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The Improvement and Irrigation Requirement of Wild Meadow and Tule Land

By

W. L. POWERS AND W. W. JOHNSTON

CORVALLIS, OREGON

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*On leave of absence.

THE IMPROVEMENT AND IRRIGATION REQUIREMENT OF WILD MEADOW AND TULE LAND

SUMMARY

1. The work herein reported is a phase of the Oregon Soil and Soil Water Investigations carried on in cooperation with the U. S. Department of Agriculture. This report is published as a phase of Cooperative Soil and Soil Water Investigations provided for in chapter 350 Session laws 1919.

2. The wild meadow and tule lands of Eastern Oregon total over 515,000 acres, of which 355,000 acres are wild meadow land and 160,000 acres are tule land. The wild meadow lands comprise over one-third of the irrigated area of the State, and the control of irrigation and drainage and the substitution of cultivated forage plants for the native grasses and tules will add a great deal to the forage production of Oregon.

3. The chief vegetation on the peat swamps is tules and flags mingled with wire grass and sugar grass, while the chief meadow grasses are redtop, bluejoint, wire grass, and wild clovers.

4. The chief soil types are silt loam and peat.

5. These swamp lands are irrigated by wild flooding from sloughs and canals led along the contour lines. The water table is raised and sheet water is kept on the surface until a short time before harvest when part of it is removed by a crude system of drainage. The substitution of the strip-border method of irrigation and the installation of proper drainage will increase the productiveness of large areas of these lands and will make possible the substitution of more productive tame grasses and legumes than for the wild grasses.

6. The average monthly precipitation for the summer months during the past five years has been slightly below normal. The temperature has been slightly higher than normal. The evaporation for the five summer months has averaged about 33 inches.

7. In the Chewaucan Basin alsike and timothy have yielded 3⅓ tons an acre as compared to ¾ ton of native grass on adjoining land. The most economical yields per acre inch have been obtained with 12 inches of irrigation water. The maximum yields have been obtained with about 18 inches.

8. Alfalfa in Harney Basin has produced about 2 tons an acre, while native wild hay has averaged but ½ ton an acre. At the Harney Valley Branch Experiment Station 6 to 10 inches depth of irrigation has given the best results with row crops. Field peas and grain have done best with 8 to 12 inches, while with alfalfa the best results have been secured with 18 inches.

9. In the Klamath Basin a duty of 12 inches has been found most profitable when the soil is saturated in the spring. Large areas of swamp lands in this section can be reclaimed at a moderate cost.

10. In the Fort Klamath country the substitution of alsike clover and timothy for the native grasses has more than doubled the production of forage.

11. The results of the past five years show that an average depth of 18 inches of water on the field could produce the maximum yield now obtained. An average of 12 inches has given the largest yield per acre inch.

12. The average water cost of dry matter under good conditions for alsike and timothy has been 600 pounds. The water cost for wild hay has averaged 1000 pounds and over.

The coarse swamp vegetation can be replaced by pasturing and mowing, or by carefully burning off when the ground is still wet.

13. Oats and field peas are suitable crops for the first year or two after reclamation; later permanent alsike and timothy meadows can be established. On new land a moist, firm seed bed and inoculated clover seed are essential. The double corrugated roller is a good tool for firming peat soil.

14. Rye, sweet clover, and copious irrigation following drainage help to reclaim alkali spots. Gypsum or sulfur aids solution and removal of black alkali.

15. The strip-border method of irrigation has been found the most successful. Sub-irrigating from field ditches has been successful on medium and shallow peat when underlaid with a retentive subsoil.

16. Barnyard manure has given a good increase on shallow peat soils. Marked increases have been secured from application of sulfur to alfalfa on swamp borders.

THE IMPROVEMENT AND IRRIGATION REQUIREMENT OF WILD MEADOW AND TULE LAND

The work herein reported is a phase of the Oregon Soil and Soil Water Investigations carried on in cooperation with the U. S. Department of Agriculture. The Office of Biophysical Investigations of the U. S. Department of Agriculture cooperated in the water requirement experiments, and the Office of Irrigation Investigations in the duty of water experiments. This report is published as a phase of Cooperative Soil and Soil Water Investigations provided for by Chapter 350, Session laws 1919.

GENERAL DESCRIPTION OF THE REGION

(TABLE I)

Few definite data have been obtainable regarding the duty of water or improvement of swamp land and wild hay meadows. These lands embrace several million acres of the inter-mountain and great basin regions. More than one-third of the irrigated land in Oregon is wild meadow. There are now more than 350,000 acres of wild hay meadows

TABLE I. WILD MEADOW AND MARSH LANDS IN EASTERN OREGON. Main areas, approximate acreage.

Locality	Wild meadow acres	Tule land acres
Fort Klamath Basin	30,000	10,000
Big or Agency Marsh	50,000	30,000
Upper Klamath Lake		5,000
Lower Klamath Marsh, E. of R.R.		27,000
Lower Klamath Marsh, W. of R.R.		15,000
Wocus Marsh and Long Lake	2,000	5,000
Sprague River Valley	10,000	
Sycan Marsh	12,000	10,000
Chewaucan marshes	22,000	5,000
Sumner Lake Valley	5,000	
Pauline Marsh	10,000	1,000
Goose Lake Valley	16,000	
Warner Valley	20,000	17,000
Blitzen Valley	30,000	20,000
Malheur Lake		6,000
Harney Valley	54,000	4,000
Upper Silver River Valley	1,000	
Warm Springs Valley	5,000	2,000
Silver Creek Valley	5,000	
Jordan Valley	5,000	
Upper Malheur and tributaries	12,000	
Upper Crooked River	5,000	
Lower Crooked River and Ochoco	2,000	
Summir Prairie	15,000	
Upper Deschutes Valley	5,000	
John Day Valley	10,000	
Burnt River Valley	5,000	1,000
Grande Ronde Valley	7,000	2,000
Umatilla Valley	3,000	
Wallowa and Imnaha valleys	3,000	
Powder River Valley	12,000	
Total	355,000	160,000

alone, and including the swamp or tule land approximately half a million acres in Central Oregon is either producing native grasses for pasture and hay or is idle tule land. Much of this land is fertile and capable of great increase in productiveness through control of the water and seeding of more valuable forage crops; whereas the present practice tends to drown out the most valuable grasses. The chief areas of swamp lands are shown in Table I.

The chief areas of our wild meadow lands occur in large depressions in the great lakes district of south central Oregon. These depressions were caused either by faulting or by lava flows which interrupted the natural drainage, giving rise to a marshy condition. The average elevation of these lands is over 4000 feet above sea level and the growing season is therefore short, ranging from three to five months for hardy plants and from ten weeks to four months for ordinary crops. The average precipitation is about twelve inches. The meadows are watered largely by the run-off from melting snows in the mountains. There is a flood season and a season of low water. A system of wild flooding has been practiced for distributing the water over the wild hay meadows. This primitive method of irrigation has been persisted in throughout much of

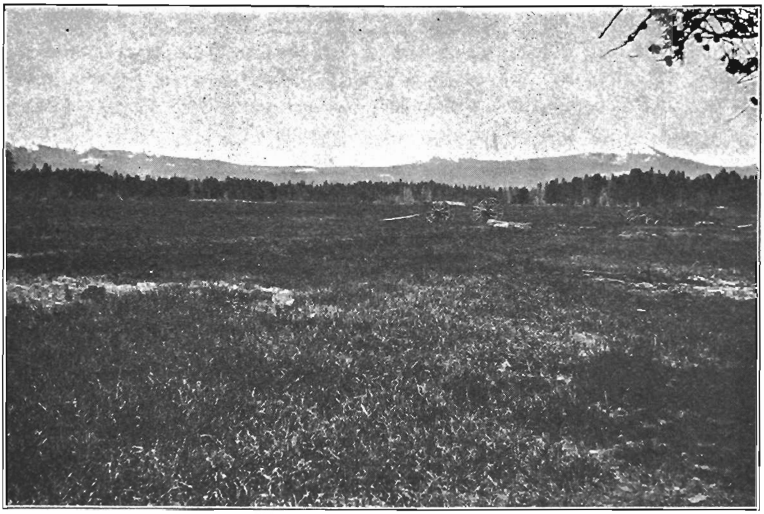


Fig. 1 WILD MEADOW IN THE FORT KLAMATH BASIN

the area due largely to the lack of transportation, large holdings of land, application of abnormally large amounts of water, and desire to maintain a low cost of production. Improvement of these lands will necessitate levees or outlet drainage ditches in places and better storage and control of the irrigation water so that it can be applied in periods. These improvements will make it possible to replace the wild grasses with more digestible, high yielding, domesticated clovers and grasses, and will afford a means of controlling the alkali.

Much difference of opinion has been found as to the proper duty of water for these lands. Development of these lands depends upon better control and use of water if the highest productive values are to be realized. A reasonable duty will need to be provided for each of the chief soil types on a basis of the yield and water requirement of important classes of crops rather than of one flat rate for a great valley. The amount of water affects estimates and final costs, determines the area it is possible to irrigate with a given supply, and has its effect upon the security of investment in irrigation and upon the ultimate agricultural and financial success of the project. It is better economy to provide only a moderately ample allowance of water with moderate-sized, reasonably-priced structures, than to provide a liberal supply at great expense and invite additional drainage assessments later, or deprive other arable land of water for irrigation. The State is concerned in these matters, for they have an important bearing upon its greatest ultimate development.

