# Application of New Techniques to Monitor Livestock Grazing Distribution by GPS and GIS

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**Abstract.** Range management needs information on distribution of livestock. The better the distribution of the livestock, the more uniform the use of the rangeland. This study was conducted to record the path of the herd steering by the shepherd. A GPS was attached to a three year old ewe which was moving with the flock. The path of flock movement was recorded for three years on a monthly basis during the grazing season. Results showed that the path was not changing within the years. On the contrary, the pattern of monthly movements showed variation. Area at the vicinity of the watering point and the sheep pen, as a sign of overgrazing for those areas, was used every day. Calculation of the grazed area showed that almost half of the range was used and the other half was left ungrazed. The map and attribute data such as speed of the movement and timing of the daily orbit could help the range manager to find a way out of over grazing problem.

**Key words:** Herding system, Iran, Over grazing, Livestock distribution.

## Introduction

Herding system in Iran uses merely shepherds who move the herd over rangelands. This system has a historical background in the country and old shepherds are well experienced experts. New generation barely satisfies to take over the job, due to their higher education and welfare expectation. Instead, Afghan refugees are used as herders. Most of them are not capable enough to do the job in a proper manner. Herding skills such as appropriate grazing distribution on the rangeland which can increase utilization of the forage resource and animal performance in this dead ended path is neglected. Some researchers believe that wherever herding system depends on shepherds, the movement skill plays a major role in livestock distribution. In a grazing system, over grazing may not only be related to over stocking but also to misdistribution of the herd. Overgrazing effects on plant communities at water points had been studied; results suggests that the distance from water could be considered as a surrogate of grazing pressure being high near the water and low away from it (Ludwig *et al.*, 2001). Changes in vegetation along a grazing gradient can be defined as a decrease in the perennial palatable plants and the dominance of unpalatable or annual plants in the vicinity of wells (Heshmatti *et al.* 2002; Tarhouni *et al.* 2007; Todd 2006). Undetected or uncorrected, grazing distribution may increase grazing pressure on the areas that are used. Range manager, therefore, should aim at the greatest safe use of as much of a pasture or ranch as possible (Robert *et al.*, 2002). Bailey (2001) showed that by using both GPS and GIS technology, livestock grazing behavior and management could be evaluated with greater resolution. Maximum daily itinerary lengths was suggested by Schlecht (2006) were 25 km for cattle, 20 km for goats and 21 km for sheep; itinerary length varied significantly between species, herd management modes and season.

It is acknowledge that farmers have had good knowledge of the browse species present in the area and their preferential classification have depended on the availability of the species, their nutritive value and also other ways of utilizing the species concerned. However, some divergence existed in the knowledge of farmers compared to the result from scientific studies, e.g. some species have been mentioned by farmers but not found in the inventory (Sanon *et al.*, 2007). It seems that a combination of local knowledge and scientific founding could always help a better land management.

Analysis of grazing system needs recording livestock distribution to show over, under and non grazing parts of the land. This will help range manager to improve the grazing system. Application of existing and novel management techniques can assist recording the past models and in many cases, altering traditional livestock grazing patterns to improve the sustainability of rangelands. Using GPS and GIS technology, livestock grazing behavior and management can be evaluated with greater resolution (Bailey, 2001). The aim of present study was to using of GPS to review the usage of the land by the shepherded who is working for the landowner. It tries to show where intensive grazing is occurred and where un/less grazed areas are.

## Materials and Method

The study area is 305 hectares and geographically located on 37º 44′ 27″ N and 46º 20′ 2″ E which is in eastern Azarbayjan province of Iran. The area is mountainous, from 2900 to 3420 m above the sea level. Altitude of the most area is within 3000 to 3100 m. Slope steepness of more than 50% of the study area is between 30% and 60%. It has a Mediterranean climate and most of rainfall belongs to winter. Annual precipitation is 326 mm. Minimum daily temperatures is 10.8ºC and maximum is 18.7ºC. Flora of the site shows rich vegetation biodiversity. Shrubs, grasses and forbs all could be found in the area. Dominant shrubs are *Onobrychis cornuta* and *Astragalus aureus* while *Festuca*

*ovina* and *Festuca rubra* are prevailing grasses. The herd under study comprises of 400 animal units, mostly from Ghezel breed. The period of grazing was 90 days that beginen from June 5th and ends on September 6th. Birth weight, weaning weight, weight at six months, average daily gain from birth to weaning (ADG1) and average daily gain from weaning to six months (ADG2) of the breed were 4.47, 20.88, 33.14 Kg, 0.184 and 0.134 gr. respectively (Nooriyan, 2000). The system of range utilization was sedentary, i.e. in summer herds were taken to the range by the herder.

