	360	2	88	36	80	84	16	0	0	0	86	0	0	0	0	0	0	WL
7_4_2007	900	4154	238	3	28	18	22	72	12	16	4	2	2	0	8	14	0	0	0	ART-SBSRB

7_4_2007	930	4154	238	3	30	14	20	80	6	14	4	8	8	0	4	14	0	0	0	ART-SBSRB
7_4_2007	1115	4137	md	md	52	30	50	94	6	0	42	0	0	6	4	0	0	0	0	UNC
7_5_2007	715	4140	1	1	26	16	2	90	6	4	2	0	0	0	4	20	0	0	0	KRLA/ ACAN
7_5_2007	730	4140	md	md	22	8	22	66	4	0	10	0	0	0	2	10	0	0	0	KRLA/ ACAN
7_6_2007	700	4419	50	4	52	34	6	72	28	2	2	0	0	20	6	24	0	0	0	ART-SBSRB
7_6_2007	700	4410	50	4	48	28	8	80	20	0	10	0	0	32	0	6	0	0	0	ART-GRS
7_6_2007	810	md	md	md	32	14	18	80	12	8	8	0	0	8	0	16	0	0	0	ART-GRS
7_6_2007	910	4407	0	8	30	20	12	80	16	4	0	0	0	4	4	22	0	0	0	ART-SBSRB
7_6_2007	910	4409	0	8	36	26	12	72	24	4	4	0	0	12	6	14	0	0	0	ART-SBSRB
7_6_2007	1000	4391	16	8	62	46	42	22	28	4	20	0	0	26	0	16	0	0	0	ART-GRS
7_6_2007	1000	4373	40	9	62	46	12	40	28	4	12	0	0	38	0	12	0	0	0	ART-GRS
7_6_2007	1100	4373	40	9	54	36	14	48	30	0	20	0	0	26	0	8	0	0	0	ART-GRS
7_6_2007	1110	4373	40	9	52	40	28	34	22	2	10	0	0	10	0	32	0	0	0	ART-GRS
7_6_2007	1110	4382	40	10	58	44	28	46	16	0	4	0	0	54	0	0	0	0	0	NEP/ ASTMA
7_6_2007	1230	4382	40	10	56	34	16	90	10	0	8	0	0	48	0	0	0	0	0	NEP/ ASTMA
7_8_2007	1615	4190	326	3	22	10	10	80	6	2	4	0	0	0	10	8	0	0	0	ART-SBSRB
7_8_2007	1730	4214	326	2	32	20	16	38	14	2	0	0	0	0	10	22	0	0	0	ART-SBSRB
7_10_2007	1520	4499	61	22	70	26	26	16	18	20	24	0	4	42	0	0	0	0	0	ALP/ OVGRZ
7_10_2007	1613	4590	299	24	54	28	18	28	14	34	16	2	2	34	2	0	0	0	0	ALP/ OVGRZ
8_15_2007	1340	4060	42	1	28	12	14	80	6	14	8	6	6	2	2	10	0	0	0	ART/ KRLA/ ACONT/ STIPA
8_15_2007	1340	4067	42	1	32	12	6	80	4	14	14	6	6	2	4	6	0	0	0	ART/ KRLA/ ACONT/ STIPA
8_15_2007	320	4077	322	6	60	24	14	94	6	0	20	2	2	38	0	0	0	0	0	ART-GRS-OVGRZD