Vegetation. The chief vegetation of the peat swamps or lower areas is tules and flags mingled with wire grass and sedges, the latter (chiefly *Carex aquatilis*) being called "sugar grass." On the margins of the low swamps where the soil is medium peat and peaty loam, rice grass and wire grass intermingle with tules and flags in low spots. On the wild hay mea-

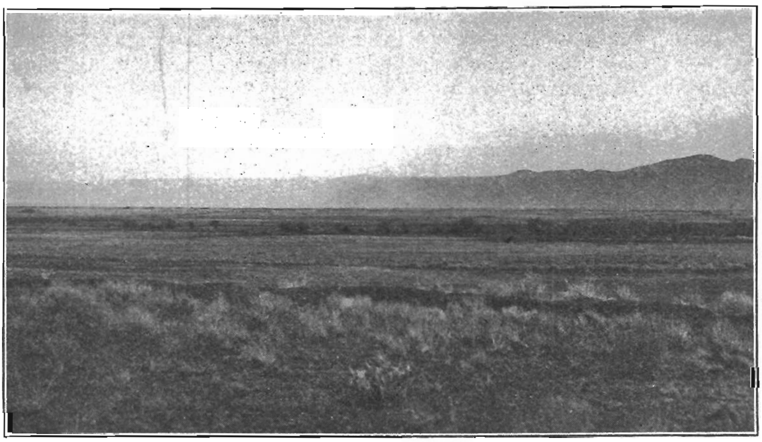


Fig. 2. GENERAL VIEW OF THE CHEWAUCAN BASIN

dows which are largely silt loam, the vegetation is chiefly redtop, bluejoint, wire grass, timothy, wild millet, and wild clover. On sub-irrigated areas the vegetation is chiefly bluejoint, blue grass, tall rye grass, and timothy. Still above the sub-irrigated areas on the hummocks are patches of salt grass, and clumps of "grease wood" (atriplex) occur on the low benches and on the valley floors in most of these lake basins. Outside of these are great areas of summer range land. The wild hay meadows are used for pasture or are cut for winter feeding of the range stock. A list is appended of grasses collected on Chewaucan Marsh. The grasses were submitted to an Oregon Agricultural College botanist for identification.

Soil Composition. (Table II.) Peat and silt loam are the two extensive soil types found in the wild meadow country. Much of the peat is of medium depth and underlaid with silty diatomaceous material which is rather chalky when dry. Below this chalky layer at a depth of five or six feet the soil is usually a medium sandy loam. Areas of deep peat occur in the lower parts of these areas toward the open water. At slightly higher elevations the peat layer becomes thin and an intermediate belt of peaty loam or muck soil occurs extending more or less continuously around the outer edge of the peat. The medium and deeper areas of peat soil show an acid reaction. The peat areas are more or less circular and in some cases partly surrounded by clay or mud flats interspersed with the peaty loam soil.

Typical silt loam in the wild meadows is a dark, deep soil, usually with a slight slope and somewhat better aerated than the swamp land proper. This type of soil is frequently found in deltas of streams entering swamps and is traversed by meandering sloughs with willows along the banks. Where drainage is fairly good the wild grasses and clovers form natural meadows on the land making a fairly good quality of hay, much better than the sedges which abound on the medium peat. This dark silt loam occurs in most of the valley floors in Eastern Oregon and probably throughout the inter-mountain region. Its composition has been found fairly uniform even in widely separated districts of Oregon and it forms one of the most desirable soil types in these wild meadow areas.

Fringing the silt loam an area of very fine sandy loam with wind-formed hummocks and a clay-loam subsoil is frequently encountered which is alkaline in character. Salt grass and grease wood occur in flats which are above the flood plain of the meadows and are not flushed by annual flooding. Alkali is likely to be drawn up from nearby land and accumulated on the higher spots or marsh rims, and it also is increased by the evaporation of water coming from higher slopes to the drainage basin. Where deep outlets are close at hand drainage and copious irrigation will reclaim all but the worst of these areas. In some cases, however, the areas are so flat, alkaline, puddled, and sticky that reclamation at present is not feasible.

Sage brush lands above and surrounding the areas already described usually have good drainage. Where a good growth of sage brush occurs the soil is usually a fine sandy loam and is desirable for irrigation. Better control of the water on the swamps will make it possible to reclaim large areas of these outlying, low, bench lands and will greatly aid the general development of the region. The composition of swamp soils is given in Table II.

Mechanical and chemical analyses from different swamps show that these dark silt loam soils are uniform in texture and of good fertility. Their usable water capacity is nearly two acre inches per acre foot under field conditions while for the peat it is nearly twice as great. In some cases the percentage of phosphorus is rather below average. The deep peat is often acid while the swamp borders are usually alkaline in reaction.

Irrigation and Drainage Conditions. The flood water is spread out over these swamp lands by wild flooding from canals led along the contour lines. The slough banks also are frequently higher than the surrounding land so that the water can be distributed from the sloughs by the use of dams and head gates. During the flood season the water

TABLE II. COMPOSITION OF WILD MEADOW AND MARSH LANDS, EASTERN OREGON

Soil type	Location: Valley	Location: Section	T	R	Fine gravel %	Coarse sand %	Medium sand %	Fine sand %	Very fine sand %	Silt %	Clay %	Analyzed by
Dark silt loam	Harney	W ½ 23	23	31	0.42	3.00	2.04	8.54	16.56	47.90	21.54	C. V. Ruzek
Dark silt loam	S. Werner	SW ¼ 27	39	24	0.38	3.64	2.88	8.42	20.22	48.08	14.85	C. V. Ruzek
Dark silt loam	Chewaucan	Goose L.	40	19	0.50	3.18	2.62	10.26	10.10	50.86	22.70	J. E. Cooter
Peaty silt loam	Harney	21	25	32	3.06	8.30	5.48	7.38	6.64	39.46	19.68	C. V. Ruzek

Chemical Analyses

Soil type	Location: Valley	Section	T	R	Total Phos. (K_2O) %	Total Potas. (P_2O_5) %	Total N %	Lime (CaO) %	Total Alkali Subsoil	Acidity or lime reqt. lbs. per A. ft.	Loss on Ignition	Analized by
Silt loam	Harney	W ½ 23	23	21					0.037			H. V. Tartar
Silt loam	Grande Ronde				0.93	0.22	0.32		0.45			H. V. Tartar
Silt loam	Goose Lake	1	40	19	0.60	0.13	0.12	3.4	.004			H. V. Tartar
Med. peat	W. Klamath	Lake W Shore			0.96	0.28						H. V. Tartar
Med. peat	L. Klamath	17	40	7		0.304	1.369				24.18	J. E. Pittman
Deep peat	Grande Ronde									538		H. V. Tartar
Deep peat	S. Warner	5	40	24	0.76	0.28	1.35			5500		H. V. Tartar
Below are strong acid analysis:												
Deep peat	L. Klamath	Ave. of ten anal.			0.24	0.22	1.10	4.12			43.90	H. W. Heileman
Peaty silt loam,	Agency Marsh	Ave. of ten anal.			0.04	0.05	0.65	.35	None		.55	H. W. Heileman
Peaty silt loam,	Agency Marsh	Range of 55 anal.			.01-11	.01-.12	.03-1.53	.01-.73			8. to 51.	H. W. Heileman

table is raised to the surface and sheet water extends over large areas. In some places drainage canals are later provided to remove the greater part of the excess and permit drying out of the land for haying and winter pasture. Few levees or ditches control the water, and thousands of acres in some cases are irrigated from one outlet. Measurements and statements made by the farmers during the past four years indicate that the average yield of native grasses on the wild meadows will not exceed three-quarters of a ton of native hay an acre. Where the flood water can be controlled it is believed the strip-border method of irrigation will be suitable for large parts of this wild meadow land. It has been tried with success on meadows under investigation. With this method the water can be more evenly applied in periods and the soil permitted to warm up and aerate between applications.

Drainage usually precedes irrigation on the tule lands. A drainage canal about sixty feet wide and twenty-five miles long has been constructed in Blitzen Valley. In Chewaucan Marsh a large drainage canal

Fig. 3. Wild meadow grasses vs. alsike clover and timothy grown in tanks with different amounts of irrigation to determine their relative water requirements

of similar length has been constructed. In the Klamath Basin the construction of levees along the lakes and Klamath River has been the first step toward reclamation. In some cases channels have been built to conduct inflowing streams across the marsh to the open water of the lakes.

