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Objectives of this study were to determine differences in herbage production of three seral stages of three habitat-types. Field studies were conducted in 1967 and 1968 on the Squaw Butte Experimental Range.

Twelve, 400-square-foot, paired exclosures were established in each habitat-type. Herbage was clipped from four, 48-square-foot samples in one of each of the paired exclosures in 1967 and in the other paired exclosure in 1968. Herbage weights were used to determine production. Classification of habitat-types and determination of seral stages were discussed relative to production data collected.

Herbage Production on Three Vegetation Types in the High Desert of Eastern Oregon

by

Peter Marion Markgraf

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INTRODUCTION

An ecological inventory of the Squaw Butte Experimental Range provided an opportunity to study relationships between herbage production and habitat-types and between herbage production and seral stages within habitat-types. Herbage production information generally was not a part of ecological investigations. However, production information was essential to range land managers as it formed the basis for stocking rates.

It was assumed that if herbage production was related to habitat-types and seral stages, and, if this relationship could be measured reliably, the information would be of value to the range manager. Hopefully, this study would complement the ecological inventory of Squaw Butte and other ecological research conducted at Oregon State University and make it more useful and meaningful to range land managers.

The specific purpose of this study was to determine the productivity of three habitat-types in the High Desert of Eastern Oregon. These ecological units were chosen because of the relative amounts of land area they occupied. The relationship of herbage production between the three habitat-types selected for study was not known. Also, the relationship of herbage production between these habitat-types and other habitat-types was not known. Final selection of the habitat-types for study was influenced by the desire to provide study results applicable to large acreages of range land.

Different seral stages in the successional development of a habitat-type were sampled to graph the approximate production curve within a habitat-type. Habitat-type production curves should then serve as useful indicators of productivity, on a habitat-type basis, much like Anderson's Range Site Guides (1) have been used as indicators of productivity, on a range site basis.

Production curves should aid the land manager in determining the potential forage production on a given piece of rangeland. Estimates of increased forage are necessary for an economic analysis of possible improvement practices. More accurate estimates could lead to more accurate economic analyses. Production curves in this study should be thought of as a first approximation to the true production curve of each habitat-type. Many sources of error may have existed in the study. Recognized sources of possible error are: 1) sample plot locations erroneously classified ecologically, 2) seral stages in each habitat-type may or may not represent equal departures from climax, prohibiting comparison between habitat-types in the same seral stage, and 3) the illustrated habitat-type production curves may represent only portions of the true production curves.

DESCRIPTION OF STUDY AREA

History

The Squaw Butte Experimental Range was used heavily by livestock from the 1880's until 1949. In 1949, grazing was reduced and controlled grazing was initiated. Range developments and improvements such as water hauling, sagebrush control, seeding and riding have allowed use to be increased to pre-1944 levels. In general, all stands of vegetation studied had been grazed heavily to lightly for different periods since the 1880's (38). In spite of this use history, numerous areas of good condition range were found.

Physiography

All study sites lay within the Squaw Butte Experimental Range which is located approximately 40 miles west of Burns in Harney County, Oregon (Figure 1). Geologists have described the Squaw Butte Range area as being related to both the Columbia Plateau to the north and the Basin and Range Country to the South (2, 22). This area is often referred to as the high desert region of Oregon. It owes its general form and much of its elevation to nearly horizontal beds of lava which are apparently little-eroded (38). It has internal drainage similar to the great basin area to the south. Its intermittent streams are lost in the loose mantel of rock or in small, seasonal

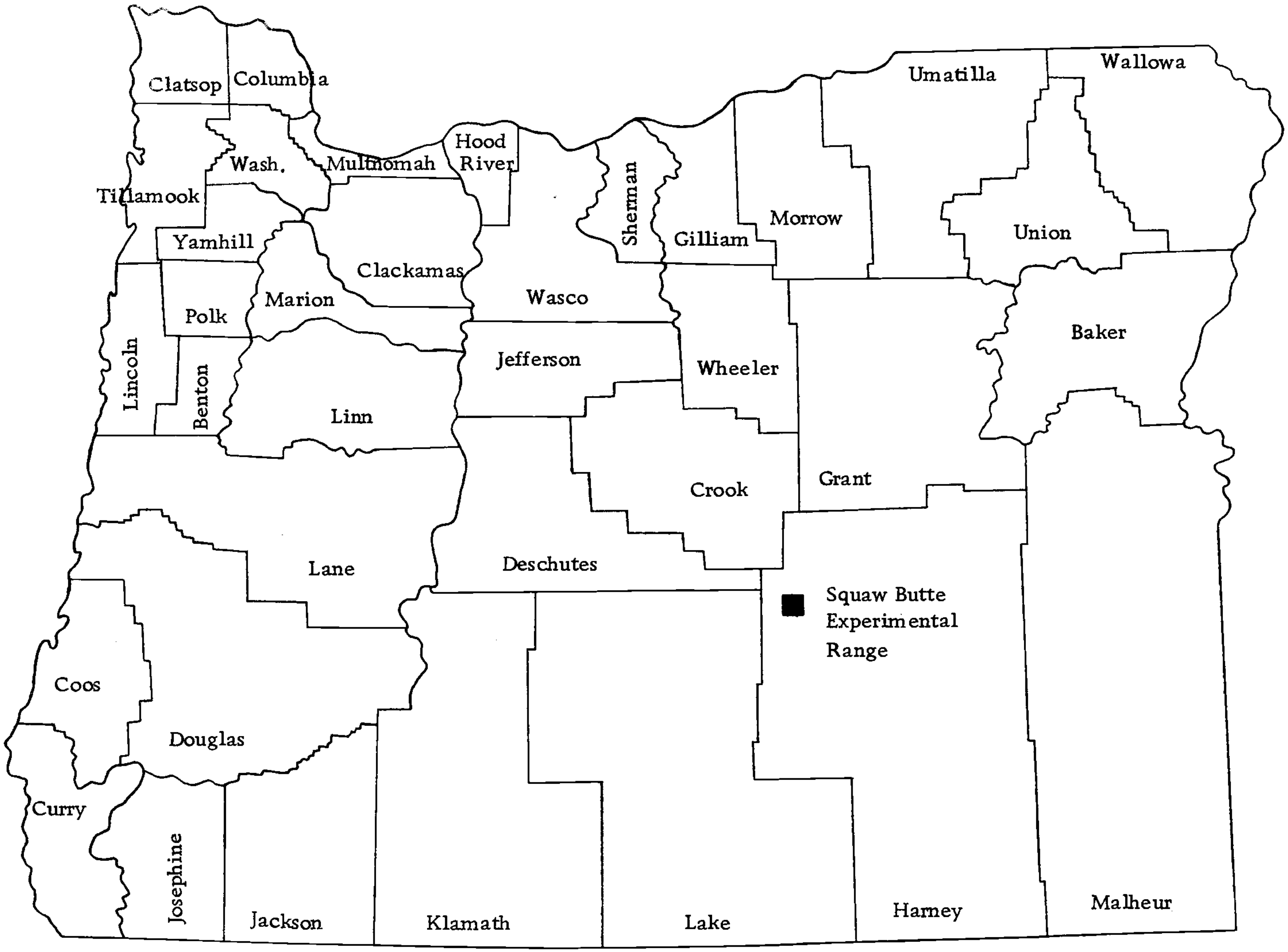

Figure 1. Map of Oregon showing location of Squaw Butte Experimental Range.

lakes. Principal rocks in this area are basalt or rhyolite (38). Elevation varies from 4,000 to 6,000 feet and the relief is generally described as moderate with a slope of less than five percent. Occasionally slopes are as steep as 20 percent and occur as cliffs or colluvial material on the ends or sides of recent lava flows. Aspects are variable and some slopes are steep enough to restrict livestock grazing. There is no real evidence of a north-south orientation of fault block mountains as is characteristic of the basins and ranges to the south. The micro-relief can be characterized as uniform.

Climate

The climate of Eastern Oregon is semi-arid with cold winters and warm, dry summers. Precipitation records from Squaw Butte Experiment Station show two peaks; one occurring during the months of December, January or February, and the second in May or June. The former is due primarily to snow, while the latter is from rain showers. Precipitation records show a low of 5.8 inches in 1949 and a high of 15.9 inches in 1941 with a long time average of 11.7 inches. The crop-year precipitation records for 1967 and 1968 are shown with the 20-year mean in Figure 2.

Average temperatures vary from 25°F in January to 67°F in July. Killing frost may occur at any time of the year. Mean

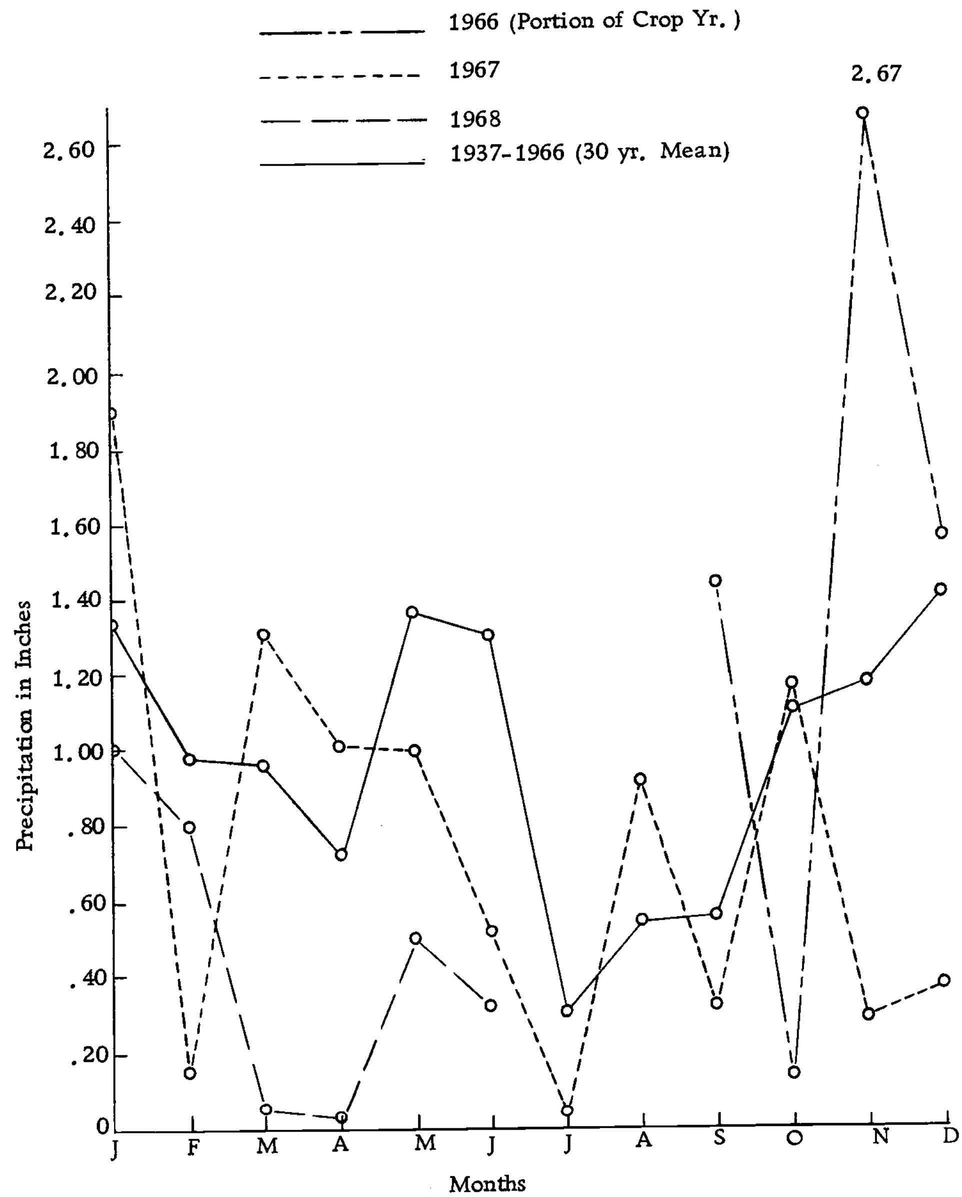

Figure 2. Precipitation chart for 1967 and 1968 crop year compared to the long term mean.

monthly minimum and mean monthly maximum temperatures are shown in Figure 3.

The relationship between mean monthly temperature and mean monthly precipitation at the Squaw Butte range is shown in Figure 4. Such figures are referred to as warming and cooling curves. Daubenmire (13) suggests that median values are more sensitive than mean values when relating climatic data to vegetation. These values become more important at low precipitation levels for the reason that a single heavy shower can have great influence on the mean, while not appreciably affecting the median value or plant production. The climatic situation throughout the study area is marginal for the cultivation of field crops, although with irrigation, cool-season crops could produce substantial yields.

Soils

Very little soil survey work had been done on the Squaw Butte Experimental Range until Eckert (19) described nine tentative soil series. Cheney et al. (9) described the Brown Great Soil Group as characteristic of much of this area. Steep north slopes, as indicated by Eckert (19), are generally described as representative of the Chestnut Great Soil Group.

Soils in this area, formerly classed in the Brown Great Soil Group, are now classed as Aridisols in the 7th Approximation (39).

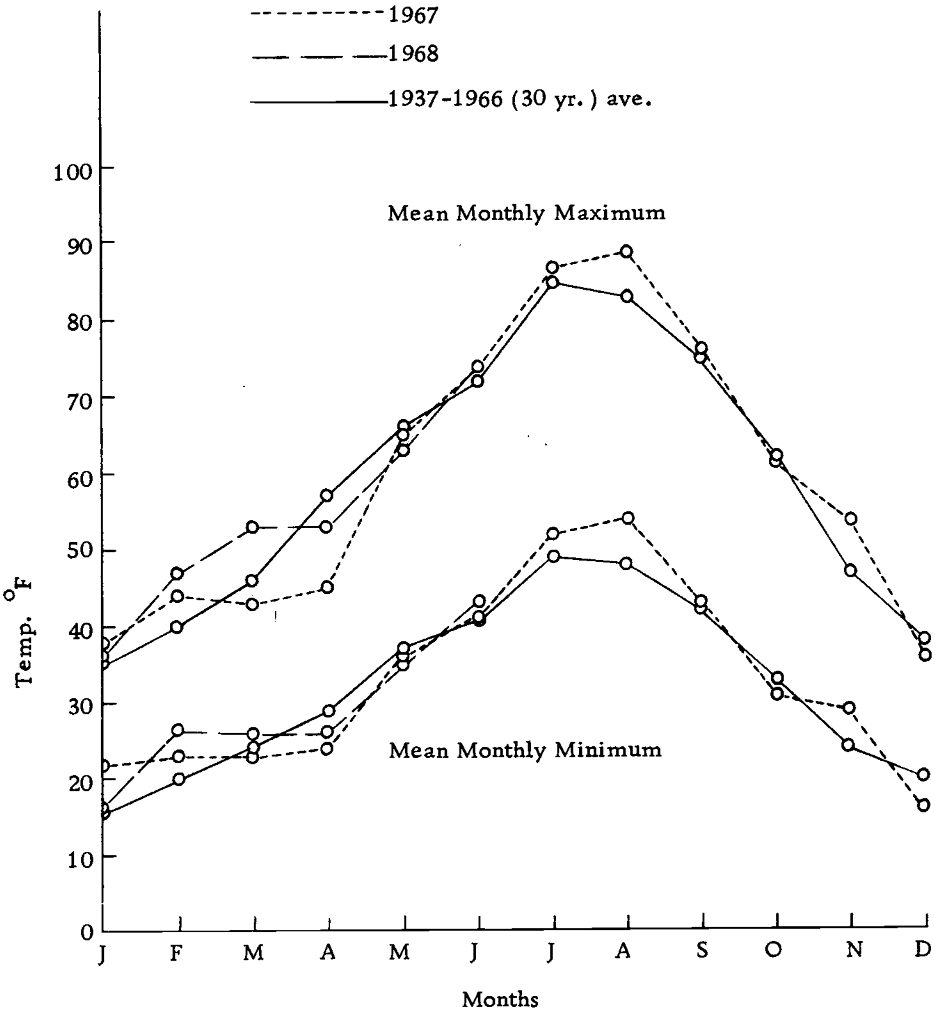

Figure 3. Mean monthly maximum and mean monthly minimum temperatures.