8_15_2007	320	4087	322	6	64	18	12	86	6	8	30	6	6	24	0	4	0	0	0	ART-GRS-OVGRZD
8_16_2007	715	4071	142	11	46	10	2	60	0	40	16	24	24	0	0	6	0	0	0	ART-ARARGRS
8_16_2007	715	4053	140	11	18	2	4	64	0	36	2	14	14	0	0	2	0	0	0	ART-ARARGRS
8_16_2007	325	4060	330	10	24	12	12	92	6	2	4	8	8	2	4	6	0	0	0	ART/ KRLA/ ACONT/ STIPA
8_16_2007	325	4060	330	10	26	16	12	86	8	14	14	2	2	4	2	4	0	0	0	ART/ KRLA/ ACONT/ STIPA
8_20_2007	200	4033	324	24	58	10	8	60	3	38	15	35	35	0	5	3	0	0	0	ART-SBSRB
8_20_2007	200	4055	324	2	40	13	0	53	3	45	10	20	20	2.5	5	3	0	0	0	ART-SBSRB
8_20_2007	300	4075	338	3	46	8	50	88	0	12	46	0	0	0	0	0	0	0	0	SALT GRS
8_20_2007	300	4075	338	3	62	8	52	88	4	8	62	0	0	0	0	0	0	0	0	SALT GRS
8_20_2007	410	4096	341	3	14	6	2	90	2	8	4	0	0	0	2	8	0	0	0	KRLA/ ART/ SBSRB
8_20_2007	410	4096	341	3	16	6	2	90	2	8	8	0	0	2	0	6	0	0	0	AR/ KR/ ACO/
8_20_2007	510	4142	340	11	32	6	10	94	6	0	26	0	0	0	2	4	0	0	0	FESCUE
8_20_2007	510	4150	340	11	54	8	4	96	2	2	38	0	0	14	0	2	0	0	0	FESCUE
8_21_2007	500	4277	330	19	42	20	58	90	10	0	32	0	0	10	0	0	0	0	0	FESCUE
8_21_2007	500	4288	330	19	56	18	66	96	4	0	52	2	2	2	0	0	0	0	0	FESCUE
8_23_2007	220	4690	29	12	70	24	24	80	16	4	30	0	2	38	0	0	0	0	0	FESCUE
8_23_2007	220	4690	29	12	56	26	18	76	14	10	28	0	0	28	0	0	0	0	0	POA
8_23_2007	410	4609	120	10	66	14	49	88	6	6	12	0	50	4	0	0	0	0	0	CAREX MEADOW
8_23_2007	410	4607	120	10	84	30	36	70	20	10	2	0	68	14	0	0	0	0	0	CAREX MEADOW
8_24_2007	800	4490	24	6	68	8	56	96	2	2	10	0	26	28	0	4	0	0	0	CAREX/ FESCUE
8_24_2007	800	4490	24	6	62	12	36	90	8	2	18	0	30	12	2	0	0	0	0	CAREX/ FESCUE
8_24_2007	915	4503	40	22	64	8	64	94	6	0	30	0	20	14	0	0	0	0	0	CAREX/ FESCUE
8_24_2007	915	4503	40	22	66	8	60	94	4	2	46	0	12	8	0	0	0	0	0	CAREX/ FESCUE
8_25_2007	710	4164	180	14	28	8	6	68	8	25	20	0	0	0	0	8	0	0	0	ARAR-KRLA-T

8_25_2007	710	4164	180	14	25	8	8	70	3	28	13	10	10	0	0	3	0	0	0	ARAR/ STIPA
8_25_2007	810	4164	0	20	25	8	20	78	8	15	20	0	0	0	3	3	0	0	0	FESCUE
8_25_2007	810	4164	0	20	48	15	15	78	8	15	33	8	7.5	7.5	0	0	0	0	0	FESCUE
8_25_2007	245	4030	332	3	12	2	0	80	2	18	8	0	0	0	0	4	0	0	0	ARAR
8_25_2007	245	4030	332	3	18	6	0	88	4	8	0	0	0	2	0	16	0	0	0	ARAR
8_27_2007	400	4039	329	0	16	6	6	78	4	18	8	0	0	0	0	8	0	0	0	ARAR
8_27_2007	400	4039	329	0	6	0	0	76	0	24	0	0	0	0	0	6	0	0	0	ARAR
8_28_2007	830	4033	322	15	16	8	0	80	4	16	6	0	0	0	0	10	0	0	0	ARAR
8_28_2007	830	4033	322	15	12	8	0	68	6	26	2	0	0	0	0	10	0	0	0	ARAR
8_28_2007	920	4040	350	11	12	8	0	66	6	26	2	0	0	0	0	10	0	0	0	ARAR
8_28_2007	920	4040	350	11	10	4	2	86	2	8	0	4	0	2	0	8	0	0	0	ARAR
8_28_2007	1015	4037	342	9	10	0	0	78	0	22	6	0	0	0	0	4	0	0	0	KRLA
8_28_2007	1015	4037	342	9	6	4	4	78	4	18	2	0	0	0	0	4	0	0	0	KRLA
8_28_2007	1100	4056	350	12	14	2	0	80	0	20	4	0	0	2	0	8	0	0	0	ARAR/ KRLA
8_28_2007	1100	4056	350	12	10	4	0	88	4	8	8	0	0	0	0	2	0	0	0	ARAR/ KRLA
8_28_2007	1130	4056	10	11	24	6	0	82	2	16	16	0	0	0	0	8	0	0	0	ARAR/ KRLA
8_28_2007	1130	4056	10	11	14	4	0	84	4	12	2	0	0	0	0	12	0	0	0	ARAR/ KRLA
8_28_2007	1415	4019	0	0	72	12	22	90	10	0	6	0	58	6	2	0	0	0	0	CAREX MEADOW
8_28_2007	1415	4019	0	0	66	36	54	70	30	0	6	14	58	2	0	0	0	0	0	CAREX/ MEADOW
8_28_2007	1520	4030	0	0	92	44	30	76	24	0	2	0	76	14	0	0	0	0	0	CAREX/ MEADOW
8_28_2007	1520	4030	0	0	78	0	0	94	6	0	2	0	64	12	0	0	0	0	0	CAREX/ MEADOW
8_29_2007	1445	4063	162	3	18	4	10	88	2	10	12	0	0	6	0	0	0	0	0	SALT GRS
8_29_2007	1445	4063	162	3	40	2	6	62	36	2	36	0	0	4	0	0	0	0	0	SALT GRS
8_29_2007	1340	4037	168	3	42	10	22	42	58	0	34	0	0	8	0	0	0	0	0	SALT GRS
8_29_2007	1340	4037	168	3	36	8	40	54	2	0	36	0	0	0	0	0	0	0	0	SALT GRS
8_29_2007	1530	4085	150	3	24	10	4	82	6	12	16	0	0	0	0	8	0	0	0	ARAR
8_29_2007	1530	4085	150	3	24	10	4	82	4	14	0	0	0	0	0	0	0	0	0	ARAR
8_29_2007	1630	4152	142	18	18	0	4	66	0	34	10	6	6	0	0	2	0	0	0	ART-KRLA-ARAR
8_29_2007	1630	4152	142	18	32	20	0	58	6	36	6	24	24	0	0	2	0	0	0	ART-KRLA-ARAR
8_30_2007	1420	4073	160	8	18	6	0	98	0	2	4	0	0	0	0	14	0	0	0	ARAR