Weather and Evaporation. (Table III.) Weather data have been compiled from U. S. Weather Bureau and Harney Valley Branch Experiment Station records to show the seasonal conditions and departure from normal (Table III). The evaporation from a free water surface is regarded of importance as showing the combined effect of the drying influences of the weather elements. Evaporation data at the Harney Valley Branch Experiment Station were obtained from a Brigg's soil pan, while the records from Klamath are from a Weather Bureau type

TABLE III. WEATHER CONDITIONS

	Rainfall May	June	July	Aug.	Sept.	5 mos. ave.	Dept. from normal	Temperature May	June	July	Aug.	Sept.	5 mos. tot. ave.	Dept. from normal	Evaporation May	June	July	Aug.	Sept.	Tot. evap. 5 mos.
Burns	in.	in.	in.	in.	in.	in.								in.	in.	in.	in.	in.	in.	in.
1915	.94	.40	.90	.06	.04	.47	— .10	50.4	58.1	64.9	73.4	61.5	61.7	+4.8	4.971	7.714	8.820	9.036	5.871	36.412
'16	.72	.98	.84	.33	.13	.60	+ .03			No Record					4.649	6.915	8.342	7.383	5.948	33.237
'17	.80	.33	.19	.04	.89	.45	— .12	51.1	56.9	72.2	70.0	58.6	61.8	+4.9	5.226	7.895	10.190	8.140	5.257	36.708
'18	.32	.92	.37	1.25	1.50	.87	+ .30	50.1	68.8	68.0	63.4	61.5	62.3	+5.4	7.186	8.611	8.657	7.252	4.674	36.380
'19	.00	.00	.25	.00	2.57	.56	— .01	55.4	61.4	71.6	69.0	57.8	63.0	+6.1						
Average						.59	— .02						61.7	+5.3						35.684
Paisley																				
1915	1.72	.23	1.56	.06	.08	.73	No normal	48.6	57.1	63.8	70.8	56.0	59.3							
'16	1.11	.28	.37	.66	...	.58		46.6	56.	62.5	65.6	58.3	57.8	No normal	5.090	5.360	6.470	5.620	.....	22.540
'17	1.02	.47	**	.29	.64	.48		47.4	58.2	71.6	69.2	61.4	61.6		4.595	7.714	8.815	9.014	5.841	35.979
'18	.50	.31	.24	.06	1.77	.58		51.4	69.6	70.2	64.3	60.2	63.1		5.800	15.400	9.920	7.750	3.790	42.660
'19	.05	.13	...	...	...	.09		55.4	60.2	....	....	....	60.45							
Average						.49														33.73
Klamath																				
1915	1.72	.00	.62	.10	.12	.51	— .11	50.2	59.3	65.8	72.2	57.8	61.1	+ .2						
'16	.55	.75	1.57	.02	.00	.58	— .04	48.2	59.1	64.0	66.3	61.4	59.8	—1.1						
'17	.73	.03	**	.46	.52	.35	— .27	49.4	60.6	72.2	70.0	60.2	62.5	+1.6			9.440	7.550		16.990
'18	.12	.08	.26	.09	1.85	.48	— .14	51.7	68.2	66.0	64.6	62.0	62.5	+1.6	5.160	6.610				11.770
'19	**	.47	.17	**	.66	.26	— .36	56.0	60.8	70.0	67.7	59.6	62.8	+1.9						
Average						.436	—.184						61.7	+ .8						
Tule Lake '18															5.550	6.060	6.130	6.580	3.830	28.150

*4 mos. only. **2 mos. only.

of pan and floated on water. The Paisley record was obtained from a soil pan two feet in diameter. A comparison of these pans (Brigg's, Weather Bureau, and Paisley), was made at Corvallis in 1917. The losses from April to October were 23.593, 28.842, and 29.71 inches respectively. Using the loss from the Brigg's tank as 100, the Weather Bureau tank lost 122% and the smaller soil pan 125% of that of the Brigg's tank.

PLANS AND METHODS

The plan followed in these studies has been to work under field conditions as far as possible.* Small plots and soil tanks have been used to check the field experiments with tests that permit more absolute control. Reconnaissance soil surveys where necessary have been made to enable the experiment fields to be located on leading soil types. The cylinder method has been used to measure the field moisture capacity of soils employed. Physical and chemical analyses have been secured and the humus content and critical moisture points of soils used has been determined. It was realized that topography, evaporation, rainfall, the growing season, irrigation season, and time and frequency of irrigation would have a bearing on the problems. It was planned to determine an economic duty of water for each of the chief soils and according to the proportion and requirement of each important class of crops for the average yields, under good, practical methods of farming.

Soil-moisture determinations have been made at time of emergence, before and after irrigation, and at harvest time to permit determination of the water cost of dry matter produced and to learn the range of moisture under field conditions.

The aim has been to determine the **economic duty** of water, that is, the quantity that will give the greatest net profit an acre; for this will generally be the limit of profitable economy under present conditions in Oregon. As water becomes very valuable in places the net profit an acre foot will become of increasing importance.

Water requirement of crops under field conditions has been given much attention in connection with this work. Water requirement refers to the total pounds of water including soil, rain, and irrigation water consumed per pound of dry matter produced. The total water requirement has also been reported in acre inches of total water consumed by crops. This item is regarded of great value in determining the irrigation requirement.

Irrigation requirement is used to refer to the portion in inches of the total water requirement that it is necessary, under good modern methods of irrigation farming, to furnish artificially as irrigation.

The basic plan used in this work and devised by Mr. Bark† consists in dividing a typical field crop into three parts. The owner applies to one part his usual irrigation in a quantity which, in his judgment, will produce the best yield. The field agent in charge then assists in applying by the same method a larger amount to a second part, and a smaller

*Powers, W. L.—The Economical Use of Irrigation Water. Oreg. Agric. Col. Exp. Sta. Bul. 140. January, 1917.

†Bark, Don H.—Experiments on Economical Use of Irrigation Water in Idaho. U. S. Dept. of Agric. Bul. 339. 1916.

amount to a third. By weir measurements of water applied and wasted, and determination of the yields at harvest time a fairly accurate conclusion can be drawn as to what amount of water pays best under the conditions. Frequently a fourth portion of the field has been treated with manure or some simple fertilizer deemed advisable, or has been irrigated by some other promising method of distributing water. In some cases more promising crops and crop varieties have been introduced where it was thought more economical returns from the water could be secured thereby. Wherever possible the experiments are carried through a series of years and the value of rotation of crops noted.

In Klamath Basin the quantity of storm water pumped out as drainage from diked areas of several hundred acres at the beginning of the season and the amount of subsequent irrigation water pumped in have been measured and analyzed. Water table and alkali studies have been included in the work.

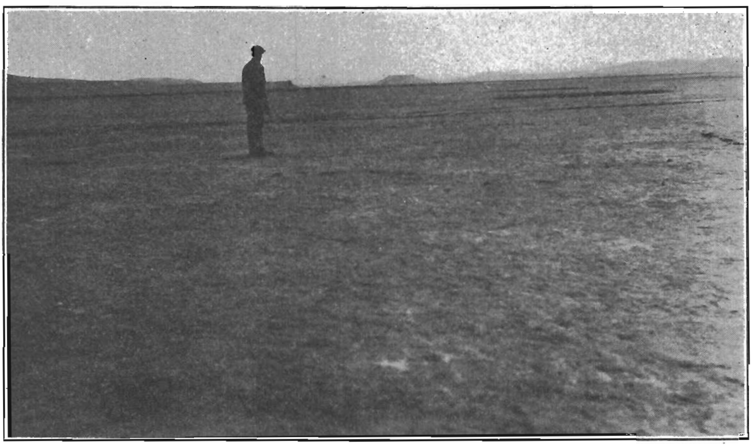


Fig. 4. BED OF MALHEUR LAKE, OCTOBER, 1919

FIVE-YEAR FIELD EXPERIMENTS WITH SWAMP AND WILD MEADOW LANDS

Field and tank experiments have been conducted on the wild meadow and tule lands during the past five seasons. Data have been secured in Chewaucan, Harney, and Klamath basins. The location of these experiments has been described in detail in a previous report.* Only the more essential features bearing on these experiments in relation to the development and irrigation requirement of the different regions are given in the present report.

Experiments in Chewaucan Valley. (Table VIIa-c.) Chewaucan Basin, located in central Lake county, at an elevation of 4300 feet, has an area of about 28,000 acres. The rainfall is perhaps 12 inches a year. Medium peat is the chief soil type below the meander line.

*Powers, W. L. The Economical Use of Irrigation Water. Oreg. Agric. Col. Exp. Sta. Bul. 140. January, 1917.

