RANGELAND ASSESSMENT OF THE WAKHAN

2006 Interim Report

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Table of Contents

Introduction **3**

Training **4**

Rangeland Assessment **5**

General Description of Area Surveyed. 5

Vegetation Description. 5

Rangeland Community Type Descriptions 6

Cold Desert Shrub 7

Ceratoides Community Type 8

Artemisia-Ceratoides Community Type 8

Artemisia-Steppe Community Type 9

Sedge Wetland Meadow Cover Type 12

Alpine Grassland Community Type 14

Salix Community Type 15

Birch Willow Forest Community Type 18

Rangeland Degradation and Threats to Wildlife **19**

Rangeland Community Mapping **20**

Literature Cited **24**

Introduction

The objective of the rangeland assessment is to provide information on rangeland types and conditions for biodiversity conservation in the Wakhan Corridor Area. The project will include the development of indicators of rangeland conditions, mapping of rangeland types and training of Afghan students in rangeland analysis. This report summarizes the activities of the first summers work in the Wakhan and provides initial descriptions of some of the major vegetation types and of general rangeland conditions. The initial section is a brief summary of the training mission. I suggest that this summary is valuable in reporting to others what the initial capacity is of the students (and probably of the student population). The second section describes the initial reconnaissance work of two major areas inspected. The reconnaissance consisted of a quick inspection of areas and some plot work that will be further described. Some initial plant community descriptions are provided as well as some general comments on rangeland degradation and possible negative consequences of the domestic livestock grazing on wildlife. The plant community descriptions are entirely subjective at this time and will be modified with further data collection and analysis. The different plant communities are the basis of resource types used by pastoralists, their animals, and wildlife. These communities will have different resource values that will be described in later documents when additional data is collected and summarized. The last two sections entitled "Rangeland Degradation and Threats to Wildlife" and "Rangeland Community Mapping" are very brief sections that describe some observations on rangeland degradation and mapping problems. However, in these sections I also provide descriptions of planned directions for developing indicators and for developing mapping methodology and procedures.

All plant community work reported in this document is considered preliminary as identification of plant species is continuing (presently, there are over 150 plants at the U.S. Department of Agriculture inspection station in Maryland for identification and entry into the U.S.) as well as further analyses of data. After specimens are identified they will transported back to the WCS office in Kabul and used for study/training specimens. Work is also continuing in the development of a geographic information system (GIS). The system will incorporate all plot data, photographs, and rangeland mapping. The attached plot data and photographs within the GIS will allow easy future comparisons of data and images. As the plot data is not complete (species identification will need to be added) I have not included the GIS system, but the system will be illustrated in an appendix.

Training

The training involved working with three Afghan students and a counterpart from the *Forestry and Rangeland Department*. The major training areas consisted of developing 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.

Surprisingly, the students had no background with a compass nor did they seem to have any knowledge for the reasons for using a compass to measure aspect and slope. I discussed how topographic aspects influence plant community development with greater runoff associated with steeper slopes and aspect (sun angle) of southern and western aspects being dryer than north and east slopes at similar elevations and slopes. After approximately 4 to 5 days all students could use a compass; although, it did not seem to come very easily to most of the students. I am not sure that before the training they had any knowledge that the compass points to magnetic north and could be set to true north with the declination adjustment.

All three students had some training with the use of the GPS; although, my counterpart had never used a GPS. The GPS units were actually mastered by the students much quicker than with the compass. However, I did have to continually make sure no one changed units or projections as this was an initial problem as students learned to use the units. I also had the students return to transect locations by placing coordinates into their GPS units. They were able to relocate transects and also pin locations of transects.

The most difficult aspect in training was plant identification. All three students had poor plant skills with little knowledge of plant families. My counterpart had much stronger plant identification skills and also had an adequate knowledge of plant families. We spent considerable time discussing the differences between grasses, grass-like plants, forbs, and shrubs. It did not appear that the students had any training in floral structures of grasses (or grass-like plants) and only very limited background in other groups. We spent considerable time developing plant identification skills; however, as I had no plant keys or any plants lists for the area this was a difficult part of the project. I believe in 2007 we will be much better prepared with many of the more common plants now being identified. Because of inadequate plant description skills I chose to use point sampling and line-intercept sampling to require all to look at very specific sites rather than larger plots for data collection on site/vegetation characteristics.

Training in rangeland/plant community analyses consisted of descriptions of plant communities. Students were trained in establishing “permanent” transects or plots, estimating plant cover using canopy cover estimation procedures within plots, estimation of above-ground biomass (double-sampling procedure), point-sampling, line-intercept sampling, and establishment of photo plots. We discussed signs of degradation such as trailing, accelerated erosion, overgrazed plants and sites, reduced plant vigor, reduced plant and litter cover, rills and other signs of water loss, and others. As stated previously, the method selected for plots for

vegetation description was a line transect (2 lines per plot) with both point-sampling and generally also with line intercept measured on vegetation. On some sites where plant cover was continual and individual plants not readily identifiable (such as sedge wetlands) only the line intercept method was used. The methodology will be further explained in the methods section regarding permanent plots.

In summary, training was a continual and time consuming process. There is no doubt that the altitude and exertion of moving almost daily into these remote areas made everything more difficult. It is expected that in 2007 the situation will be improved with experience gained during summer of 2006.

Rangeland Assessment

General Description of Area Surveyed. A major objective of my initial year of the rangeland assessment was to observe several areas of the study area to determine study needs and to provide information on rangeland types and conditions for biodiversity conservation. A primary component is to develop a set of indicators in regards to rangeland deterioration and to hypothesize on potential impacts of rangeland degradation and overgrazing on wildlife. To develop indicators requires knowledge of plant communities of the area and potential changes of plant communities associated with livestock grazing or other uses (fuel-wood gathering). We initiated plot work to develop a general view of plant community types and conditions associated with those community types (amount of bareground, plant cover, litter, signs of grazing impacts, etc.).

Following discussions with other team members it was decided that I would initially move my team up from Goz Khun along the Pamir River in order to acclimate to the elevation and also to see the vegetation types of these lower areas. This route allowed us to examine rangelands near the Pamir River and in the Wakhan Range. We moved through most areas relatively rapidly in order to reconnoiter a larger area, but established a number of plots and viewed portions of the Big Pamir Hunting Reserve. After 18 days we returned to a road at Sargez to resupply and to move farther into the valley. Following one day rest at Sargez we traveled to Sarhad by vehicle. It was my understanding that the upper Wakjhir River Valley had low grazing pressure by livestock and thus an important area to examine for comparison to other areas. We therefore traveled from Sharhad into the Little Pamir and up the Wakjhir River Valley to the China border by foot and with animals. This was a shorter trip of 14 days round-trip.

Vegetation Description. During our field work we established 42 “monitoring plots” that varied in elevation from 3474 to 4718 meters (Appendices 3 and 4). Plots were generally comprised of two transects (50 m) spaced 5 or 10 m apart (depending on site). GPS coordinates, photographs, aspect, slope and plant cover and ground cover (litter, rock, or bareground) 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 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 vegetation types using remote sensed data (Landsat ETM+). 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 if possible later in the winter of 2007. Petocz (1978) provided some description of community types. Also, Breckle (1971) provided a more in-depth discussion of alpine flora of Afghanistan describing a number of species.

Rangeland Community Type Descriptions

The rangelands of the study area are variable associated with differences in soils, aspect, elevation, and landform. The main limiting factor for forage production is water in much of the area; although, certainly low temperatures during most of the year also greatly limits plant growth and also livestock production. I identified a number of community types that I have categorized into five broad types for discussion: (1) a Cold-Desert Shrub; (2) a Sedge Meadow/Wetland Type; (3) an Alpine Type; (4) a *Salix* Shrub type, and (5) a Birch-Willow Forest Type. The descriptions of these types are subjective and based on relatively small number of samples, but will be used to further develop plant community groupings.

The cold-desert shrub type dominates much of the area sampled with a sagebrush (*Artemisia spp.*) steppe the most common vegetation type. The sagebrush steppe is variable in both shrub and grass cover with grasses becoming uncommon at lower elevations. Common grasses and grass-like plants include species of *Festuca*, *Poa*, *Stipa*, *Elymus*, *Hordeum*, *Agropyron* and *Elytrigia.* Annuals grasses were uncommon in 2006, but not rare. A *Ceratoides*[1] shrub type was common, as were sites with a mixture of *Artemisia* and *Ceratoides*. In general, the *Ceratoides* cold-desert shrub type had little or no grass cover and was more common on areas with higher salt content, at lower elevations, or where the sites were more xeric. The Cold Desert Shrub type produces relatively low amounts of forage/browse per unit area (100 to 600 kg/ha), but the large area of this type makes it a very important type for livestock and wildlife.

The most productive rangeland type is the Sedge (*Carex* 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. Along the Pamir River and at other localized sites there are saline wetland sites with high amounts of *Pucinella sp*., *Hordeum sp*. *Juncus sp*. and other halophytes. The more common Sedge Meadow/Wetland are generally the most productive rangeland type. These areas often have 100% plant cover and we clipped one site with 3,600 kg/ha of standing crop (air-dry weight). The Sedge Meadows are limited in area, but no doubt supply significant amounts of forage for livestock as these sites are often grazed heavily.

