Journal of
Volume 15, Number 5
September, 1962
RANGE MANAGEMENT

Behavior of Forage Yields on Some Range Sites in Oregon

E. WILLIAM ANDERSON

Range Conservationist, Soil Conservation Service, Pendleton, Oregon.

Range management is a newcomer. Livestock breeding, feeding and disease control, pasture and hay production, marketing and transportation are old-timers, comparatively. Newcomers and old-timers, that is, in the field of economic evaluation as a normal part of modern range livestock ranching.

Good information about forage yields, particularly potentials, is essential for reliable economic evaluation of range improvements and management. Yield information, on a range site-by-range-site basis, enhances the usefulness of surveys that delineate soils, range sites and range condition classes. Together, they provide the means for assembling a composite analysis of the landscape within a pasture or ranch. This can be done irrespective of the different kinds of land involved, the pattern of occurrence, or whether the differences are due to topography, climate, soils and/or vegetation, since these make up the survey data.

The purpose of this report is to (a) explain how yield characteristics of some range sites in Oregon are being derived and portrayed tentatively as a normal effort to learn more about range sites, their soils and potentials; (b) emphasize some logical, apparent differences in the way yield behaves on different sites; (c) point out certain interpretations that seem useful for ranchers and technicians when judging cost-benefit relationships; and (d) suggest the need for research assistance in this area.

Examples cited represent data from cattle ranches, primarily. Yield data are based almost entirely on forage from perennials. This is done to clarify the relatively stable forage supply and to eliminate a much as possible the influence of extreme fluctuations in the production of annuals.

Figure 1 illustrates a typical yield-behavior curve. It represents the Moderate-South-Exposure site in Oregon's Columbia Basin. The original plant community of this site is dominated by bluebunch wheatgrass *(Agropyron spicatum)* and Sandberg bluegrass *(Poa secunda)*. The soil, called Lickskillet very stony loam, is classed in the Brown Great Soil Group[1].

The curve, or envelope, represents how the forage-yielding ability of this site varies according to the ecological condition of the plant community. For example, on this site, a plant community that rates at the top of the Good range condition class will yield about one hundred seventy five pounds more usable forage, on the average, than if it rates at the top of the Fair class.

The curve implies that changes in yield have character. As the plant community changes from one condition class to another, the curve changes pitch and thickness. On this particular site, more producing capacity is lost —or gained—proportionately during changes in its plant community that are represented by Good condition class than for any other class. The least proportion is related to changes represented by Poor range condition class. This suggests that returns on investments that will improve the ecological condition of this site's plant community probably will be greater if the condition class is high Fair or Good, rather than low Fair or Poor, at the start. For ranges that are deteriorating ecologically, the curve provides an indication of the economic urgency for reversing the downward trend. Even doubling the yield of a low producing, Poor condition site doesn't return much on the investment at the start.

It is important to note that the time factor is not represented in the yield-behavior curve. Each stage of improvement or deterioration of the plant community

[1] *Persons unfamiliar with the concepts of great soil groups will find them defined and discussed in the 1938 Yearbook of Agriculture SOILS AND MEN.*