Fig. 5. TULES ON MEDIUM PEAT SOIL, CHEWAUCAN BASIN

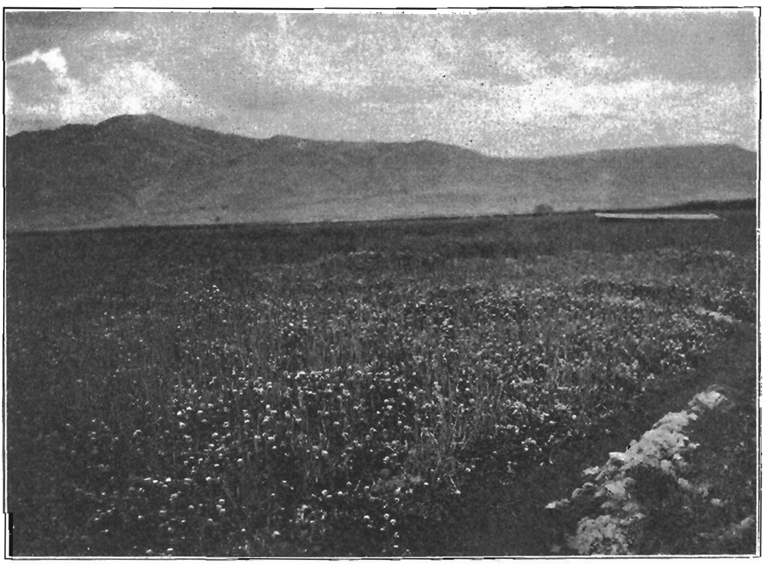


Fig. 6. Alsike clover and timothy on diked experimental area, Chewaucan Basin, This tract yielded 3 1/3 tons an acre besides affording fall pasture, when the adjoining wild meadow yielded 3/4 ton an acre, 1915

Above this line smaller areas of peaty loam, dark silt loam, and brown sandy loam occur. On the terrace north of Paisley the higher portion is coarse sand with gravel in the deep subsoil. Farther north at a little lower elevation is a considerable area of medium sand. Sedges predominate on the swamps while wire grasses are common on the swamp border. Measurements indicate a yield of ¾ to 1½ tons of swamp hay an acre. Chewaucan River enters the swamp near Paisley and is spread out over the surface by dams and marginal ditches. This excess is later removed by means of a drainage ditch through the trough of the area.

Experiments were conducted in Chewaucan Basin for three seasons beginning 1915. In these experiments alsike clover and timothy yielded 3⅓ tons of hay when the surrounding land yielded ¾ ton of wild hay. The former was more nutritious feed and afforded better fall pasture. The most economical yields per acre inch of water have been obtained in this swamp with the use of 12 acre inches an acre, while the maximum yield has been obtained with 18 inches depth an acre for the season. Allowing 25 percent for loss in distribution this would give a duty of 16 to 24 acre inches an acre delivered to the farm unit.

It is believed that it will be to the best interests of the swamp land owners to have the water stored and applied in periods and gradually to replace the native growth with domesticated grasses and legumes. The excess water can then be used to develop the finer textured areas of sage-brush lands south and north of Paisley. A drainage ditch is needed leading along near the meander line below Paisley and then out to the center canal to aid in flushing alkali in the vicinity of the meander line down and out of the land.

Experiments in Harney Basin. (Table VIIIa-f.) The mean elevation of Harney Valley is 4125 feet and the annual precipitation 8 to 10 inches. About 60,000 acres is irrigated by a crude system of flooding. The soil type on most of this area is silt loam with chalky sub-strata in places, and then medium sand at a depth of 5 to 8 feet. There is a little peaty silt loam in the lower valley where tules and flags occur. Vegetation on the silt loam is native meadow, which is made up of about the same grasses as occur on the silt loam of the Chewaucan Valley. The black sage land east of the flooded valley, which it is possible to reach by water, is mainly brown, very fine, sandy loam, with a smaller area of fine sand. The report of the soil survey made of this basin for the Reclamation Service contains a soil map and a general description of conditions. In addition to natural meadows, a small amount of grain and alfalfa is grown, the grain yields running from 15 to 80 bushels an acre, and the alfalfa yields from 2 to 5 tons. The average yield of wild hay for the whole flooded area will not exceed ½ ton an acre. The average 8 months' evaporation in Harney Valley is about 42 inches. The growing season is short, with light frosts which may occur any month. Conditions are suitable for only hardy grain and forage crops. The irrigation is of the crudest kind, being applied from sloughs by means of dams, dikes, and ditches in a very irregular way. More field laterals and levees are needed and later strip borders to permit irrigation by periods, which is possible only when water can be stored and controlled.

The experiments at the Harney Valley Branch Experiment Station are under conditions similar to the meadow land and include variety trials and crop rotations under irrigation. The value of manure, crop rotation, and fertilizers is also included, in connection with elaborate water variation experiments where there are duplicate plots.

Compilation of results for the season of 1919 is not completed. Superintendent Shattuck reports, however, that 15 inches depth of irrigation for the season gave the largest yield of field peas, or 36.5 bushels of seed and 3.35 tons pea hay an acre. The largest yield of half sugar beets, 10 tons an acre, was secured with 15 inches total depth of irrigation for the season. These irrigations were applied too late to get the most economical returns. The largest yield of alfalfa, 5 tons an acre, was secured with a total depth of 13½ inches of irrigation for the season.

Experiments for the four-year period strongly indicate a proper duty of water for cultivated crops to be 6 to 10 inches depth, while for field peas and grain it runs 8 to 12 inches and for alfalfa about 18 inches.

Fig. 7. Alfalfa. Harney Valley Branch Experiment Station, arranged for strip-border method of irrigation. Plots receiving 13½ in. total depth of irrigation yielded 5 tons an acre, 1919

These returns correspond very closely with estimates of irrigation requirement previously made for these crops in the Harney report.* It appears from these trials that where land values are to be placed on an alfalfa basis so that no less than 50 percent of the area is in this crop, an average duty of not less than one acre foot an acre will be required. The experiments indicate the possibility of securing somewhat larger yields of alfalfa than previously, and in the case of alfalfa 18 inches depth will probably be required to supplement the precipitation where a four-ton yield is obtained, unless the crop can utilize moisture from the water table which occurs at a depth of 8 to 12 feet over considerable areas. Irrigation may wet down through the compact subsoil and establish capillary connection with the moist zone below so as to lessen the irrigation requirement.

*Whistler, J. T., Lewis, I. H., et al.—Harney and Silver Creek Projects. U. S. Reclamation Service. 1916.

In Harney Basin there is more good arable land than there is water to cover and a fairly high duty will be in the interest of the greatest development; it will secure the greatest crop-producing power for the quantity available, especially on the black sage lands. Storage and control of the water should make it possible to double the productiveness of the wild meadows and to raise legumes thereon. Alfalfa is easily established and with water controlled should replace much of the wild hay. The Harney report places the additional lands it is possible to irrigate at thirty to forty thousand acres. The most accessible and desirable lands for such use are situated in the black sage area surrounding the Harney Valley Branch Experiment Station. Other small areas can be developed by storage and use of numerous streams entering the north part of the valley and below which irrigable lands occur. Considerable areas are underlaid by a water table and can be reclaimed by pumping. Data at hand show pumping on alfalfa to be profitable at the Harney

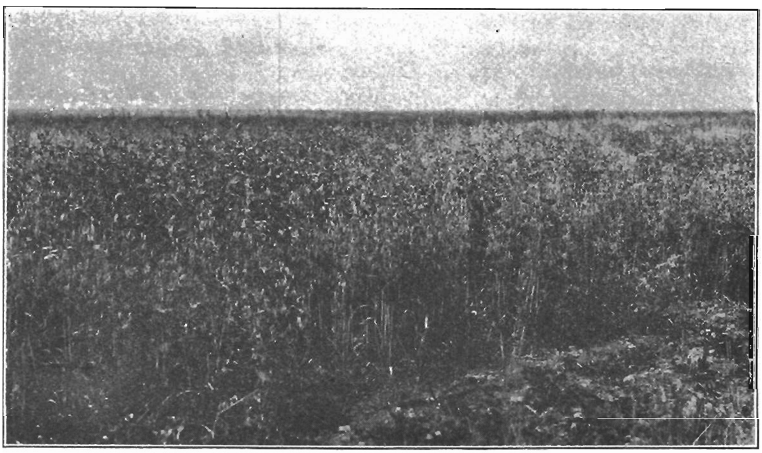


Fig. 8. Field peas and oats. A good first crop for reclaimed swamp land. View on experimental tract near Keno, 1918. This crop yielded 4 tons an acre.

Valley Branch Experiment Station under present conditions. Pumping from driven wells is a promising method of irrigation in different parts of Harney Basin where gravity water cannot be secured, and an electric power line that would provide energy at reasonable rates should stimulate development along this line and improve the lighting in the towns of the valley as well.

Experiments in Klamath Basin. (Table IXa-c.) The Klamath Basin is situated in the south central part of Klamath county and extends into California. It has an average annual precipitation of fourteen inches, the larger part of which comes in the form of snow during the winter months. Due to the presence of large areas of open water and to the high hills which surround this region, the relative humidity is somewhat higher than it is in the Harney or Chewaucan valleys. The average altitude is 4100 feet. The chief soils of the swamp areas in the vicinity of Klamath Falls are deep and medium peat, with some muck and clay adobe on the borders. These soils are underlaid with a layer of dense, chalky silt muck, with medium sand underneath.

The natural vegetation on the peat soils consists almost wholly of coarse tules, while on reclaimed areas alsike and timothy, redtop, and grain hay are produced. Experiments also indicate that beets, potatoes, celery, and other of the hardier vegetables will do well on these soils. On the borders of these swamps and on most of the Fort Klamath area native grasses such as wire grass (*Juncas balticus*) and sugar grass (*Carex aquatilis*) grow in the native state.