The Alpine Grassland type is a diverse and productive type with high vegetation cover. This type has a variety of forbs and grasses including species of *Trisetum*, *Agrostis*, *Poa*, *Festuca*, *Agropyron, Ranunculus*, *Anemone, Potentilla, Pedicularis, Oxytropis, Gentiana, Primula, Allium, Taraxacum, Polygonum*, *Papaver*, *Nepeta*, and *Geranium*. There is no doubt

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[1] I have used *Ceratoides* as the cover type genus as this name is more common in the literature and in description of similar types in Central Asia; although, the current recognized name is likely *Krascheninnikovia*. I believe the species is *Krascheninnikovia ceratoides* (http://www.efloras.org/florataxon.aspx?flora_id=5&taxon_id=117271).

that these areas are often critical for a number of wild species, but are also used by livestock. Near the Wakjhir Pass the alpine grasslands had low livestock use and were some of the most diverse sites visited. Above ground biomass was estimated at 800 kg/ha, but varied greatly with different site conditions.

A *Salix* community type can be found along some water courses at lower and mid elevations. These communities are generally very productive and heavily grazed, but are often in a very narrow riverine or small stream setting. As classified below, these communities always have a *Salix* overstory component. An associated type, which I will refer to as a Birch (*Betula*)-Willow (*Salix*) Forest community type, was more limited in extent, but similar to the *Salix* type in a number of ways. In general, these communities were found along stream courses, but also occasionally on hillsides where springs or seeps exist. The *Salix* community type and Birch-Willow Forest types provide forage and browse for livestock and wildlife and often supply fuel woods and building materials for pastoral communities. Generally, these communities had a variety of S*alix*, *Rosa*, and *Ribes* shrubs, with a rich herbaceous component and a relatively high shrub and/or tree cover. *Juniperus* was also an uncommon tree on some sites, but these areas are unique because of the juniper. These areas will be mapped in future work.

In the following sections I further describe different rangeland types and cover types using sites using photographs and site descriptions. The photographs are identified to a plot or transect number. Information on these plots and transects is also presented in Appendices 1 and 2.

Cold Desert Shrub

The most common vegetation type is a cold desert shrub type. This type varies from an *Artemisia* steppe to a *Ceratoides* community with little associated vegetation. Winter precipitation and the low growing precipitation favor shrubs over grasses; however, as elevation increases there is a greater cover of perennial grasses associated with increased precipitation. At lower elevations much of the precipitation is likely lost through evaporation (sublimation in the winter). Windy conditions are prevalent and likely also result in wind erosion and deposition in down-slope areas. Petocz (1978) referred to this type as an Alpine Steppe, but I have preferred to refer to these types as a Cold Desert Shrub type because of the dominance of shrubs and cold dry conditions.

Below I provide an initial description of three broad types within the Cold Desert Shrub. These community types vary by shrub dominant and amount of graminoids and will be a (1) a *Ceratoides* community cover type, (2) a *Ceratoides-Artemesia Steppe* cover type, and (3) a *Artemisia* Steppe cover type. There is no doubt that many more community types will be designated with additional rangeland surveys.

Ceratoides Community Type

A dry *Ceratoides* community type was common along many of the dryer areas at lower elevations and dryer ridges. It appeared that salinity levels may be higher on many of these sites, but I was not able to actually measure salinity levels. Photo Cer CT1 shows a *Ceratoides* community near the Big Pamir River at an elevation of 3663 m. The ground cover was predominately soil (76%) and small rock (21%) with vegetation cover only 3%. *Ceratoides* comprised 83.5% of the vegetation (4% foliar cover from line intercept), *Ephedra* spp. (very low type) was 2% composition (less than 1% line transect cover). *Stipa, Cousinia, Astragalus, Oxytropis*, *Kochia scoparia,* annual *Brome* were present. An unknown perennial forb (Polygonaceae) comprised the remainder of the cover on the site.

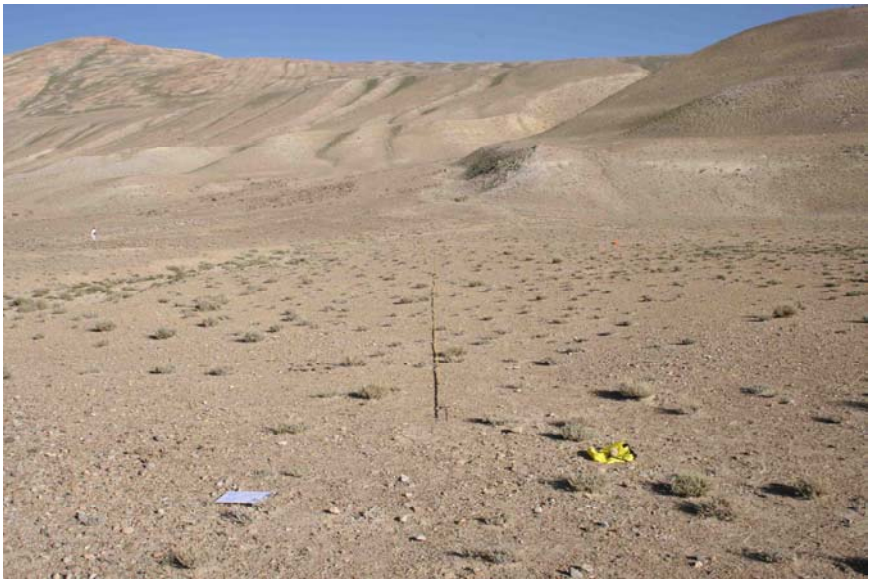

Photo Cer CT 1. Transect July28_06 at 3660m of a illustrating a *Ceratoides* community (37 17.919N; 73 16.855E). Other photos of this community type are found at: Ceratoides CT of the Wakan.

Artemisia-Ceratoides Community Type

As conditions became more mesic coverage of *Ceratoides* decreased and *Artemisia* and grasses increased. Photos ArtCerCT1a, 1b are photos illustrating such plots described as this cover type. Photo ArtCerCT1a is in the Tulabi area located at 4025 m with a 140° aspect and 5 % slope. Cover was 72% soil, 10% rock, 8% litter and 10% plant cover. Plant composition on cover basis was 68%, 23%, 8%, and 1% for *Artemisia, Ceratoides, Stipa* and *Carex*. Photo ArtCerCT1b shows a site with much higher grass cover. This site had 48% composition by coverage of shrubs (predominately *Artemisia*) and 28% grasses (predominately *Stipa* and *Hordeum*) and 17% *Carex*, and the remainder forbs. The increased *Hordeum* and *Ceratoides* compared to the first site may be a result of elevated salinity as some salt deposits were apparent in the area.

Photo ArtCer1a. An *Artemisia-Ceratoides* cover type with low grass cover. 4025 m with a 140° aspect and 5 % slope. Location was approximately 37 19.422N; 73 15.265E.

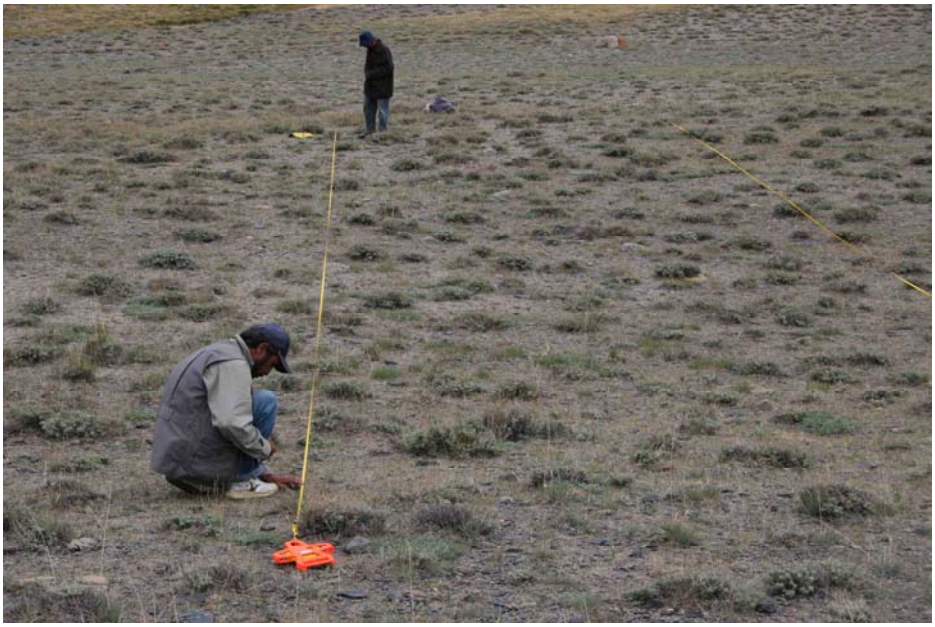

Photo ArtCer1a. An *Artemisia-Ceratoides* cover type with higher grass cover (Plot Aug22-03 at 4121m with a S aspect 200 (slope 8%). Location was approximately 37 04.287N; 74 07.730E.