To find the logic of movement, we should be aware of topography, slope angle and aspect, water sources and range vegetation types (RVT). Digital Elevation Model (DEM) was built using 1:50000 scale topographic map. Topographic distribution of range vegetation types was also determined. Slope angle map was made of that DEM as well as a slope aspect map. Water drinking points were determined and their positions were recorded by GPS. Using distance operation a distance map was made on which distances from water sources could be seen. Range vegetation types were determined and mapped on the basis of species physiognomy. Ten $1m^2$ plots were randomly placed on each vegetation type and vegetation cover percentage, yield and density of the plants were measured. To record the path of the herd, a three-year old ewe was selected and a GPS was attached to her body. The GPS was Garmin GPS60 and accuracy of location fixes was within 3 to 5 m. Location fixes were recorded at intervals of every 20 second. During the course of the study, three months for three years, once a month, movement of the herd was monitored and data were collected. Grazing start and end, time of leaving and returning to pen, length of daily orbit, speed of movement, time for grazing, rest and moving were recorded via GPS tracking application.

Since grazing by herd and not a single animal was the aim of study, width of the herd was measured and a buffer of that size, 100m, was made around the tracking line which was created by the ewe movement. To get a better sense of rangeland use, the movement of herd was simulated in Map Source and ILWIS environments. Yearly, the path of herd was compared month by month through overly application of the software. An integrated grazing area was calculated through the combination of all paths together. Then, the area of this map was subtracted from DEM map to be able to look at the maximum and minimum elevation of ungrazed area and to compare it to those that have been grazed.

**Results**

Two range vegetation types were demonstrated on vegetation map (RVT1 & RVT2). The area of RVT1 which was covered by *Astragalus aureus, Festuca ovina* and *Festuca rubra* is 147 h and RVT2 with *Onobrychis cornuta*, *Astragalus aureus* and *Festuca ovina* was 159 h. Products of RVT1 and RVT2 were 1726 kg/h and 1262 kg/h, respectively. Topographic distribution of vegetation types (Fig. 1) shows that the minimum and maximum altitudes for RTV1 and RTV2 are 2937, 3120, 3040 and 3395 meter above the sea level, respectively. Analysis of vegetation data shows that the maximum plant stand for RVT1 and RVT2 belongs to *Cirsium haussknechtii* and *Lolium* spp (Tables 1 and 2). For species yield however, the maximum frequency were observed for *Festuca ovina* and *Onobrychis cornuta* for RVT1 and RVT2, respectively.

Yearly, the movement of herd during the grazing season shows a steady path for the same months in all three years.

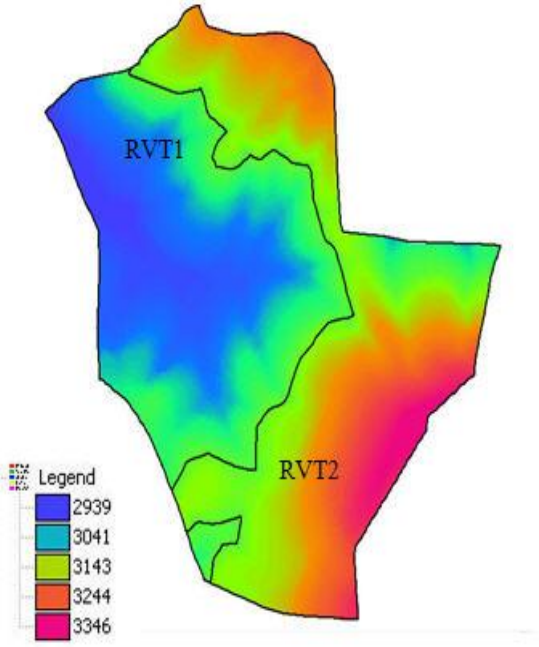


Fig. 1. Topographic distribution of vegetation in the study area. The highest area is located on the south, covered by range vegetation type 2 and is in the grazing area.

