INFLUENCE OF RANGE IMPROVEMENT ACTIVITIES ON SUSTAINED PRODUCTIVITY OF RANGE WATERSHED RESOURCES[1]

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ABSTRACT

This study was carried out for 6 years (1989-94) in the moist temperate zone of Mansehra District (NWFP) to investigate the effect of range improvement activities on protective and vegetation cover, forage production and species composition. Four major variables namely; no grazing, no grazing + over-sowing, conventional grazing + over sowing and conventional grazing only were tested in two replications. The variables were assigned randomly to 4 plots of 10x10 m. Each plot was subdivided into two subplots of 10x5 m and one sub plot under each major variable was fertilized for Ist 3 years with uniform dose of NPK (1:2:2) at the rate of 100 kg N, 200 Kg P and 200 Kg K per ha/year.

The results indicated manifold increase in protective and vegetation cover and forage production under combined effect of fertilizer application, protection and over sowing compared to conventional grazing. Forage production was 5 times higher under fertilizer application. The study has demonstrated that range improvement activities will not only enhance the socioeconomic conditions of the graziers through increase in forage production but will also play an important role in the improvement of watershed values. This implied that appropriate range improvement activities are imperative for sound pastoral economy and sustainable watershed resources of the mountainous region of the NWFP.

INTRODUCTION

The important mountain ranges namely; Himalayas, Karrakorum and Hindu Kush meet in the north of Pakistan and exert considerable influence on the climatic and physiographic factors of the region. These mountainous watersheds are characterised by series of altitudinal zonations giving rise to complex ecosystems. However, ecologically suitable use patterns have been adopted by the local and nomadic graziers. The major use patterns of the complex eco-zones are (i) extensive pasturing of alpine/subalpine zones by the transhumant group and (ii) a mosaic land use pattern of middle hills (temperate zone) and foot hills (sub mountain) mostly by the local inhabitants.

Livestock grazing is one of the important activities of the subsistence farmers in and around the temperate zone of the mountainous watersheds. However, uncontrolled heavy grazing is destructive to soil and vegetation. Free range grazing, which is very common in these areas, is causing impoverishment of palatable vegetation. Similarly heavy grazing, trampling and soil compaction of this zone, which is an important water producing land resource, have deteriorated the intake of rainfall and water holding capacities of the soil. Hence the zone contributes major portion of sediment yield to the multipurpose water reservoirs and canal irrigation in the down country.

No doubt, uncontrolled heavy grazing is detrimental to watershed values, affecting surface runoff, accelerates soil erosion and brings changes in species composition. Moreover, soil and water pollution also takes place due to dung and urine of the grazing animals (Johnsten et al, 1971) and Packer, 1953). However, the socio-economic benefits of grazing to the small farmers can not be ignored. Moreover, moderate and controlled grazing has positive effects on vegetation. It reduces the chances of accidental fires, helps seed spreading and seed germination. In an economic environment, where

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animal husbandry is integrated to farming and provides income and security to the small farmers grazing can not be eliminated all together.

This study, to evaluate the improvement potential of range watershed through improvement in management practices, was carried out in the temperate zone (middle hills) of Mansehra district. The study aimed at inducing improvement in vegetation cover and species composition which in turn reduce surface water runoff, soil erosion and improve range productivity.

MATERIAL AND METHODS

A degraded site, forest gap, facing south-western aspect on a ridge located in compartment No.10(1) Punjul Reserved Forest near Kund Forest Rest House (Mansehra) at an elevation of 2650 m was selected for this study. The site was being used as grazing ground and also as corridor by nomadic livestock. Total annual precipitation of the study area may exceed 1700 mm with mean maximum temperature of 22°C. Soil is blackish brown loamy silt with high nitrogen contents and moderate level of Potassium (Sardar, 1994).

The experiment was laid out in June, 1989 in two replications, each with 4 plots of 10x10 m. Each plot was sub-divided into two equal sub-plots of 10x5 m. Major treatments (variants) were assigned randomly while sub-treatments were subjected to systematic arrays in the sub plots. The major treatments were:

A = No grazing
B = No grazing + over-sowing
C = Conventional grazing
D = Conventional grazing + over-sowing

The plots receiving major treatments A and B were fenced and C and D were open to grazing round the season. There were 8 sub plots in each replications namely; a1, a2, b1, b2, c1, c2, d1 and d2. The sub plots a1, b1, c1 and d1, were fertilized with uniform dose of NPK (1:2:2) at the rate of 100 kg N, 200 kg P and 200 kg K per ha during July each year. Fertilizer was applied for 3 consecutive seasons from 1989 to 1991. The experiment was maintained for 6 grazing seasons. For last 3 grazing season (1992-94) fertilizer was not applied to evaluate its residual effect.