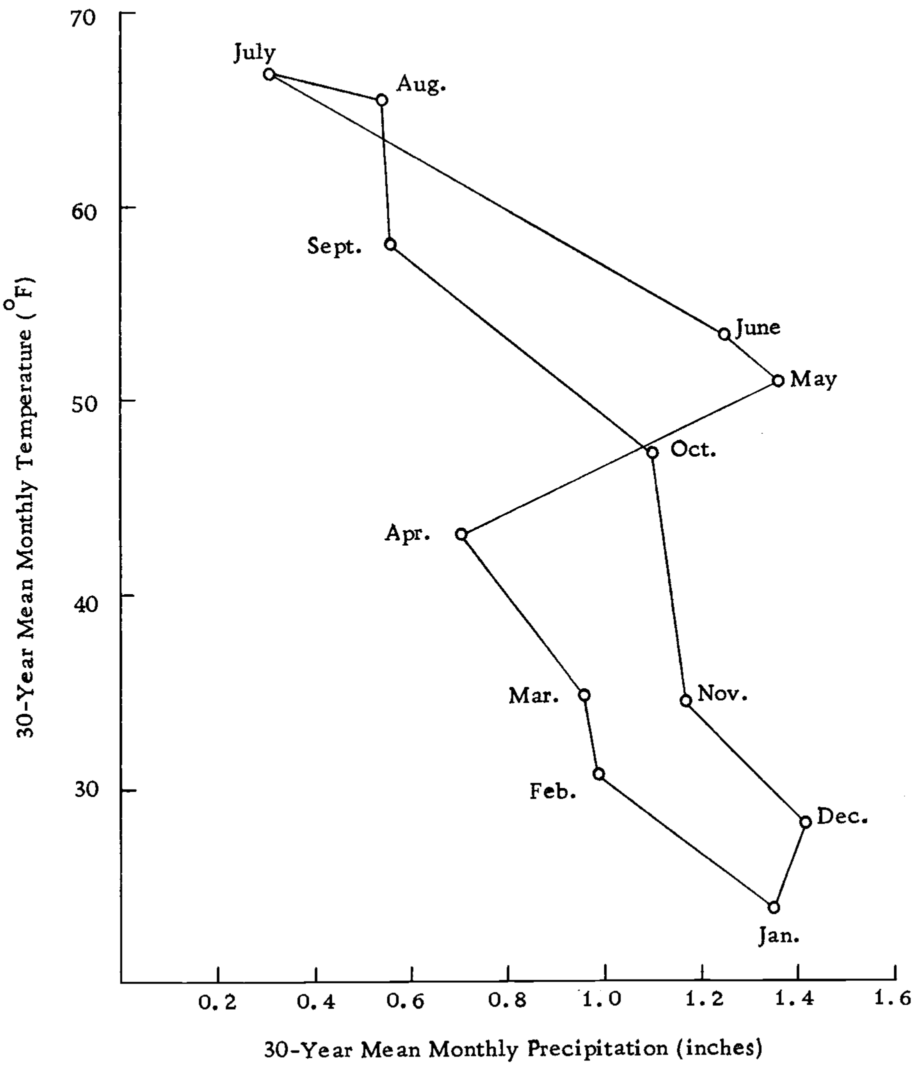

Figure 4. Hythergraph based on weather records from the Squaw Butte Experimental Range for 1937-1966 inclusive.

Under this classification, soils of steep north slopes, formerly called the Chestnut Great Soil Group, are now classed as Mollisols.

No detailed soils information was taken in this study. The lack of soils information presented in this study was in no way intended to imply that soils information was not important.

Vegetation

Semi-arid rangelands characterize much of southeastern and central Oregon. Vegetation is notably shrubs with an understory of bunchgrasses. Dominant shrubs are species of sagebrush, *Artemisia spp.* *Juniperus occidentalis* Hook. forms a sparse overstory in much of central Oregon and on selected areas of southeastern Oregon. Different plant assemblages occupy this land area in a patchy, mosaic pattern. These plant communities have been described and classified under the habitat-type concept of plant ecology.

Eckert (19) described several stands and classified the stands into associations. Culver and Poulton (12) completed an ecological inventory of the Squaw Butte Experimental Range. They described plant assemblages and associated soils which they called taxonomic units, and classified them under the habitat-type concept.

Daubenmire (16) defined habitat-type as: "All the area (sum of discrete units) that now supports, or within recent time has supported, and presumably is still capable of supporting, one plant association will be called a habitat type". Poulton (31) summed up this idea by stating, "a habitat-type denotes an ultimate unit of the sum environment," and that "these basic units constitute the basic subdivisions of the landscape for management purposes."

Culver and Poulton (12) characterized several habitat-types as a result of their inventory of the Squaw Butte Experimental Range. The *Juniperus occidentalis/Artemisia tridentata/Agropyron spicatum/Festuca idahoensis* (Juoc/Artr/Agsp/Feid), *Artemisia tridentata/Agropyron spicatum-Stipa thurberiana* (Artr/Agsp-Stth), and *Juniperous occidentalis/Artemisia arbuscula/Festuca idahoensis/Agropyron spicatum* (Juoc/Arar/Feid/Agsp) habitat-types were chosen for this study (Figures 5, 6, and 7).

Figure 5. Juoc/Artr/Agsp/Feid habitat-type (top, landscape view; bottom, close-up).

Figure 6. Artr/Agsp-Stth habitat-type (top, landscape view; bottom, close-up).

Figure 7. Juoc/Arar/Feid/Agsp habitat-type (top, landscape view; bottom, close-up).

METHODS

Related Ecological Principles

In the summer and fall of 1966, an ecological inventory was made of the entire Squaw Butte Experimental Range (12). The inventory consisted of stratification of the landscape into homogenous vegetation-soil units. The vegetation-soil units were termed taxonomic units (12).

> A taxonomic unit is defined as: ...the basic unit of the landscape for classifying rangelands. It is the fundamental ecological unit of the landscape recognized and defined by its characteristic plant community with related soils and physiographic features. Vegetation-soil unit could be taken as a synonym for taxonomic unit (12).

Pertinent ecological data were taken within the taxonomic units and used to classify these taxonomic units into habitat-types (12).

Selection of Ecological Units

The Juoc/Artr/Agsp/Feid, Artr/Agsp-Stth, and Juoc/Arar/Feid/Agsp habitat-types described by Culver and Poulton (12) were considered representative of large areas of the High Desert Ecological Province and were selected for study. Stands in high, medium, and low seral stages were selected for the production study within each habitat-type. The designations (high, medium, low) were intended to represent different stages in seral succession. Lacking concrete information, the assumption was made that herbage production would follow seral succession with the high stage being the most productive.

Sampling Design

A two-way stratified sampling design was employed. Stratification was, first, into habitat-types, and second, into seral stages. Four stands representing each unit of the two-way stratification were chosen for sampling. This arrangement yields four replications in each of the three seral stages of each of the three habitat-types or 36 field sample locations.

Sample plots within stands were located as close as possible to the site where Culver and Poulton (12) obtained their ecological data. Some departure was required to facilitate pairing of plots or to obtain a better representation of a desired seral stage. However, plot locations were always confined to the same stand described by Culver and Poulton (12).

Plots

Paired plots, 400-square-feet in area, were located in each of the 36 sites. Plots were fenced where necessary to exclude livestock. One of the paired plots, chosen at random, was clipped the first year and the other was clipped the second year to eliminate clipping effects.

Sub-plots

Work at Squaw Butte (35, 36) has shown 48-square-foot plots to be the most efficient size to determine variation in vegetation on the Squaw Butte Experimental Range. Sample degrees of freedom were increased by taking four, 48-square-foot sub-plots in each 400-square-foot area instead of one 192-square-foot sub-plot. Fencing costs were reduced by clustering the four, 48-square-foot sub-plots. A total of 144 sub-plots, or four sub-plots in each of the 36 sites, were clipped each year.

Data Collection

Data were collected by clipping at ground level and removing herbaceous vegetation on each sub-plot. Vernal vegetation was clipped when *Poa secunda* Presl. seed was in the dough stage. Summer vegetation was clipped about the time *Agropyron spicatum* (Pursh) Scribn. and Smith seed was ripe. Grasses were kept separate by species and forbs were put together for each sub-plot. Vegetation samples were oven dried at 160° C until constant weights were reached. Clipped samples were then weighed and recorded in grams per sub-plot.

Data Analysis

Herbage weight data collected in this study were statistically analyzed utilizing the hierarchical classification technique discussed by Li (26). This technique was designed to test for variation between strata (habitat-types) and between factors (seral stages) within strata. This technique used analysis of variance to detect the presence or absence of significant variation with the "F" statistic. It did not detect the source of variation within strata or among factors. To determine where the significance of this variation occurred, the Least Significant Difference (L.S.D.) procedure was used as described by Petersen (30).

Analyses of raw data were compared with analyses of data adjusted to the median crop year using the technique developed by Sneva and Hyder (34). Production curves for different habitat-types were graphically compared and similarities and differences discussed.

Production data from the study plots were ranked in order of decreasing total production in search of possible habitat-type groupings more meaningful than those of Culver and Poulton (12). Production data from the study plots were also ranked, in order of decreasing total production, in search of more meaningful seral arrangements of plots within Culver and Poulton's (12) habitat-type groupings. Naturally occurring separations in total herbage production were used to divide seral stages within the habitat-types.

RESULTS

Habitat-types

Total Production

Each year's data were analyzed separately to eliminate possible variation between years. For each year, no significant difference was found between habitat-types when total herbage production was considered (Tables 1-2).

Since no significant difference in herbage production was found between habitat-types, they were combined and a test was made for variation in total herbage production between years. Analysis of variance showed a significant difference in herbage production between years at the .01 level of significance (Table 3). Average total production in 1967, for the three habitat-types combined, was 338 pounds of herbage per acre compared to 114 pounds per acre for 1968.

Data in this study were adjusted with Sneva and Hyder's (34) technique to eliminate variation in production between years. An analysis of adjusted yield data showed no significant difference in total herbage production between years at the .01 level of significance (Table 4). Adjusted to the median crop year, average total production for the three habitat-types combined, was 316 pounds of herbage per acre in 1967 compared to 325 pounds per acre for 1968.

Table 1. Analysis of unadjusted 1967 total production data[1/]

Seral Stages	Habitat-types Juoc/Artr/ Agsp/Feid	Artr/ Agsp-Stth	Juoc/Arar/ Feid/Agsp
High	3949	3183	2651
Medium	2652	2698	2444
Low	2819	2241	1663
Total	9420	8122	6758

Grand (Σ y) = 24, 300

Preliminary Calculations

(1) Type of Total	(2) Total of Squares	(3) No. of Items Squared	(4) Obs. Per Squared Item	(5) Total of Squares Per Obser. (2) ÷ (4)
Grand (Σ y)	590, 490, 000	1	144	4, 100, 625
Tier A (Habitat Types)	200, 373, 848	3	48	4, 174, 455
B within A (Seral Stages)	68, 773, 746	9	16	4, 298, 359
Observations (y)	4, 808, 028	144	1	4, 808, 028

Analysis of Variance

Source of Variation	Sum of Squares	D.F.	Mean Square	F
Tier A (Habitat Types)	73, 830	2	36, 915	1.7876
B within A (Seral Stages)	123, 904	6	20, 651	5.4704**
Error (Within Seral Stages)	509, 669	135	3, 775	
Total	707, 403	143		

[1/] Data in Appendix C.

Table 2. Analysis of unadjusted 1968 total production data[1/]

	Habitat-types		
Seral Stages	Juoc/Artr/ Agsp/Feid	Artr/ Agsp-Stth	Juoc/Arar/ Feid/Agsp
High	1323	1005	866
Medium	803	910	902
Low	1311	578	486
Total	3437	2493	2254

Grand (Σy) = 8, 184

Preliminary Calculations

(1)	(2)	(3)	(4)	(5)
Type of Total	Total of Squares	No. of Items Squared	Obs. Per Squared Item	Total of Squares Per Obser. (2) ÷ (4)
Grand (Σ y)	66, 977, 856	1	144	465, 124
Tier A (Habitat Types)	23, 108, 534	3	48	481, 428
B within A (Seral Stages)	8, 085, 824	9	16	505, 364
Observations (y)	601, 718	144	1	601, 718

Analysis of Variance

Source of Variation	Sum of Squares	D.F.	Mean Square	F
Tier A (Habitat Types)	16, 304	2	8, 152	2.0436
B within A (Seral Stages)	23, 936	6	3, 989	5.5868**
Error (Within Seral Stages)	96, 354	135	714	
Total	136, 594	143		

[1/] Data in Appendix C.

Table 3. Analysis of unadjusted total production data between years[1/]

Seral Stages	Years 1967	1968
High	9,783	3,194
Medium	7,794	2,615
Low	6,723	2,375
Total	24,300	8,184

Grand (Σy) = 32,484

Preliminary Calculations

(1) Type of Total	(2) Total of Squares	(3) No. of Items Squares	(4) Obs. Per Squared Item	(5) Total of Squares Per Obser. (2) ÷ (4)
Grand (Σy)	1,055,210,256	1	288	3,663,924
Tier A (Years)	657,467,856	2	144	4,565,749
B within A (Seral Stages)	224,332,740	6	48	4,673,599
Observations (y)	5,409,746	288	1	5,409,746

Analysis of Variance

Source of Variation	Sum of Squares	D.F.	Mean Square	F
Tier A (Years)	901,825	1	901,825	33.4480**
B within A (Seral Stages)	107,850	4	26,962	10.3302**
Error (within Seral Stages)	736,147	282	2,610	
Total	1,745,822	287		

[1/]Data in Appendix C.

Table 4. Analysis of adjusted total production data between years[1/]

Seral Stages	Years 1967	1968
High	9140	9128
Medium	7280	7473
Low	6282	6788
Total	22702	23389

Grand (Σy) = 46, 091

Preliminary Calculations

(1) Type of Total	(2) Total of Squares	(3) No. of Items Squared	(4) Obs. Per Squared Items	(5) Total of Squares Per Obser. (2) ÷ (4)
Grand (Σ y)	2, 124, 380, 281	1	288	7, 376, 320
Tier A (Years)	1, 062, 426, 125	2	144	7, 377, 959
B within A (Seral Stages)	361, 244, 581	6	48	7, 525, 929
Observations (y)	9, 112, 597	288	1	9, 112, 597

Analysis of Variance

Source of Variation	Sum of Squares	D. F.	Mean Square	F
Tier A (Years)	1, 639	1	1, 639	.0443
B within A (Seral Stages)	147, 970	4	36, 992	6.5752**
Error (within Seral Stages)	1, 586, 668	282	5, 626	
Total	1, 736, 277	287		

[1/] Data in Appendix C.

Adjusted yield data showed no significant difference in total production between habitat-types (Appendix D).

Production by Species

Separate analyses were made of the three major herbage-producing plants to see how individual production compared with the total. The plant species were Festuca idahoensis Elmer., Agropyron spicatum, and Stipa thurberiana Piper. Vernal vegetation (Poa secunda, Bromus tectorum L., and annual forbs) provided information on spring herbage separate from summer herbage and in comparison with the total. Adjusted data eliminated variation in production between years for Agropyron spicatum, Festuca idahoensis, and Stipa thurberiana, but did not completely remove the significant difference in production of vernal vegetation between years. Vernal vegetation production adjusted to the median crop year remained significantly different between years at the .01 level in the Artr/Agsp-Stth and Juoc/Arar/Feid/Agsp habitat-types. The technique did, however, greatly reduce variation in yield of vernal vegetation in these two habitat-types (Appendices T and U). Blaisdell (6) found that early plant growth and development were closely related to temperature. This relationship could also be expected at Squaw Butte.

Analysis of variance suggested no significant difference between habitat-types in the production of *Agropyron spicatum*. *Festuca idahoensis*, and vernal vegetation at the .01 level of significance (Appendices G, J, and Q). Analysis of variance showed a significant difference between habitat-types in the production of *Stipa thurberiana* at the .05 level (Appendix M). The L.S.D. test failed to isolate between which habitat-types the difference in production of *Stipa thurberiana* existed (Appendix O).