Artemisia-Steppe Community Type

The most widely distributed cover type we measured in 2006 was an Artemisia-Steppe cover type found on mountain slopes and wide valleys. A number of *Artemisia* species (shrubs, subshrubs and herbaceous species) occur, but the predominant shrub of this cover type is thought to be *Artemisia rutaefolia*. With further plant community analysis there is no doubt other *Artmesia* cover types will be described. The *Artemisia* Steppe cover type is described here as predominatly a Artemisia-Subshrub Cover Type. This type had a relatively large coverage of

sub-shrubs. I classified as subshrubs several cushion-like plants and other woody based plants. These sub-shrubs included *Acantholimon* sp., *Arenaria* sp., and *Saxifraga* sp. Legumes (mostly *Astragalus*) were relatively common. Grasses were predominately species of *Festuca*, *Poa*, *Oryzopsis,* and *Stipa*. The *Artemisia* –Subshrub CTs had very little *Ceratoides* and were at higher elevations than the *Artemisia*-*Ceratodies* CT. On two plots we had no subshrubs. In these plots we had relatively high cover of *Stipa* and the sagebrush was a lower type (species). Additional data is needed to determine other cover types in this community type and to determine if the high sub-shrub cover may be associated with degradation processes.

Photo Art Steppe-Subshrub CT 2a. Plot Aug8She-T2 (37° 08.689N; 72° 58.085E) was at 4196 m with an aspect of 310° and 8% slope. Cover composition for *Artemesia*, subshrubs, grasses, *Carex* and forbs averaged 28%, 25%, 20%, *Carex* 3%, and forbs 24%, respectively. Bareground and rock averaged 85% cover on plot with only 5% and 10% plant cover and litter cover.

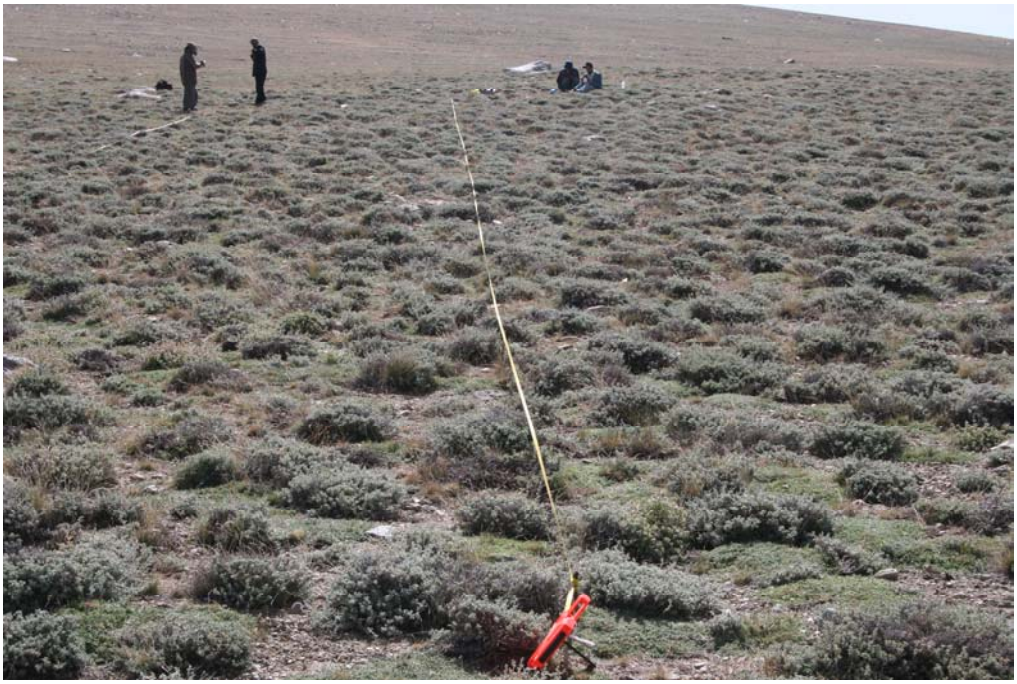

Photo Art Steppe-Subshrub CT 2b. Plot Aug2Camp1km (37 ^{o} 17.142N; 73 ^{o} 07.774E) was at 4417 m with an aspect of 317° and 12% slope. Cover composition for *Artemesia*, subshrubs, grasses, *Carex* and forbs averaged 55%, 11%, 13%, 1%, and f 20%, respectively.

Photo Artemisia-Grass CT 1a. Plot Aug22-02 (37° 3.627N; 74 ^{o} 10.075E) at 4256 m with a south aspect (195°) and 12% slope. Cover composition of *Artemisia*, grass (predominately *Stipa*), and forbs was 70%, 22%, and 6%, respectively. An upland sedge (*Carex* sp) averaged 3% of the cover composition. Bareground, rock, and litter were 52%, 36%, and 8 % point coverage, respectively.

Sedge Wetland Meadow Cover Type

The most productive rangeland type is the Sedge (*Carex* 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. Often these sites are "boggy" and have a high organic layer (peat) that may be burned. Along the Pamir River and at other localized sites there are saline wetland sites with high amounts of *Pucinella sp*., *Hordeum sp*. *Juncus sp*. and other halophytes. The more common Sedge Meadow/Wetland are not associated with salinity and are the most productive rangeland type. These areas should naturally have little or no bareground exposed. On the sites in which we established transects bareground was relatively low, but litter was high as these site receive heavy livestock use. Photo Sedge-Wetland 1a is one such site. This site had 2% soil cover, 56% litter cover and 42% plant cover (almost entirely *Kobresia* and *Carex*). On one site we clipped a Sedge Wetland site that had not been grazed and found 3,600 kg/ha of air-dry standing crop. The Sedge Meadows are limited in area, but no doubt supply significant amounts of forage for livestock as these sites are often grazed heavily. The predominant cover is nearly 100% sedges, but the sites do have significant diversity (low coverage of other species). At times pastoralists use "peat" from these communities.

Photo Sedge-Wetland 1a. Plot Jul31Tul6 at 4043 m (37 17.439N; 73 16.855E) illustrating a site with high productivity of sedges (*Kobresia* and *Carex*).

Photo Sedge-Wetland 1b. Same plot as above showing open water adjacent to the site.

Photo Sedge-Wetland 1c. Plot Aug7SHE (37 05.589N; 73 00.937E) at 4577 m.

Alpine Grassland Community Type

An Alpine Grassland Cover Type 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*, *Agropyron, Ranunculus*, Aconitum, *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. Near the Wakjhir Pass the alpine grasslands had low livestock use and were some of the most diverse sites visited.

Photo Alpine Steppe CT-1 and CT-2 show two alpine plots that were almost identical in elevation, but one was much more rocky. In plot Aug7MawT grass composition was 47% and was about equal amounts of *Poa* and *Festuca*. Forbs were diverse and made up the remaining plant cover composition. Legumes were very common as was *Sedum*, *Leontopodium*, and several Asteraceae and Brassicaceae. Photo Alpine CT 2 is of plot Aug20T1. Plant composition on a cover basis was 43% grass, 13% sedges and 44% forbs. Grasses were *Trisetum*, *Poa*, *Festuca* and *Elymus*. *Potenilla*, *Astragalus* and *Sedum* were dominant forbs.

Photo Alpine Steppe CT1. This is plot Aug7MawT located at 37 04.739N; 73 02.867 W at 4718 m. It had a slight north aspect of 10° aspect (4% slope). Soil, rock, and litter cover using point intercept were 56%, 36%, and 7%, respectively.

Photo Alpine CT2. Plot Aug20T1 (37 05.172N; 74 27.961E) at 4716 m with 120 aspect and 15% slope. Soil, rock, and litter cover using point intercept were 36%, 16%, and 16%, respectively with grasses and forbs both comprising 16% coverage.

Salix Community Type

A number of *Salix* community types exist along creeks and rivers at in the Wakhan. These types vary in elevation and species of *Salix* as well as associated species and although small in area represent productive sites. We established plots in only two types during the 2006 field season mainly as potential permanent monitoring of the sites. A *Salix-Elymus* community was found at some of the lower creek valleys and along the Big Pamir River in the lower Wakhan valleys. These communities were dominated by a shrub *Salix* (few plants above 2 m) and a simple understory dominated by a rhizomatous *Elymus*. The *Salix* was browsed but as can be seen in the following photo (photo *Salix-Elymus* CT-1a) the *Salix* plants were quite productive. Adjacent to the creek there were a few *Tamarix* and the plant community was more diverse. Soil development along these areas was young with recent flood deposits and significant grazing use (see photo *Salix-Elymus* CT-1b) which possibly maintains the *Elymus* community. These communities were quite productive and by preserving these areas from growing season grazing a "standing hay" could be produced.

Photo Salix-Elymus CT-1a. A *Salix-Elymus* community in Alisu creek valley (transect July29_06Alisu2) at 3658 m (37°16.140N; 72° 58.918E.). The site had a slight westerly aspect (300° and 2 % slope) and 26% soil cover.