Ten semi-permanent quadrats of 1 square meter in each sub plot were laid out. There were 20 quadrats in each major treatment and in all 160 quadrats in two replications. Data regarding forage production (by clipping method), species-wise areal cover and soil protective cover (plant base, litter, cryptogams and bare soil) were collected regularly. Last two parameters were measured twice in August and September each year. Data on forage production was collected during September (end of growing seasons) each year.

RESULTS AND DISCUSSION

Protective Cover:

Percent soil surface covered under plant base, litter, cryptogams and rock pavement is collectively expressed as protective cover percentage or surface material distribution. These parameters provide protection to soil surface from direct effect of rain drops and wind velocity. The underlying concept explains that more the soil surface of a range area is covered under these parameters the less would be soil disturbance due to rain or wind velocities and hence minimum would be the soil erosion.

In June, 1989 the accumulative protective cover was 27.7 percent and bare soil was 72.3 percent under uncontrolled grazing before the application of treatments (Table 1). The higher value of bare soil(72.3%) was clearly indicative of degraded range watershed which would result in accelerated runoff and soil erosion.

Table 1. Soil Protective Cover before Application of Treatments (June, 1989)

(Cover percent)

Protective cover	A		B		C		D		Average
	a1	a2	b1	b2	c1	c2	d1	d2	
Plant base	7.2	5.5	6.1	5.2	4.8	4.3	5.6	5.3	5.5
Litter	5.8	12.9	8.9	6.3	5.1	1.6	3.4	3.1	5.9
Cryptogams	0.6	1.5	4.8	3.2	6.0	5.9	3.7	6.1	4.0
Rocks pavement	10.1	8.2	15.4	20.9	13.1	20.4	4.7	5.9	12.3
Bare soil	76.3	71.9	64.8	64.4	71.0	67.8	82.6	79.6	72.3

Three year's (1989-91) data showed about 15 percentage points increase in protective cover. Bare soil, on the average, decreased from 72.3 percent to 57.5 percent. Effect of no grazing, protection and fertilizer application on protective cover was highest (47.5%). Under this treatment plant base had increased from 7.2 percent to 17.0 percent. Litter cover was also highest (19.8 percent), (Table 2). Later 3 years (1992-94) showed increase in plant base but decrease in litter and cryptogams cover. This and further protection (no grazing) not only sustains it but continues the successional process.

Table 2. Effect of Range Improvement Activities on Soil Protective Cover

Protective cover	A (No grazing)		B (Conventional grazing)		C (No grazing + over-sowing)		D (Conventional grazing + over sowing)		Average values
	F*	UF*	F	UF	F	UF	F	UF	
I. Fertilizer Effect (Sept., 1989 - Sept., 1991)									
Plant base	17.0	10.3	8.8	8.1	12.3	9.7	8.8	8.2	10.4
Litter	19.8	19.0	15.1	16.4	19.8	18.7	14.0	15.4	17.3
Cryptogams	6.2	11.2	4.4	7.5	8.7	11.3	4.5	6.4	7.5
Rocks pavement	4.5	5.5	14.0	13.9	5.5	3.9	5.0	6.4	7.3
Bare soil	52.5	54.0	57.7	54.1	53.7	56.4	67.7	63.6	57.5
II. Residual Effect (Sept., 1992 to Sept., 1994)									
Plant base	17.9	16.1	9.8	8.3	17.5	14.1	10.2	8.9	12.9
Litter	19.7	19.5	12.4	12.8	18.1	17.1	12.9	12.2	15.6
Cryptogams	2.9	2.6	0.3	0.4	2.6	1.0	0.5	0.5	1.4
Rocks pavement	3.9	3.5	15.8	14.5	4.7	10.9	9.2	6.7	6.7
Bare soil	55.6	58.3	61.7	64.0	57.1	56.9	67.2	71.7	61.4