Classification by Production

When plots were ranked in order of decreasing total production they occurred in segments of the original classification. Production data of plots from one habitat-type would occur in a group followed by production data of plots from another habitat-type. High seral stage plots from one habitat-type ranked next to medium seral stage plots of another habitat-type (Table 5).

Seral Stages

Total Production

The variation in total production between seral stages within habitat-types was analyzed with adjusted data (Figure 8).

Total herbage production in the Juoc/Artr/Agsp/Feid habitat-type was 1) highest on plots in the high seral stage with 467 pounds of

Table 5. Ranked samples to determine seral productivity within habitat-types.

Habitat-types	Juoc/Artr/Agsp/Feid											
Seral stages	High			Medium		Low						
Plot numbers	C106	C243	S62	C103	S30	S163	2M	S169	S144	C114	S175	S71
Total production	2408	2129	2090	1706	1704	1402	1327	1248	1187	1182	1172	1170
Feid production	758	77	163	119	0	151	435	537	178	209	298	117
Agsp production	1188	1522	731	868	644	288	405	471	662	533	560	597
Stth production	135	173	438	408	398	403	190	75	40	3	24	105
Vernal vegetation production	118	186	372	58	652	466	96	113	230	221	220	217

	Artr/Agsp-Stth											
	High			Medium				Low		Excluded		
Plot numbers	C85	C68	4M	C34	5M	C56	C55	C245	C46	C213	C215	C181
Total production	1701	1633	1517	1107	1063	962	932	716	466	1992	1350	1275
Feid production	0	34	0	0	23	35	0	0	0	952	120	191
Agsp production	657	10	1039	149	23	274	69	0	0	493	802	763
Stth production	654	330	226	693	616	479	154	339	135	398	75	71
Vernal vegetation production	182	252	135	228	87	131	183	220	181	52	177	65

	Juoc/Arar/Feid/Agsp											
	High					Medium		Low			Excluded	
Plot numbers	S107	C110	S172	S38G	S177	1M	S77	S38M	C108	C107	S65	S29
Total production	1474	1466	1401	1373	1261	1056	1056	725	723	685	689	843
Feid production	1030	664	792	698	468	652	673	395	293	214	53	0
Agsp production	254	600	178	507	353	239	198	130	72	31	306	295
Stth production	58	0	37	24	83	23	0	28	8	41	55	93
Vernal vegetation production	170	186	213	81	260	71	98	146	272	239	168	249

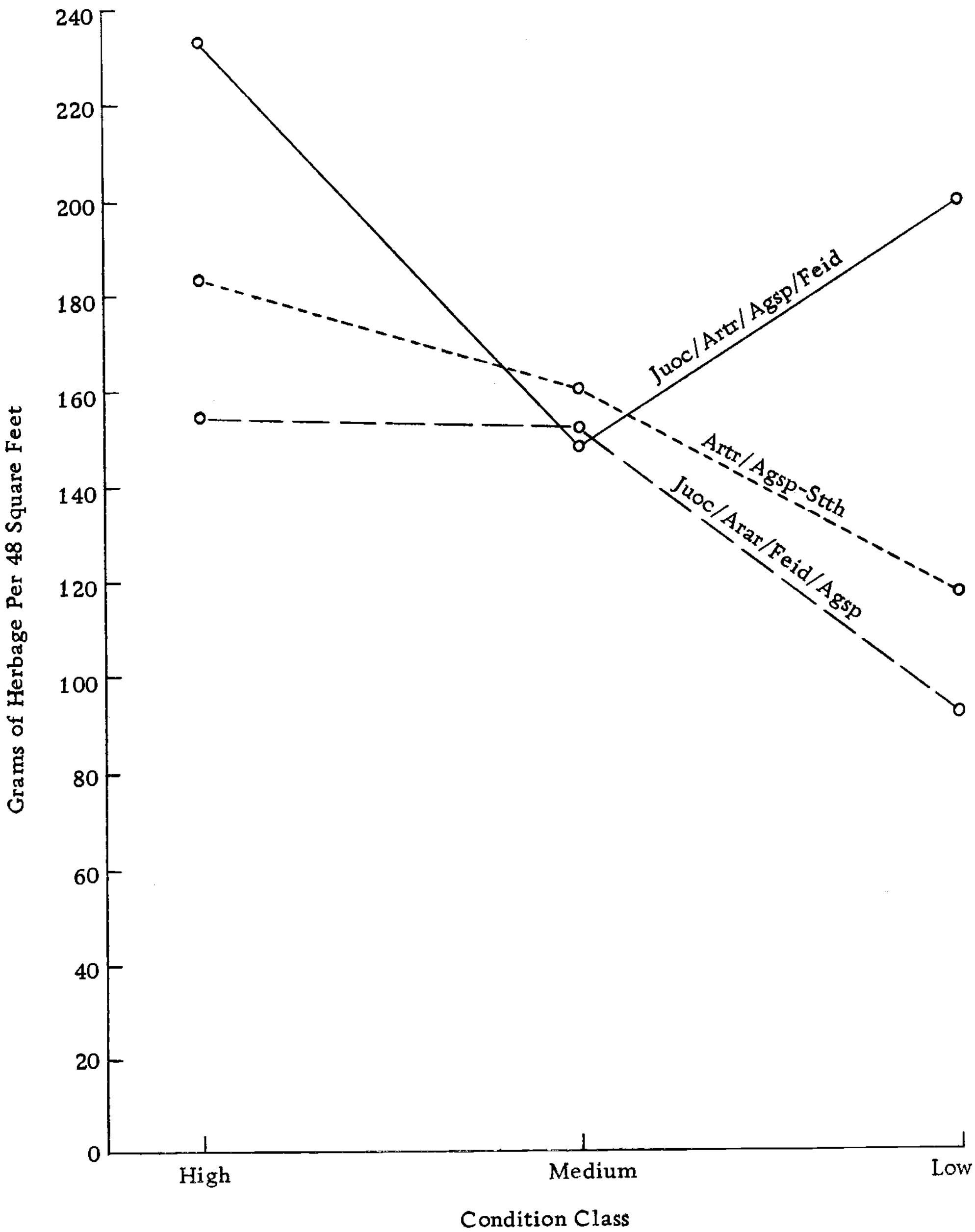

Figure 8. Total herbage production curves of three habitat-types. (Developed from 1967-1968 combined adjusted data)

herbage per acre, 2) next highest on plots in the low seral stage with 400 pounds of herbage per acre, and 3) lowest on plots in the medium seral stage with 298 pounds of herbage per acre. Production on plots in the high seral stage was significantly higher, at the .05 level, than production on plots in the low seral stage and production on plots in the low seral stage was significantly higher, at the .01 level, than production on plots in the medium seral stage (Appendix E).

Total herbage production on plots in the Artr/Agsp-Stth habitat-type steadily decreased from high to low seral stage. Total production was highest on plots in the high seral stage with 366 pounds of herbage per acre. Total herbage production on high seral stage plots was not significantly different from the 320 pounds of herbage per acre produced on plots in the medium seral stage. Total herbage production on plots in the high and medium seral stages were significantly greater, at the .05 level, than the 234 pounds of herbage per acre produced on plots in the low seral stage (Appendix E).

In the Juoc/Arar/Feid/Agsp habitat-type, there was no significant difference in total herbage production on plots in the high and medium seral stages. The production was 310 and 304 pounds of herbage per acre respectively. The 184 pounds of herbage per acre produced on plots in the low seral stage was significantly less at the .01 level (Appendix E).

Production by Species

Agropyron spicatum. Production of this plant decreased rather sharply from high to medium seral stage and increased slightly from medium to low seral stage in the Juoc/Artr/Agsp/Feid habitat-type. In the other two habitat-types, it decreased in production from high to low seral stages. Analysis of variance suggested a difference in herbage production between seral stages at the .01 level of significance. The L.S.D. test showed: 1) in the Juoc/Artr/Agsp/Feid habitat-type, an .01 level of significance in herbage production between high and low seral stage and no difference between low and medium seral stage, 2) in the Artr/Agsp-Stth habitat-type, an .01 level of significance in herbage production existed between medium and low seral stages, and 3) in the Juoc/Arar/Feid/Agsp habitat-type, no difference in herbage production existed between any of the three seral stages (Appendices F, G and H; Figures 9, 10, and 11).

When production of Agropyron spicatum was analyzed as a percent of the total production, it steadily decreased in production from high to low seral stages in the Juoc/Artr/Agsp/Feid and Artr/Agsp-Stth habitat-types. In the Juoc/Artr/Agsp/Feid habitat-type, Agropyron spicatum maintained a position of dominance in production

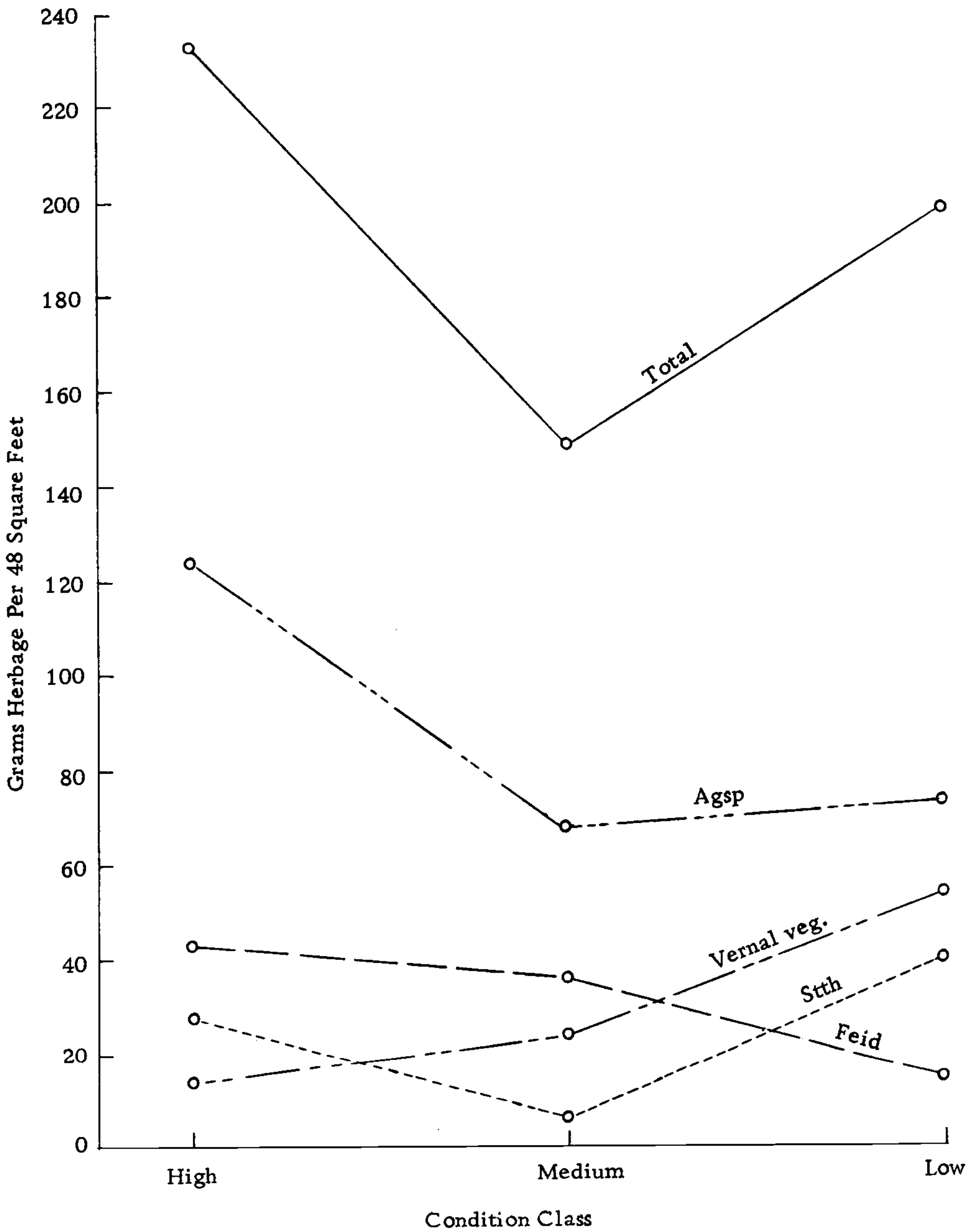

Figure 9. Production of Juoc/Artr/Agsp/Feid habitat-type. (Developed from 1967-1968 combined adjusted data)

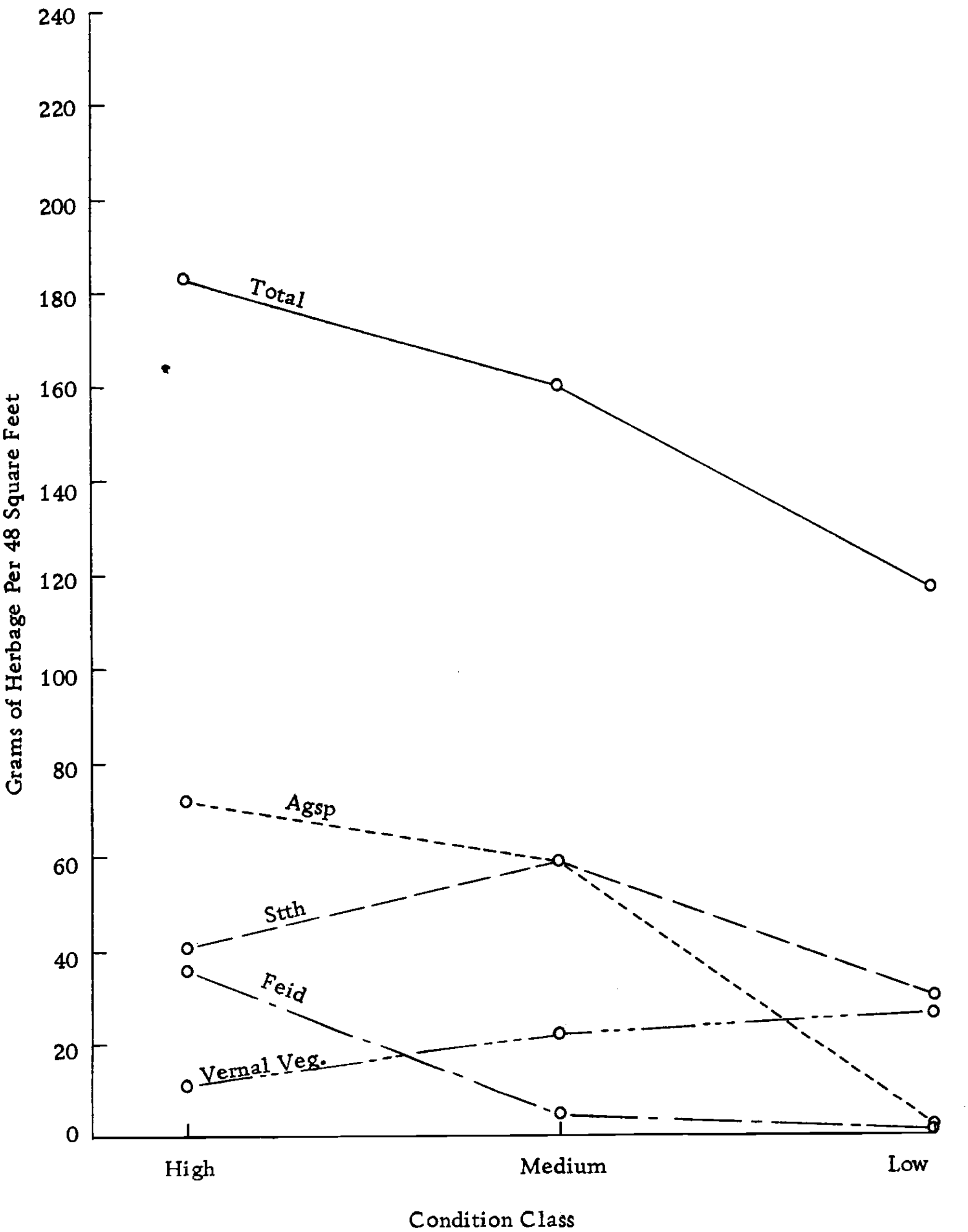

Figure 10. Production of Artr/Agsp-Stth habitat-type.
(Developed from 1967-1968 combined adjusted data)