Photo Salix-Elymus CT-1b. *Salix-Elymus* community type in Alisu creek valley at 3700 m (37°16.150N; 72° 58.920E.). The site has a slight westerly aspect (290° and 2 % slope).

In wetter sites there was a *Salix*-Sedge community (Photo Salix-Sedge CT-1a,b). These sites were subirrigated whereas the *Salix-Elymus* community showed no evidence of a subirrigated surface condition. It is possible the *Salix-Elymus* community type was at one time a wetter type and is becoming dryer and elevated from down-cutting of the adjacent stream. These *Salix*-Sedge communities were heavily grazed as they are "oasis" in a mostly desert environment. Photo *Salix-Sedge* CT-1b shows a plot (200m^2) established in this area late in the evening. *Salix* averaged 1 m in height, *Salix* canopy cover was10% and there were 21 individual *Salix* plants. Common Poaceae included *Poa, Pucinella, Hordeum*, and *Elymus*. Sedges and rushes were common with plant canopy cover over 100%.

Photo Salix-Sedge CT-1a. *Salix* – Sedge type along the Big Pamir River (37 17.740N; 72 59.300E).

Photo Salix-Sedge CT-1b. Salix – Sedge CT along the Big Pamir River at 3650 m (37 17.740N; 72 59.300E).

Birch-Willow Forest Community Type

A Birch-Willow Forest type exists as small, narrow and isolated riverine forest types along several streams (especially streams entering into the Wakhan River from about Langar to Sharad)(Photo BWCT-1a,b) and around seeps on some hillsides (Photo BWCT-2). These communities are generally protected by narrow valleys and the major overstory dominants are *Betula* and *Salix*. A shrub understory is generally present with species of *Rosa, Salix, Ribes, and Lonicera.* The community type also occurs on as small isolated areas on hillsides where there are springs or seeps (Photo BWCT-2) at lower elevations. In some areas *Juniperus* was an associated tree mostly on drier slopes than where the birch and willow were dominant. No measurements were taken in any of these areas in 2006, but the type is mentioned as they are unique environments in this area. Livestock grazing is often heavy and some harvesting of trees was observed.

Photo BWCT-1a. A narrow rocky Riverine-Forest Community between Sharhad and Borak.

Photo BWCT-1a. A Riverine-Forest community dominated by *Betula* and *Salix*. 36 59.865N; 73 33.873E (3525 m).

Photo BWCT-2. A Birch-Willow Forest cover type found on a north slope (3585 m) above the Wakhan River between Langar and Borak (photo was taken from point 37 00.131N; 73 40.527E).

Rangeland Degradation and Threats to Wildlife

The extreme climatic and geomorphological conditions of the area create conditions where soil and vegetation are very vulnerable to human impacts. The extreme conditions however have likely reduced past human pressures by keeping both the human and livestock populations low. Livestock populations are susceptible to large winter losses and likely these occur during "bad winters" associated with greater snow cover or ice as little reserve forage (hay)[2] is kept by herders. It is my hypothesis that rangeland degradation is not uncommon associated with overgrazing and human use of shrubs for fuel. The difficult question is if the majority of use is non-sustainable and also in quantifying impacts to vegetation and wildlife.

It is likely that many of the dwarf-shrub communities, especially adjacent to camps are under pressure due to both grazing and fuel wood harvesting. Shrubs (*Artemisia* and *Ceratoides,* predominately) are the main fuel resource for most of the population. Certainly, collection of shrubs near camps impacts plant communities in a number of ways (reduces soil protective cover, reduces the ability of shrubs to hold snow, reduces protection of grasses and other forage plants in shrub canopies, etc.). In the Eastern Pamirs of Tajikistan Droux and Hoeck (2004) estimated that the collection of shrubs for fuel purpose results in the annual loss of vegetation cover on a estimated area of 350 km^2 or 11ha per household. It is unknown how long it may take for shrubs to reestablish or if these changes result in a complete state change of the vegetation and site conditions.

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[2] Some hay is kept in winter areas but the total amount appears very small. Smaller animals are also moved lower in the valley where Wakhi are able to feed some animals. Petocz (1978) reported that herders told him of 50% losses a few years before his work in the Wakhan.

A number of other livestock impacts are readily observable. These include trailing on slopes, grass plants "hiding" in shrubs, low vegetation cover and production on sites away from camps, and little or no litter. Likewise, impacts on riparian areas and meadows are often very noticeable. These include low vegetation height (from grazing), low species diversity, low litter biomass, increased weeds and often increased soil cover. However, for all these mentioned "signs" of degradation it is difficult to speculate how bad the degradation is because there is no "benchmark" for comparison (no sites that have not been impacted). As such, it is also difficult at this time to speculate on potential impacts on wild species. It is very noticeable that livestock, especially yak are seen on very steep slopes at about the vegetation-scree interface (above which little vegetation is seen) and that in many of these areas production of vegetation appears lower and soil cover higher than one would expect.

The development of community types and inspection of sites with low impacts is a major objective of this study to allow for a better quantification of degradation. The major site indicators of rangeland degradation generally used in rangeland inventories are a comparison of current soil/site characteristics such as signs of accelerated erosion (rills, gullies, water flow patterns, wind scoured areas, litter movement, etc.) and biotic integrity or plant community characteristics (vigor and production, species composition, weeds, reproduction, etc.) compared with a reference site (same site without significant impacts). Appendix 3 shows some site indicators used in rangeland site description that were considered in site descriptions during 2006. Appendix 4 is a first draft of a degradation classification of the Alpine Steppe Community Type.

Rangeland Community Mapping

We have been mapping some communities using Landsat ETM+ images and field notes. The resolution of the Landsat ETM+ image certainly does not allow for very specific mapping but can be used in gross mapping of vegetation types. For example, wet meadows show prominently (Fig. 1). We will attempt to map some community types using field mapping in 2007 and will add this information to the GIS system. All data from the plots and their associated photographs will be part of the GIS being developed. A general overview is presented for one such point in Appendix 5. We have developed a medium scale mapbook for rudimentary navigation which includes 179 individual maps covering the extreme eastern portion of Badakhshan province and surrounding territory. The scale of the mapbook is 1:65,000, roughly equivalent to a USGS 15 minute map (1:62,500). Each map is an area approximately 8.7 miles (14 km) wide and 11 miles (17.8 km) high and an example is shown as figure 2 with an index shown as figure 3 (each page of the mapbook corresponds to a single grid in the grid index (described below). We are continuing to "fine-tune" the map book and will likely modify the scale to about 1:42,000. Information on baseline imagery and the development of grid indexing is shown below.

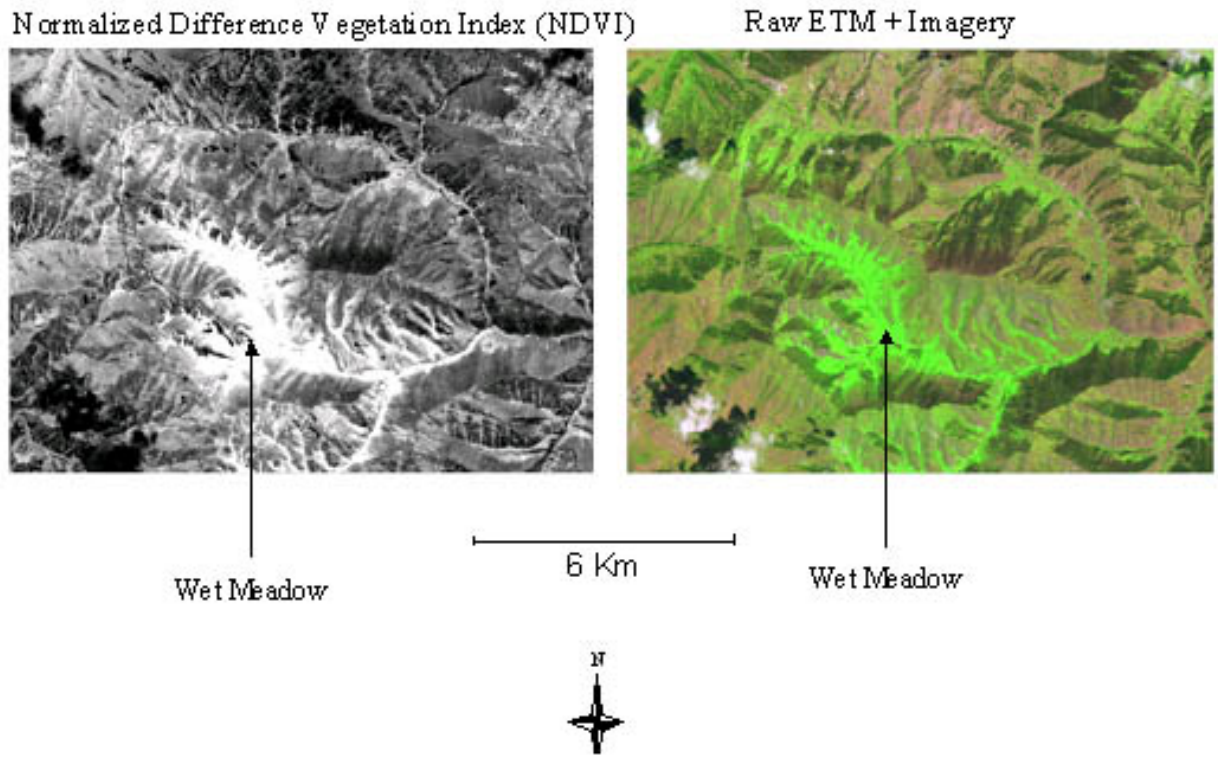

Fig. 1. Normalized difference vegetation index and "raw" ETM+ image showing a Wet Meadow

Basemap Satellite Imagery. The satellite imagery shown in the mapbook is a false color composite, with a band combination of 4, 3, 2 as red, green and blue color channels respectively. Band 4 is the near-IR channel while bands 3 and 2 are the red and green channels respectively. This color combination is especially useful for identifying vegetation which appears red in figure 2. The spatial resolution of these data is 15 m because the multispectral data were pan-sharpened with the panchromatic band which has a nominal pixel resolution of 15 meters. Each detailed page of the mapbook contains tick marks and crosshairs spaced at 2.5 minute intervals. These grids are labeled with conventional degrees, minutes and seconds of latitude and longitude. These marks represent the world geodetic system (WGS84) datum.