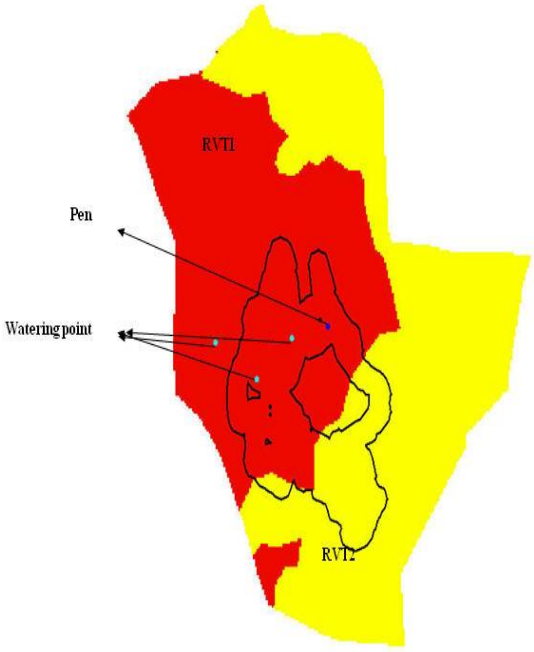


Fig. 2. Grazing path of the herd in June, recorded by GPS attached to an ewe. A 100 m buffer for simulation of herd size is also added to the recorded line.

**Movement patterns**

In June, herd was out at 5:40 am and grazes until 9:40. Then, it rests for an hour and later on they moved to watering point and grazes on surrounding area until 13:10, which was the time of milking for 2 hours. Grazing starts again and goes on until 21:50 pm. This means 17 hour presence on range vegetation, of which nearly 12 hour are dedicate to the grazing. Total length of the path was 10.6 Km. The maximum speed of the herd was recorded as 12.9 km/h. The highest elevation it has taken is 3252 m above the sea level and the minimum is 2952. Total grazed area in June is 46.6 ha of which 16.6 ha is located in range RVT 1 and 30 ha in RVT 2. Maximum distances from watering points and pen are 1400 m and 1019 m, respectively (Fig. 2).

In July, herd was out at 6:14am and grazes until 9:36; then it rests for an hour. Grazing starts again whereas the herd was moved toward watering point. Herd grazes on surrounding area until 13:51 which was the time of milking for 2 hours. Grazing starts again and continued by 21:40. This means 16.37 hours presence on range vegetation, of which nearly 12.5 hours are dedicated to grazing. Total length of the path is10.6 Km. The maximum speed of the herd is recorded as 8.9 km/h. The highest elevation it has taken is 3196 m above the sea level and the minimum is 2968. Total grazed area in July is 50.5 ha of which 44 ha is located in RVT1 and 6.5 ha in RVT2. Maximum distances from watering points and pen are 937 m and 808 m respectively (Fig. 3).

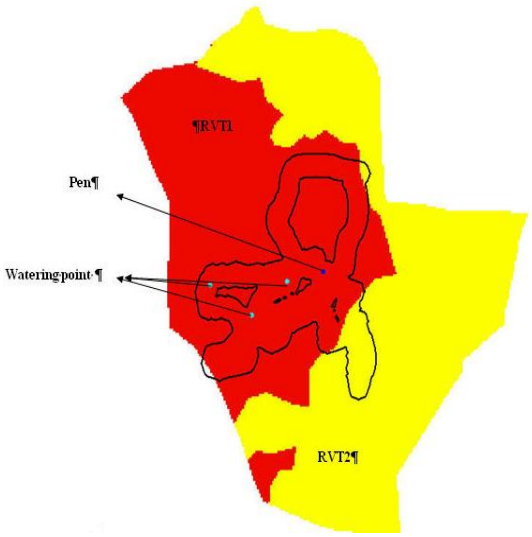


Fig. 3. Grazing path of the herd in July, recorded by GPS attached to an ewe. For calculation of the herd grazed area, a 100 m buffer is added to the recorded line

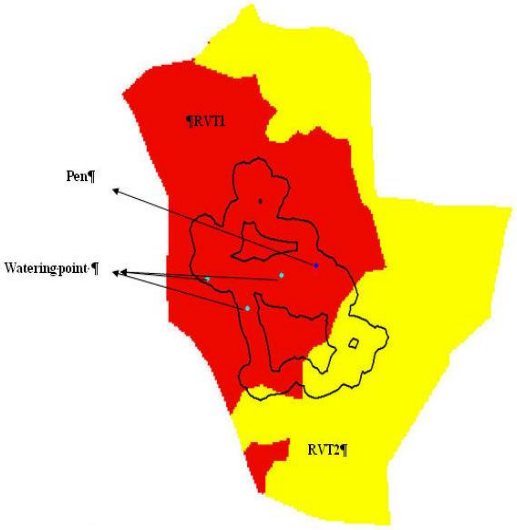


Fig. 4. Grazing path of the herd in August recorded by GPS attached to an ewe. A 100 m buffer is added to the recorded line for simulation of the herd instead of a tracking of a single animal