8_30_2007	1420	4073	160	8	20	6	2	90	4	6	4	2	2	0	0	14	0	0	0	ARAR
8_30_2007	1520	4094	160	4	10	4	0	96	4	0	0	0	0	0	0	10	0	0	0	ARAR
8_30_2007	1520	4094	160	4	16	2	0	86	2	12	10	0	0	2	0	4	0	0	0	ARAR
8_30_2007	1620	4087	320	0	14	4	4	99	0	0	12	0	0	0	2	0	0	0	0	ARAR
8_30_2007	1620	4087	320	0	32	10	0	80	10	0	10	10	10	0	2	10	0	0	0	ARAR
8_31_2007	1530	3970	166	12	16	4	8	94	0	6	6	0	0	0	0	10	0	0	0	KRLA
8_31_2007	1530	3970	166	12	20	4	6	92	0	8	10	0	0	0	0	10	0	0	0	KRLA
8_31_2007	1610	4006	166	10	8	2	2	99	0	0	2	0	0	0	0	6	0	0	0	KRLA
8_31_2007	1610	4006	166	10	6	2	2	70	0	30	4	0	0	0	0	2	0	0	0	KRLA-SBSRB
9_1_2007	800	3960	142	14	16	8	4	84	8	8	0	0	0	0	2	14	0	0	0	KRLA
9_1_2007	800	3960	142	14	10	4	10	96	0	4	0	0	0	0	4	6	0	0	0	KRLA
9_1_2007	840	3972	152	13	16	2	6	94	0	6	6	0	0	0	0	10	0	0	0	KRLA
9_1_2007	840	3972	152	13	2	2	2	98	0	2	0	0	0	0	2	0	0	0	0	KRLA-SBSRB
9_1_2007	910	3963	156	12	8	2	8	92	2	6	6	0	0	0	2	0	0	0	0	KRLA-SBSRB
9_1_2007	910	3963	156	12	18	4	4	99	0	0	6	0	0	0	0	12	0	0	0	KRLA-SBSRB
9_1_2007	945	3958	136	11	28	6	8	70	4	26	22	0	0	2	2	2	0	0	0	KRLA LEYMUS
9_1_2007	945	3958	136	11	18	2	2	82	0	18	12	0	0	2	2	0	0	0	0	KRLA LEYMUS
9_1_2007	1030	3948	154	8	34	6	10	72	6	18	14	10	10	6	0	6	0	0	0	ARAR
9_1_2007	1030	3948	154	8	40	0	14	92	0	8	26	0	0	0	2	12	0	0	0	KRLA ARAR/ LEYMUS
9_1_2007	1115	3936	15	12	6	2	2	90	0	10	0	0	0	0	0	6	0	0	0	KRLA
9_1_2007	1115	3936	15	12	6	4	0	88	0	12	0	0	0	0	0	6	0	0	0	KRLA
9_2_2007	1515	3850	186	1	92	56	82	92	8	0	92	0	0	0	0	0	0	0	0	SALT GRS
9_2_2007	1515	3850	186	1	76	24	6	88	12	0	74	0	0	2	0	0	0	0	0	SALT GRS
9_2_2007	1630	3841	0	0	99	60	44	0	80	0	0	0	96	0	0	0	0	0	4	WL
9_2_2007	1630	3882	0	0	99	98	66	0	88	0	0	0	98	0	0	0	0	0	0	WL
9_3_2007	800	3945	342	25	40	28	10	74	14	12	16	0	0	12	10	2	0	0	0	ART-SBSRB
9_3_2007	800	3945	342	25	36	26	8	86	8	6	22	0	0	2	8	4	0	0	0	ART-SBSRB
9_3_2007	915	3887	0	0	32	12	0	96	4	0	12	8	8	4	0	8	0	0	0	ART-SBSRB
9_3_2007	915	3887	0	0	32	14	2	92	8	0	12	12	12	0	0	8	0	0	0	ARAR/ ARGRSS
9_3_2007	1030	3923	155	1	24	8	4	52	0	48	8	0	0	0	0	16	0	0	0	ART-STIPA