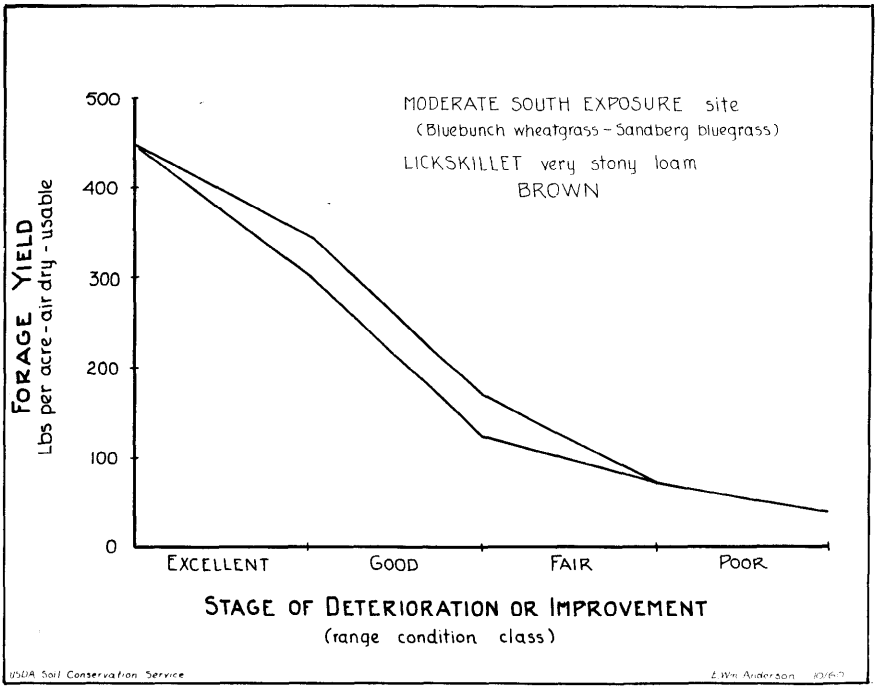

FIGURE 1. Typical yield-behavior curve representing the average amount and variation in forage yield that can be expected from a range site according to range condition class.

is represented by equal segments of the horizontal axis. The steep pitch in the Good class does not indicate a greater rate of change in forage yield. It merely indicates that a greater amount of change takes place during the time the plant community progresses through this ecological stage.

If time could be represented by the segments of the horizontal axis along with stages of improvement, the chart could be made to indicate rate as well as amount of potential forage increase. Records on the amount of time and the kind of mismanagement it took to deteriorate a site from one class to another probably are available. Records on the time and kind of good management it took for a site to recover from one class to another probably are available, also. An effort to obtain such records is needed. Observations by ranchers and technicians having long local experience is a potential source. Re-examination of areas having old survey data might be another source.

Use of the Curve

The curve provides a general guideline for predicting the increased yield that can be expected from a site if its plant community can be improved ecologically from one stage to another. Judgment and local experience are important for adjusting the potential of a deteriorated site according to degree of erosion and formation of stone pavements, since these reduce the site's producing capacity almost permanently. Such guidelines, rough as they may be, are helpful in judging cost-benefits of range practices locally. They contribute to better uniformity of judgment between people and help avoid undue optimism. They aid in training young technicians. They help emphasize certain principles to ranchers and range administrators.

Many people, including ranchers, work with plant communities and soils of range sites in areas for which little specific information is available. One of the most useful applications of information on yield behavior has been for predicting potential forage production in areas for which yield data are not available. This is done merely by associating plant communities and soil characteristics of the unknown sites to those of similar sites for which yield information is available. The procedure has helped speed up range improvement activities in certain areas where little real investigative range work has been done.

Theory of Curve

A variety of factors can influence the behavior of forage yields on a range site. Change in the make-up of the plant community surely is a major factor. Probably, this is true whether changes in the plant community are of the long-lasting type associated with changes in range condition class, or of a more temporary nature associated with short-time climatic fluctuations. Annual climatic fluctuation caused by changes in amount and timeliness of precipitation, temperature, sunshine, wind and so on, also is a major factor. Changes in the vigor of major forage plants, whether due to adverse weather or excessive grazing, strongly influences forage yield.

The upper line of the curve is based upon the average high yield that has been recorded for each condition class. The terminal point represents the average lowest yield that has been recorded for the site. Logically, high yield is consistent with high degree of vigor. It is concluded, therefore, that the upper line of the curve primarily represents conditions where the forage plants are as vigorous as could be expected consistent with the ecological condition of the plant community.

The lower line of the curve is based upon the average lowest yield recorded for each condition class. Lowest yields probably are associated with low-vigor forage plants. It is concluded, therefore, that the lower line primarily represents conditions where the forage plants are as weak as they could be and still maintain the ecological condition of the plant community. Further reduction in vigor would be associated with further ecological deterioration.

Thickness of the curve, or vertical distance between the two lines, represents the variation in average forage yield, due to changes in vigor caused by grazing or drought, that could occur without changing the ecological condition of the plant community. Using Figure 1 for example, a plant community on this site rating in Good class but having weak perennial forage plants, produces about two hundred pounds usable forage per acre. By improving the vigor of the forage plants, and without changing the make-up or stand of the plant community, the average yield could be raised to about two hundred fifty pounds per acre. Further increase in average yield probably would be accompanied by ecological improvement and the position of the plant community in relation to the horizontal axis would change accordingly.

Top Excellent condition and highest average yield always would be associated with vigorous forage plants. Severest deterioration and lowest average yield always would be accompanied by weak perennial forage plants. At these extremes, the curve shows no yield variation since these points were used merely to begin and end the curve. Fluctuations in yield that normally occur at these points are taken into account by the use of average yields, as are similar periodic fluctuations all along each line of the curve.