F* = Fertilized
UF* = Unfertilized

VEGETATION COVER

Areal cover of the range vegetation provides effective protection to the soil from eroding away by the erosive forces particularly during heavy down pour in the monsoon period. This study has demonstrated that vegetation cover could be enhanced manifold by applying certain range improvement activities. The result showed that vegetation cover increased from 24.4 percent in June 1989 under continuous grazing (Table 3) to 73.4 percent under combined effects of different improvement activities (Table 4). No grazing (protection) and fertilizer application have shown the maximum vegetation cover of 96.8% over the period of 3 seasons (1989-91) against the lowest cover percent of 44.8 under continuous grazing for same period. During the second period (1992-94) there were negligible changes in total vegetation cover percent. However, the forbs cover has shown increase and grass cover has shown slight decrease (Table 4). This may be due to chemical changes in the soil by fertilizer application in Ist. period and withdrawal of it in the second period.

Application of fertilizer in grazed plots has negligible effects on cover percent. Similarly over-sowing has not shown any influence on cover percent, This indicates that protection (resting) for at last 3 years is necessary for ecological recovery to initiate. For sustainability of this process another 3 years are also required. Effect of over-sowing would depend upon successful germination and seedling establishment. Seeds would require "bed" for proper contacts with soil and consequent their germination.

Table 3. Vegetation Cover Percent Before Application of Treatment (June, 1989)

(Cover percent)

Protective cover	A		B		C		D		Average
	a1	a2	b1	b2	c1	c2	d1	d2	
Plant base	14.0	14.2	11.7	11.9	7.4	7.4	8.6	12.2	10.9
Forbs	12.8	11.8	18.2	13.4	12.3	11.4	10.7	10.1	12.6
Shrubs	-	-	0.5	-	0.3	-	4.0	3.0	0.9
Total:	26.8	25.9	30.4	25.3	20.0	18.8	23.3	25.3	**24.4**

FORAGE PRODUCTION

Clipping method was applied to estimate air dried (AD) forage production. Entire vegetation in one square meter was clipped at 2.5 cm stubble height during September each year. Variation in forage production from year to year indicates the influence of precipitation in addition to fertilizer application and protection. Average forage production for first period of 3 years was 4138 kg/ha (AD) against 1164 kg/ha (AD) under protected area (Table 5). This indicates that about 3.6 times more forage was produced by application of fertilizer. Over sowing did not influence the forage production, however, fertilizer effect was pronounced in this treatment too. During the 2nd period of 3 years average forage production showed increase from same plots. Further, in September, 1994 the highest production of 8646 kg/ha (AD) was recorded under no grazing + over-sowing and fertilizer treatment followed by 7761 kg/ha under no grazing + fertilizer. Further in unfertilized plots also the production was higher than other years. This increase was mostly attributed to the good rainfall in 1994.

Table 4. Effect of Improvement Activities on Vegetation Cover

Protective cover	No grazing		Conventional grazing		No grazing + over-sowing		Conventional grazing + over sowing		Average value
	F	UF	F	UF	F	UF	F	UF	
I. Fertilizer Effect (Sept.,1989 - Sept., 1991)									
Grasses	77.3	54.6	43.3	31.7	55.9	40.0	33.4	32.8	46.4
Forbs	18.5	32.4	21.6	13.0	37.1	31.6	23.9	22.1	25.0
Shrubs	1.0	0.3	0.1	0.1	0.3	1.7	5.0	7.1	2.0
Total:	96.8	87.3	65.0	**44.8**	93.3	73.1	64.3	62.0	**73.4**
II. Residual Effect (Sept., 1992 to Sept., 1994)									
Grasses	74.0	51.1	37.7	26.7	53.0	34.6	32.5	29.5	42.4
Forbs	23.1	34.6	20.0	15.4	40.5	35.6	20.9	23.6	26.7
Shrubs	1.4	0.0	0.0	1.9	0.0	1.4	7.2	11.0	2.9
Total:	98.4	85.7	57.7	44.0	93.5	71.6	60.6	64.1	72.0
Six years average value	97.7	86.5	61.4	44.4	93.4	72.4	62.5	63.1	72.7

Table 5. Effect of Range Improvement Activities on Forage Production

Year	No grazing		Conventional grazing		No grazing + over-sowing		Conventional grazing + over sowing	
	F	UF	F	UF	F	UF	F	UF
I. Effect of Fertilizer Application								
September, 1989	3427	800	-	-	3550	907	-	-
September, 1990	5760	1563	-	-	4552	883	-	-
September, 1991	3228	1130	-	-	2170	510	-	-
Average:	**4138**	**1164**	-	-	3414	767	-	-
II. Residual Effect								
September, 1992	2835	860	-	-	3100	640	-	-
September, 1993	2270	835	-	-	2147	715	-	-
September, 1994	**7761**	2424	-	-	**8646**	1957	-	-
Average:	4288	1406	-	-	4631	1104	-	-

Note (-) Indicates that in grazed plots there was no herbage available for clipping during September due to heavy grazing.