In August, the herd was out at 6:39 local time and grazes till 9:54. Then it rests for 50 minutes. Grazing starts again while the herd was moved toward watering point. Herd grazes on surrounding area until 13:13 and then rests. This part is extended until 15:05, later on grazing starts and continued till 19:42. Then, it was the time of milking and lasts for 2 hours. Grazing starts again and goes on until 21:40. This means 13 hours and 45 Minute's presence on range vegetation, of which nearly 11 hour belongs to grazing. Total length of the path was 9 Km. The maximum speed of the herd was recorded as 13.4 km/h. The highest elevation it has taken was 3229 m above the sea level and the minimum was 2951. Total grazed area in August was 53.4 ha of which 42 ha is located in range RVT 1 and 11.4 ha in RVT 2. Maximum distances from watering points and pen were 722 m and 1044 m, respectively (Fig. 4). With respect to slope angle, the results show that herd movements were mostly on 30-60 slope classes while slopes less than 5% and more than 60% had less movement (Table 3).

Overall pattern of movement in the area shows that only 151 hectares of the area was grazed (Table 4) and 154 hectare was left ungrazed. The maximum and minimum of the ungrazed area (Figs. 5 and 6) were in range of 3382 and 2937 m above the sea level, respectively.

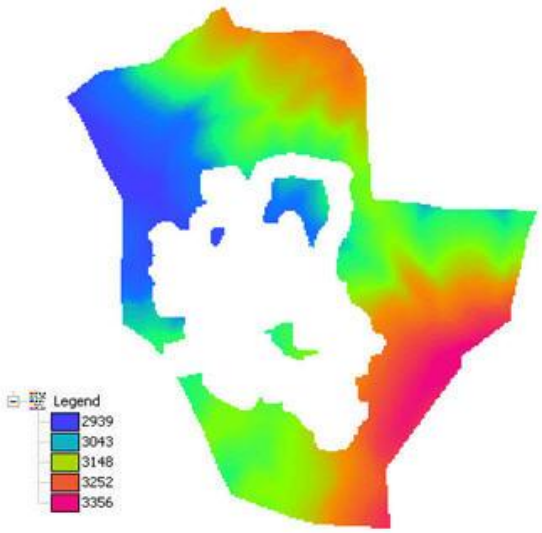


Fig. 5. All grazing paths are merged and subtracted from DEM map of the whole area and maximum and minimum of ungrazed are calculated

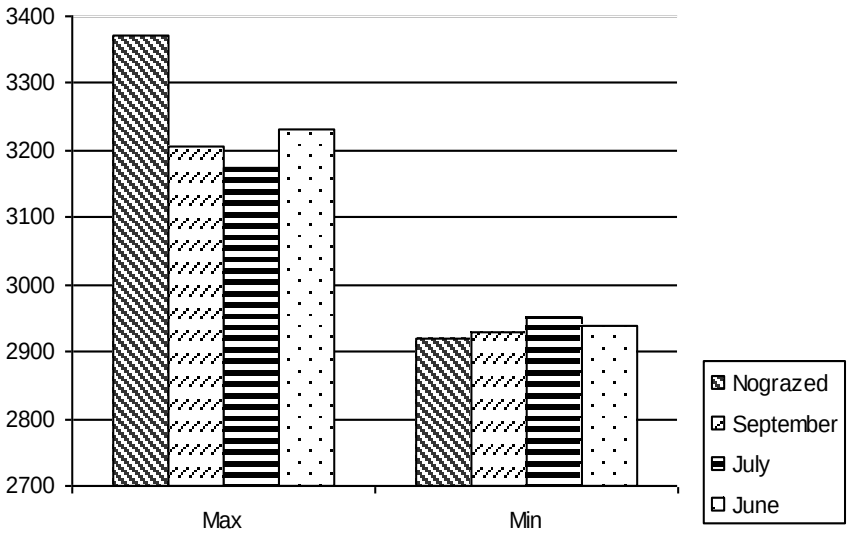


Fig. 6. Graphic representation of elevation grazed during three months and non grazed area