Pitch of the curve, as previously stated, does not represent rate-of-change in forage yield since the time factor is not represented on the horizontal axis. Pitch does indicate the relative amount of change in forage producing capacity for each stage of deterioration or improvement as measured by range condition class.

The pitch of the curve is associated primarily with changes in the make-up of the plant community, particularly with changes in the major forage producing plants. This is illustrated by comparing Figures 1 and 2.

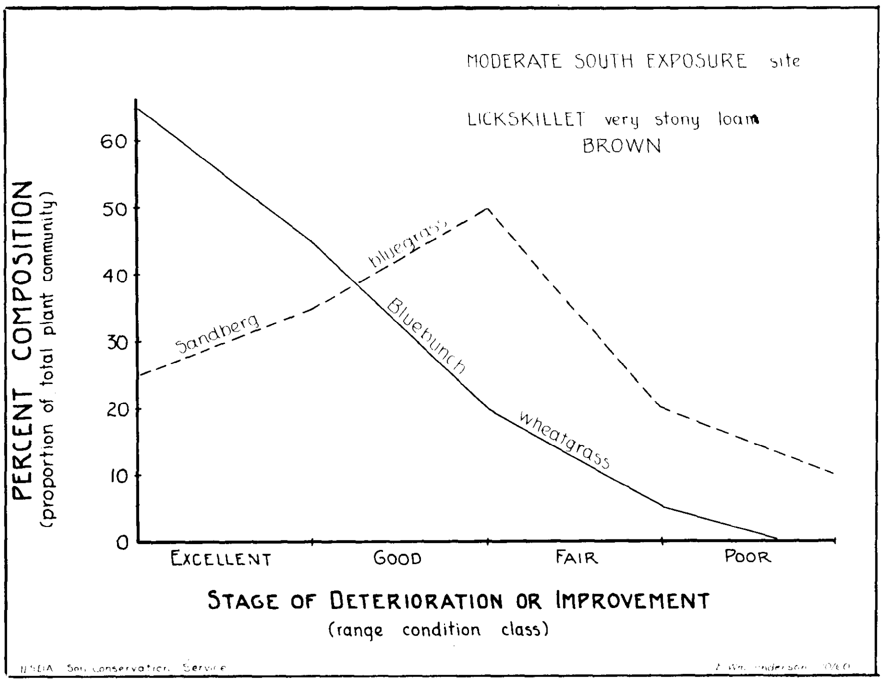

FIGURE 2. Typical behavior of two major plants, composition-wise, as the plant community of a range site changes according to range condition class under cattle use.

Figure 2 illustrates how two major forage plants on this site, bluebunch wheatgrass and Sandberg bluegrass, behave composition-wise as the plant community changes from Excellent to Poor condition class under cattle use. As the wheatgrass decreases in the composition, the bluegrass increases for a time. Eventually, due to the lack of forage from the wheatgrass, the grazing pressure shifts to include the bluegrass. Being a palatable forage plant, it, too, then decreases in the composition. This chart verifies that bluebunch wheatgrass is a strong *decreaser*[2] and Sandberg bluegrass a strong, palatable *increaser* on this site when grazed by cattle. These plants behave differently when grazed by sheep.

Bluebunch wheatgrass is a high-yielding forage plant. When its proportion in the plant community is reduced, yield is affected markedly. Sandberg bluegrass is a small, low-yielding forage plant. Changes in its proportion of the plant community have little effect upon the behavior of yields. For these apparent reasons, the yield-curve for this site simulates the composition-curve of bluebunch wheatgrass, except that under extreme deterioration, the bluegrass persists and produces a small amount of forage.

Comparison Locally

Different range sites within a locality may have different yield-curves. In Figure 3, three grassland sites that join each other on the same hill are compared. Each site has its distinc-

[2] *Dyksterhuis, E. J. 1949. Condition and Management of Range Land Based on Quantitative Ecology. Jour. Range Mangt. Vol. 2. No. 3. 104-115*

[3] *For more specific data on soils cited in this paper, refer to Table 1.*

tive plant community, topographic position, microclimate and soil. All three soils are derived primarily from aeolian material of the same geological age and overlie basalt bedrock[3].