9_3_2007	1030	3923	155	1	18	8	6	32	2	66	8	0	0	2	0	8	0	0	0	ART-STIPA
9_4_2007	705	3465	160	1	30	16	30	52	4	44	0	0	0	0	6	8	16	0	0	JUNIPER
9_4_2007	700	3435	161	1	44	32	18	46	10	44	0	0	0	12	0	0	18	0	0	JUNIPER
9_4_2007	1100	3491	176	5	53	40	18	43	3	53	0	0	0	3.3	0	3	0	30	17	BIRCH
9_4_2007	1100	3491	176	5	83	69	40	50	3	47	0	0	0	0	0	0	0	53	30	BIRCH
9_4_2007	1330	3717	208	40	14	8	2	48	4	48	0	0	0	0	2	10	2	0	0	ARWH-JUN
9_4_2007	1330	3707	208	40	12	8	2	34	0	66	0	0	0	0	0	12	0	0	0	ARWH-JUN

[1] CC is canopy cover, Appendix includes foliar cover and basal cover for shrubs, sub-shrubs, forbs, Carexdl, CarexWl, and grasses.
[2] Cover type/Community type were designated in the field and may not be final type.

Appendix 3. Summary table of percent total Canopy Cover, Foliar Cover (FC) and Basal Cover (BC) for total shrubs, sub-shrubs, forbs, Carexdl, Carex W, Grass and total foliar cover and basal cover. Date and time of transects and elevation (m) are also provided for comparison to Appendix 2.

DATE (month_day)	TIME	ELEVATION (m)	CANOPY COVER	FC SHRUBS	FC SUB-SHRUBS	FC FORBS	FC CAREXDL	FC CAREX W	FC GRASS	FC TREE	TOTAL FOLIAR COVER	BC SHRUBS	BC SUB SHRUBS	BC FORBS	BC CAREXDL	BC CAREX WL	BC GRASS	BC TREE	TOTAL BASAL COVER
7_27	730	4352	34	0	0	28	0	0	0	0	28	0	0	18	0	0	0	0	18
7_27	1000	4356	46	0	0	24	0	0	6	0	30	0	0	10	0	0	4	0	14
6_27	1730	4172	46	0	0	22	0	4	2	0	28	0	0	6	0	0	4	0	10
6_29	800	4131	28	18	0	2	0	0	0	0	20	4	0	0	0	0	0	0	4
6_29	1000	4142	30	16	0	0	0	0	2	0	18	2	0	0	0	0	2	0	4
6_29	1400	4133	36	16	0	4	0	0	8	0	28	2	0	2	0	0	8	0	12
6_29	1500	4121	16	0	0	2	0	0	8	0	10	0	0	0	0	0	4	0	4
6_29	1600	4121	18	0	0	6	0	0	6	0	12	0	0	2	0	0	0	0	2
6_30	635	4109	28	0	0	6	0	0	12	0	18	0	0	2	0	0	8	0	10
6_30	730	4102	20	0	0	4	0	0	4	0	8	0	0	2	0	0	4	0	6
6_30	830	4108	32	0	0	6	2	0	6	0	14	0	0	2	0	0	0	0	2
6_30	900	4108	30	0	0	16	0	0	6	0	22	0	0	12	0	0	4	0	16
6_30	md	4402	md	md	md	md	md	md	md	md	md	md	md	md	md	md	md	md	md
7_2	1610	4453	58	0	0	28	0	0	18	0	46	0	0	10	0	0	8	0	18
7_3	1530	4185	34	12	4	2	4	0	0	0	22	0	4	0	0	0	0	0	4
7_3	1600	4187	30	8	10	0	2	0	0	0	20	0	10	0	0	0	0	0	10
7_3	1640	4205	48	0	0	16	2	0	6	0	24	0	0	2	0	0	2	0	4
7_3	1745	4206	58	4	0	16	2	0	10	0	32	2	0	8	0	0	2	0	12
7_4	730	4166	88	0	0	0	0	58	2	0	60	0	0	2	0	22	0	0	24
7_4	830	4173	88	0	0	0	0	36	0	0	36	0	0	0	0	16	0	0	16
7_4	900	4154	28	6	8	0	0	0	4	0	18	2	8	0	0	0	2	0	12
7_4	930	4154	30	10	0	2	2	0	0	0	14	6	0	0	0	0	0	0	6
7_4	1115	4137	52	0	4	8	0	0	18	0	30	0	2	2	0	0	2	0	6
7_5	715	4140	26	12	4	0	0	0	0	0	16	2	4	0	0	0	0	0	6
7_5	730	4140	22	4	2	0	0	0	2	0	8	2	2	0	0	0	0	0	4
7_6	700	4419	52	14	6	14	0	0	0	0	34	12	6	10	0	0	0	0	28
7_6	700	4410	48	4	0	22	0	0	2	0	28	4	0	14	0	0	2	0	20
7_6	810	md	32	8	0	2	0	0	4	0	14	6	0	2	0	0	4	0	12
7_6	910	4407	30	14	4	4	0	0	0	0	22	8	4	4	0	0	0	0	16
7_6	910	4409	36	8	6	10	0	0	2	0	26	6	6	10	0	0	2	0	24
7_6	1000	4391	62	10	0	24	0	0	12	0	46	4	0	18	0	0	6	0	28
7_6	1000	4373	62	8	0	32	0	0	6	0	46	6	0	16	0	0	2	0	24
7_6	1100	4373	54	6	0	20	0	0	10	0	36	6	0	16	0	0	8	0	30
7_6	1110	4373	52	24	0	8	0	0	8	0	40	12	0	6	0	0	4	0	22
7_6	1110	4382	58	0	0	40	0	0	4	0	44	0	0	16	0	0	0	0	16
7_6	1230	4382	56	0	0	30	0	0	4	0	34	0	0	8	0	0	2	0	10
7_8	1615	4190	22	2	8	0	0	0	0	0	10	0	6	0	0	0	0	0	6
7_8	1730	4214	32	14	6	0	0	0	0	0	20	8	8	0	0	0	0	0	16