In addition to tick marks, contour intervals are also present. The contour interval is 150 meters. Contours often appear irregular and unsmooth in places. This is partly caused by the coarse resolution of the digital elevation model used to construct the contours. The contours were derived from the Shuttle Radar Topography Mission elevation dataset. For the Badakhshan region, these data were available at a nominal pixel resolution of about 800 meters after some post-processing was applied.

Roads/trails are also present in the mapbook. These roads/trails are categorized based on their "class", either 1, 2 or 3. It should be noted that the road coverage does not align perfectly with the position of the roads that are clearly visible on the satellite imagery. The roads may have been originally digitized at a fairly coarse scale.

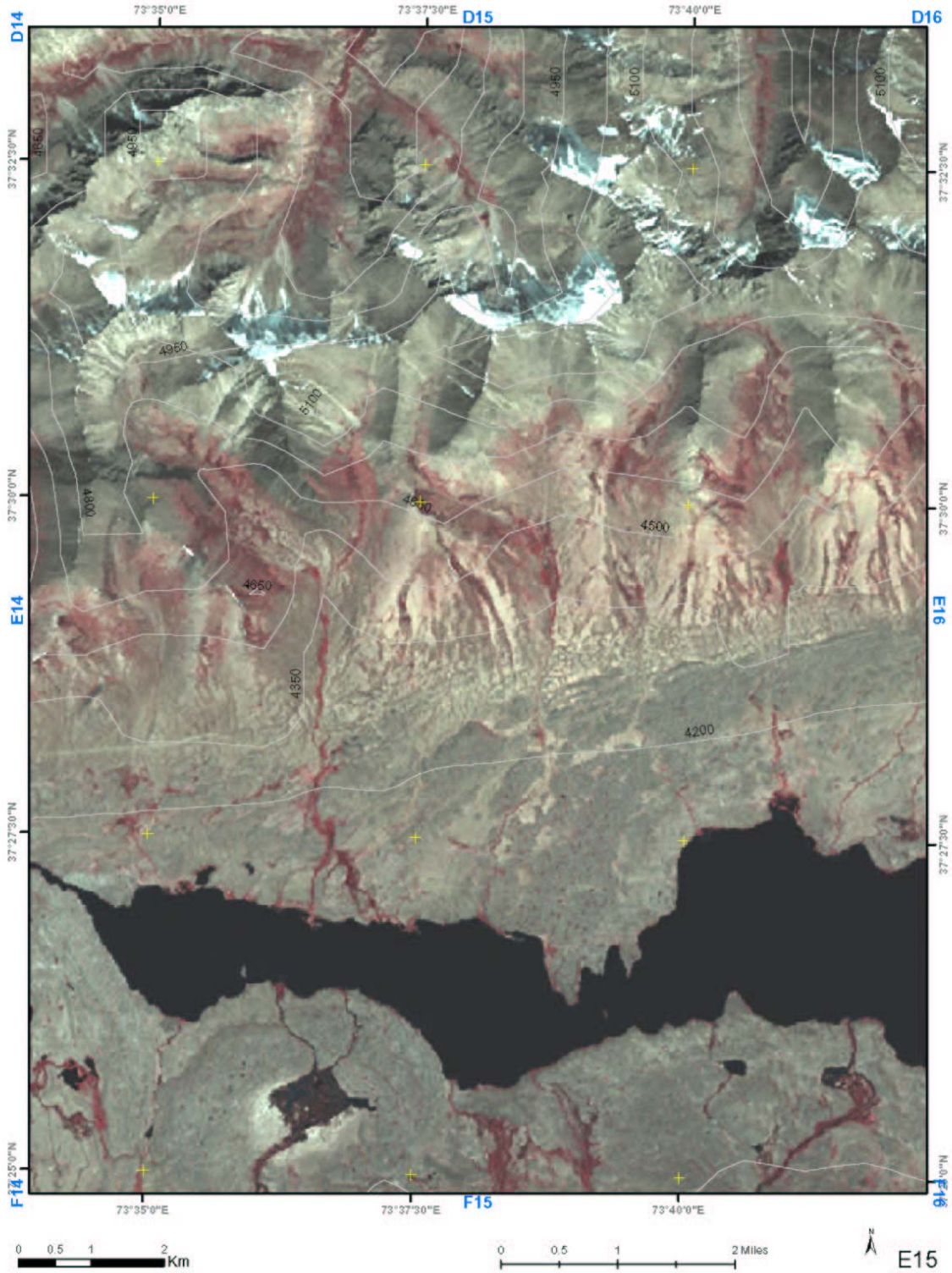

Fig. 2. A map developed using Landsat ETM+ image with a resolution merge. This figure is at a scale of 1:65,000 and shows the Zorkol Lake area. This is an area of roughly 61,500 ac or 25,000 ha.

The Grid Index. The Grid Index is a series of rectangles equally dividing the eastern portion of Badakhshan province (Fig. 3). Each individual grid is referred to by a unique alpha-numeric code the origins of which are in the northwestern most grid. The alpha-numeric designation can be found on the lower right corner of each individual map page.

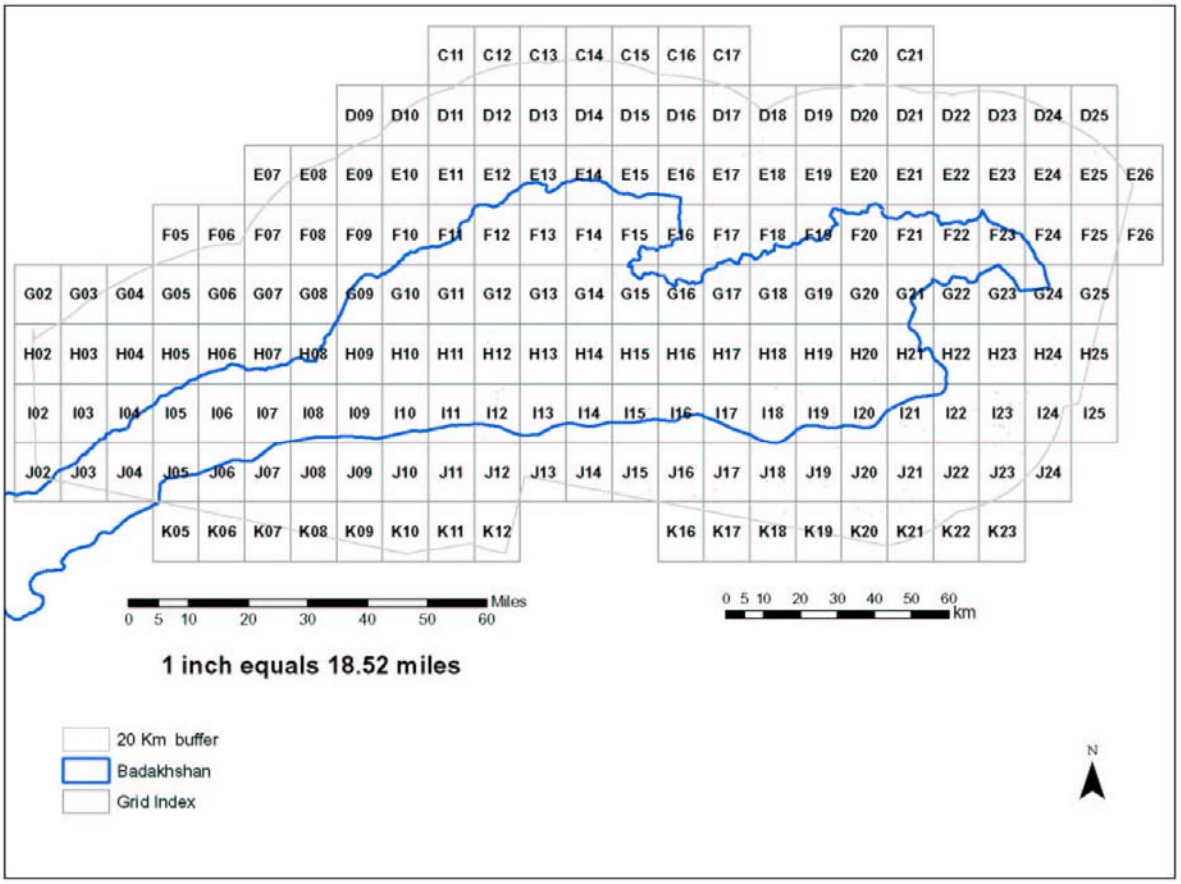

Fig. 3. Currently developed map book index.

