EFFECT OF ALTITUDE UPON THE COMPOSITION OF FORAGE PLANTS

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There is little question that a knowledge of the effects of altitude upon the growth and composition of plants is important not only from a scientific standpoint, but also for practical reasons. A better knowledge of these effects and the primary causes which go to produce them will undoubtedly throw some light upon our problems and help us to understand better the effects of slight changes of altitude which may be difficult to determine directly. Then, too, this subject is of special importance to those who are interested in agricultural practice at the higher altitudes.

Between the altitudes of 4,500 feet and 7,500 feet there are three Agricultural Experiment Stations in the United States —Utah Station at Logan, altitude 4,500 feet; Colorado Station at Fort Collins, altitude 5,000 feet, and Wyoming Station at Laramie, altitude 7,200 feet. The altitude of the last named station is at about the limit of successful agriculture for the latitude in which it is situated, but in the mountainous sections of the world there are considerable areas of land in

the aggregate between the elevations of the Utah and the Wyoming stations, which are devoted to successful agriculture and in the three states in which these stations are located there are more than a million acres, so the subject becomes of some importance locally.

It is generally known that the environmental factors vary with change in altitude, but the extent of the change is not so well understood, empirically an increase of a thousand feet in altitude is equivalent to a shift of 300 miles from the equator, so it would be possible upon land elevated at the equator to have all the zones with corresponding flora and fauna. Actually, however, conditions are not the same as, but similar to, the zonal.

The higher altitudes are marked by the following peculiar climatic conditions, which are not necessarily peculiar to changes in latitude:

A marked daily range of temperature which increases with altitude.

Mean daily temperature decreasing with altitude.

Comparatively high solar radiation.

Prevailing high winds, increasing with altitude.

Comparative high evaporation because of the lowered air pressure.

As we pass to the higher altitudes the following changes are noted in vegetation:

The less hardy varieties and species give place to the more hardy.

The average height of the plants of any species decreases.

The proportion of plant above ground to that below decreases.

The proportion of seed to stock and leaves tends in general to increase.

The period between germination and seeding decreases.

Decreased acre yields.

A greater resistance to frosts.

All of these known changes would be expected to produce an effect upon the vegetation.

Investigations were begun at the Wyoming Experiment Station several years ago (Wyoming Forage Plants and Their Chemical Composition. Bulletins Nos. 65 (1905); 70 (1906); 76 (1908); and 87 (1911). Knight, Hepner and Nelson) which seemed to throw some light upon the change in composition of plants with change in altitude.

Samples of native forage plants were collected at various altitudes, but otherwise under as near similar conditions as possible.

Table I gives the complete approximate analyses of some of these native plants.

TABLE I.

Year	Altitude	Ash	Ether Ext.	Crude Fiber	Nitrogen X6.25	N. Free Ext.	No. Samples
			Mountain Timothy				
1905	7500	3.82	1.78	39.74	5.00	46.99	1
1909	9500	5.15	1.69	38.54	9.59	45.03	1
1908	10000	4.47	2.35	30.69	11.46	51.03	1
1909	10000	4.31	1.66	35.66	9.43	48.94	1
1907	10500	4.54	2.55	31.84	12.04	49.03	1
			Bearded Wheat Grass				
1905	7000	8.31	1.95	36.64	7.85	45.25	1
1905	7500	6.02	1.96	37.09	8.28	46.65	1
1909	9500	4.73	2.00	36.15	8.56	48.56	1
1909	10000	4.98	1.49	36.97	14.05	42.51	1
			Western Wheat Grass				
1908	4300	8.63	2.68	37.31	8.70	42.67	2
1908	7200	8.93	2.11	34.18	10.92	43.68	1
1905	7200	8.31	2.24	33.94	10.19	45.32	4

It will be noted that the nitrogen content increases with the altitude, while there are no regular changes to be noted in the other plant constituents. As further evidence of the change in nitrogen content with changes in altitude Table II is given.

TABLE II.

Name of Plant	Altitude	Year	N. X. 6.25	No. of Samples
Tufted Hair Grass	10800	1907	10.95	1
Tufted Hair Grass	11000	1907	17.93	1
Tufted Hair Grass	7200	1908	6.07	1
Tufted Hair Grass	10500	1908	12.98	1
Mountain Blue Grass	10000	1908	9.36	1
Mountain Blue Grass	10500	1908	11.87	2
Mountain Spear Grass	8000	1909	7.78	1
Mountain Spear Grass	10000	1909	8.18	1
Fine Topped Salt Grass	4300	1908	7.79	2
Fine Topped Salt Grass	7100	1908	12.82	1
Canadian Needle Grass	9500	1909	7.79	2
Canadian Needle Grass	10000	1909	11.21	1

Downy Oat Grass	10000	1907	9.69	1
Downy Oat Grass	11000	1907	12.20	1
Giant Sedge	9500	1908	10.00	1
Giant Sedge	10000	1908	11.76	1
Mountain Sedge	9500	1908	13.26	1
Mountain Sedge	10500	1908	15.76	1
Mountain Sedge	8000	1909	7.12	1
Mountain Sedge	10000	1909	12.37	1
Parry's Rush	9500	1909	11.96	1
Parry's Rush	10500	1909	16.75	1
Western Wheat Grass	4300	1908	8.71	2
Western Wheat Grass	7200	1908	10.92	1
Rough Hair Grass	8000	1909	7.47	1
Rough Hair Grass	10000	1909	9.87	1
Slough Grass	8000	1905	6.33	1
Slough Grass	8500	1905	7.54	1

As a summary of forage during the years 1908, 1909 the following table is given:

TABLE III.

No. of Samples	Altitude	N. X. 6.25 1908	1909
39	4100 to 4500	8.29	
1	4700	12.59	
1	5700	9.09	
6	7200	9.63	
4	8000		8.55
1	8500	7.08	
3-9	9500	8.56	8.97
5-14	10000	10.85	10.40
9	10500	12.32	
1	11000	12.30	
	Sedges		
3	4200 to 4500	9.53	
1	7100	8.09	
1	8000		7.99
4-4	9500	12.76	13.46
6-7	10000	13.56	12.11
3	10500	14.16	
1	11000	18.77	

The nitrogen content of the forage plants increases with altitude. It was believed that this might be explained by differences in soils, but investigations with this in view have not thus far supported this theory. The other accepted factors such as light, heat, air and moisture have been given consideration, but no one of them seems to afford an adequate explanation, but the changes in the first four together are the probable cause of the difference noted. Under the more adverse conditions of the higher altitudes plants must in a shorter time come to the fruiting period if the species are to survive. Since seed require larger proportions of nitrogen than the foliage, we would, since the weight of foliage becomes less, expect that a higher nitrogen content would be found in the foliage of the plants at higher altitudes in preparation for the fruiting period.

CONCLUSIONS

The nitrogen content of forage plants increases with altitude.

No regular changes were noted in the other plant constiuents as represented by the approximate analysis.

The probable cause is the change in habitat of the plants due to change in general climatic conditions.