7_10	1520	4499	70	0	0	18	0	0	8	0	26	0	0	12	0	0	6	0	18
7_10	1613	4590	54	0	0	24	2	0	2	0	28	0	0	14	0	0	0	0	14
8_15	1340	4060	28	6	2	2	0	0	2	0	12	2	2	0	0	0	2	0	6
8_15	1340	4067	32	2	2	0	2	0	6	0	12	0	2	0	0	0	2	0	4
8_15	320	4077	60	0	2	10	0	0	12	0	24	0	2	0	0	0	4	0	6
8_15	320	4087	64	0	0	8	0	0	10	0	18	0	0	0	0	0	4	0	4
8_16	715	4071	46	6	0	0	0	0	4	0	10	0	0	0	0	0	0	0	0
8_16	715	4053	18	2	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
8_16	325	4060	24	6	4	0	0	0	2	0	12	2	4	0	0	0	0	0	6
8_16	325	4060	26	2	0	2	2	0	6	0	12	0	0	2	0	0	6	0	8
8_20	200	4033	58	3	3	0	3	0	3	0	10	0	3	0	0	0	0	0	3
8_20	200	4055	40	0	3	3	5	0	3	0	13	0	3	0	0	0	0	0	3
8_20	300	4075	46	0	0	0	0	0	8	0	8	0	0	0	0	0	0	0	0
8_20	300	4075	62	0	0	0	0	0	8	0	8	0	0	0	0	0	4	0	4
8_20	410	4096	14	2	2	0	0	0	2	0	6	0	2	0	0	0	0	0	2
8_20	410	4096	16	2	0	0	0	0	4	0	6	0	0	0	0	0	2	0	2
8_20	510	4142	32	0	2	0	0	0	6	0	8	0	0	0	0	0	2	0	2
8_20	510	4150	54	0	0	4	0	0	4	0	8	0	2	0	0	0	4	0	6
8_21	500	4277	42	0	0	6	0	0	14	0	20	0	0	0	0	0	2	0	2
8_21	500	4288	56	0	0	0	0	0	18	0	18	0	0	0	0	0	10	0	10
8_23	220	4690	70	0	0	14	0	0	10	0	24	0	0	0	0	0	4	0	4
8_23	220	4690	56	0	0	12	0	0	14	0	26	0	0	10	0	0	6	0	16
8_23	410	4609	66	0	0	4	2	8	0	0	14	0	0	10	0	0	4	0	14
8_23	410	4607	84	0	0	0	0	30	0	0	30	0	0	2	0	4	0	0	6
8_24	800	4490	68	0	0	4	0	2	2	0	8	0	0	0	0	20	0	0	20
8_24	800	4490	62	0	2	2	0	2	6	0	12	0	0	0	0	0	2	0	2
8_24	915	4503	64	0	0	2	0	0	6	0	8	0	0	4	0	0	4	0	8
8_24	915	4503	66	0	0	2	0	2	4	0	8	0	0	0	0	0	6	0	6
8_25	710	4164	28	0	0	0	0	0	8	0	8	0	0	2	0	0	2	0	4
8_25	710	4164	25	0	0	0	0	0	5	0	5	0	0	0	0	0	8	0	8
8_25	810	4164	25	0	3	0	0	0	5	0	8	0	3	0	0	0	5	0	8
8_25	810	4164	48	0	0	0	3	0	13	0	15	0	0	0	0	0	8	0	8
8_25	245	4030	12	0	0	0	0	0	2	0	2	0	0	0	0	0	2	0	2
8_25	245	4030	18	4	0	2	0	0	0	0	6	2	0	2	0	0	0	0	4
8_27	400	4039	16	6	0	0	0	0	0	0	6	4	0	0	0	0	0	0	4
8_27	400	4039	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8_28	830	4033	16	6	0	0	0	0	2	0	8	4	0	0	0	0	0	0	4
8_28	830	4033	12	6	0	0	0	0	2	0	8	4	0	0	0	0	2	0	6
8_28	920	4040	12	2	0	0	0	0	2	0	4	0	2	0	0	0	2	0	4
8_28	920	4040	10	4	0	0	0	0	0	0	4	2	0	0	0	0	0	0	2
8_28	1015	4037	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8_28	1015	4037	6	4	0	0	0	0	0	0	4	4	0	0	0	0	0	0	4
8_28	1100	4056	14	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0
8_28	1100	4056	10	0	0	0	0	0	4	0	4	0	0	0	0	0	4	0	4
8_28	1130	4056	24	2	0	0	0	0	4	0	6	0	0	0	0	0	2	0	2
8_28	1130	4056	14	4	0	0	0	0	0	0	4	4	0	0	0	0	0	0	4
8_28	1415	4019	72	0	0	0	0	8	4	0	12	0	0	0	0	2	2	0	4
8_28	1415	4019	66	0	0	2	4	26	4	0	36	0	0	0	0	6	24	0	30
8_28	1520	4030	92	0	0	16	0	28	0	0	44	0	0	6	0	14	0	0	20
8_28	1520	4030	78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