The Moderate South Exposure site represents the "poorest" environment of the three. The original plant community of this site is very strongly dominated by bluebunch wheatgrass. Lickskillet soil, developed under this plant community in this environment, has thinner but more distinct horizons, stronger development and lighter colored surface layers than the other two soils. It has been classed as a Brown soil.

The Rolling Hills site represents the intermediate environment of the three. Bluebunch wheatgrass dominates and Idaho fescue *(Festuca idahoensis)* is prominent in the composition of the original plant community. Condon soil, developed under this plant community in this environment, has moderately thick but very indistinct horizons, weak development and is intermediate in color of the surface layers. It has been classed as a Chestnut soil.

The Steep North Exposure site represents the "best" environment of the three. Idaho fescue strongly dominates the original plant community. Wrentham soil, developed under this plant community in this environment, has moderately thick, distinct horizons, moderate development and is darker colored in surface layers than the other two. It has been classed as a Chernozem soil.

Several differences are apparent in the yield-behavior curves of these three range sites:

a. As the environment improves, so does the potential forage-producing capacity of the site. This is indicated on the vertical axes of the charts.

b. Based upon the top line of the curves, the sites differ somewhat as to the proportion of the potential yield that is related to changes in the plant community as represented by each range condition class. The "poorer" the enviroment, the greater is the proportion lost during changes represented by Excellent and Good classes. Probably, this is due to the kind of plants that increase as the major original forage plants begin to diminish in the stand. Under "poor" environmental conditions in the portion of Oregon being discussed, *increasers* generally are low-yielders or unpalatable. Decline in yield in almost directly related to the decrease of major original forage plants in the stand. Under "good" environmental conditions, a variety of