SPECIES COMPOSITION

Sixteen (16) different range vegetation species were recorded during June, 1989 before application of treatments. Out of it 7 were grasses/grass likes and 9 were forbs. Among the grasses *Chrysopogon echinulatus* was dominant (9.4 percent cover) followed by *Carex* species (1.2 percent cover). Among the forbs *Taraxacum officinale* was dominant (2.8 percent cover) followed by *Thymus serpyllum* (2.1 percent cover), (Appendix-I). Accordingly *Chrysogpogon-Taraxacum-Thymus* community was found under heavily grazed condition.

Ecological recovery was prominent during 6 years of study duration (1989-94). Thirty six (36) species were recorded of which 10 were grasses/grass-likes, 24 were forbs and 2 were shrubs. Among grass species *Chrysopogon echinulatus* with 27.9 percent cover was dominant followed by *Agrostis gigantea* with 8.5 percent cover. Among forbs *Trifolium repens* with 8.8 percent cover was dominant followed by *Thymus serpyllum* having 2.5 percent cover (Appendix-II). During study period *Chrysopogon-Trifolium-Thymus* range type was noticed.

This study showed that *Chrysopogon* spp., which is highly palatable, was resistant to grazing pressure. Further, secondary succession had quick response to the treatments. It also proved that scientific grazing management would quickly initiate the process of succession and hence the range conditions improve subsequently.

CONCLUSION

The temperate grazing lands responded positively to different range improvement activities like protection (No grazing), application of fertilizer and over-sowing. Further application of fertilizer and over-sowing without protection do not influence any appreciable change in vegetation. Range vegetation parameters like cover, forage production and species composition show considerable improvement under treated conditions. Fertilizer application enhanced forage production upto about 4 times against protection only.

A rest of 3 to 6 years and application of fertilizer improved the growth characteristics of degraded vegetation of temperate grazing lands. It means that if rest and rotational grazing programmes are employed that will improve the present range conditions. Further increased forage production would enhance the quality and quantity of livestock and their products. This in turn would enhance the household income and the conventional pastoralism would be transformed into scientific pasturing. This would not only help the sustainability of watershed values but also improve the regional economy.

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Appendix I: Species Composition in the Temperate Zone During June, 1989 Under Grazed Conditions (DM kg/ha)

	No grazing		Conventional grazing		No grazing + over-sowing		Conventional grazing + over sowing		Average value
	F	UF	F	UF	F	UF	F	UF	
I. Grasses/grass-likes									
Agrostis gigantea	-	0.5	-	-	-	-	-	-	0.06
Bothriochloa intermedia	0.1	-	-	0.1	1.3	0.1	-	-	0.2
Carex sp.	1.2	1.6	0.7	0.3	1.7	1.5	1.2	1.2	**1.2**
Chrysopogon echinulatus	12.3	12.7	6.4	6.8	9.6	8.7	7.7	10.6	**9.4**
Festuca ovina	-	-	0.3	-	0.5	0.5	-	-	0.2
Poa alpina	0.5	0.5	-	3.9	-	1.3	-	0.5	0.8
Setaria glauca	0.5	-	0.6	0.4	0.9	0.7	-	-	0.4
II. Forbs									
Filago spathulata	2.3	1.8	1.6	2.2	0.1	2.8	1.7	0.6	1.6
Medicago lupulina	-	0.1	-	-	-	-	-	-	-
Plantago ovata	1.1	1.2	1.5	1.9	1.6	2.0	2.1	1.8	1.7
Polygonum amplexicaule	1.3	1.3	1.0	0.7	2.6	2.9	1.8	1.8	1.7
Potentilla fragalioides	0.5	0.4	0.5	0.3	0.2	0.2	0.1	0.4	0.3
P. sibbaldi	1.6	1.4	0.8	0.5	1.6	1.4	3.2	1.8	1.6
Thymus serpyllum	2.1	2.0	2.9	2.1	3.2	0.7	2.2	1.8	**2.1**
Taraxacum officinale	2.4	3.3	1.0	3.4	5.3	3.7	1.6	1.9	**2.8**
Trifolium repens	1.4	0.3	-	-	1.2	0.1	-	-	0.4