8_29	1445	4063	18	0	0	0	0	0	4	0	4	0	0	0	0	0	2	0	2
8_29	1445	4063	40	0	0	0	0	0	2	0	2	0	0	0	0	0	2	0	2
8_29	1340	4037	42	0	0	0	0	0	8	0	8	0	0	0	0	0	0	0	0
8_29	1340	4037	36	0	0	0	0	0	10	0	10	0	0	0	0	0	2	0	2
8_29	1530	4085	24	4	0	0	0	0	6	0	10	2	0	0	0	0	4	0	6
8_29	1530	4085	24	6	0	0	0	0	4	0	10	2	0	0	0	0	2	0	4
8_29	1630	4152	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8_29	1630	4152	32	2	0	0	14	0	4	0	20	0	0	0	4	0	2	0	6
8_30	1420	4073	18	4	0	0	0	0	2	0	6	0	0	0	0	0	0	0	0
8_30	1420	4073	20	2	0	0	0	0	4	0	6	2	0	0	0	0	2	0	4
8_30	1520	4094	10	4	0	0	0	0	0	0	4	4	0	0	0	0	0	0	4
8_30	1520	4094	16	0	0	0	0	0	2	0	2	0	0	0	0	0	2	0	2
8_30	1620	4087	14	0	2	0	0	0	2	0	4	0	0	0	0	0	0	0	0
8_30	1620	4087	32	4	2	0	0	0	4	0	10	4	2	0	0	0	4	0	10
8_31	1530	3970	16	4	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
8_31	1530	3970	20	4	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
8_31	1610	4006	8	2	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
8_31	1610	4006	6	2	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
9_1	800	3960	16	6	2	0	0	0	0	0	8	6	2	0	0	0	0	0	8
9_1	800	3960	10	2	2	0	0	0	0	0	4	0	0	0	0	0	0	0	0
9_1	840	3972	16	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0
9_1	840	3972	2	0	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0
9_1	910	3963	8	0	2	0	0	0	0	0	2	0	2	0	0	0	0	0	2
9_1	910	3963	18	2	2	0	0	0	0	0	4	0	0	0	0	0	0	0	0
9_1	945	3958	28	2	2	0	0	0	2	0	6	2	2	0	0	0	0	0	4
9_1	945	3958	18	0	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0
9_1	1030	3948	34	6	0	0	0	0	0	0	6	6	0	0	0	0	0	0	6
9_1	1030	3948	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9_1	1115	3936	6	2	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
9_1	1115	3936	6	4	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
9_2	1515	3850	92	0	0	2	0	0	54	0	56	0	0	4	0	0	4	0	8
9_2	1515	3850	76	0	0	4	0	0	20	0	24	0	0	0	0	0	12	0	12
9_2	1630	3841	99	0	0	0	0	46	0	14	60	0	0	0	0	26	0	6	32
9_2	1630	3882	99	0	0	0	0	98	0	0	98	0	0	0	0	40	0	0	40
9_3	800	3945	40	0	10	10	0	0	8	0	28	0	4	6	0	0	4	0	14
9_3	800	3945	36	2	6	0	0	0	18	0	26	2	2	2	0	0	2	0	8
9_3	915	3887	32	4	0	2	0	0	6	0	12	2	0	0	0	0	2	0	4
9_3	915	3887	32	4	0	0	2	0	8	0	14	2	0	0	0	0	6	0	8
9_3	1030	3923	24	6	0	0	0	0	2	0	8	0	0	0	0	0	0	0	0
9_3	1030	3923	18	4	0	0	0	0	4	0	8	0	0	0	0	0	2	0	2
9_4	705	3465	30	4	2	0	0	0	0	10	16	2	2	0	0	0	0	0	4
9_4	700	3435	44	2	4	8	0	0	0	18	32	0	2	2	0	0	0	6	10
9_4	1100	3491	53	3	0	3	0	0	0	36	43	0	0	0	0	0	0	3	3
9_4	1100	3491	83	0	0	0	0	0	0	70	69	0	0	0	0	0	0	3	3
9_4	1330	3717	14	8	0	0	0	0	0	2	10	2	0	0	0	0	0	2	4
9_4	1330	3707	12	8	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0