Some preliminary studies were made in the Klamath Basin during 1916. An area of 460 acres of medium peat soil five miles north of Klamath Falls is enclosed with 1½ miles of dikes three feet in height, having a ten-foot top and a thirty-foot base. A drainage ditch on the low part of this area leads excess water and seepage to a pumping plant by which it is pumped out into the lake. This pumping plant operates about two weeks in the year. There is practically no seepage through the dikes during the growing season, and previous to 1916 irrigation had been found to be helpful. During 1917 and subsequent seasons field and tank experiments have been conducted on this and on a similarly diked area in lower Klamath Basin to determine the duty of water for these lands. The results indicate that where the soil is not drained until spring and is therefore saturated at the beginning of the growing season, one acre foot per acre should be sufficient for the most profitable crop production on these soils. This figure is based on the assumption that most of the land would be used in the production of tame grasses and legumes, and it has been made large enough to allow for considerable wastage in irrigating. In the experiments conducted 9 inches depth of irrigation water has given the largest and most profitable yields with alsike and timothy. Row crops have required from 6 to 10 inches and the best results with grain hay have been secured with a single irrigation of 4 to 6 inches applied when the crop was in the early boot stage. Tank experiments with native grass show that this crop requires from 1 to 24 inches for maximum production; 12 to 16 inches of water under similiar conditions applied to tanks of alsike clover and timothy have produced on the average over 4 times as much forage as the wild hay with the heavier irrigation. The detailed data are appended in Table IX.

Both the experimental work conducted and observation of the results obtained by farmers indicate that the reclamation of large areas of tule land in Klamath county is feasible and desirable from an agricultural and economic standpoint. In a number of these swamps reclamation is most attractive on the borders, due to more serious alkali drainage and soil conditions in the lower portions of these areas.

The experiment station assisted several farmers in establishing clover and timothy meadows in the Fort Klamath country in 1912. Since that time several thousand acres of wild hay land have been seeded to this crop. Statements of farmers indicate that the average yield of alsike and timothy in this section runs about 2½ tons to the acre, while the yield of wild hay does not exceed 1 ton an acre.

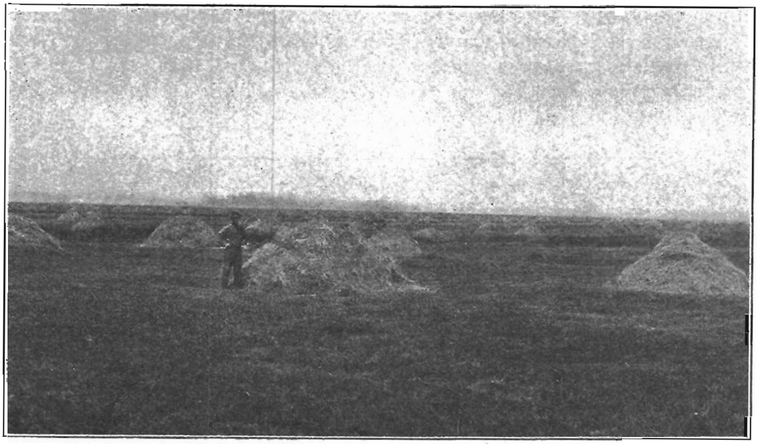


Fig. 9. WILD MEADOW IN FORT KLAMATH. YIELD, 1 TON AN ACRE

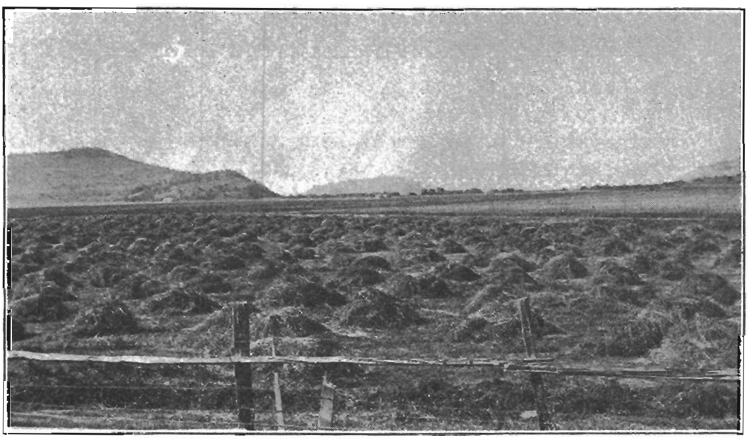


Fig. 10. Alsike clover and timothy on reclaimed tule land, Upper Klamath Lake, Yield 3½ tons an acre

TABLE IV. COMPOSITION AND AMOUNT OF DRAINAGE WATER KLAMATH 1917

Tract	Area	Total drainage Amount	Depth	Total salts removed Ave. parts per million	Per acre in.	Per acre
	acres	A. in.	in.		lbs.	lbs.
McCornack	500	2509.64	4.83	311.00	183,303	399.45
Nelson	800	1672.00	2.09	306.00	115,632	144.54

In 1916 the gross amount of water pumped for irrigation purposes on the McCornack tract was approximately 10 acre inches per acre. In

1919, 138 acre feet were pumped, this amount being used on approximately 175 acres. In 1919, 140 acre feet were used on approximately 130 acres of the Nelson tract. This amount represents the gross use without corrections for wastage. In the spring of 1919, 99.44 acre feet of drainage water was pumped from the Nelson tract. Attention is called to Figs. 15, 16, and 17.

Fig. 11. Alsike and timothy (left) vs. wild grass (right) at time the wild hay was cut. Alsike and timothy here yielded 4 times as much with about the same water.

IRRIGATION REQUIREMENTS OF WILD HAY MEADOWS AND TULE LANDS (Five-Year Summary, Table VIII)

Proper Field Duty. The results obtained during the past five years show that an average depth of 18 inches of water on the field could produce the maximum yields secured at present, or a little more than the most profitable yields of hay crops on the swamp lands. The greatest yield of wild hay per acre inch has been secured frequently with a net use of 12 inches depth of water an acre. The yield per acre inch becomes more important where water is limited and the land area available for irrigation is in excess of the water supply. In such cases it is more important to use tame grasses which require less water to the pound of dry matter produced. A small portion of these wild meadow lands can be cultivated, using hardy grain crops and row crops with some rotation and an occasional loosening up of the soil to give a better distribution and more efficient use of the water. The quantity of flood water pumped from two diked tracts in Klamath county ranged from none to 3½ acre inches an acre, while the quantity pumped on for irrigation later in the season ranged from 6 to 12 acre inches. From the quantities pumped on and off these diked swamp areas, containing several hundred acres in each case and fairly free from sub-irrigation, it would seem that where some excess water is to be drawn off at the beginning of the growing season, leaving the soil in a very moist condition, it would not be necessary to apply more than 12 acre inches an acre as supplemental irrigation later in the season. Under this condition a pumping plant serves a dual purpose. Analyses show that an appreciable quantity of alkali is removed in this irrigation and drainage process. The supplemental irrigation late in the season provides a favorable moisture condition for the feeding roots in the surface soil layers where the most available plant food is to be found and forces growth during the best growing weather. It also serves to some extent as a protection

TABLE V. FIVE YEARS TRIALS ON SWAMP LANDS IN EASTERN OREGON.

Valley	Crop	Soil	Best return per unit water		Maximum yield per acre	
			Water applied	Yield per A.	Water applied	Yield per A.
A. Field Trials, Summary 1915			in.	tons	in.	tons
Chewaucan	Marsh grass	Peaty loam	11.28*	1.030	11.280	1.030
Chewaucan	Marsh grass	Loam	6.60	.730	6.600	.730
Summary 1916						
Chewaucan	Marsh grass	Silt loam	5.75	.570	26.200	.600
Chewaucan	Marsh grass	Medium peat	8.50	1.245	19.200	1.940
Harney	Marsh grass (Sub-irrig.)	Silt loam		*2.178	Sub-irrig.	*2.173
Harney	Marsh grass (Sub-irrig.)	Silt loam		*2.613	Sub-irrig.	*2.613
Harney	Marsh grass (Sub-irrig.)	Silt loam		*1.960	14,000	2.841
Summary 1917						
Chewaucan	Marsh grass	Medium peat	3.00	.945	27.900	1.030
Klamath Basin	Alsike and Timothy (Sub-irrig.)	Deep-peat		3.000	6.500	3.400
Klamath Basin	Sugar beets (Sub-irrig.)	Deep-peat				
Summary 1918				10.000	3.340	12.000
Klamath Basin	Alsike and timothy	Med. peat	6.20	2.672	9.600	3.706
Klamath Basin	Grain hay (Oats and barley)	Med. peat	5.42	1.070	5.420	1.070
Ave. Field Trials			6.68	1.180	10.648	2.946
B. Tank Trials—Summary 1915			in.	grams	in.	grams
Chewaucan	Marsh grass	Med. peat	4.00	94.00	26.475	125.000
Summary 1916						
Chewaucan	Marsh grass	Med. peat	16.00	56.73	32.000	69,360
Harney	Marsh grass	Silt loam	4.00	72.40	6.000	81.300
Summary 1917						
Chewaucan	Marsh grass	Med. peat	33.48	215.90	33.480	215.900
Klamath Basin	Wire grass	Med. peat	20.00	100.50	20.000	100.500
Chewaucan	Alsike and timothy	Med. peat	3.07	65.00	8.490	117.800
Klamath Basin	Alsike and timothy	Med. peat	11.00	89.20	17.000	103.600
Summary 1918						
Klamath Basin	Sugar grass	Med. peat	6.00	18.50	17.000	39.750
Klamath Basin	Alsike and timothy	Med. peat	13.00	47.00	13.000	47.000
Summary 1919						
Klamath Basin	Wire grass	Med. peat	8.00	32.56	16.000	42.180
Klamath Basin	Alsike and timothy	Med. peat	8.00	145.00	29.500	246.000
Average tanks			12.59	85.67	19.900	108.360
Ave. tanks and field			10.59		16.810	

*Not included in average.

against fire on the peat marshes in extremely dry seasons and keeps any alkali salts distributed through the soil. The irrigation requirement is a little greater on the silt loam than on the peat.