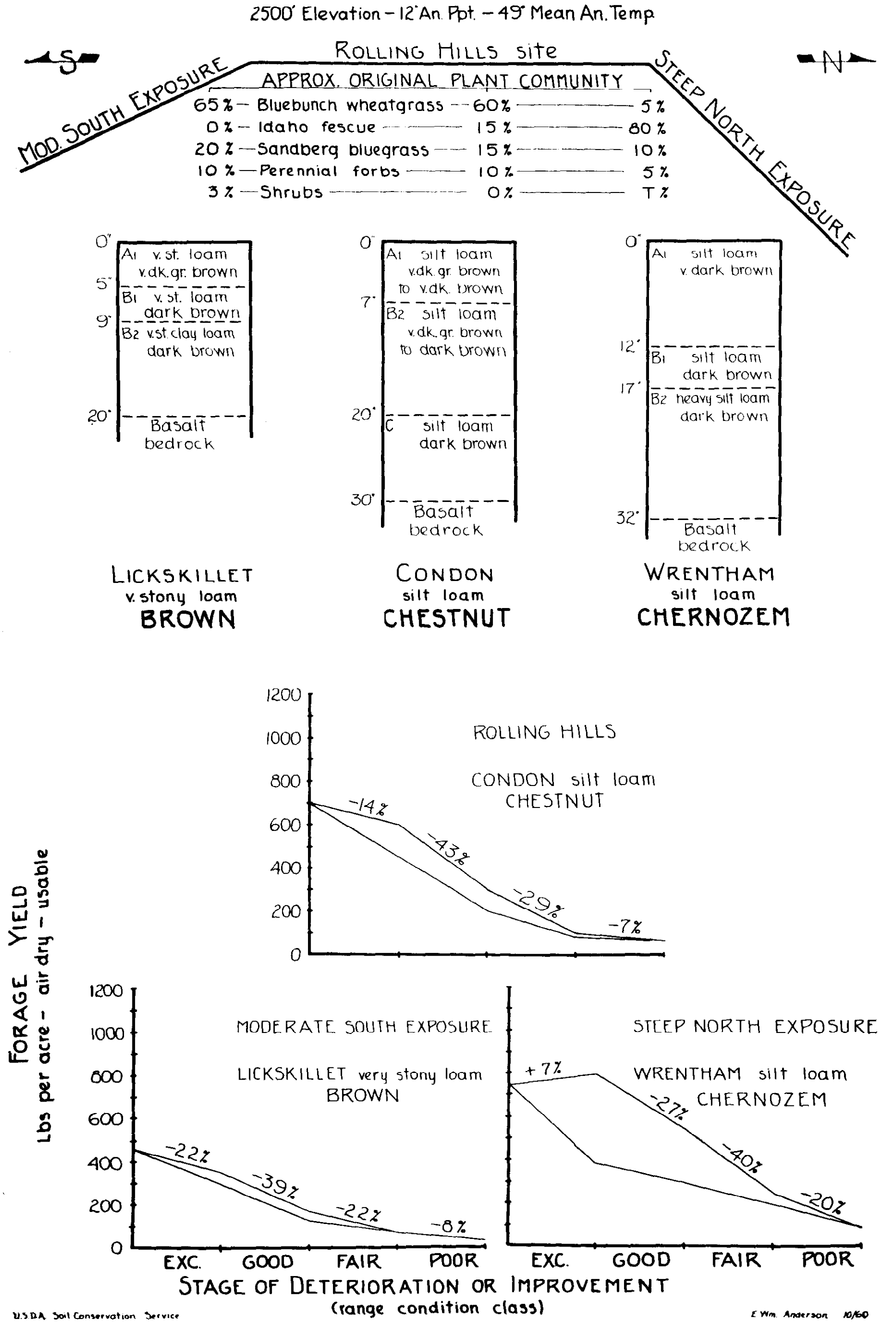

FIGURE 3. Comparison of three range sites that occur on the same hill, illustrating differences in yield behavior related to plant communities in different effective environments.