Appendix 4. Preliminary list of plants of the Wakhan Corridor study area by family.

APIACEAE
Bupleurum gracillimum
Carum carvi
Platytaenia lasiocarpa
Heracleum sp.

ASTERACEAE
Acroptilon repens
Anaphalis virgata
Artemisia albida
Artemisia dracunculus
Artemisia leucotricha
Artemisia perisica
Artemisia rutaefolia
Artemisia santolinifolia
Artemisia scoparia
Artemisia vachanica
Aster flaccidus
Chondrilla leiosperma
Chickorium intybus
Cirsium argyracanthum
Cirsium arvense
Cousinia bupthalmoides
Cousinia thompsonii
Crepis pulchra
Erigeron petroiketes
Inula salsoloides
Gypsophila herneriarioides
Lactuca tatarica
Lactuca orientalis
Lactuca scariola
Leontopodium ochroleucum
Mulgedium tataricum
Psychrogeton andryaloides
Psychrogeton olgae
Saussurea gilesii
Saussurea jacea
Saussurea gnaphaloides
Senecio korshinskyi
Spathipappus griffithii
Tanacetum djilgense
Tanacetum pyrethroides
Waldheimia tomentosa
Scariola orientalis
Scorzonera virgata
Taraxacum bessarabicum
Taraxacum bicolor
Tragopogon gracilis

BETULACEAE
Betula chitralica

BORAGINACEAE

Anchusa ovata
Arnebia euchroma
Asperugo procumbens
Cynoglossum glochidiatum
Lindelofia macrostyla
Mattiastrum acrocladum
Myosotois asiatica
Tianschaniella wakhanica

BRASSICACEAE
Chorispora macropoda
Conringia planisiliqua
Descurainia sophia
Draba altaica
Draba korshinskyi
Draba oreades
Draba stenocarpa
Goldbachia laevigata
Lepidium latifolium
Malcolmia strigosa
Matthiola tenera
Neuroloma kunawarense
Sisymbrium brassiciforum
Smelowskia sp.
Tetracme pamirica
Tetracme quadricornis
Thalaspi cochlearioides

CAPPARIDACEAE
Capparis spinosa

CAPRIFOLIACEAE
Lonicera asperifolia
Lonicera semenovii
Lonicera obovata
Lonicera spinosa
Lonicera microphylla (*L. pamirica syn*).
Lonicera stenantha
Lonicera Korolkovii
Lonicera nummulariifolia

CAROPHYLLACEAE
Arenaria griffithii
Arenaria serphllifolia
Cerastium cerastioides
Lepyrodiclis holosteoides
Silene conoidea
Silence gonosperma
Silene pamirensis
Silene takhtensis
Silene winkleri
Vaccaria pyramidata

CHENOPODIACEAE
Chenopodium album
Chenopodium botrys
Kochia prostrata
Krascheninnikovia ceratoides
Salsola collina
Salsola iberica

CONVULACEAE
Convolvulus arvensis

CRASSULACEAE
Rosularia alpestris
Sedum heterodontum
Sedum pamiroalaicum
Sedum recticaule

CUPRESSACEAE
Juniperus semiglobosa

CUSCUTACEAE
Cuscuta europaea

CYPERACEAE
Carex gilesii
Carex melanantha
Carex nivalis
Carex orbicularis
Carex stenophylla
Elocharis quinqueflora
Koebresia pamiroalaica
Kobresia stenocarpa
Schoenoplectus tabernaemontani
Scirpus pumilus

ELAEAGNACEAE
Hippophae rhamnoides

EPHEDRACEAE
Ephedra fedtschenkoi
Ephedra regeliana
Ephedra intermedia

EUPHORBIACEAE
Euphorbia sp.