Absolute Duty. The average water cost per pound of dry matter for alsike and timothy grown on these meadows under good conditions averaged about 600 pounds per pound of dry matter, while for native or wild grasses it runs from 1,000 pounds per pound of dry matter upward. The average yield of wild hay is about ¾ of a ton an acre, whereas the alsike and timothy has averaged about three tons an acre, or has given twice the yield with about half the water commonly used on the wild hay land. In the Klamath region, about 5,000 acres of wild meadow lands have been converted to alsike and timothy fields and are producing twice as much forage and of a higher quality than was formerly secured.

Gross Duty on Wild Meadows and Similar Projects. Measurements made by agents of the State Engineer's office and the U. S. Geological Survey to gauge the gross amount of water flowing onto and wasting off from several of the large meadow areas of the State, show approxi-

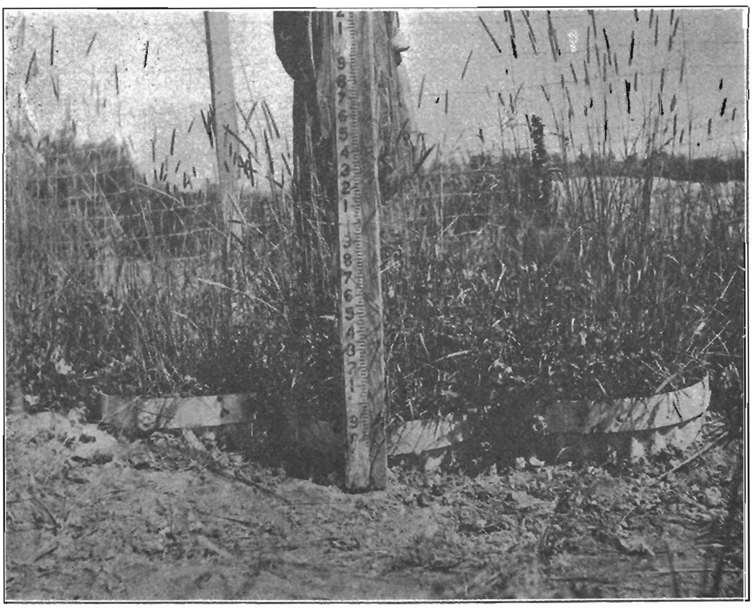


Fig. 12. WATER VARIATION TRIAL WITH ALSIKE AND TIMOTHY IN TANKS. The middle tank received 16 inches total depth of irrigation and yielded nearly as much as the maximum tank which received 29 inches

mately the amount of water consumed on these lands. It will be noted that the average amount of water retained is less than 1½ feet depth an acre. A small amount of water was received onto the marshes which could not be measured.

TABLE VI. GROSS DUTY ON WILD MEADOWS

Meadow	Area	Amount consumed	Amount an acre	Year
	acres	Acre ft.	Acre ft.	
Chewaucan	20,538	31,390	1.52	Jan. 19 to July 1, 1914
Lower Chewaucan	7,792	10,760	1.38	Jan. 19 to July 1, 1914
Harney Valley	61,000	81,770	1.34	Approx., 1912
Klamath project	25,000	5-yr. av.	1.30	1908 to 1912
Klamath project		6-yr.av.	1.12	1912 to 1918

Drainage. Drainage is the first step in the development of tule lands. Large outlet ditches have been dredged through the Blitzen and Chewaucan areas, while in the Klamath section diking and some pumping are often required. In Klamath Basin during the year 1917 the storm water was pumped out at the beginning of the season from two diked areas of several hundred acres each. Irrigation water was pumped on later in the season. This water was measured and analyzed, and an appreciable amount of alkali was removed by this process. Under the climatic conditions peat lands are readily protected from excess moisture, and an extensive system of interior field drainage is not required. Under some conditions an open ditch every five hundred feet may be desirable. As the peat decays some deep drains at frequent intervals may come to be profitable. Good crops are being raised on marshes up to one thousand acres in area where only a center drainage ditch is provided,

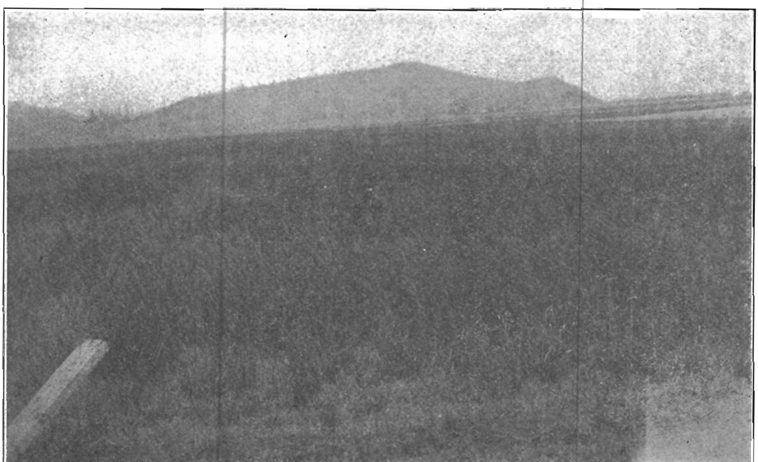


Fig. 13. Heavy growth of alsike clover and timothy on reclaimed tule land near Upper Klamath Lake

leading the surface water left from winter precipitation to a pumping plant, where when necessary it is lifted over the dike. On the wild meadows better control of irrigation is the first step in improvement. Along the tule marshes drainage is of first importance.

In planning a drainage system numerous deep borings and a few test pits may be necessary. The water table will fluctuate considerably during the irrigation season so that a number of carefully located observation wells will be helpful. An average depth for drains in irrigated lands is six and one-half to seven feet, while the spacing is relatively greater than in rainfall farming.

Subduing the Land. Following drainage the rank mass of tules can be removed by burning off when dry and while the soil below is still moist enough not to be burnt out. Burning off the tules provides a little available plant food and tends to overcome any rawness or sourness of the soil. It must be carefully done to avoid injury. The first year the plowing should be of only moderate depth. To aid decay the furrows should be turned over almost flat. A wide plow and the caterpillar tractor have been used with success on these lands. A corrugated roller has been found valuable for firming these marsh soils to secure good germination.

Choice of Crops. Oats for hay will usually be the first crop, or before seeding down to meadow, oats and field peas may be grown one or two years to subdue the sod. These crops yield three or four tons an acre. As a permanent meadow mixture which has been successfully used alsike and timothy is recommended. This crop is not difficult to establish where a firm, well prepared seed bed is provided and where good inoculated seed is used. The practice of seeding without a nurse crop and keeping the ground moist during germination has been most successful. This crop yields on trial an average of about three tons

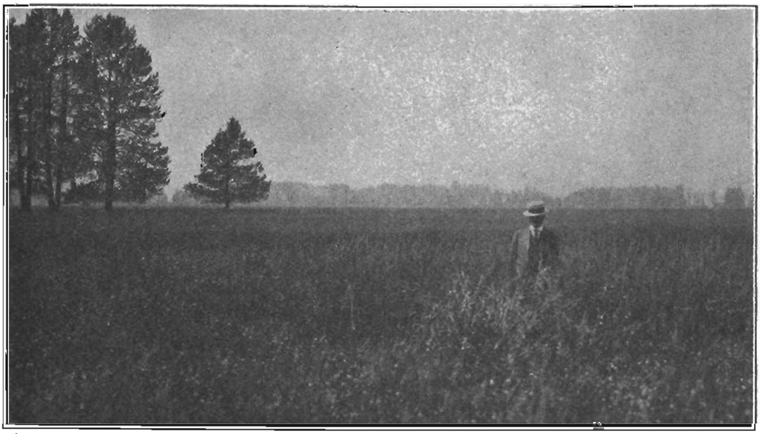
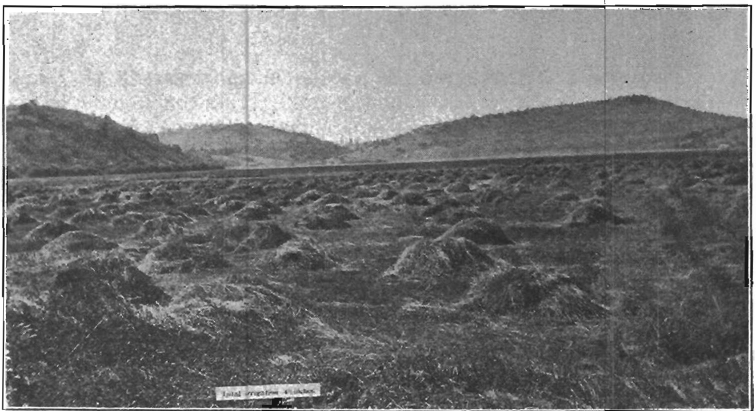