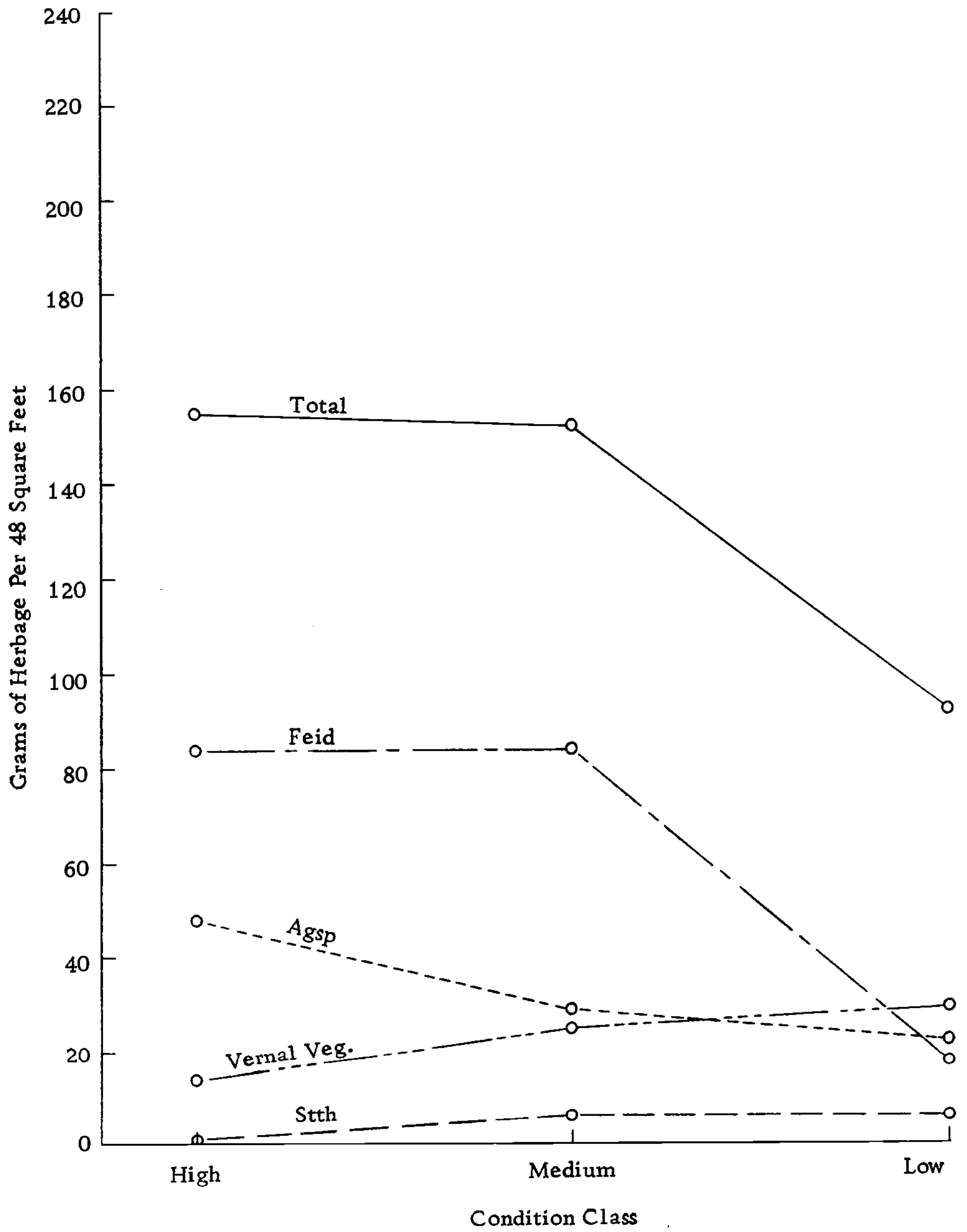

Figure 11. Production of Juoc/Arar/Feid/Agsp habitat-type. (Developed from 1967-1968 combined adjusted data)

throughout the seral stages. In the Artr/Agsp-Stth habitat-type, it was the dominant producer in the high seral stage. In the medium seral stage, Agropyron spicatum was codominant with Stipa thurberiana. In the low seral stage, Agropyron spicatum relinquished dominance in production to Stipa thurberiana. In the Juoc/Arar/Feid/Agsp habitat-type, production of Agropyron spicatum decreased from high to medium seral stage and increased from medium to low seral stage (Table 6).

Festuca idahoensis. Production of this species consistently decreased in amount from high to low seral stage in all three habitat-types. Analysis of variance showed a significant difference in production between seral stages at the .01 level of significance. The L.S.D. test suggested a difference in production of Festuca idahoensis, at the .05 level, between medium and low seral stages of the Juoc/Artr/Agsp/Feid habitat-type. A difference in production of Festuca idahoensis, at the .01 level, was shown between medium and low seral stages of the Juoc/Arar/Feid/Agsp habitat-type. No difference in herbage production was inferred between high and medium seral stages of these two types. A significant difference in production of Festuca idahoensis existed, at the .01 level, between high and medium seral stages of the Artr/Agsp-Stth habitat-type.

Table 6. Select individuals expressed as percentages of total production.

Seral* Stage	Juoc/Artr/Agsp/Feid				Artr/Agsp-Stth				Juoc/Arar/Feid/Agsp			
	Feid	Agsp	Stth	Vernal Veg.	Feid	Agsp	Stth	Vernal Veg.	Feid	Agsp	Stth	Vernal Veg.
High	18	53	12	6	20	40	22	6	54	31	1	9
Medium	24	45	4	16	3	36	37	14	55	19	4	16
Low	8	37	20	27	1	2	26	23	19	23	7	32

*Possible unequal departure from climax of the seral stages prevents meaningful quantitative comparisons of seral stages between habitat types.

No difference in production of Festuca idahoensis was inferred between medium and low seral stages of the Artr/Agsp-Stth habitat-type (Appendices I, J and K; Figures 9, 10, and 11).

When analyzed as a percent of total production (Table 6), Festuca idahoensis increased from high to medium seral stage and decreased from medium to low seral stage in the Juoc/Artr/Agsp/Feid and Juoc/Arar/Feid/Agsp habitat-types. Festuca idahoensis decreased abruptly in the Artr/Agsp-Stth habitat-type. Most of the Festuca idahoensis production in the Artr/Agsp-Stth habitat-type occurred in two of the four high seral stage plots.

Stipa thurberiana. Analysis of variance suggested a significant difference in production of Stipa thurberiana between seral stages at the .01 level. To determine where this difference existed, L.S.D. tests were made between seral stages within habitat-types. In the Juoc/Artr/Agsp/Feid habitat-type, there was no significant difference in production of Stipa thurberiana between the high and low seral stages but the medium seral stage was significantly different, at the .01 level, from the high seral stage in production of this species. The low seral stage produced the most herbage and the medium seral stage produced the least. In the Artr/Agsp-Stth habitat-type, the L.S.D. test showed a .05 significant difference in production of _Stipa thurberiana_ between medium and high seral stages and no difference between high and low seral stages. _Stipa thurberiana_ was most productive in the medium seral stage and least productive in the low seral stage. In the Juoc/Arar/Feid/Agsp habitat-type, no significant difference in production of _Stipa thurberiana_ was suggested between seral stages with the L.S.D. test (Appendices L, M and N; Figures 9, 10 and 11).

When production of _Stipa thurberiana_ in the Juoc/Artr/Agsp/Feid habitat-type was analyzed as a percent of total production (Table 6), production decreased between the high and medium seral stage and increased between the medium and low seral stage. _Stipa thurberiana_ production in the Artr/Agsp-Stth habitat-type increased between the high and medium seral stage and decreased between the medium and low seral stage. However, _Stipa thurberiana_ production steadily increased from high to low seral stage in the Juoc/Arar/Feid/Agsp habitat-type.

Vernal Vegetation. Spring vegetation steadily increased in production from high to low seral stage in all three habitat types. Analysis of variance showed a significant difference in vernal vegetation production between seral stages at the .01 level of significance. The L.S.D. test showed production of vernal vegetation in the

Juoc/Artr/Agsp/Feid habitat-type was significantly different between low and medium seral stages, at the .01 level, and between medium and high seral stages, at the .05 level. A significant difference, at the .05 level, was shown in vernal vegetation production between the medium and high seral stages of the Artr/Agsp-Stth and Juoc/Arar/Feid/Agsp habitat-types. No difference in herbage production was shown between the low and medium seral stages of these last two habitat-types (Appendices P, Q and R; Figures 9, 10 and 11).

When analyzed as a percent of total production (Table 6), production of vernal vegetation increased from high to low seral stage in all three habitat-types.

Classification by Production

Some seral stages were represented by as many as seven plots and other seral stages were represented by as few as two plots.

Three plots were excluded from the Artr/Agsp-Stth habitat-type. Excluded plots had high production of *Festuca idahoensis*. Remaining plots in this habitat-type were nearly void of *Festuca idahoensis*.

Two plots were excluded from the Juoc/Arar/Feid/Agsp habitat-type. *Agropyron spicatum* was the dominant producing plant species in the excluded plots. *Festuca idahoensis* was the highest producing species in the other plots of this habitat-type.

DISCUSSION AND CONCLUSIONS

This study gave support to Sneva and Hyder's (34) technique for adjusting actual to normal range herbage production of summer vegetation. This meant the summer, green-feed production period was closely tied to crop-year moisture. The study did not support the use of this technique for estimating production of spring vegetation (Appendices T and U).

This study also illustrated that the majority of the herbage production within a habitat-type was produced by one or two dominant grass species. These grass species usually retained production dominance regardless of seral condition and usually varied between habitat-types.

Grazing considerations, for a particular habitat-type, should be geared to the requirements of the grass species that produces the majority of the herbage in the habitat-type. In the Artr/Agsp-Stth habitat-type, grazing management may favor either *Agropyron spicatum* or *Stipa thurberiana*, depending on which provides the best supply of forage for a critical period of time. The strong affinity of *Festuca idahoensis* for the Juoc/Arar/Feid/Agsp habitat-type necessitates basing management of this habitat-type on *Festuca idahoensis*. The same is true for *Agropyron spicatum* on the Juoc/Artr/Agsp/Feid habitat-type. With this kind of information, the land manager will be equipped to combine compatable habitat-types into pastures and establish a sequence of grazing that is advantageous to both plants and animals. Knowledge of herbage production on a habitat-type basis, provides information for intelligent decisions on acquisition or improvement of land areas supporting plant communities that will strengthen the year-long forage supply. A particular habitat-type may be more valuable to one manager than another because of different operations and different forage requirements.

Nutritional value of range herbage is an important consideration and should be studied. Nutritional information is needed on a seasonal and habitat-type basis. The information could be plotted against seasonal grazing damage of the major forage-producing plant and optimum periods for grazing could be determined. This kind of information could be readily manipulated by computers to aid the manager.

Habitat-types

Total Production

Statistical analysis indicated no significant difference in total herbage production between habitat-types. Such an indication was conceivable but appeared contradictory to a cursory examination of the data. The consoling rational was that variation in production within habitat-types was sufficient to mask possible variation in production between habitat-types. Average forage production from the Juoc/Artr/Agsp/Feid, Artr/Agsp-Stth, and Juoc/Arar/Feid/Agsp habitat-type was 388, 306,and 266 pounds per acre, respectively.

Ecologically, two questions were paramount: How much of the variation in production encountered in this study could possibly be created by human error; and was there sufficient evidence from data analysis to separate the habitat-types? The most likely source of human error was the possible inclusion of samples from stands not accurately representative of the desired habitat-type (Table 5). Statistical analysis of production data indicated differences were not great enough to separate the habitat-types. The ranked-plot classification of sampled stands suggested the possibility that differences actually existed (Figure 12). However, data as arranged in the ranked-plot classification were not statistically analyzed. An examination of the production of individual plant species in each habitat-type left little doubt that habitat-types should be separated (Figures 9, 10, 11 and 13, 14, 15). Eckert (19) discussed an Artemisia tridentata/Agropyron spicatum association in this area. He indicated that the association may occur with or without an overstory of Juniperous occidentalis. He considered Festuca idahoensis and Stipa thurberiana relatively unimportant components of the typical association. He recognized a Stipa phase of the Artemisia tridentata/

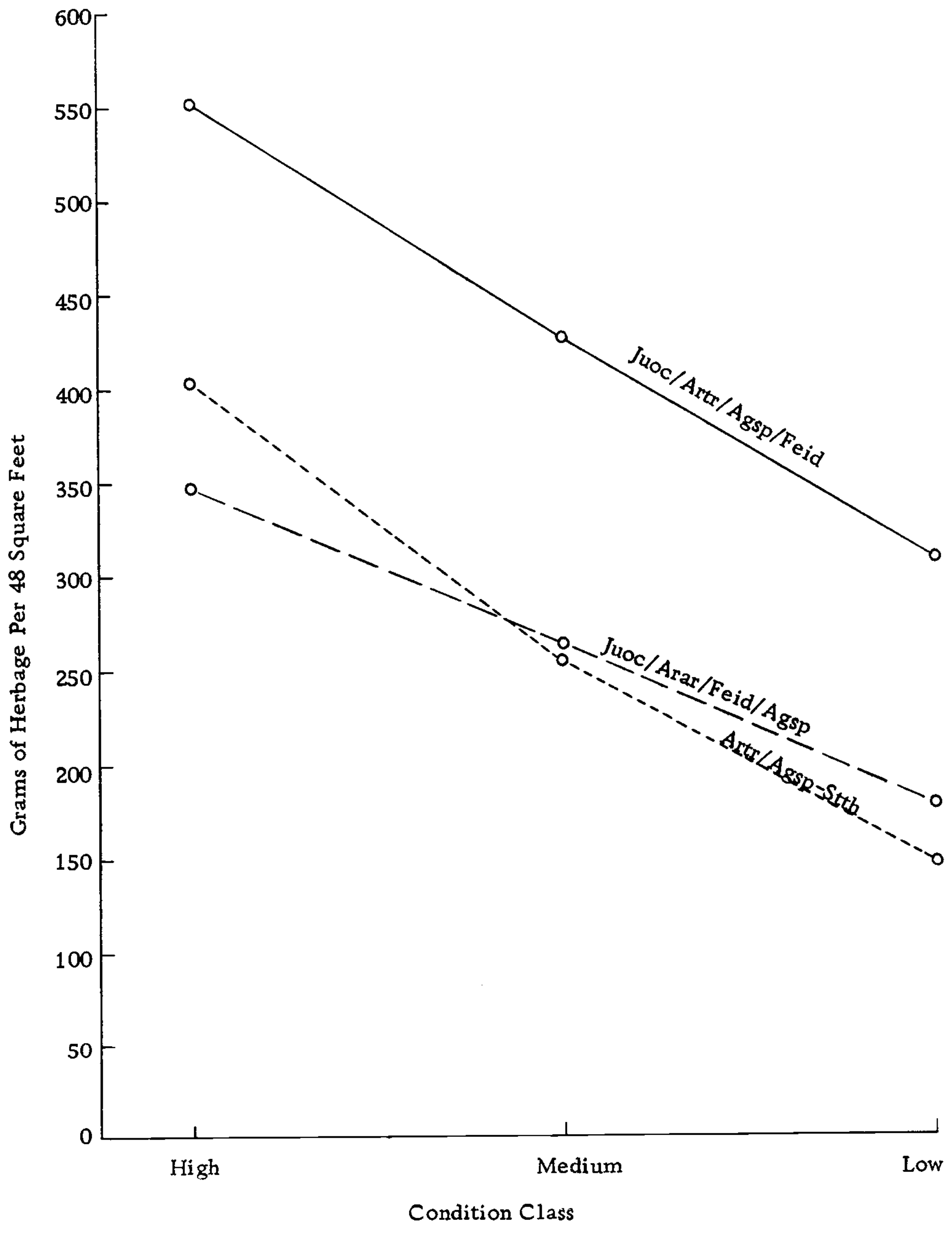

Figure 12. Total herbage production curves with ranked plots. (Plots ranked by decreasing total production with 1967-1968 combined adjusted data)