FABACEAE
Astragalus adpressipilosus
Astragalus lasiosemius
Astragalus melanostachys
Astragalus schacdarius
Astragalus webbianus
Cicer macracanthum
Cicer fedtschenkoi
Glycyrrhiza glabra
Lathyrus sativus
Medicago sativa
Melilotus officinalis
Oxytropis hirsutiuscula
Pisum sativum (cultivated)
Trigonella pamirica

FUMARIACEAE
Corydalis fedtashenkoana

GENTIANANCEAE
Gentiana prostrata
Gentiana longicarpa
Gentiana stricta
Gentiana olivieri
Gentiana kaufmanniana
Genitana longicarpa
Gentiana marginata
Gentiana minutissima
Gentiana riparia
Gentiana aquatica
Lomatogonium carinthiacum
Swertia lactea
Swertia petiolata

GERANIACEAE
Geranium collinium
Geranium himalayense
Geransium regelii

GROSSULARIACEAE
Ribes villosum

HIPPURIDACEAE
Hippuris vulgaris

JUNCACEAE
Juncus articulatus

JUNCAGINACEAE
Triglochin maritimum
Triglochin palustre

LAMINACEAE
Dracocephalum stamineum
Eremostachys sp.
Elsholtzia densa
Hymenocrater sessilifolius
Lagochilis cabulicus
Mentha longifolia
Nepeta fedtschenkoi
Nepeta floccose
Nepeta pamirensis
Nepeta podostachys
Phlomis sp.
Prunella vulgaris\
Salvia sp.
Scutellaria heydei
Thymus linearis
Thymus sp.
Ziziphora clinopodioides

LENTIBULARIACEAE
Utricularia vulgaris

LILIACEAE
Allium fedtschenkoanum
Allium sp.
Eremurus stenophyllus
Gagea exilis
Lloydia serotina

MALVACEAE
Malva pusilla

ONAGRACEAE
Epilobium angustifolium
Epilobium latifolium
Epilobium tibetanum

ORCHIDACEAE
Dactylorrhiza kafiriana

OROBANCHACEAE
Orobanche cernua

PAPAVERACEAE
Papaver nudicaule

PARNASSIACEAE
Parnassia palustris

PLANTAGINACEAE
Plantago gentianoides
Plantago depressa

PLUMBAGINACEAE
Acantholimon erythraeum
Acantholimon gili
Acantholimon pamiricum

POACEAE
Achnatherum splendens
Agrostis stolonifera
Aloepecurus himalaicus.
Avena septentrionalis
Bromus gracillimus
Bromus japonicus
Bromus lanceolatus
Bromus stenostachyus
Calamagrostis dubia
Deschampsia pamirica
Elymus cognatus
Elymus dahuricus
Elymus dasystachys
Elymus hispidus (A. intermedium)?
Elymus nutans
Elymus repens
Eremopoa perisica
Festuca alaica
Festuca arundinacea
Festuca pamirica
Festuca rubra
Festuca valesiaca
Hordeum turkestanicum
Hordeum vulgare
Koeleria cristata
Malacurus lanatus
Melica jacquemontii
Panicum miliaceum (millet)
Phleum alpinum
Piptatherum laterale
Piptatherum gracile
Poa litvinoviana
Poa sp.
Polypogon monspeliensis
Puccinellia distans
Secale cereale (cultivated)
Stipa breviflora
Stipa caucasica
Stipa trichoides

POLYGONACEAE
Atraphaxis spinosa
Oxyria digna
Polygonum aviculare
Polygonum convolvulus
Polygonum molliaeforme
Polygonum thymifolium
Rheum tibeticum
Rheum spiciforme
Rumex patientia
Rumex paulsenianus

PRIMULACEAE
Glaux maritma
Primula macrophylla
Primula pamirica

RANUNCULACEAE
Clematis tangutica
Delphinium brunonianum
Halerpestes sarmentosa
Ranunculus rufosepalus

RHAMANACEAE
Rhamnus prostrata

ROSACEAE
Amygadalus sp.
Potentilla anserina
Potentilla argentea
Potentilla bifurca
Potentilla dealbata
Potentilla gelida
Potentilla multifida
Potentilla phyllocalyx
Potentilla sericea
Potentilla supine
Rosa webbiana

RUBIACEAE
Galium ibicinum
Galium tricornutum
Rubia citralensis

SALICACEAE
Populus pamirica
Salix exceisa
Salix pycnostachya
Salix schugnanica
Salix turanica

SAXIFRAGACEAE
Saxifraga komarovii (Syn S. flagellaris
Saxifraga hirculus var alpine
Saxifraga sibirica

SCROPHULARIACEAE
Euphrasia secundiflora
Linaria bamianica
Pedicularis dolichorrhiza
Pedicularis rhinanthoides
Pedicularis verae
Scrophularia dentate
Veronica michauxii

TAMARICACEAE
Myricaria germanica
Myricaria squamosa

URTICACEAE
Utrica sp.

ZYGOPHYLLACEAE
Peganum harmala
Tribulus ?