Fig. 14. A 3-TON CROP OF ALSIKE CLOVER AND TIMOTHY, FORT KLAMATH BASIN

of hay an acre and affords additional late pasture. On low-lying meadows unsuitable for clover, redtop and timothy can be harrowed in and established without plowing up. Some improvement can be had in this way until better drainage and control of water can be provided. On the best quality of wild meadows some clover has been established together with timothy by feeding out timothy and clover hay on the land. The best wild meadows should be the last to be plowed up and reseeded as they are fair producers and not so badly in need of leveling. Clover will remain in the meadow more permanently where the water table is kept down below the level of the bulk of the root system. In much of this peat soil under field conditions capillary action tends to bring moisture to the surface at a distance of 24 to 30 inches above the water table. The water table should be at a distance of at least 2 feet below the surface during most of the growing season. This water should not be stagnant. With good drainage and control of irrigation alfalfa can



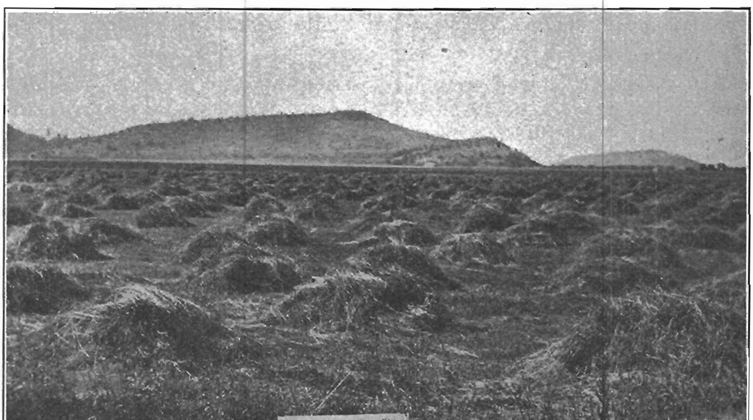


Fig. 15. Light irrigation 5 inches total depth. Fig. 16. Medium irrigation 6½ inches total depth. Fig. 17. Heavy irrigation 9 inches total depth. Water variation trial near Upper Klamath Lake, 1919.

be grown on much of this area. Since the meadow should be renewed or renovated every few years, something of a rotation should be practiced. Where the climate permits a reasonable chance of its maturing some small grain should be grown each year for seed.

Alkali Control. Lands known to be injuriously alkaline should be provided with drainage at the same time irrigation is provided and before cultivation. The productive value must justify the total cost of reclamation. The character of the soil must be such that drains will operate promptly to render reclamation of such lands feasible. Some of these alkali, grease-wood swamp border lands at the higher elevations or remote from outlets and having puddled structure or compact subsoils are not attractive for reclamation.

The maximum amount of alkali usually occurs where the water table is thirty to fifty inches from the surface so that extensive capillary action without resolution occurs. Drains must be provided that will lower the water below the capillary limits of the soil. Deep drainage is essential.

Rye or sweet clover will help loosen up the alkaline sub-surface strata in the margin of the marshes and afford some pasture during reclamation. The alkali land being reclaimed should be leveled into regular or contour checks and given deep cultivation. Copious irrigation and deep drainage will keep the alkali moving down and out in affected under-drained areas. Sweet clover and rye are crops that can be used to advantage for pasture on such alkaline land during reclamation. To establish sweet clover successfully, it is necessary to use good scarified seed and a firm seed bed so as to keep the soil moist until the young plants are established. After the crop shades the ground the sweet clover is fairly resistant to alkali. This crop helps to loosen up the land and facilitate reclamation.

Methods of Irrigation. The most promising method of irrigation where flood water can be controlled on these meadows is the strip-border system. This method consists of dividing the land into strips 2 or 3 rods wide and 330 to 660 feet long, running with the slope. Levees can be made between strips by plowing a double back furrow and then going over it with a ridger. The latter is made of two planks 6 feet long held together with braces so they stand on edge and are spaced 3 feet in front and 14 inches at the rear. The strip should be level crosswise and have a fairly uniform slope. A level place at the upper end aids in spreading the water so it will flow down the strip in an even sheet. A strong head ditch and substantial gate should be provided so water can be quickly changed to the next strip when it reaches the lower end of the run. A good-sized irrigating head should be used and the surface rapidly covered.

Where the peat is but medium in depth and the substrata compact, sub-irrigation from small open ditches about five rods apart is a promising method of controlling the irrigation, but this will be found of less general application than the strip-border method.

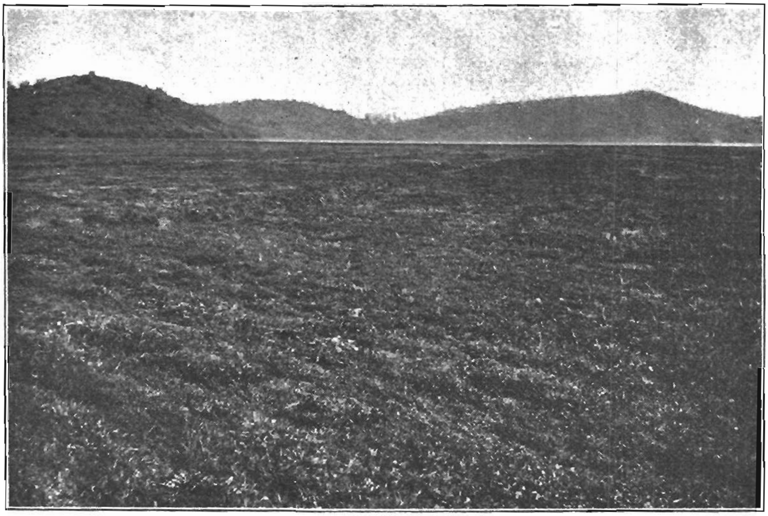


Fig. 18. General view of alsike clover and timothy meadow fitted with strip borders for irrigation. Near Upper Klamath Lake

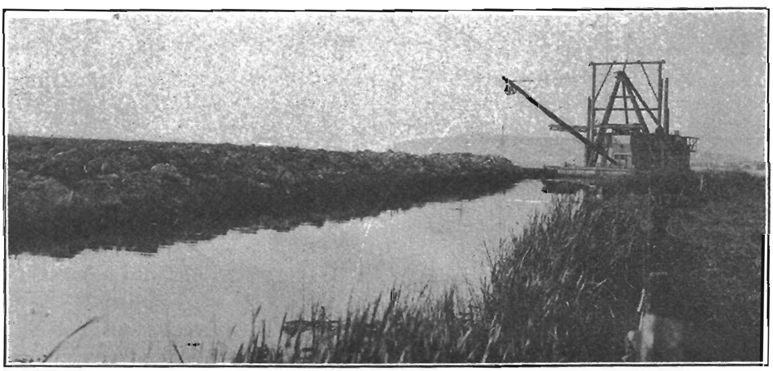


Fig. 19. Dredger in operation diking land near Upper Klamath Lake
KLAMATH LAKE

Summary of Fertilizer Trials on Swamp Lands. Fairly complete fertilizer trials have been conducted on the wild meadow and tule lands during the past five years in three swamp areas. Since these fertilizer trials will be reported separately only the practical results are here briefly presented. These trials do not show a profitable increase from applications of either phosphorus or potash. There is some indication that potash will help on the deep peat, and that in the long run phosphorus will need to be supplied on the silt loam soils of the wild meadow areas. Lime has benefited alsike clover on medium peat soils but has aggravated the alkaline conditions due to increase in bicarbonate. Clay loam and shallow silt loam on the swamp rims have responded markedly to applications of elemental sulfur where crops such as alfalfa have been grown. Calcium sulfate has greatly benefited alsike clover on shallow silt loam in the Fort Klamath meadows. Increases of 2 tons an acre have been obtained from use of sulfur on alfalfa in these trials and its use as a result of experiments conducted promises to increase yields, returns per unit of water, and land values in several valleys. Barnyard manure has proved profitable on medium and shallow peat. One effect

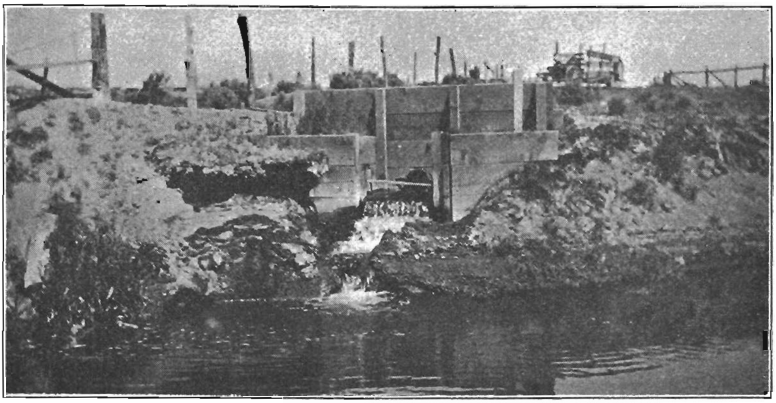


Fig. 20. MEASURING WEIR AT DRAINAGE OUTLET, KLAMATH BASIN

may be that bacteria contained with it may aid decomposition of the raw peat. Use of manure and rotation of crops are important in connection with economical use of water, as is also sulfur or other fertilizer where it causes substantial increases in yields.