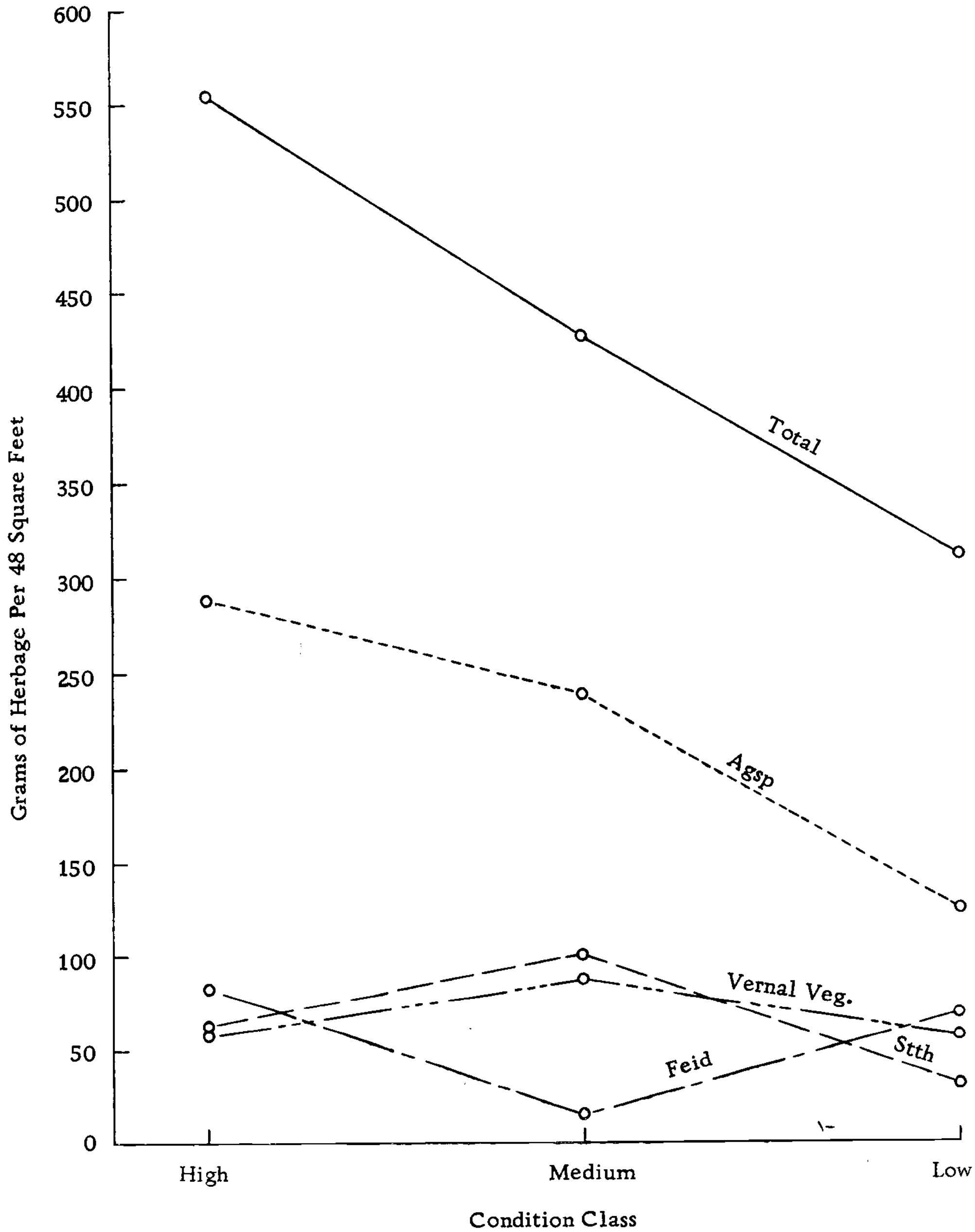

Figure 13. Production of Juoc/Artr/Agsp/Feid habitat-type with ranked plots. (Plots ranked by decreasing total production with 1967-1968 combined adjusted data)

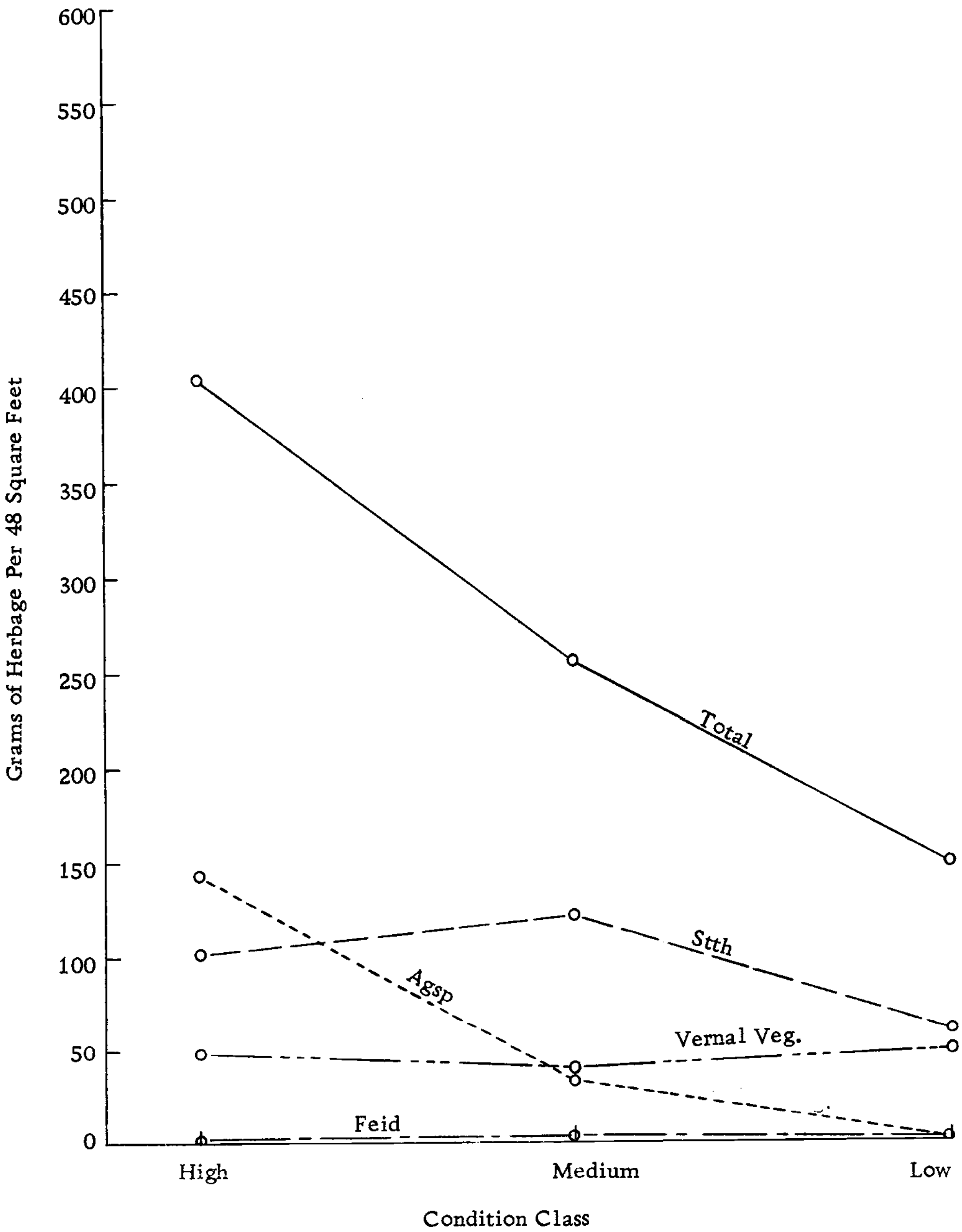

Figure 14. Production of Artr/Agsp-Stth habitat-type with ranked plots. (Plots ranked by decreasing total production with 1967-1968 combined adjusted data)

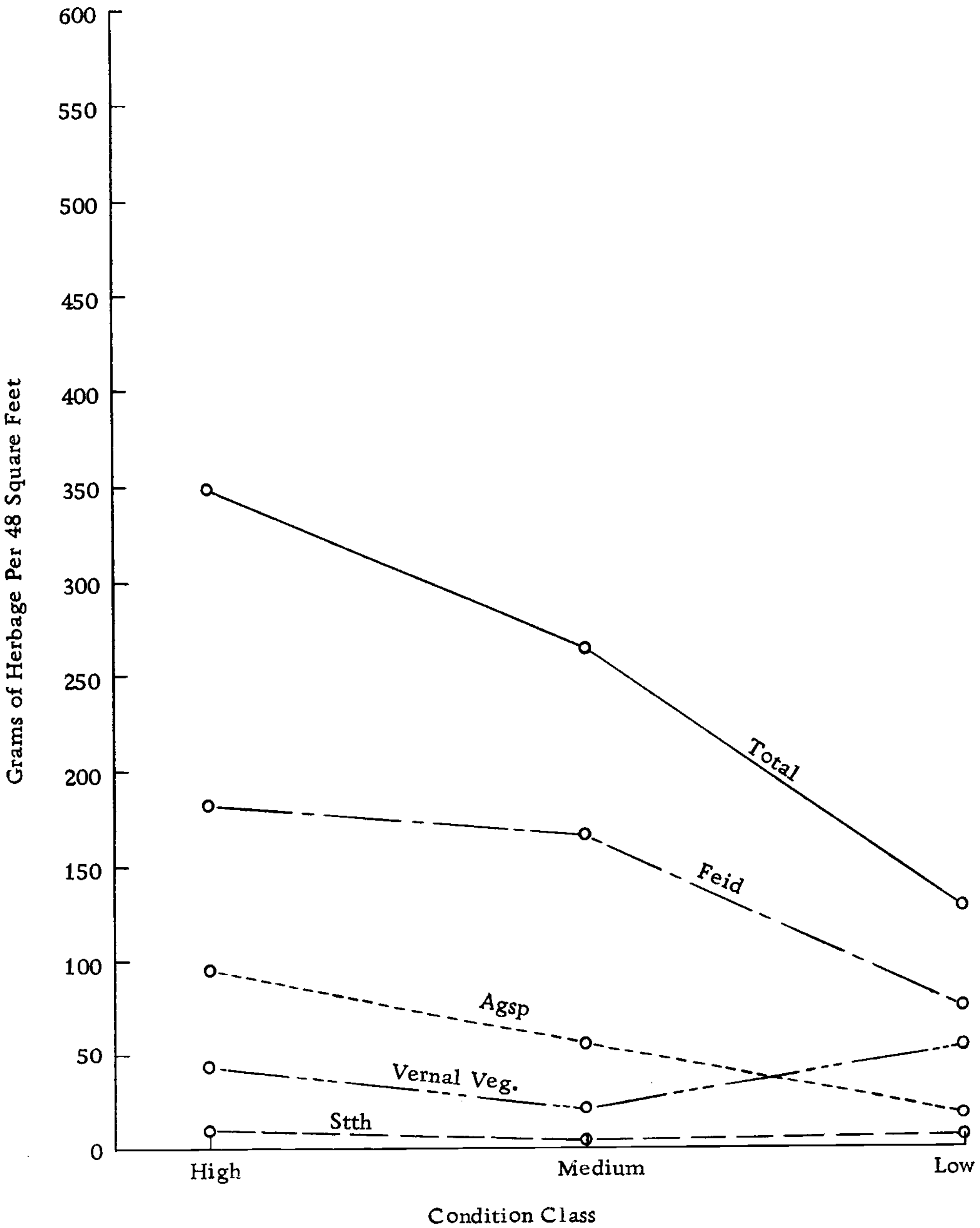

Figure 15. Production of Juoc/Arar/Feid/Agsp habitat-type with ranked plots. (Plots ranked by decreasing total production with 1967-1968 combined adjusted data)

Agropyron spicatum association but suggested that further study may indicate a need for subdivision. The Juoc/Artr/Agsp/Feid habitat-type described by Culver and Poulton (12) and sampled in this study was considered a part of Eckert's Artemisia tridentata/Agropyron spicatum association. The Artr/Agsp-Stth habitat-type also described by Culver and Poulton (12) and sampled in this study was considered representative of Eckert's Stipa phase.

Eckert (19) also discussed an Artemisia arbuscula/Festuca idahoensis association. He indicated the association also occurred with or without a Juniperous occidentalis overstory. The Juoc/Arar/Feid/Agsp habitat-type described by Culver and Poulton (12) and sampled in this study was considered a part of Eckert's Artemisia arbuscula/Festuca idahoensis association.

The previous controversy over separation of the habitat-types, raises a question of the value of the three habitat-types for animal grazing--in terms of both total quantity and seasonal quality. Both value considerations are of economic importance to the manager. Consideration of Figure 12 leads the writer to believe that more money could be paid for the Juoc/Artr/Agsp/Feid habitat-type, than for the other two habitat-types, as long as Agropyron spicatum can be grazed during the season that forage is needed. Total forage production of the other two habitat-types is very similar. The value, to a grazing program, of these two habitat-types depends on whether Festuca idahoensis or Stipa thurberiana can best provide needed forage. The foregoing discussion indicates sufficient evidence is available to justify separation of the habitat-types. The justification is based on ecological considerations of economic and management importance.

Production by Species

Launchbaugh (25), in his work on a clay, upland range site in Kansas, found that important basal cover and botanical composition shifts in response to grazing intensity, occurred during the first ten years of his 20-year grazing study. Basal cover and botanical composition changes were caused by different grazing intensities applied repeatedly during summer grazing seasons. Additional variables have compounded vegetation reactions on the Squaw Butte area. Changes in grazing season, grazing intensity, and different age classes of livestock have all contributed to variation in plant species production within sampled habitat-types in different pastures. Launchbaugh (25) indicated that approximately ten years were needed for vegetation to adjust to such changes. If Launchbaugh's findings are valid for the Squaw Butte area, few of the habitat-types sampled in this study are in a botanically stable state. Samples from the same habitat-type in different pastures tended to support this opinion. Grazing effects in pastures within habitat-types were only moderately pronounced,which may be due to recent changes in grazing or a number of possible unknown factors.

The foregoing discussion presented reasons why changes in species production, as a result of grazing disturbance, should be expected within habitat-types. Changes in species production did occur within habitat-types in this study. The ability of one or two grass species to maintain production dominance regardless of seral condition indicated the validity of the habitat-types. Variation encountered in species production within habitat-types was possibly a product of different grazing treatments between pastures.

An extended grazing study of habitat-types within pastures, designed to study botanical variation due to grazing treatments and seasonal nutritional value to animals of forage from the habitat-types, would provide additional valuable information.

Classification by Production

The process of ranking the study plots by total production supported Culver and Poulton's (12) habitat-type classification. It would have been extremely difficult to determine sociability of sampled stands of vegetation with just the production data available in this study. Culver and Poulton's (12) technique consisted of listing all species in the stand and rating their relative importance. Data were arrayed in a society table to determine sociability of the stands. Classification of stands into habitat-types by their technique was well supported by the results of this study.

Seral Stages

Total Production

Total herbage production generally declined with lowered seral condition except in the Juoc/Artr/Agsp/Feid habitat-type. In this habitat-type, total production declined sharply from high to medium and then increased from medium to low seral stage. The unusual production pattern of the Juoc/Artr/Agsp/Feid habitat-type was a result of Culver and Poulton's (12) arrangement of the sere according to subjective criteria. Their plant species dominance ratings within stands were not valid for comparison of species abundance between stands.

Production by Species

Table 6 shows the percent that each of the major herbage producing species contributes to total production. A review of these data shows how herbage production of different species changed with seral condition. It is also interesting to note that for seral stages in each habitat-type the majority of the herbage is produced by a single plant species. Total production pattern of a habitat-type usually closely follows that of the most important plant species (Figures 9, 10, 11). The main difference between the two production patterns is that in the lower seral stages total production declines less rapidly than production of the individual species. The less rapid decline of total production is due to a slight increase in production of less dominant plants.