Appendix II: Effect of Range Improvement Activities on Range Floristic Composition in Temperate Zone Rangelands

(Average cover % September, 1989 to September, 1994)

Vegetation form	No grazing		Conventional grazing		No grazing + over-sowing		Conventional grazing + over sowing		Average value
	F	UF	F	UF	F	UF	F	UF	
I. Grasses/grass-likes									
Agrostis gigantea	20.8	6.5	4.2	3.1	17.7	7.6	7.2	2.7	**8.5**
Bothriochloa intermedia	0.1	1.5	-	0.1	0.8	0.3	-	-	0.3
Carex spp.	4.9	2.6	2.4	1.8	2.6	1.8	1.3	2.2	5.4
Chrysopogon echinulatus	40.2	37.6	30.1	20.1	20.6	26.2	23.0	25.1	**27.9**
Cynodon dactylon	0.1	0.1	-	-	-	-	-	-	0.03
Dactylis glomerata	-	-	-	-	8.1	0.5	0.7	0.3	2.4
Digitaria sanguinalis	3.6	0.4	1.5	1.0	1.0	0.2	0.7	0.3	1.1
Festuca ovina	-	-	-	-	0.5	0.5	-	-	0.3
Pennisetum lulisitis	5.0	3.9	-	-	-	-	-	-	1.1
Poa alpina	1.8	0.3	2.6	3.5	4.2	0.6	3.2	0.9	2.1
II. Forbs									
Ajuga pariflora	0.4	0.1	0.4	0.2	0.2	0.1	0.2	0.2	0.2
Cerastium triviale	0.3	0.3	0.4	0.4	0.3	0.1	0.9	0.3	0.4
Chenopodium album	0.1	1.9	0.4	0.5	0.1	2.7	0.4	1.2	9.9
Conyza japonica	0.4	1.0	-	0.3	0.7	0.3	-	0.3	0.4
Fern spp.	-	-	2.8	0.3	-	-	2.3	1.8	0.8
Filago spathulata	0.1	1.9	0.4	0.5	0.1	2.7	0.4	1.2	0.9
Galium triflorum	0.4	1.0	-	0.3	0.7	0.3	-	0.3	0.4
Geranium gibiricum	-	-	-	-	0.1	-	-	-	0.01
Mentha longifolia	-	-	0.1	0.1	-	-	-	-	0.03
Medicago lupulina	0.1	0.1	0.1	0.5	0.2	0.2	0.1	0.3	0.2
Phlomos bracteosa	1.5	0.1	-	-	0.4	0.2	0.1	0.1	0.3
Plantago ovata	1.5	4.1	2.0	2.3	1.5	0.6	1.5	1.6	1.9
Polygonum amplexicaule	1.9	2.5	1.9	0.3	2.8	2.5	1.6	5.2	2.3
P.aviculare	0.8	0.8	-	-	2.6	6.1	-	-	0.5
P.nepalensis	2.0	0.6	-	-	2.6	0.1	-	-	0.7
Potentilla fragalioides	1.3	1.2	0.6	0.7	0.8	0.3	0.7	0.7	0.8
P.sibbaldi	3.2	3.7	0.7	-	0.7	3.6	2.0	2.6	2.1
Ranunculus laetus	-	-	0.1	-	-	-	-	-	0.01
Rumex nepalensis	-	-	0.1	-	-	-	0.1	-	0.03
Thymus serpyllum	0.9	3.1	3.3	2.4	0.9	5.3	1.4	2.3	**2.5**
Taraxacum officinale	0.9	5.6	3.1	3.2	1.2	3.5	2.1	2.9	2.8
Trifolium repens	5.7	5.3	4.5	4.0	25.5	12.5	9.4	2.9	**8.8**
Veronica laxa	-	0.2	-	0.2	0.1	0.1	0.1	0.3	0.1
III. Shrubs									
Cotoneaster numularia	-	0.3	-	-	-	-	6.7	9.2	2.0
Indigofera gerardiana	1.3	-	0.1	1.0	-	0.3	1.6	-	0.4