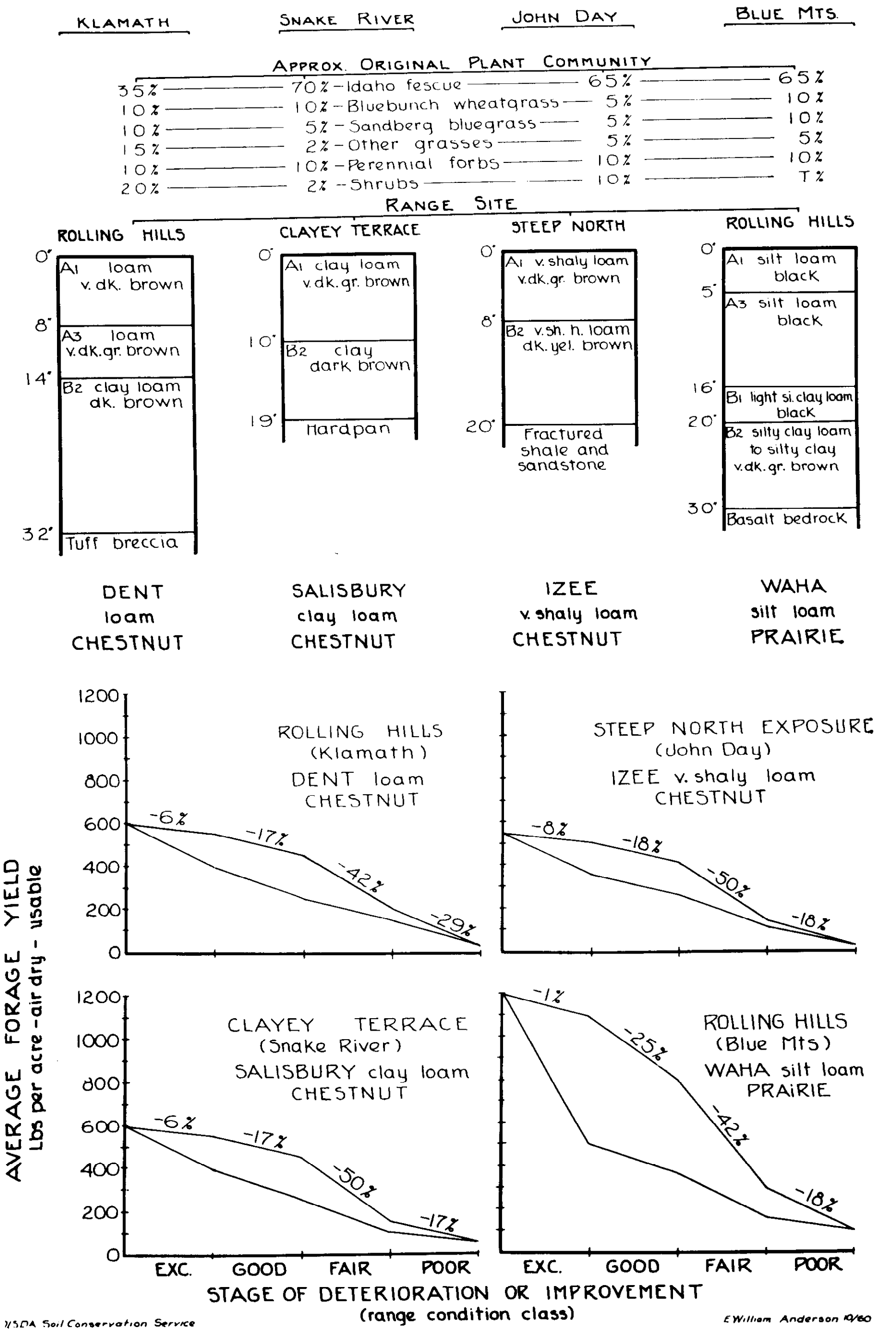

FIGURE 4. Yield behavior of four widely separated sites having original plant communities dominated by Idaho fescue. Comparison with the Columbia Basin site having Wrentham soil illustrates apparent widespread conformity of yield behavior on sites having comparable effective environments.

palatable forage plants temporarily increase in the plant community as the original major forage plants decrease in the stand. Decline in yield is delayed until these palatable *increasers* also diminish in the stand.

c. The thickness of the curve varies with changes in the environment. In the "poorest" environment, the thin curve reflects the inability of that plant community to maintain a stable composition with low-vigor forage plants. On this site, it doesn't take much excessive grazing or adverse weather before the reduced vigor is accompanied by further deteriorating changes in the make-up of the plant community. In the "best" environment, the thick curve indicates that the forage plants on this site can stand considerable reduction in vigor before they decline in the composition. Ability of the plant community to retain its composition with low-vigor forage plants is reduced as deterioration progresses. This is indicated by the narrowing of the curve toward Fair and Poor condition classes.

d. Yields decline steadily throughout the process of deterioration on two of these sites. The Steep North Exposure site with Wrentham soil, however, is one of those sites on which the yields increase during early stages of deterioration, provided that bluebunch wheatgrass, a large forage-producing *increaser* on this site, remains vigorous.

Widespread Comparison

Relationships of yield to environment that exist on this one hill apparently hold true for zonal soils generally over a wide area. This is illustrated by Figure 4, which depicts yield curves and soils for four widely separated sites in eastern Oregon, as shown in Figure 5. Each of these four sites has an original plant community dominated by Idaho fescue and, in this way, is comparable to the Columbia Basin site with Wrentham soil.

Marked similarities in yield behavior are apparent between these five sites. On each, the decline in yield is proportionately greatest in Fair condition class. Other condition classes are comparable. Relatively thick curves are typical.

From the local situation represented in Figure 3, it would be easy to conclude that a close relationship exists between character of yield behavior and Great Soil Group. Figure 4 emphasizes that the closest relationship actually is based upon certain similarities between the original plant communities. Of these five soils, each of which produces a

Table 1. Some characteristics and qualities of soils cited.