Management, for greatest herbage production from a particular habitat-type, should be based on the needs of the dominant plant species once it has been identified. Identification of the dominant plant species need not be on the basis of production. The dominant plant species of the two habitat-types studied by Tueller (38) can be determined from basal area and frequency data. Use of basal area and frequency data would have to be supplemented with considerations of the physiognomy of the plant species. Judgements based upon physiognomy are subjective. Thus, major herbage producing species are more accurately determined by use of production data.

Herbage production on ecologically similar vegetation units would be more meaningful if supported by animal grazing information. Seasonal plant preference of animals would indicate what species of plants carry the bulk of the grazing pressure. Animal grazing information might help explain some of the variation in species production within habitat-types. If total herbage production is actually related to production of a single species in each habitat-type, grazing information may help isolate some variation in total production.

Classification by Production

Seral arrangement of plots on the basis of total production enabled individual species interactions to express themselves. Such was the case with the Artr/Agsp-Stth habitat-type when *Agropyron spicatum* yielded production dominance to *Stipa thurberiana* as total production declined. Arrangement of seres on the basis of herbage production supported the common opinion that high seral condition was most productive. The argument may be circular because data were ordinated on the basis of production. However, arrangement of seres on the basis of production were more rational than arrangements based on Culver and Poulton's (12) estimated cover values of plant species as explained in the discussion of total production of seral stages (Figures 9, 10, 11 and 13, 14, 15).

In the process of determining seral stages based on production data, three samples were deleted from the Artr/Agsp-Stth habitat-type. The plots were deleted because an abundance of *Festuca idahoensis* was clipped from these plots while other plots of this habitat-type were nearly void of this plant species. Samples from the deleted plots more closely resembled samples of the Juoc/Artr/Agsp/Feid habitat-type. The plots were not included in the analysis of the Juoc/Artr/Agsp/Feid habitat-type because production data failed to provide sufficient information for the determination of habitat-types. The two plots deleted from analysis of the Juoc/Arar/Feid/Agsp habitat-type appeared to be more representative of an *Artemisia arbuscula*/*Agropyron spicatum* association described by Eckert (19).

SUMMARY

Objectives were to determine differences in herbage production of three seral stages of three habitat-types.

This study was conducted on the Squaw Butte Experimental Range. This area was characterized by nearly horizontal beds of little-eroded lava. Drainage was internal as moisture eventually entered the soil or ran off into small lakes. Climate was semi-arid with cold winters and warm, dry summers. The vegetation was predominantly Artemisia spp. with an understory of bunchgrasses. A sparse overstory of Juniperous occidentallis occurred intermittently. Squaw Butte weather records showed a 30-year mean annual precipitation of 11.8 inches. July, the hottest month of the year, had a mean annual temperature of 67°F and January, the coldest month, had a mean annual temperature of 25°F.

Field data were taken during the summer of 1967 and 1968. Sample locations were selected utilizing Plant Society Tables of the Juoc/Artr/Agsp/Feid, Artr/Agsp-Stth and Juoc/Arar/Feid/Agsp habitat-types of Culver and Poulton (12). Paired, 400-square-foot exclosures were constructed at each location. Herbage production was clipped from four, 48-square-foot samples in one exclosure the first year and four in the other exclosure the second year. Spring herbage was clipped, dried, and weighed when Poa secunda seed was

in the dough stage and summer herbage when Agropyron spicatum seed was ripe.

Herbage weights collected in this study were statistically analyzed with the Hierarchical Classification and Least Significant Difference techniques. Extreme variation in actual herbage production existed between years. Variation in herbage production was adjusted to the median year using a technique developed by Sneva and Hyder (34). Statistical analysis showed no significant difference in total herbage production between the three habitat-types. Statistical analysis did show a significant difference in total herbage production between seral stages within habitat-types.

Major forage producing plants and vernal vegetation were analyzed separately. No significant difference in production existed between habitat types for Agropyron spicatum, Festuca idahoensis and vernal vegetation. Analysis of variance suggested a significant difference in production of Stipa thurberiana between habitat-types. Statistical analysis of important forage plants and vernal vegetation suggested a difference in production between seral stages of each habitat type. Figures 9, 10, and 11 illustrated that producitivity of plant species varied with seral changes within habitat types. Figures 13, 14, and 15, developed by ranking production data within habitat-types, also illustrated that productivity of plant species varied with seral changes within habitat-types. The latter set of figures suggested a difference in herbage production between habitat-types. Data, as arranged for development of these figures were not statistically analyzed.

Herbage samples were ranked in order of decreasing production. The ranked arrangement of herbage production samples supported the floristic habitat-type classification of Culver and Poulton (12). Samples were separated into habitat-types and again ranked in order of decreasing production. The latter arrangement of samples formed herbage production curves more commonly associated with seral regression.

Herbage production appeared closely related to seral stages within habitat-types. Lower seral stages resulted in decreased herbage production. Herbage production was shown to be a satisfactory criteria on which to determine seral stages for the three habitat-types studied.

A relationship between herbage production and habitat-types was not clearly determined. One of the three habitat-types studied graphically appeared different, in total herbage production, than the other two. The difference wasnot supported statistically and consequently the three habitat-types were not considered significantly different in total herbage production.

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APPENDIX

Appendix A. Crop year precipitation for 1967 and 1968, Squaw Butte, Oregon, Weather Station.

Month	Crop Year - 1967		Crop Year - 1968	
	Year	Precipitation (Inches)	Year	Precipitation (Inches)
Sept.	1966	1.44	1967	0.32
Oct.	1966	0.14	1967	1.16
Nov.	1966	2.67	1967	0.29
Dec.	1966	1.57	1967	0.38
Jan.	1967	1.90	1968	1.00
Feb.	1967	0.15	1968	0.80
March	1967	1.31	1968	0.06
April	1967	1.01	1968	0.03
May	1967	0.99	1968	0.50
June	1967	0.51	1968	Clipped
TOTAL		11.69		4.54

Appendix B. Monthly temperature summaries for 1967 and 1968 for Squaw Butte, Oregon, Weather Station.

Month	1967			1968			1937-61 (25 yrs.)		
	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean
Jan.	37.6	21.6	29.6	36.3	16.0	26.1	34.9	15.2	25.0
Feb.	44.5	23.1	33.8	47.1	26.8	36.9	40.0	20.1	30.1
March	42.8	23.4	33.1	52.6	25.7	39.1	46.5	23.5	35.0
April	45.4	24.0	34.7	53.4	25.8	39.3	57.3	29.1	43.2
May	64.6	35.8	57.5	63.0	34.7	48.8	65.7	36.6	51.2
June	74.0	41.1	57.5	74.5	42.8	58.6	72.5	41.3	57.0
July	86.9	52.5	69.7				85.1	48.9	67.0
Aug.	89.0	52.8	70.9				83.2	47.6	65.3
Sept.	75.9	42.9	59.4				75.3	41.6	58.5
Oct.	61.0	30.9	45.9				62.3	32.9	47.6
Nov.	53.5	29.1	41.3				46.8	23.7	35.2
Dec.	36.0	16.4	26.2				38.3	19.5	28.9

Temperatures are in degrees Fahrenheit.

Appendix C. Total herbage production

	Habitat-types														
	Juoc/Artr/Agsp/Feid					Artr/Agsp-Stth					Juoc Arar Feid/Agsp				
Seral Stage	Plot # & Sample	1967	1967*	1968	1968*	Plot # & Sample	1967	1967*	1968	1968*	Plot # & Sample	1967	1967*	1968	1968*
HIGH	C103-1	297	278	109	311	C213-1	306	286	107	306	S77 -1	133	124	35	100
	2	268	250	57	163	2	198	185	105	300	2	128	120	43	123
	3	224	209	33	94	3	298	278	65	186	3	206	192	45	129
	4	209	195	72	206	4	204	191	91	260	4	122	114	54	154
	C106-1	354	331	88	251	C181-1	103	96	93	266	S38C-1	147	137	76	217
	2	182	170	164	469	2	84	78	60	171	2	213	199	81	231
	3	256	239	126	360	3	224	209	47	134	3	229	214	44	126
	4	213	199	136	389	4	187	175	51	146	4	117	109	49	140
	C243-1	311	291	68	194	5M -1	188	176	24	69	C110-1	203	190	48	137
	2	233	218	108	309	2	90	84	57	163	2	124	116	60	171
	3	367	343	47	134	3	163	152	33	94	3	309	289	49	140
	4	318	297	85	243	4	145	136	66	189	4	232	217	72	206
	2M -1	191	178	66	189	4M -1	362	338	37	106	1M -1	150	140	65	186
	2	244	228	66	189	2	219	205	64	183	2	116	108	46	131
	3	168	157	47	134	3	239	223	52	149	3	110	103	40	114
	4	114	106	51	146	4	173	162	53	151	4	112	105	59	169
	Sum	3949	3689	1323	3781	Sum	3183	2974	1005	2873	Sum	2651	2477	866	2474
MEDIUM	S175-1	159	149	22	63	C215-1	186	174	65	186	S172-1	250	234	45	129
	2	165	154	64	183	2	135	126	66	189	2	154	144	90	257
	3	253	236	23	66	3	180	168	61	174	3	148	138	51	146
	4	151	141	63	180	4	149	139	68	194	4	145	136	76	217
	C114-1	233	218	64	183	C56 -1	150	140	25	71	S177-1	195	182	21	60
	2	159	149	41	117	2	111	104	50	143	2	192	179	63	180
	3	153	143	39	111	3	152	142	12	34	3	135	126	63	180
	4	154	144	41	117	4	198	185	50	143	4	140	131	78	223
	S71 -1	116	108	43	123	C34 -1	207	193	46	131	S107-1	221	206	58	166
	2	228	213	60	171	2	98	92	26	74	2	161	150	71	203
	3	170	159	34	97	3	303	283	37	106	3	185	173	80	229
	4	139	130	59	169	4	106	99	45	129	4	121	113	82	234
	S169-1	134	125	82	234	C85 -1	165	154	123	351	S28M-1	152	142	36	103
	2	60	56	67	191	2	162	151	78	223	2	100	93	29	83
	3	245	229	49	140	3	171	160	115	329	3	90	84	29	83
	4	133	124	52	149	4	225	210	43	123	4	55	51	30	86
	Sum	2652	2478	803	2294	Sum	2698	2520	910	2600	Sum	2444	2282	902	2579
LOW	S144-1	403	377	12	34	C245-1	213	199	22	63	S65 -1	69	64	23	66
	2	166	155	22	63	2	78	73	16	46	2	66	62	46	131
	3	195	182	37	106	3	109	102	18	51	3	44	41	37	106
	4	172	161	38	109	4	70	65	41	117	4	60	56	57	163
	S30 -1	177	165	86	246	C68 -1	265	248	63	180	S29 -1	163	152	20	57
	2	156	146	101	289	2	275	257	44	126	2	172	161	20	57
	3	232	217	73	209	3	169	158	72	206	3	97	91	47	134
	4	62	58	131	374	4	215	201	90	257	4	119	111	28	80
	S62 -1	157	147	178	509	C46 -1	90	84	7	20	C107-1	61	57	33	94
	2	117	109	134	383	2	97	91	15	43	2	102	95	26	74
	3	224	209	114	326	3	79	74	18	51	3	118	110	17	49
	4	176	164	85	243	4	61	57	16	46	4	120	112	33	94
	S163-1	108	101	80	229	C55 -1	133	124	47	134	C108-1	160	150	25	71
	2	140	131	79	226	2	110	103	28	80	2	132	123	32	91
	3	178	166	61	174	3	186	174	51	146	3	60	56	19	54
	4	156	146	80	229	4	91	85	30	86	4	120	112	23	66
	Sum	2819	2634	1311	3749	Sum	2241	2095	578	1652	Sum	1663	1553	486	1387
	Total	9420	8801	3437	9824	Total	8122	7589	2493	7125	Total	6758	6312	2254	6440

* Sample data adjusted to median crop year.

Appendix D. Analysis of total herbage production data (1967-1968 combined adjusted data from Appendix C)

	Habitat-types		
Seral Stages	Juoc/Artr/ Agsp/Feid	Artr/ Agsp-Stth	Juoc/Arar/ Feid/Agsp
High	7470	5847	4951
Medium	4772	5120	4861
Low	6383	3747	2940
Total	18625	14714	12752

Grand (Σ y) = 46,091

Preliminary Calculations

(1)	(2)	(3)	(4)	(5)
Type of Total	Total of Squares	No. of Items Squared	Obs. Per Squared Item	Total of Squares Per Obser. (2) $\div$ (4)
Grand (Σ y)	2,124,380,281	1	288	7,376,320
Tier A (Habitat-types)	726,005,925	3	96	7,562,562
B within A (Seral Stages)	250,542,713	9	32	7,829,460
Observations (y)	9,112,597	288	1	9,112,597

Analysis of Variance

Source of Variation	Sum of Squares	D.F.	Mean Square	F
Tier A (Habitat-types)	186,242	2	93,121	2.0934
B within A (Seral Stages)	266,898	6	44,483	9.6723 **
Error (within Seral Stages)	1,283,137	279	4,599	
Total	1,736,277	287		

Appendix E. L. S. D. test: Between seral stages within habitat-types using total herbage production data (1967-1968 combined adjusted data from Appendix C.

Critical Values	
95 Percent Level $\alpha = .05$ $\alpha/2 = .025 (279\ d.f.) = 1.96$	99 Percent Level $\alpha = .01$ $\alpha/2 = .005 (279\ d.f.) = 2.576$
$LSD = 1.96\sqrt{\frac{(2)(4599)}{32}}$	$LSD = 2.576\sqrt{\frac{(2)(4599)}{32}}$
$LSD = 1.96\sqrt{287}$	$LSD = 2.576\sqrt{287}$
$LSD = (1.96)(17)$	$LSD = (2.576)(17)$
$LSD = 33.32$	$LSD = 43.592$

Habitat-types								
Juoc/Artr/Agsp/Fedi			Artr/Agsp-Stth			Juoc/Arar/Feid/Agsp		
Seral Stage	Ranked Mean	Difference	Seral Stage	Ranked Mean	Difference	Seral Stage	Ranked Mean	Difference
H	233	34*	H	183	23	H	155	3
L	199	50**	M	160	43*	M	152	60**
M	149		L	117		L	92	