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Appendix 1. Site characteristics (elevation, aspect slope) and cover* of different site variables for 2006 transects.

Transect	Elevation	Aspect	Slope	Soil Cover	Rock Cover	Litter Cover	Shrub Cover	Sub-shrub	Grass Cover	Sedge Cover	Legume Cover	Forb Cover
Aug22ST04	4004	0	0	88	4	4	0	4	0	0	0	0
Aug22NT04	4000	0	0	80	4	8	0	0	4	0	4	0
Aug22T-04	4002	0	0	84	4	6	0	2	2	0	2	0
Aug22ST03	4128	200	10	76	4	4	12	0	0	4	0	0
Aug22NT03	4124	200	10	80	4	8	4	4	0	0	0	0
Aug22T-03	4128	200	10	78	4	6	8	2	0	2	0	0
Aug22WT02	4257	200	12	40	40	12	4	0	0	4	0	0
Aug22ET02	4256	190	12	64	32	4	0	0	0	0	0	0
Aug22T-02	4256	195	12	52	36	8	2	0	0	2	0	0
Aug22WT01	4216	170	7	72	24	4	0	0	0	0	0	0
Aug22ET01	4216	170	7	52	36	0	8	0	4	0	0	0
Aug22T-01	4216	170	7	62	30	2	4	0	2	0	0	0
Aug21ET03	4272	153	7	72	12	12	4	0	0	0	0	0
Aug21WT03	4272	153	5	84	8	4	0	0	0	0	4	0
Aug21-T03	4272	153	6	78	10	8	2	0	0	0	2	0
Aug21ST02	4288	250	1	48	32	4	8	0	0	0	0	8
Aug21NT02	4288	250	1	12	60	24	0	0	0	0	0	4
Aug21T-02	4288	250	1	30	46	14	4	0	0	0	0	6
Aug21SE01	4371	237	3	67	0	12	0	0	8	4	0	9
Aug21NW01	4371	237	3	36	4	40	0	0	16	0	0	4
Aug21-01	4371	237	3	51.5	2	26	0	0	12	2	0	6.5
Aug20ST1b	4716	120	15	36	16	16	0	0	16	0	0	16
Aug20NT1a	4716	120	15	64	8	8	0	0	4	0	4	12
Aug201ab	4716	15	120	50	12	12	0	0	10	0	2	14
Aug9ST	4319	53	5	80	20	0	0	0	0	0	0	0
Aug9NT	4318	53	5	76	24	0	0	0	0	0	0	0
Aug9SNT	4319	53	5	78	22	0	0	0	0	0	0	0
Aug9WT	4297	13	5	60	0	20	0	0	16	0	4	0
Aug9ET	4300	17	5	92	0	0	0	0	8	0	0	0
Aug9WET	4297	13	5	76	0	10	0	0	12	0	2	0
Aug8She8ST	4116	258	6	64	32	0	0	0	4	0	0	0
Aug8She8NT	4119	240	4	92	4	0	0	4	0	0	0	0
Aug8She8SN	4117	249	5	78	18	0	0	2	2	0	0	0
Aug8She7ST	4115	225	6	88	4	0	0	8	0	0	0	0

Transect	Elevation	Aspect	Slope	Soil Cover	Rock Cover	Litter Cover	Shrub Cover	Sub-shrub	Grass Cover	Sedge Cover	Legume Cover	Forb Cover
Aug8She7NT	4114	220	4	80	16	0	0	4	0	0	0	0
Aug8She7NS	4114	222	5	84	10	0	0	6	0	0	0	0
Aug8She6ST	4115	207	6	76	16	4	0	0	4	0	0	0
Aug8She6NT	4115	207	6	88	8	0	4	0	0	0	0	0
Aug8She6NS	4115	207	6	82	12	2	2	0	2	0	0	0
Aug8She5ST	md**	226	6	80	12	4	0	4	0	0	0	0
Aug8She5NT	4118	220	4	80	8	8	0	4	0	0	0	0
Aug8She5NS	4118	223	5	80	10	6	0	4	0	0	0	0
Aug8She4ST	md	200	3	80	10	5	0	0	5	0	0	0
Aug8SherNT	4129	192	4	80	16	4	0	0	0	0	0	0
Aug8She4SN	4129	196	4.5	80	13	4.5	0	0	2.5	0	0	0
Aug8She3WT	4237	180	12	72	12	8	0	4	0	0	4	0
Aug8She3ET	4240	186	12	68	24	4	0	0	0	0	0	4
Aug8She3WE	4238	183	12	70	18	6	0	2	0	0	2	2
Aug8She2WT	4196	305	8.5	58	18	18	2	0	4	0	0	0
Aug8She2ET	4196	315	8	88	6	4	0	2	0	0	0	0
Aug8She2WE	4196	310	8	73	12	11	1	1	2	0	0	0
Aug7SheST	4577	179	5	24	0	12	0	0	0	64	0	0
Aug7SheNT	4577	179	5	64	2	12	0	0	20	0	0	2
Aug7SheSNT	4577	179	5	44	1	12	0	0	10	32	0	1
Aug7MawWT	4718	10	4	56	36	8	0	0	0	0	0	0
Aug7MawET	4718	10	4	36	48	12	0	0	0	0	0	4
Aug7MawWE	4718	10	4	46	42	10	0	0	0	0	0	2
Aug7DarST	4100	220	6	96	0	2	0	2	0	0	0	0
Aug7DarNT	4100	220	6	80	4	8	0	8	0	0	0	0
Aug7DarNS	4100	220	6	88	2	5	0	5	0	0	0	0
Aug6ST2	4255	30	28	60	24	4	0	0	4	0	8	0
Aug6NT2	4259	30	28	36	32	12	0	4	12	0	4	0
Aug6_2	4257	30	28	48	28	8	0	2	8	0	6	0
Aug6ST1	4160	19	18	64	20	2	0	6	2	0	6	0
Aug6NT1	4156	19	18	34	20	10	0	6	6	0	16	8
Aug6_1	4158	19	18	49	20	6	0	6	4	0	11	4
Aug2G105a	4339	310	6	60	8	4	6	20	0	0	2	0
Aug2G105b	4339	310	6	70	14	0	2	10	0	0	0	4
Aug2G105ab	4339	310	6	65	11	2	4	15	0	0	1	2
Aug2G65a	4350	327	9	60	30	4	2	2	0	0	2	0

Transect	Elevation	Aspect	Slope	Soil Cover	Rock Cover	Litter Cover	Shrub Cover	Sub-shrub	Grass Cover	Sedge Cover	Legume Cover	Forb Cover
Aug2G65b	4350	327	9	78	8	4	0	8	0	0	0	2
Aug2G65ab	4350	327	9	69	19	4	1	5	0	0	1	1
Aug2W53	4338	0	10	82	2	2	0	0	0	0	14	0
Aug2E53	4338	0	10	68	8	4	0	0	2	0	14	4
Aug2WE53	4338	0	10	75	5	3	0	0	1	0	14	2
Aug2Gel42W	4350	330	8	46	40	0	0	14	0	0	0	0
Aug2Gel42E	3357	330	8	68	26	4	2	0	0	0	0	0
Aug2Gel42WE	3853	330	8	57	33	2	1	7	0	0	0	0
Aug2Gela	4345	304	9	56	24	8	2	6	2	0	2	0
Aug2Gelb	4345	304	9	76	16	0	0	2	2	0	4	0
Aug2Gelab	4345	304	9	66	20	4	1	4	2	0	3	0
Aug2Cam2W	4467	281	8	78	10	6	0	2	0	0	2	2
Aug2Cam2E	4467	281	8	42	18	16	2	0	8	0	14	0
Aug2Cam2WE	4467	281	8	60	14	11	1	1	4	0	8	1
Aug2Cam1.5W	4442	322	2	42	30	4	0	0	6	0	14	4
Aug2Cam1.5E	4442	322	12	64	10	6	0	0	8	0	6	6
Aug2Cam1.5WE	4442	322	7	53	20	5	0	0	7	0	10	5
Aug2Cam1W	4417	317		60	20	14	0	0	4	0	2	0
Aug2Cam1E	4417	317	12	70	14	6	4	4	2	0	0	0
Aug2Cam1WE	4417	317	6	65	17	10	2	2	3	0	1	0
Aug1Gel450a	4374	330	8	68	10	2	0	4	2	0	14	0
Aug1Gel450b	4374	330	8	48	10	8	0	6	2	0	26	0
Aug1Gel450ab	4374	330	8	58	10	5	0	5	2	0	20	0
Aug1Gel150a	4366	324	6	72	16	2	2	6	0	0	2	0
Aug1Gel150b	4366	324	12	52	26	2	0	16	0	0	2	2
Aug1Gel150ab	4366	324	9	62	21	2	1	11	0	0	2	1
Aug1a	4372	330	5	76	2	4	0	2	2	0	12	2
Aug1b	4372	330	5	56	8	4	0	6	10	0	16	0
Aug1ab	4372	330	5	66	5	4	0	4	6	0	14	1
July31Tul6bS	4042	49	30	0	0	22	0	0	0	78	0	0
July31Tul6aN	4043	49	3	2	0	56	0	0	0	42	0	0
July31Tul6abNS	4042	49	16	1	0	39	0	0	0	60	0	0
July31Tul5W	4039	90	1	90	0	8	0	0	0	0	2	0
July31Tul5E	4028			88	0	10	0	0	2	0	0	0
July31Tul5WE	4233	90	1	89	0	9	0	0	1	0	1	0
July31Tul4/3E	4032	45	12	72	0	22	2	2	0	0	2	0
July31Tul3/4W	4028	140	5	72	10	10	8	0	0	0	0	0