	SOIL SERIES						
	LICK-SKILLET	CONDON	WRENTHAM	WAHA	IZEE[1]	SALISBURY	DENT[1]
Elevation	800 - 2,800	1,600 - 3,000	900 - 2,800	1,500-3,500	4,200 - 5,000	3,400 - 4,500	5,000 - 6,000
Av. An. Ppt. (inches)	10 - 12	10 - 12	10 - 12	15 - 20	11 - 14	13 - 16	12 - 16
Av. Jan. Temp. (°F.)	30	30	29	23	25	25	23
Av. July Temp. (°F.)	70	68	68	63	62	65	62
Av. Mean Temp. (°F.)	50	49	48	44	42	45	42
Av. Frost Free Days	155	152	144	126	frost every mo.	110	100
Av. Growing Season (major forage grass)	3/1 - 6/1	3/1 - 7/1	3/15 - 7/1	4/1 - 7/15	4/15 - 7/15	4/1 - 7/1	4/15 - 7/15
Parent Material	loess and basalt colluvium	loess	loess	loess	shale, sandstone and graywacke	mixed argillitic, granitic and basaltic material of fluvial origin	residium from volcanic tuff
Topography of mapping unit	south facing slopes of canyons	nearly level to rolling plateau	steep north facing slopes of canyons	gently to steeply sloping uplands	steep to very steep north facing slopes	sloping tops of old terraces	undulating mountain foot-slopes
A Horizon							
Av. thickness (in.)	3 - 5	7 - 12	7 - 18	12 - 16	5 - 13	7 - 14	11 - 21
Texture	v. stony loam	silt loam	rocky silt loam	silt loam	v. shaly loam	clay loam	loam
Color—dry	grayish brown	grayish brown	dk. grayish brown	dark gray	dark gray	dark gray	dark gray
moist	v. dk. gr. brown	very dark brown	very dark brown	black	v. dk. gr. brown	v. dk. gr. brown	v. dark brown
Structure[2]	wk. fine granular	wk. med. granular	wk. med. subangbky.	mod. crs. prismatic	wk. fine subangbky.	wk., v.f. granular	wk. med. subangbky.
Consistence dry	slightly hard	slightly hard	slightly hard	slightly hard	slightly hard	slightly hard	slightly hard
moist	friable	friable	friable	friable	friable	firm	friable
wet	sl. sticky, sl. plastic	sl. sticky sl. plastic	sl. sticky sl. plastic	sticky sl. plastic	sticky plastic	sticky plastic	sl. sticky sl. plastic
Reaction (pH)	6.4	6.6	6.5	6.8	6.8	6.8	6.6
B Horizon							
Av. thickness (in.)	7 - 15	12 - 18	12 - 14	12 - 18	10 - 20	6 - 10	12 - 18
Texture	v. st. heavy loam	silt loam	h. silt loam to silty clay loam	silty clay loam to silty clay	v. shaly h. loam	clay	clay loam
Color—dry	yellowish brown	pale brown	brown	dk. grayish brown	brown	brown	lt. yel. brown
moist	dk. yel. brown	dark brown	dark brown	v. dk. gr. brown	dk. yel. brown	dark brown	dark brown
Structure	mod. med. subangbky	wk. fine subangbky	wk.-med. subangbky.	st. crs. prismatic	med. subangbky.	mod. med. prismatic	wk. med. prismatic
Consistence dry	hard	slightly hard	hard	hard	slightly hard	very hard	hard
moist	firm	friable	firm	firm	friable	very firm	friable
wet	sticky plastic	sl. sticky sl. plastic	sticky plastic	sticky plastic	sticky plastic	v. sticky v. plastic	sticky plastic
Reaction (pH)	6.6	7.2	6.8	6.9	7.1	6.9	6.6
Underlying material	basalt bedrock (related)	basalt bedrock (unrelated)	basalt bedrock (unrelated)	basalt bedrock (unrelated)	Fractured sandstone and shale (related)	Indurated silica-cemeted pan (related)	Tuff breccia (related)

Great Soil Group[3]	BROWN	CHESTNUT	CHERNOZEM	PRAIRIE	CHESTNUT	CHESTNUT	CHESTNUT
Av. Effective Depth	16	30	30	30	30	18	32
Permeability[4]	moderately slow	moderate	moderately slow	moderately slow	moderate	slow	moderate
Moisture Supplying Capacity[5]	low	fair	high	high	good	good	high

[1] These soils have not been correlated and the names are tentative
[2] Grades of structure and consistence are defined in Soil Survey Manual, USDA Handbook No. 18, pages 225-234
[3] Great Soil Groups are defined and discussed in 1938 Yearbook of Agriculture, SOILS AND MEN. Improvements in the soil classification system being currently developed may somewhat change the present classification of certain soil series mentioned in this paper.
[4] Defined in Soil Survey Manual, page 167 as "that quality of the soil that enables it to transmit water or air". Classes are very slow, slow, moderately slow, moderate, moderately rapid, rapid, very rapid.
[5] Defined in Soil Survey Manual, page 416 as "relative capacity of the soil to take in and hold supply of moisture in amounts favorable to most crop plants. It reflects slope, infiltration capacity, moisture retentiveness and depth of the soil". Classes are very high, high, good, fair, low or very low.

fescue-dominant original plant community, three are classed as Chestnuts, one as Chernozem and one as Prairie. The Great Soil Group is a man-defined category of a system for classifying soils. Edaphic characteristics are used solely as differentiating criteria. Other environmental factors, such as microclimate, that strongly influence the kind of plant community locally, are not necessarily represented, according to current concepts, by edaphic characteristics. Therefore, a direct relationship between yield behavior and Great Soil Group should not be expected always. If it does occur, the local limitation of this relationship should be observed carefully.