Table 1. Vegetation composition and yield in range vegetation type 1

| Species | RVT1 | | |
|---|---|---|---|
| | Vegetation cover (%) | Density (stand/ha) | Production (kg/ha) |
| *Alopecurus textilis* | 3.6 | 800 | 101.9 |
| *Arenaria dianthiodes* | 1.6 | 300 | 6.48 |
| *Astragalus aureus* | 10 | 700 | 455.4 |
| *Astragalus pinetorum* | 0.9 | 400 | 10.6 |
| *Bromus tomentellus* | 9.2 | 1000 | 77.0 |
| *Cirsium haussknechtii* | 0.7 | 200 | 62.5 |
| *Festuca ovina* | 26.8 | 3700 | 479.5 |
| *Festuca rubra* | 13.8 | 2600 | 420.6 |
| *Tanacetum chiliophyllum* | 4.5 | 600 | 59.8 |
| *Taraxacum montanum* | 1.0 | 600 | 12.6 |
| *Thymus kotschyanus* | 4.9 | 600 | 31.7 |
| *Tragopogon marginatus* | 1.7 | 1000 | 8.2 |
| litter | 7.8 | | |
| Gravel | 5.2 | | |
| Bare soil | 8.3 | | |
| Sum | 100 | | |

Table 2. Vegetation composition and yield in range vegetation type 2

| Species | RVT2 | | |
|---|---|---|---|
| | Vegetation cover (%) | Density (stand/ha) | Production (kg/ha) |
| *Agropyron trichophorum* | 1.5 | 500 | 75.4 |
| *Alopecurus textilis* | 1.8 | 400 | 25.2 |
| *Astragalus aureus* | 16.9 | 1100 | 262.7 |
| *Bromus tomentellus* | 3.5 | 600 | 70.5 |
| *Dactylis glomerata* | 0.9 | 500 | 50.0 |
| *Festuca ovina* | 6.8 | 1800 | 136.6 |
| *Festuca rubra* | 4.2 | 600 | 82.2 |
| *Lolium spp.* | 5.0 | 2400 | 66.2 |
| *Onobrychis cornuta* | 16.5 | 800 | 302.3 |
| *Poa bulbosa* | 2.4 | 800 | 72.8 |
| *Polygonum aviculare* | 0.9 | 500 | 19.7 |
| *Thymus caucasica* | 1.6 | 500 | 16.8 |
| *Trifolium repens* | 4.7 | 1700 | 81.5 |
| Litter | 17.3 | | |
| Gravel | 7.1 | | |
| Bare soil | 8.9 | | |
| Sum | 100 | | |

Table 3. Slopes taken by herd in different months. As it is shown, slope classes between 30 to 60 percents are more paved by the herd.

| Slope classes (%) | June | July | August |
|---|---|---|---|
| 0-5 | 0.00 | 0.20 | 0.10 |
| 5-15 | 1.3 | 3.9 | 3.50 |
| 15-30 | 8.9 | 16 | 19.3 |
| 30-60 | 30.4 | 30 | 28.5 |
| >60 | 5.80 | 0.40 | 0.20 |

Table 4. Area grazed by herd on each vegetation types in three different months

| Vegetation types | Species composition | Grazed area (ha) | | | |
|---|---|---|---|---|---|
| | | June | July | August | Total |
| (RVT1) | *As. aureus, Fe. ovina- Fe. rura* | 17 | 44 | 42 | 103 |
| (RVT2 | *On. cornuta, As. aureus- Fe. ovina* | 30 | 7 | 11 | 48 |
| Total | | 47 | 51 | 53 | 151 |

**Discussion**

This study shows that close water points were used every day during the grazing season that was in agreement with Ludwig *et al.* (2001); Heshmatti *et al.* (2002); Tarhouni *et al.* (2007); Todd (2006). Half of the study area, which was the property of a range manager, was left ungrazed this confirm that the knowledge of the shepherd was not enough as it was said by Sanon *et al.* (2007) or for any unknown reason the shepherd does not like to take the folk to those areas. Topography might not be the case since the area above the maximum grazed one was 5600 $m^2$. There are not distinct data on vegetation of grazed and ungrazed areas. Data on vegetation of each vegetation type are available and do not show so much variation within the same RVT. Simultaneous study by the author method through camera recording of

grazing behavior of the herd shows that plant species were well grazed in the area even for *Astragalus aureus* which was known as a poisonous plant. This plant was grazed in the beginning of the grazing season. Distance also could not be the reason since the maximum distance to those ungrazed was 1437 m that was much shorter than that record by Schlecht *et al.* (2006).

This kind of studies will give the landowner the opportunity to look for the reasons. Perpetuation of this system will lead to the depletion of land and palatable species in the vicinity of the watering points and the pen as it was said by Heshmatti *et al.* (2002); Tarhouni *et al.* (2007); Todd (2006). To tackle the problem, range improvement and rehabilitation might be practice or grazing paths should be shifted. This is what range owner should decide and our maps could help him to do so.

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