Transect	Elevation	Aspect	Slope	Soil Cover	Rock Cover	Litter Cover	Shrub Cover	Sub-shrub	Grass Cover	Sedge Cover	Legume Cover	Forb Cover
July31Tul4/3	4030	92	8	72	5	16	5	1	0	0	1	0
July31Tul2E	3999	100	5	0	0	88	0	0	0	12	0	0
July31Tul2W	3999	100	5	0	0	84	0	0	0	4	12	0
July31Tul2EW	3999	100	5	0	0	86	0	0	0	8	6	0
July29a	3791	30	24	56	12	28	0	0	4	0	0	0
July29b	3798	162	30	68	32	0	0	0	0	0	0	0
July29ab	3794	96	27	62	22	14	0	0	2	0	0	0
July29AliW	3695	290	2	46	0	54	0	0	0	0	0	0
July29AliSW	3658	300	2	26	0	74	0	0	0	0	0	0
July28a	3663	md	4	68	30	0	0	0	0	0	0	2
July28b	3657	md	4	84	12	4	0	0	0	0	0	0
July28ab	3660	md	4	76	21	2	0	0	0	0	0	1
July27a	3723	12	14	80	10	6	0	0	2	0	2	0
July27b	3474	md		84	8	4	2	0	2	0	0	0
July27ab	3598	12	14	82	9	5	1	0	2	0	1	0
July30TulabiW	4008	0	5	68	14	8	2	6	0	0	2	0
July30TulabiE	4000	0	0	78	2	6	0	14	0	0	0	0
July30Tulabi	4004	0	2	73	8	7	1	10	0	0	1	0

* Coverage is point sampling and is basal cover of plant attributes.

** Missing data of elevation will be added from elevation from GIS and aspect will be estimated from GIS.

Appendix 2. Summary table of composition (determined from line intercept of foliar cover) of *Artemisia* sp., *Ceratoides* sp., subshrubs, grasses, s edges, legumes, and forbs*.

Transect	Artemisia	Ceratoides	Subshrub	Grass	Carex	Legumes	Forbs
Aug22-04	24.4	0	19.1	14.8	18	18.4	5.3
Aug22ST03	19.1	4.3	6.4	50.3	19.1	0	0
Aug22NT03	47.9	0	18.2	7.3	15.5	9.6	1.5
Aug22-03	33.5	2.15	12.3	28.8	17.3	4.8	0.75
Aug22WT02	44.3	0	0	51.3	4.4	0	0
Aug22ET02	69.6	0	0	22.6	1.3	0	6.4
Aug22-02	56.95	0	0	36.95	2.85	0	3.2
Aug22WT01	60.2	0	0	36.6	3.3	0	0
Aug22ET01	63.6	0	6.7	20.2	3.2	0	6.2
Aug22-01	61.9	0	3.35	28.4	3.25	0	3.1
Aug21ET03	43.9	0	22.4	7.1	2.1	21.3	3.2
Aug21WT03	45.3	0	0	18.4	1.2	31.8	3.3
Aug22-01	44.6	0	11.2	12.75	1.65	26.55	3.25
Aug21ST02	0	0	0	16.2	0.8	7.2	75.8
Aug21NT02	0	0	0	14.8	1.4	9.6	74.1
Aug21-02	0	0	0	15.5	1.1	8.4	74.95
Aug21SET1	0	0	0	40.8	17.3	0	41.9
Aug21WT03	0	0	0	60	0.1	0	39.8
Aug21-03	0	0	0	50.4	8.7	0	40.85
Aug20T1b	0	0	0	64	7.3	17.6	12.1
Aug20T1a	0	0	0	21.6	18.4	10.7	49.3
Aug20-T1	0	0	0	42.9	12.9	14.2	30.7
Aug8She2W	30.7	0	28.2	18.7	0	6.2	16.1
Aug8She2E	25.5	0	22.8	20.5	6.5	2.6	22.2
Aug8She-T2	28.1	0	25.5	19.6	3.3	4.4	19.2
Aug7SheS	0	0	0	0	87.8	0	12.2
Aug7SheN	0	0	0	5.7	85.3	0	9
Aug7She T	0	0	0	2.9	86.6	0	10.7
Aug7MawW	0	0	0	33.7	0	30.6	35.7
Aug7MawE	0	0	0	47.4	0	18.7	33.8
Aug7Maw T	0	0	0	40.6	0	24.7	34.9
Aug7DarS	41.5	0	34.2	10.5	9.3	3.7	0.8
Aug7DarN	52.7	0	22.4	2.9	18.6	2.4	0.9
Aug7Dar T	47.1	0	28.3	6.8	14	3.1	0.9
Aug6Men2S	0	0	0	46	0	27.1	26.8
Aug6Men2N	1.8	0	0	29.6	0	38.9	29.7
Aug6MenT2	0.9	0	0	37.8	0	33	28.3
Aug6Men1S	0.9	0	29.2	16.7	3.1	37.9	12.4
Aug6Men1N	0	0	30.8	16.5	2.4	32.3	18.2
Aug6MenT1	0.5	0	30	16.7	2.8	35.1	15.4
Ag2GEL105a	40.2	0	39.9	10.3	0	9.5	0
Ag2GEL105b	36.9	0	42.2	1.9	0	4.1	14.9
Ag2GEL105	38.6	0	41.1	6.2	0	6.8	7.5
Aug2Gel_65W	30.6	0	35.5	8.1	0	13.3	12.5

Aug2Gel_65W	16.6	0	42.9	7.5	0	18.4	14.6
Aug2Gel_65	23.6	0	39.2	7.9	0	15.9	13.6
Aug2Gel_53W	0	0	0	4	17.7	56.4	21.9
Aug2Gel_53E	0	0	0	4.3	27.3	59.6	8.8
Aug2Gel_53	0	0	0	4.2	22.5	58	15.4
Aug2Gel42W	33.4	4.9	53.3	8.4	0	0	0
Aug2Gel42E	35.5	8.9	42.7	13	0	0	0
Aug2Gel42	34.5	6.9	48	10.8	0	0	0
Aug2Gel22W?	27.5	0	13.3	3.5	0	52.7	3.1
Aug2Gel22E?	30	0	25.5	9.9	0	25	9.6
Aug2Gel22	28.8	0	19.4	6.8	0	38.9	6.4
Aug2Camp2W	46.2	0	0	6.9	0	30.6	16.3
Aug2Camp2E	47.8	0	0.9	11.4	0	38.1	1.7
Aug2Camp2	47	0	0.5	9.2	0	34.4	9.1
Aug2Camp1.5W	5.4	0	0	11	7.8	43.5	32.3
Aug2Camp1.5E	1.7	0	0	14.5	2.5	44.4	36.9
Aug2Camp1.5	3.6	0	0	12.9	5.2	44	34.7
Aug2Camp1W	55.4	0	12.2	11.1	0	21.2	0
Aug2Camp1E	53.9	0	9	15.7	2.3	12.2	6.9
Aug2Camp1	54.7	0	10.6	13.5	1.2	16.7	3.5
Aug1Gel_450_2?	22.3	0	5.8	9.9	0	57.7	4.5
Aug1Gel450_2?	24.5	0	10.5	15.4	0	49.5	0
Aug1Gel_2	23.4	0	8.2	12.7	0	53.6	2.3
Aug1Gel1_2150m Pg2	40.3	3.6	43	5.3	0	7.9	0
Aug1Gel1_2150m Pg1	36.3	0.4	45.7	3.4	0	14.2	0
Aug1Gel1_2150m	38.3	2	44.4	4.4	0	11.1	0
Aug1pg2	20.5	0	8.2	11.6	0	58.7	1.1
Aug1pg2	18	0	17.1	15	0	49.9	0
1-Aug	19.3	0	12.7	13.3	0	54.3	0.6
Jul31Tul6bS	0	0	0	0	100	0	0
Jul31Tul6aN	0	0	0	0	100	0	0
Jul31Tul6	0	0	0	0	100	0	0
Jul31Tul5	0	0	0	0	0	0	0
Jul31Tul4	61.6	4.5	13.6	13.9	6.4	0	0
Jul31Tul3	68	23.1	0	7.9	1	0	0
Jul31Tul2W	0	0	0	0	100	0	0
Jul31Tul2E	0	0	0	0	100	0	0
Jul31Tul2	0	0	0	0	100	0	0
Jul30TulW	46.6	2.1	34.9	8.8	0	7.7	0
Jul30TulE	50.8	3.7	32.8	8.8	0	4	0
Jul30Tul	48.7	2.9	33.9	8.8	0	5.9	0
Jul29-37 19.692	0	98.3	0	1.7	0	0	0
Jul29-37 19.751	16.6	71.2	0	0	0	0	12.2
29-Jul	8.3	84.8	0	0.9	0	0	6.1
July28Site37 17.919	0	83.5	2	0	0	0	14.5
July28Site37 17.918	0	0	0	0	100	0	0

* Groupings of species is discussed in text.