Great Soil Groups do, however, generally reflect environmental conditions, both broadly and locally, that are expressed by yield behavior. For example, of the five soils that produce similar plant communities, the three classed as Chestnuts have lower potential production than the other two. The production potential of the Chernozem soil, Wrentham, lies between the Chestunts and the Prairie, as it should. The Chestnut soil, Condon, on which bluebunch wheatgrass dominates, has lower production potential than the Chestnut soils on which Idaho fescue dominates. The Brown soil has a lower potential than the soils that classify in the Chestnut group.

Thickness of yield curve, too, follows a logical pattern for these widely varying environmental situations.

Source of Data

The data from which yield curves are developed originate in soil-range site-range condition surveys of ranches that are made for conservation planning purposes. They are supported by carefully recorded notes taken during soil survey progress reviews and for special plots. Yields, estimated at the time of the surveys, are tabulated col- the surveys, are tabulated collectively for each range site and arranged according to range condition class. For example, the tabulation for the site represented by Figure 1 contains 172 samples taken from surveys made between 1949 and 1960 on seventy one cattle ranches representing about 400,000 acres in the Columbia Basin.

During the survey period, a reasonably normal range of weather conditions occurred, which are reflected in the tabu-

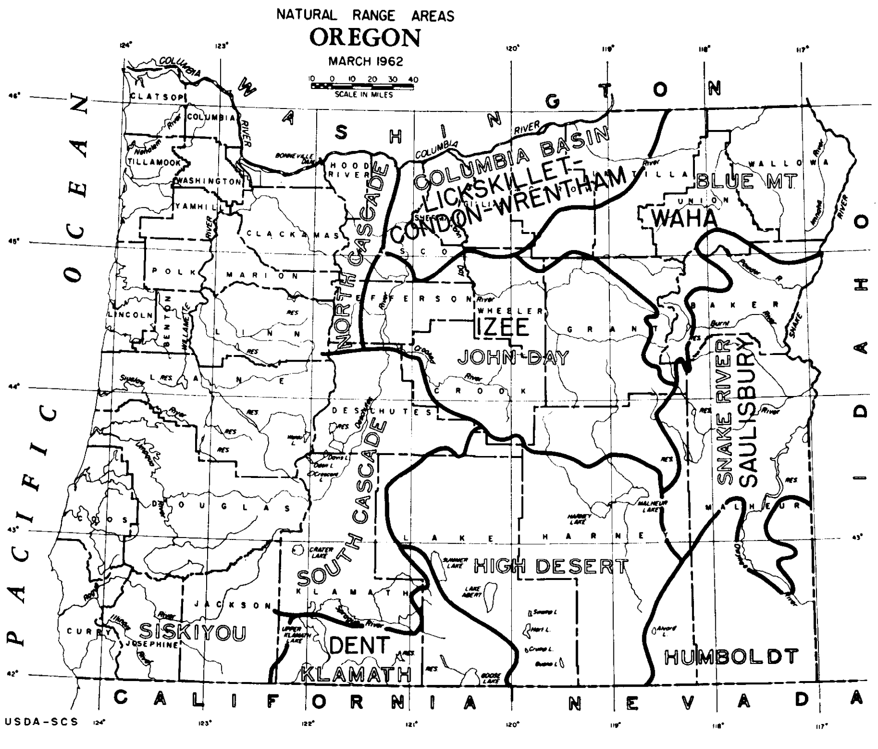

FIGURE 5. General location in which each of the seven soils cited occur in eastern Oregon and their relation to Oregon's natural range areas.

lated yields. Following is the precipitation for each year of the survey period averaged for twelve weather stations that represent the survey area.

Inches Precipitation

1959	1958	1957	1956	1955	1954
9.1	13.4	14.3	11.1	12.9	9.6

1953	1952	1951	1950	1949
14.6	9.1	12.1	15.5	7.8

For the survey period, the average for the twelve stations is 11.8 inches. The long-time average for these stations is 11.0 inches. Timeliness of precipitation, temperature, wind, sunshine and other important factors that influence forage production obviously are not reflected by precipitation records.

The many inaccuracies associated with estimated yield data, due to differences between people, varying standards, and so on, are acknowledged. Accuracy and statistical reliability of sampling is not implied herein. A relatively large number of recordings of estimated yield for each condition class and site, made by a variety of trained people over a widespread area and during a number of years, however, adds credence to the patterns of yield-behavior. The consistency with which certain fundamental yield-site-soil relationships have been repeated under widespread testing in eastern Oregon indicates reliability of certain principles that have been presented.