Appendix F. Agropyron spicatum production

		Habitat-types													
		Juoc/Artr/Agsp/Feid					Artr/Agsp-Stth					Juoc/Ara. Feid/Agsp			
Seral Stage	Plot # & Sample	1967	1967*	1968	1968*	Plot # & Sample	1967	1967*	1968	1968*	Plot # & Sample	1967	1967*	1968	1968*
HIGH	C103-1	81	76	79	226	C213-1	30	28	26	74	S77 -1	0	0	0	0
	2	214	200	21	60	2	73	68	36	103	2	59	55	20	57
	3	72	67	15	43	3	5	5	36	103	3	8	7	4	11
	4	131	122	26	74	4	83	78	12	34	4	5	5	22	63
	C106-1	46	43	21	60	C181-1	8	7	57	163	S386-1	52	49	45	129
	2	76	71	84	240	2	38	36	35	100	2	115	107	36	103
	3	114	106	104	297	3	91	85	37	106	3	28	26	15	43
	4	86	80	102	291	4	141	132	47	134	4	20	19	11	31
	C243-1	111	104	65	186	5M -1	0	0	0	0	C110-1	69	64	18	51
	2	182	170	94	269	2	0	0	0	0	2	50	47	25	71
	3	316	295	19	54	3	0	0	0	0	3	85	79	26	74
	4	225	210	82	234	4	0	0	8	23	4	58	54	56	160
	2M -1	56	52	18	51	4M -1	285	266	10	29	1M -1	54	50	18	51
	2	71	66	33	94	2	181	169	33	94	2	10	9	5	14
	3	45	42	13	37	3	178	166	36	103	3	9	8	0	0
	4	0	0	22	63	4	130	121	32	91	4	39	36	25	71
	Sum	1826	1704	798	2279	Sum	1243	1161	405	1157	Sum	661	615	326	929
MEDIUM	S175-1	49	46	8	23	C215-1	145	136	31	89	S172-1	46	43	0	0
	2	37	35	45	129	2	100	93	43	123	2	20	19	0	0
	3	173	162	5	14	3	115	107	29	83	3	41	38	0	0
	4	40	37	40	114	4	109	102	24	69	4	44	41	13	37
	C114-1	99	92	35	100	C56 -1	0	0	0	0	S177-1	107	100	1	3
	2	22	20	30	86	2	27	25	32	91	2	69	64	6	17
	3	0	0	32	91	3	32	30	0	0	3	0	0	13	37
	4	62	58	30	86	4	42	39	31	89	4	28	26	37	106
	S71 -1	50	47	23	66	C34 -1	33	31	10	29	S107-1	115	107	0	0
	2	164	153	35	100	2	1	1	12	34	2	0	0	0	0
	3	46	43	17	49	3	55	51	0	0	3	0	0	22	63
	4	70	65	26	74	4	3	3	0	0	4	16	15	24	69
	S169-1	6	6	35	100	C85 -1	0	0	41	117	S38M-1	30	28	4	11
	2	15	14	45	129	2	7	6	22	63	2	11	10	5	14
	3	120	112	11	31	3	0	0	74	211	3	19	18	6	17
	4	45	42	13	37	4	178	166	33	94	4	6	6	9	26
	Sum	998	932	430	1229	Sum	847	790	382	1092	Sum	552	515	140	400
LOW	S144-1	239	223	2	6	C245-1	0	0	0	0	S65 -1	0	0	0	0
	2	122	114	10	29	2	0	0	0	0	2	0	0	26	74
	3	110	103	13	37	3	0	0	0	0	3	10	9	26	74
	4	142	133	6	17	4	0	0	0	0	4	0	0	52	149
	S30 -1	79	74	16	46	C68 -1	0	0	0	0	S29 -1	43	40	5	14
	2	110	103	35	100	2	0	0	0	0	2	44	41	5	14
	3	161	150	19	54	3	11	10	0	0	3	40	37	38	109
	4	43	40	27	77	4	0	0	0	0	4	33	31	3	9
	S62 -1	65	61	85	243	C46 -1	0	0	0	0	C107-1	0	0	0	0
	2	37	35	49	140	2	0	0	0	0	2	0	0	2	6
	3	73	68	44	126	3	0	0	0	0	3	0	0	5	14
	4	29	27	11	31	4	0	0	0	0	4	0	0	4	11
	S163-1	28	26	26	74	C55 -1	0	0	24	69	C108-1	54	50	0	0
	2	16	15	15	43	2	0	0	0	0	2	9	8	0	0
	3	75	70	15	43	3	0	0	0	0	3	0	0	0	0
	4	6	6	4	11	4	0	0	0	0	4	0	0	5	14
	Sum	1335	1248	377	1077	Sum	11	10	24	69	Sum	233	216	171	488
	Total	4159	3884	1605	4585	Total	2101	1961	811	2318	Total	1446	1346	637	1817

* Sample data adjusted to median crop year

Appendix G. Analysis of Agropyron spicatum production data (1967-1968 combined adjusted data from Appendix F)

Seral Stages	Juoc/Artr/ Agsp/Feid	Artr/ Agsp-Stth	Juoc/Arar/ Feid/Agsp
	Habitat-types		
High	3983	2318	1544
Medium	2161	1882	915
Low	2325	79	704
Total	8469	4279	3163

Grand (Σ y) = 15,911

Preliminary Calculations

(1) Type of Total	(2) Total of Squares	(3) No. of Items Squared	(4) Obs. Per Squared Item	(5) Total of Squares Per Obser. (2) ÷ (4)
Grand (Σy)	253,159,921	1	288	879,028
Tier A (Habitat Types)	100,038,371	3	96	1,042,066
B within A (Seral Stages)	38,577,901	9	32	1,205,559
Observations (y)	1,973,189	288	1	1,973,189

Analysis of Variance

Source of Variation	Sum of Squares	D.F.	Mean Square	F
Tier A (Habitat-types)	163,038	2	81,519	2.9916
B within A (Seral Stages)	163,493	6	27,249	9.9051**
Error (within Seral Stages)	767,630	279	2,751	
Total	1,094,161	287		

Appendix H. L. S. D. test: Between seral stages within habitat-types using Agropyron spicatum production data (1967-1968 combined adjusted data from Appendix F).

Critical Values	
95 Percent Level	99 Percent Level
$\alpha = .05$	$\alpha = .01$
$\alpha/2 = .025(279\ \text{d.f.}) = 1.96$	$\alpha/2 = .005(279\ \text{d.f.}) = 2.576$
$LSD = 1.96\sqrt{\frac{(2)(2751)}{32}}$	$LSD = 2.576\sqrt{\frac{(2)(2751)}{32}}$
$LSD = 1.96\sqrt{171.9}$	$LSD = 2.576\sqrt{171.9}$
$LSD = (1.96)(13.1)$	$LSD = (2.576)(13.1)$
$LSD = 25.676$	$LSD = 33.7456$

Habitat-types								
Juoc/Artr/Agsp/Feid			Artr/Agsp-Stth			Juoc/Arar/Feid/Agsp		
Seral Stage	Ranked Mean	Difference	Seral Stage	Ranked Mean	Difference	Seral Stage	Ranked Mean	Difference
H	124	51**	H	72	23	H	48	19
L	73	5	M	59	57**	M	29	7
M	68		L	2		L	22	

Appendix I. Festuca idahoensis production

	Habitat-types														
	Juoc Artr Agsp Feid					Artr/Agsp-Stth					Juoc Arar/Feid/Agsp				
Seral Stage	Plot # & Sample	1967	1967*	1968	1968*	Plot # & Sample	1967	1967*	1968	1968*	Plot # & Sample	1967	1967*	1968	1968*
HIGH	C103-1	44	41	0	0	C213-1	237	221	51	146	S77 -1	123	115	26	74
	2	0	0	5	14	2	98	92	11	31	2	57	53	16	46
	3	7	6	4	11	3	217	203	24	69	3	141	132	34	97
	4	11	10	13	37	4	93	87	36	103	4	100	93	22	63
	C106-1	189	177	45	129	C181-1	35	33	20	57	S38G-1	65	61	27	77
	2	41	38	61	174	2	6	6	17	49	2	72	67	44	126
	3	76	71	16	46	3	20	19	6	17	3	168	157	25	71
	4	74	69	19	54	4	8	7	1	3	4	53	50	31	89
	C243-1	0	0	0	0	5M -1	0	0	0	0	C110-1	93	87	26	74
	2	0	0	11	31	2	15	14	0	0	2	30	28	30	86
	3	0	0	15	43	3	0	0	0	0	3	184	172	20	57
	4	0	0	1	3	4	0	0	3	9	4	135	126	12	34
	2M -1	64	60	41	117	4M -1	0	0	0	0	1M -1	83	78	36	103
	2	36	34	21	60	2	0	0	0	0	2	79	74	35	100
	3	20	19	24	69	3	0	0	0	0	3	83	78	34	97
	4	45	42	12	34	4	0	0	0	0	4	42	39	29	83
	Sum	607	567	288	822	Sum	729	682	169	484	Sum	1508	1410	447	1277
MEDIUM	S175-1	78	73	0	0	C215-1	0	0	13	37	S172-1	169	158	39	111
	2	96	90	0	0	2	0	0	10	29	2	56	52	50	143
	3	52	49	4	11	3	0	0	12	34	3	60	56	44	126
	4	62	58	6	17	4	0	0	7	20	4	56	52	33	94
	C114-1	45	42	25	71	C56 -1	37	35	0	0	S177-1	42	39	3	9
	2	31	29	4	11	2	0	0	0	0	2	87	81	27	77
	3	24	22	0	0	3	0	0	0	0	3	75	70	33	94
	4	27	25	3	9	4	0	0	0	0	4	52	49	17	49
	S71 -1	2	2	14	40	C34 -1	0	0	0	0	S107-1	187	175	44	126
	2	0	0	14	40	2	0	0	0	0	2	87	81	51	146
	3	22	21	5	14	3	0	0	0	0	3	166	155	49	140
	4	0	0	0	0	4	0	0	0	0	4	83	78	45	129
	S169-1	57	53	44	126	C85 -1	0	0	0	0	S38M-1	102	95	23	66
	2	15	14	18	51	2	0	0	0	0	2	60	56	12	34
	3	87	81	24	69	3	0	0	0	0	3	40	37	17	49
	4	56	52	32	91	4	0	0	0	0	4	22	21	13	37
	Sum	654	611	193	550	Sum	37	35	42	120	Sum	1344	1255	500	1430
LOW	S144-1	57	53	0	0	C245-1	0	0	0	0	S65 -1	25	23	0	0
	2	0	0	0	0	2	0	0	0	0	2	9	8	5	14
	3	43	40	18	51	3	0	0	0	0	3	9	8	0	0
	4	0	0	12	34	4	0	0	0	0	4	0	0	0	0
	S30 -1	0	0	0	0	C68 -1	0	0	11	31	S29 -1	0	0	0	0
	2	0	0	0	0	2	0	0	0	0	2	0	0	0	0
	3	0	0	0	0	3	0	0	1	3	3	0	0	0	0
	4	0	0	0	0	4	0	0	0	0	4	0	0	0	0
	S62 -1	0	0	22	63	C46 -1	0	0	0	0	C107-1	0	0	3	9
	2	0	0	30	86	2	0	0	0	0	2	34	32	11	31
	3	0	0	0	0	3	0	0	0	0	3	36	34	4	11
	4	0	0	5	14	4	0	0	0	0	4	55	51	16	46
	S163-1	32	30	7	20	C55 -1	0	0	0	0	C108-1	19	18	8	23
	2	0	0	2	6	2	0	0	0	0	2	45	42	23	66
	3	7	6	0	0	3	0	0	0	0	3	30	28	10	29
	4	46	43	0	46	4	0	0	0	0	4	47	44	15	43
	Sum	185	172	112	320	Sum	0	0	12	34	Sum	309	288	95	272
	Total	1446	1350	593	1692	Total	766	717	223	638	Total	3161	2953	1042	2979

* Sample data adjusted to median crop year.

Appendix J. Analysis of Festuca idahoensis production data (1967-1968 combined adjusted data from Appendix I)

	Habitat - types		
Seral Stages	Juoc/Artr/ Agsp/Feid	Artr/ Agsp-Stth	Juoc/Arar/ Feid/Agsp
High	1389	1166	2687
Medium	1161	155	2685
Low	492	34	560
Total	3042	1355	5932

Grand (Σ y) = 10,329

Preliminary Calculations

(1) Type of Total	(2) Total of Squares	(3) No. of Items Squares	(4) Obs. Per Squared Item	(5) Total of Squares Per Obser. (2) $\div$ (4)
Grand (Σ y)	106,688,241	1	288	370,445
Tier A (Habitat-types	46,278,413	3	96	482,067
B within A (Seral Stages)	19,646,837	9	32	613,964
Observations (y)	958,901	288	1	958,901

Analysis of Variance

Source of Variation	Sum of Squares	D.F.	Mean Square	F
Tier A (Habitat-types)	111,622	2	55,811	2.5388
B within A (Seral Stages)	131,897	6	21,983	17.7856**
Error (within Seral Stages)	344,937	279	1,236	
Total	588,456	287		

Appendix K. L. S. D. test: Between seral stages within habitat-types using Festuca idahoensis production data (1967-1968 combined adjusted data from Appendix I).

Critical Values	
95 Percent Level $\alpha = .05$ $\alpha/2 = .025(279 \text{ d.f.}) = 1.96$	99 Percent Level $\alpha = .01$ $\alpha/2 = .005(279 \text{ d.f.}) = 2.576$
$LSD = 1.96\sqrt{\frac{(2)(1236)}{32}}$	$LSD = 2.576\sqrt{\frac{(2)(1236)}{32}}$
$LSD = 1.96\sqrt{77.25}$	$LSD = 2.576\sqrt{77.25}$
$LSD = (1.96)(8.8)$	$LSD = (2.576)(8.8)$
$LSD = 17.248$	$LSD = 22.6688$

Habitat-types								
Juoc/Artr/Agsp/Feid			Artr/Agsp-Stth			Juoc/Arar/Feid/Agsp		
Seral Stage	Ranked Mean	Difference	Seral Stage	Ranked Mean	Difference	Seral Stage	Ranked Mean	Difference
H	43	7	H	36	31**	H	84	0
M	36	21*	M	5	4	M	84	66**
L	15		L	1		L	18	

Appendix L. Stipa thurburiana production

	Habitat-types														
	Juoc-Artr/Agsp-Feid					Artr/Agsp-Stth					Juoc-Arar/Feid/Agsp				
Seral Stage	Plot # & Sample	1967	1967*	1968	1968*	Plot # & Sample	1967	1967*	1968	1968*	Plot # & Sample	1967	1967*	1968	1968*
HIGH	C103-1	45	42	29	83	C213-1	12	11	25	71	S77- 1	0	0	0	0
	2	21	20	30	86	2	12	11	45	129	2	0	0	0	0
	3	41	38	13	37	3	52	49	3	9	3	0	0	0	0
	4	17	16	30	86	4	19	18	35	100	4	0	0	0	0
	C106-1	34	32	16	46	C181-1	23	21	0	0	S38G-1	4	4	0	0
	2	27	25	0	0	2	13	12	5	14	2	8	7	0	0
	3	11	10	0	0	3	26	24	0	0	3	6	6	0	0
	4	5	5	6	17	4	0	0	0	0	4	4	4	1	3
	C243-1	136	127	0	0	5M -1	135	126	14	40	C110-1	0	0	0	0
	2	0	0	0	0	2	39	36	35	100	2	0	0	0	0
	3	21	20	0	0	3	40	37	28	80	3	0	0	0	0
	4	28	26	0	0	4	94	88	38	109	4	0	0	0	0
	2M -1	32	30	0	0	4M -1	39	36	20	57	1M -1	0	0	0	0
	2	7	6	7	20	2	11	10	24	69	2	12	11	0	0
	3	59	55	3	9	3	13	12	4	11	3	5	5	0	0
	4	38	36	12	34	4	0	0	11	31	4	8	7	0	0
	Sum	522	488	146	418	Sum	528	491	287	820	Sum	47	44	1	3
MEDIUM	S175-1	0	0	0	0	C215-1	0	0	15	43	S172-1	0	0	0	0
	2	2	2	6	17	2	0	0	2	6	2	24	22	1	3
	3	0	0	0	0	3	0	0	6	17	3	10	9	0	0
	4	5	5	0	0	4	0	0	3	9	4	3	3	0	0
	C114-1	0	0	0	0	C56 -1	79	74	18	51	S177-1	0	0	0	0
	2	3	3	0	0	2	67	63	12	34	2	0	0	21	60
	3	0	0	0	0	3	87	81	4	11	3	0	0	5	14
	4	0	0	0	0	4	137	128	13	37	4	0	0	3	9
	S71 -1	11	10	0	0	C34 -1	123	115	30	86	S107-1	0	0	5	14
	2	9	8	0	0	2	54	50	8	23	2	29	27	6	17
	3	29	27	4	11	3	201	188	29	83	3	0	0	0	0
	4	0	0	17	49	4	76	71	27	77	4	0	0	0	0
	S169-1	44	41	0	0	C85 -1	75	70	47	134	S38M-1	0	0	2	6
	2	0	0	0	0	2	88	82	30	86	2	6	6	0	0
	3	3	3	6	17	3	98	92	27	77	3	5	5	1	3
	4	0	0	5	14	4	20	19	33	94	4	5	5	1	3
	Sum	106	99	38	108	Sum	1105	1033	304	868	Sum	82	77	45	129
LOW	S144-1	33	31	3	9	C245-1	150	140	4	11	S65 -1	7	6	1	3
	2	0	0	0	0	2	27	25	4	11	2	8	7	1	3
	3	0	0	0	0	3	52	49	2	6	3	0	0	5	14
	4	0	0	0	0	4	0	0	34	97	4	24	22	0	0
	S30 -1	18	17	15	43	C68 -1	20	19	19	54	S29 -1	24	22	0	0
	2	11	10	29	83	2	91	85	11	31	2	36	34	0	0
	3	39	36	35	100	3	6	6	34	91	3	9	8	0	0
	4	0	0	38	109	4	14	13	11	31	4	0	0	10	29
	S62 -1	7	6	39	111	C46 -1	33	31	1	3	C107-1	0	0	0	0
	2	5	5	0	0	2	41	38	1	3	2	14	13	0	0
	3	65	61	53	151	3	14	13	10	29	3	10	9	0	0
	4	75	70	12	34	4	4	4	5	14	4	20	19	0	0
	S163-1	0	0	23	66	C55 -1	25	23	4	11	C108-1	0	0	1	3
	2	51	48	25	71	2	7	6	1	3	2	0	0	0	0
	3	52	49	19	54	3	8	7	13	37	3	0	0	0	0
	4	44	41	26	74	4	44	41	9	26	4	5	5	0	0
	Sum	400	374	317	905	Sum	536	500	163	458	Sum	157	145	18	52
	Total	1028	961	501	1431	Total	2169	2024	754	2146	Total	286	266	64	184