Appendix 3. An example of a rangeland health evaluation summary form where a site is compared to a reference site (descriptors not established).

	Descriptors/Rating Classes				
Indicators	**Mostly Disagree**	**Moderately Disagree**	**Intermediate Agreement**	**Moderately Agree**	**Mostly Agree**
1. Rills					
2. Water Flow Patterns					
3. Pedestals or Terracettes					
4. Bare Ground					
5. Gullies					
6. Wind Scoured Areas					
7. Litter Movement					
8. Physical & Chemical Soil Crusts					
9. Soil Surface Organic Matter					
10. Plant Community Composition & Distribution-Relative to Infiltration and Runoff					
11. Compaction layer					
12. Plant Functional/Structural Groups					
13. Plant Mortality					
14. Litter Amount					
15. Annual Production					
16. Noxious & Invasive Plants					
17. Perennial Plant Reproductive Capability					
Indicator Summary					
Soil/Site Stability (Indicator 1-11)					
Biotic Integrity (Indicator 9, & 11-17)					

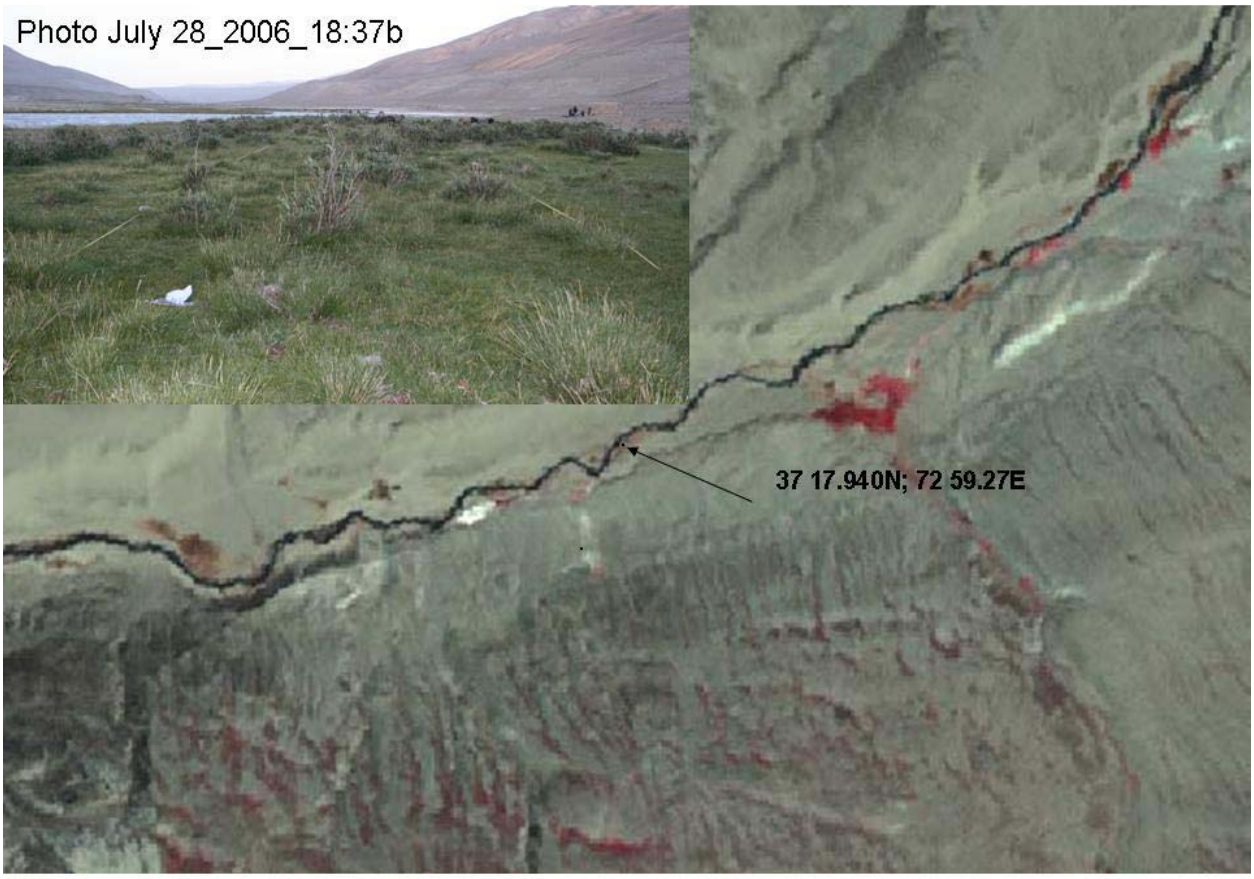
Comments on Indicator(s):

Appendix 4. A degradation classification of vegetation of an alpine steppe ecological site*.

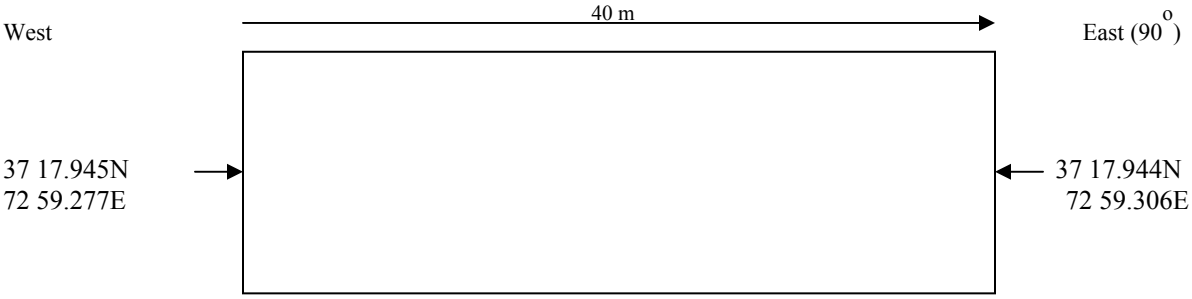
Heavily Degraded Pasture. The alpine-steppe pasture is classified as heavily degraded if it has the following characteristics: 1) Previously dominant perennial species have been replaced by less productive and often forbs. 2) Vegetation per unit of area of grassland is below 20%. 3) The average height of grasses per unit area is less than 10 cm. 4) The dry matter production is less than 300 kg/ha per annum.
Moderate Degraded Pasture. The alpine-steppe pasture is classified as moderately degraded will have the following characteristics. 1) Annual/less productive than dominant species are common on the site. 2) Vegetation coverage per unit area range between 20% and 40%. 3) The average grass height is 10 cm to 15 cm. 4) The average dry matter production is between 300 and 500 kg/ha.
Lightly Degraded Pasture. The alpine-steppe pasture is classified as lightly degraded if it has the following characteristics. 1) The average vegetation coverage per unit area is greater than 40% to 50%. 2) The average height of grasses is between 15 and 20 cm. 3) The average dry matter production is greater than 500 to 700 kg/ha.
Non-Degraded Pasture. The alpine-steppe pasture is classified as non-degraded if it has the following characteristics. 1) The average vegetation coverage per unit area is greater than 50%. 2) The average height of grasses is greater than 20 cm. 3) The average dry matter production is greater than 700 kg/ha.

*** A hypothetical example of a simple degradation procedure to illustrate methodology.**

Appendix 5. An example of image data, plot data, and photographs with the GIS system.



Data and Notes:



This point was a *Salix*-Riverine Community at 3654 m established on July 28, 2006. It was established as a quick plot to allow for quantification of *Salix* number and cover at this specific plot. Data collected was only associated with height measurements of Salix and cover of *Salix* and not of other vegetation as it was done late in the evening (darkness of photos associated with lateness of photograph). The plot was 40m by 5 m (200 m^2). Coordinates were taken at the center of the plot at the east and west ends (2.5 m). The plot contained 21 individual *Salix* plants that averaged 1.0 m in height. Plant cover was determined by measuring canopy diameter of

each shrub. Cover was determined as a sum of area of each shrub. Canopy cover of Salix was 20 m^2 or 10%. Additional photographs of the area (not plot) can be found at http://) (which will be a hyperlink to photos like the one below).

Photo July28_2006_18:37a