* Sample data adjusted to median crop year

Appendix M. Analysis of Stipa thurberiana production data (1967-1968 combined adjusted data from Appendix L)

	Habitat-types		
Seral Stages	Juoc/Artr/ Agsp/Feid	Artr/ Agsp-Stth	Juoc/Arar/ Feid/Agsp
High	906	1311	47
Medium	207	1901	206
Low	1279	958	197
Total	2392	4170	450

Grand (Σy) = 7,012

Preliminary Calculations

(1)	(2)	(3)	(4)	(5)
Type of Total	Total of Squares	No. of Items Squared	Obs. Per Squared Item	Total of Squares Per Obser. (2) ÷ (4)
Grand (Σy)	49,168,144	1	288	170,723
Tier A (Habitat-types)	23,313,064	3	96	242,844
B within A (Seral Stages)	8,833,266	9	32	276,040
Observations (y)	515,232	288	1	515,232

Analysis of Variance

Source of Variation	Sum of Squares	D.F.	Mean Square	F
Tier A (Habitat-types)	72,121	2	36,061	6.5174*
B within A (Seral Stages)	33,196	6	5,533	6.4562**
Error (within Seral Stages)	239,192	279	857	
Total	344,509	287		

Appendix N. L. S. D. test: Between seral stages within habitat-types using Stipa thurberiana production data (1967-1968 combined adjusted data from Appendix L.)

Critical Values	
95 Percent Level $\alpha = .05$ $\alpha/2 = .025$ (279 d.f.) = 1.96	99 Percent Level $\alpha = .01$ $\alpha/2 = .005$ (279 d.f.) = 2.576
$LSD = 1.96\sqrt{\frac{(2)(857)}{32}}$	$LSD = 2.576\sqrt{\frac{(2)(857)}{32}}$
$LSD = 1.96\sqrt{53.5625}$	$LSD = 2.576\sqrt{53.5625}$
$LSD = (1.96)(7.32)$	$LSD = (2.576)(7.32)$
$LSD = 14.3472$	$LSD = 18.85632$

Habitat-types								
Juoc/Artr/Agsp/Feid			Artr/Agsp-Stth			Juoc/Arar/Feid/Agsp		
Seral Stage	Ranked Mean	Difference	Seral Stage	Ranked Mean	Difference	Seral Stage	Ranked Mean	Difference
L	40	12	M	59	18*	M	6	0
H	28	22**	H	41	11	L	6	5
M	6		L	30		H	1	

Appendix O. L. S. D. test: Between habitat-types using *Stipa thurberiana* production data (1967-1968 combined adjusted data from Appendix L.

Critical Values	
95 Percent Level $\alpha = .05$ $\alpha/2 = .025(6\text{ d.f.}) = 2.447$	99 Percent Level $\alpha = .01$ $\alpha/2 = .005(6\text{ d.f.}) = 3.707$
$LSD = 2.447\sqrt{\frac{(2)(5533)}{96}}$	$LSD = 3.707\sqrt{\frac{(2)(5533)}{96}}$
$LSD = 2.447\sqrt{115.270833}$	$LSD = 3.707\sqrt{115.270833}$
$LSD = (2.447)(10.736)$	$LSD = (3.707)(10.736)$
$LSD = 26.2710$	$LSD = 39.7984$

Habitat-types	Ranked Means	Difference
Artr/Agsp-Stth	43	18
Juoc/Artr/Agsp/Feid	25	20
Juoc/Arar/Feid/Agsp	5	

Appendix P. Vernal vegetation production

	Habitat-types														
	Juoc/Artr/Agsp/Feid					Artr/Agsp-Stth					Juoc/Arar/Feid/Agsp				
Seral Stage	Plot # & Sample	1967	1967*	1968	1968*	Plot # & Sample	1967	1967*	1968	1968*	Plot # & Sample	1967	1967*	1968	1968*
HIGH	C103-1	18	17	1	3	C213-1	16	15	1	3	S 77-1	10	9	4	11
	2	6	6	1	3	2	9	8	3	9	2	8	7	5	14
	3	13	12	1	3	3	10	9	1	3	3	16	15	3	9
	4	12	11	1	3	4	6	6	3	9	4	14	13	7	20
	C106-1	27	25	2	6	C181-1	7	6	2	6	S38G-1	22	21	2	6
	2	26	24	3	9	2	8	7	3	9	2	12	11	1	3
	3	25	23	5	14	3	18	17	1	3	3	16	15	1	3
	4	12	11	2	6	4	12	11	2	6	4	20	19	1	3
	C243-1	60	56	3	9	5M -1	17	16	3	9	C110-1	44	41	2	6
	2	38	36	2	6	2	21	20	2	6	2	41	38	4	11
	3	30	28	4	11	3	18	17	2	6	3	40	37	2	6
	4	36	34	2	6	4	11	10	1	3	4	38	36	4	11
	2M -1	13	12	4	11	4M -1	36	34	2	6	1M -1	10	9	5	14
	2	16	15	3	9	2	20	19	1	3	2	9	8	2	6
	3	16	15	3	9	3	22	21	3	9	3	12	11	4	11
	4	12	11	5	14	4	31	29	4	11	4	7	6	2	6
	Sum	360	336	42	122	Sum	262	245	34	101	Sum	319	296	49	140
MEDIUM	S175-1	23	21	14	40	C215-1	33	31	4	11	S172-1	29	27	5	14
	2	19	18	11	31	2	28	26	8	23	2	35	33	13	37
	3	17	16	13	37	3	28	26	4	11	3	25	23	7	20
	4	36	34	8	23	4	31	29	7	20	4	24	22	13	37
	C114-1	48	45	4	11	C56 -1	28	26	3	9	S177-1	43	40	9	26
	2	40	37	4	11	2	17	16	4	11	2	33	31	9	26
	3	45	42	4	11	3	31	29	4	11	3	47	44	9	26
	4	47	44	7	20	4	19	18	4	11	4	44	41	9	26
	S71 -1	34	32	3	9	C34- 1	51	48	5	14	S107-1	19	18	4	11
	2	39	36	3	9	2	39	36	4	11	2	41	38	9	26
	3	66	62	4	11	3	46	43	7	20	3	19	18	3	9
	4	52	49	3	9	4	27	25	11	31	4	17	16	12	34
	S169-1	16	15	3	9	C85 -1	18	17	17	49	S38M-1	14	13	7	20
	2	18	17	3	9	2	27	25	4	11	2	20	19	7	20
	3	22	21	7	20	3	19	18	13	37	3	22	21	5	14
	4	17	16	2	6	4	17	16	3	9	4	20	19	7	20
	Sum	539	505	93	266	Sum	459	429	102	289	Sum	452	423	128	366
LOW	S144-1	38	36	7	20	C245-1	31	29	9	26	S65-1	22	21	8	23
	2	42	39	14	40	2	40	37	4	11	2	39	36	8	23
	3	19	18	4	11	3	35	33	7	20	3	23	21	4	11
	4	28	26	14	40	4	57	53	4	11	4	24	22	4	11
	S30-1	77	72	55	157	C68 -1	61	57	2	6	S29 -1	53	50	10	29
	2	35	33	36	103	2	38	36	4	11	2	21	20	12	34
	3	31	29	18	51	3	38	36	4	11	3	22	21	9	26
	4	19	18	66	189	4	51	48	17	49	4	34	32	13	37
	S62 -1	72	67	19	54	C46 -1	36	34	2	6	C107-1	53	50	5	14
	2	54	50	17	49	2	40	37	5	14	2	49	46	8	23
	3	45	42	13	37	3	45	42	3	9	3	46	43	4	11
	4	50	47	9	26	4	38	36	1	3	4	34	32	7	20
	S163-1	42	39	15	43	C55 -1	39	36	5	14	C108-1	67	63	10	29
	2	54	50	37	106	2	37	35	1	3	2	70	65	5	14
	3	36	34	24	69	3	39	36	9	26	3	22	21	7	20
	4	60	56	24	69	4	20	19	5	14	4	55	51	3	9
	Sum	702	656	372	1064	Sum	645	604	82	234	Sum	634	594	117	334
	Total	1601	1497	507	1452	Total	1366	1278	218	624	Total	1405	1313	294	840

* Sample data adjusted to median crop year.

Appendix Q. Analysis of vernal vegetation production data (1967-1968 combined adjusted data from Appendix O)

	Habitat-types		
Seral Stages	Juoc/Artr/ Agsp/Feid	Artr/ Agsp-Stth	Juoc/Arar/ Feid/Agsp
High	458	346	436
Medium	771	718	789
Low	1720	838	928
Total	2949	1902	2153

Grand (Σ y) = 7,004

Preliminary Calculations

(1)	(2)	(3)	(4)	(5)
Type of Total	Total of Squares	No. of Items Squared	Obs. Per Squared Item	Total of Squares Per Obser. (2) $\div$ (4)
Grand (Σ y)	49,056,016	1	288	170,333
Tier A (Habitat-types)	16,949,614	3	96	176,558
B within A (Seral Stages)	6,773,890	9	32	211,684
Observations (y)	294,032	288	1	294,032

Analysis of Variance

Source of Variation	Sum of Squares	D.F.	Mean Square	F
Tier A (Habitat-types)	6,225	2	3,112	0.5316
B within A (Seral Stages)	35,126	6	5,854	19.8441**
Error (within Seral Stages)	82,348	279	295	
Total	123,699	287		

Appendix R. L. S. D. test: Between seral stages within habitat-types using vernal vegetation production data (1967-1968 combined adjusted data from Appendix O).

Critical Values	
95 Percent Level $\alpha = .05$ $\alpha/2 = .025 (279\ d.f.) = 1.96$	99 Percent Level $\alpha = .01$ $\alpha/2 = .005 (279\ d.f.) = 2.576$
$LSD = 1.96\sqrt{\frac{(2)(295)}{32}}$	$LSD = 2.576\sqrt{\frac{(2)(295)}{32}}$
$LSD = 1.96\sqrt{18.4375}$	$LSD = 2.576\sqrt{18.4375}$
$LSD = (1.96)(4.293)$	$LSD = (2.576)(4.293)$
$LSD = 8.4143$	$LSD = 11.0588$

Habitat-types								
Juoc/Artr/Agsp/Feid			Artr/Agsp-Stth			Juoc/Arar/Feid/Agsp		
Seral Stage	Ranked Mean	Difference	Seral Stage	Ranked Mean	Difference	Seral Stage	Ranked Mean	Difference
L	54	30**	L	26	4	L	29	4
M	24	10*	M	22	11*	M	25	11*
H	14		H	11		H	14	

Appendix S. Test for variation of vernal vegetation production between years on the Juoc/Artr/Agsp/Feid habital-type

	Unadjusted Data	Adjusted Data
Total Production	2108	2949
1967 Production	1601	1497
1968 Production	507	1452

ANALYSIS OF UNADJUSTED DATA

Preliminary Calculations

(1) Type of Total	(2) Total of Squares	(3) No. of Items Squared	(4) Obs. Per Squared Items	(5) Total of Squares Per Obser. (2) ÷ (4)
Grand (Σ y)	4,443,664	1	96	46,288
Tier A (Years)	2,820,250	2	48	58,755
Observations (y)	81,648	96	1	81,648

Analysis of Variance

Source of Variation	Sum of Squares	D.F.	Mean Square	F
Tier A (Years)	12,467	1	12,467	51.0943**
Error (within Years)	22,893	94	244	
Total	35,360	95		

ANALYSIS OF ADJUSTED DATA

Preliminary Calculations

(1) Type of Total	(2) Total of Squares	(3) No. of Items Squared	(4) Obs. Per Squared Item	(5) Total of Squares Per Obser. (2) ÷ (4)
Grand (Σ y)	8,696,601	1	96	90,590
Tier A (Years)	4,349,313	2	48	90,611
Observations (y)	173,697	96	1	173,697

Analysis of Variance

Source of Variation	Sum of Squares	D.F.	Mean Square	F
Tier A (Years)	21	1	21	0.0238
Error (within Years)	83,086	94	884	
Total	83,107	95		

Appendix T. Test for variation of vernal vegetation production between years on the Artr/Agsp-Stth habital-type

	Unadjusted Data	Adjusted Data
Total Production	1,584	1,902
1967 Production	1,366	1,278
1968 Production	218	624

ANALYSIS OF UNADJUSTED DATA

Preliminary Calculations

(1) Type of Total	(2) Total of Squares	(3) No. of Items Squared	(4) Obs. Per Squared Items	(5) Total of Squares Per Obser. (2) ÷ (4)
Grand (Σ y)	2,509,056	1	96	26,136
Tier A (Years)	1,913,480	2	48	39,864
Observations (y)	49,114	96	1	49,114

Analysis of Variance

Source of Variation	Sum of Squares	D.F.	Mean Square	F
Tier A (Years)	13,728	1	13,728	140.0816**
Error (Within Years)	9,250	94	98	
Total	22,978	95		

ANALYSIS OF ADJUSTED DATA

Preliminary Calculations

(1) Type of Total	(2) Total of Squares	(3) No. of Items Squared	(4) Obs. Per. Squared Item	(5) Total of Squares Per. Obser. (2) ÷ (4)
Grand (Σ y)	3,617,604	1	96	37,683
Tier A (Years)	2,022,660	2	48	42,139
Observations (y)	54,992	96	1	54,992

Analysis of Variance

Source of Variation	Sum of Squares	D.F.	Mean Square	F
Tier A (Years)	4,456	1	4,456	32.5255**
Error (Within Years)	12,853	94	137	
Total	17,309	95		

Appendix U. Test for variation of vernal vegetation production between years on the Juoc/Arar/Feid/ Agsp habital-type

	Unadjusted Data	Adjusted Data
Total Production	1,699	2,153
1967 Production	1,405	1,313
1968 Production	294	840

ANALYSIS OF UNADJUSTED DATA

Preliminary Calculations

(1)	(2)	(3)	(4)	(5)
Type of Total	Total of Squares	No. of Items Squared	Obs. Per Squared Item	Total of Squares Per Obser. (2) ÷ (4)
Grand (Σ y)	2,886,601	1	96	30,069
Tier A (Years)	2,060,461	2	48	42,926
Observations (y)	55,181	96	1	55,181

Analysis of Variance

Source of Variation	Sum of Squares	D.F.	Mean Square	F
Tier A (Years)	12,857	1	12,857	98.9**
Error (Within Years)	12,255	94	130	
Total	25,112	95		

ANALYSIS OF ADJUSTED DATA

Preliminary Calculations

(1)	(2)	(3)	(4)	(5)
Type of Total	Total of Squares	No. of Items Squared	Obs. Per Squared Item	Total of Squares Per. Obser. (2) ÷ (4)
Grand (Σ y)	4,635,409	1	96	48,286
Tier A (Years)	2,429,569	2	48	50,616
Observations (y)	65,343	96	1	65,343

Analysis of Variance

Source of Variation	Sum of Squares	D.F.	Mean Square	F
Tier A (Years)	2,330	1	2,330	14.8408**
Error (Within Years)	14,727	94	157	
Total	17,057	95		