ADVANTAGES OF DEVELOPMENT

The time seems ripe for converting large portions of these wild hay meadows to tame clover and grass lands. It is believed that in large portions of these areas, when the water can be controlled so tame grasses can be grown, the lands will pay a better rate of interest on the total investment. In other words, where the net profit over the cost of production under present conditions would represent interest on a valuation of perhaps $40 to $60 an acre, good clover and timothy meadows should pay a similar rate of interest on a valuation of $70 to $100 an acre.

Modern agriculture contemplates the use of well-bred domesticated plants. It is fundamental that something of a rotation be practiced including growing of leguminous crops and application of barnyard manure in rotation. Even on fairly permanent meadows the clovers will help to keep the land loosened up and offset the tendency of the water to crack the soil. The roots of these legumes add nitrogen to the soil besides increasing the valuable protein substances in the forage.

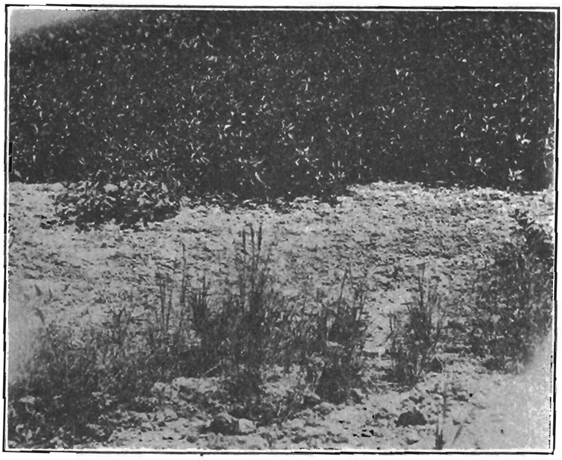


Fig. 21. Heavy growth of sweet clover on alkali land showing crust in foreground from trial in Klamath Basin (Photo by H. R. Glaisyer)

Fig. 22. FIELD FITTED FOR THE STRIP-BORDER METHOD OF IRRIGATION. New seeding of alsike, timothy, and rye grass, Harney Branch Experiment Station

A wise system of irrigation contemplates applying soil water at the time when the supply for the crop is down near the wilting point and in just sufficient amount to raise the supply to the excess point throughout the soil strata within the reach of plant roots. Under proper irrigation little or no moisture should escape over the surface or below the reach of roots to contribute to the formation of a high water table. While a little loss may be allowable under present economic conditions,

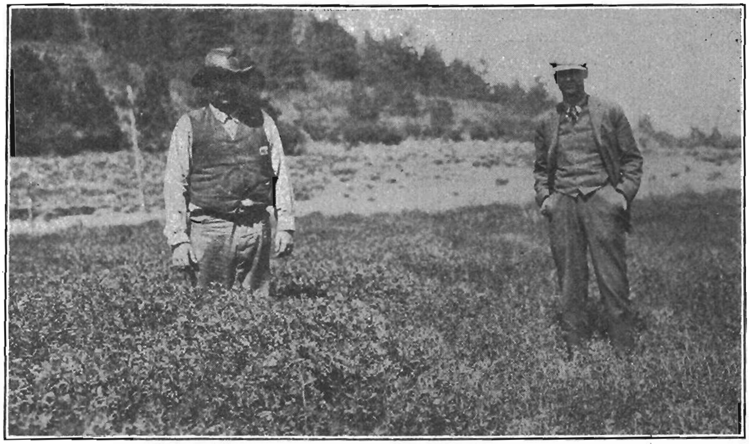


Fig. 23. FIRST CUTTING OF ALFALFA, UPPER KLAMATH BASIN, 1918. Sulfur applied to tract at left increased yield 1.2 tons first cutting and over 2 tons for the season

Fig. 24. Alfalfa near Upper Klamath Lake showing the effect of sulfur; untreated in the foreground

still these are the standards for modern irrigation to work toward if the highest development and the most profitable system of irrigation agriculture is to be reached and maintained. Moisture should be kept moving down by intermittent irrigation and cultivation whenever necessary. The fact that dry-farmed lands do not "go to alkali" if not so affected in the initial state shows that with proper control of moisture soluble salts in soil can be kept distributed or removed. Drainage is the real remedy in such cases of excess alkali in these meadow lands.

Fig. 25. COMPARATIVE YIELD FROM SULFURED AND UNSULFURED PLOTS. Sulfur at left, yield 8.45 tons an acre. Untreated at the right, yield 5.74 tons an acre.

The feeding experiments of our branch experiment stations and analyses* show that the marsh grasses are higher in crude fiber and lower in digestibility than the tame grasses and legumes. It is believed that the control of water and the establishment of domesticated crops will double the productiveness in large parts of our several million acres of meadow lands in the mountain country and great basin region, and so permit saving of water to be applied to fertile adjacent bench lands.

*Hepner, E. E., and Nelson, A. Wyo. Exp. Sta. Bul. 87.

TYPICAL PLANTS GROWING ON CHEWAUCAN MARSH

From a collection made in 1916.

Sporobolus asperifolius Nees and Meyen.
Common name—Tickle grass

Elymus macounii Vasey.
Common name—Wild rye

Elymus triticoides Buckl.
Common name—Wild rye
Local name—Bluejoint

Distichlis spicata Greene.
Common name—Salt grass

Juncus balticus Willd
Common name—Wire grass

Muhlenbergia squarrosa Rydberg.
No common name

Agrostis alba L.
Common name—Redtop

Sparganium greenii Morong.
Common name—Bur reed

Alisma brevipes Greene
Common name—Water plantain

Panicularia grandis (S. Watson) Nash
Common name—Rice grass

Stachys palustris L.
Common name—Hedge nettle

Trifolium tridentatum var. Melananthum (Hook and Arn.) Wat.
Common name—Bur clover

Trifolium tridentatum Lindl.
Common name—Wild clover

Sagittaria latifolia Willd.
Common name—Arrowhead

Phleum pratense L.
Common name—Timothy

Carex aquatilis Wahl.
Common name—Sugar grass

Beckmannia erucaeformis (L.) Host.
Common name—Wild millet or slough grass

TABLE VIIa. SUMMARY, CHEWAUCAN VALLEY, DUTY OF WATER TRIALS
Soil and weather conditions, water used, crop yields, 1915.

Crop and location	Plot	Altitude	Soil Type	Percent humus	Usable water capacity In.	Soil depth	Plot area	Rain and soil water used - Inches	Date of first irrigation	Irrigation season in days	Total depth irrigation in inches	Total water used in inches	Yield per acre	Yield per acre inch	Pounds yield marketable dry matter	Pounds water per pound Total D.M
Marsh grass	Max.	4300	Peaty si loam	10	2.5	deep	acres 1/10	5.67	June 3	—	27.48	33.15	Tons .89	Tons .030	1325	4407
	Ave.	"	" "	"	"	"	"	3.16	" "	—	11 28	14.44	1.03	.091	1534	2256
29-34S-19E	Min.	"	" "	"	"	"	"	3.31	—	—	0.00	3 31	.57	—	849	881
Marsh grass	Max.	4300	Silt loam	7.6	2.1	deep	1/10	6.50	June 1	—	18.12	27 62	.70	.038	1042	4378
	Ave.	"	" "	"	"	"	"	5.04	June 15	—	6 60	11 67	.73	.110	1087	2419
19-34S-19E	Min.	"	" "	"	"	"	"	4.32	—	—	0.00	4.32	.70	—	1042	936
Marsh grass	Max.	43 00	peat	48	3.8	deep	Sq Ft 1.4	13.49	June 20	—	26 47	39.96	grams 125.	grams 4.64	grams 78	1684
in Tanks	Ave.	"	"	"	"	"	"	9.89	" "	—	13 81	23.70	71	5 14	46	1696
	Min.	"	"	"	"	"	"	18.11	" "	—	4 00	22 11	94	23.5	70	1022

TABLE VIIb. SUMMARY, CHEWAUCAN VALLEY, DUTY OF WATER TRIALS

Soil and weather conditions, water used, crop yields, 1916.

Crop and location	Plot	Altitude	Soil type	Percent humus	Usable water capacity inches	Soil depth	Plot area, acres	Rain and soil water used-inches	Date of first irrigation	Irrigation season in days	Total depth irrigation in inches	Total water used in inches	Yield per acre bu. or tons	Yield per acre inch bu. or tons	Pounds yield marketable dry matter	Pounds water per pound total D.M.
Natural meadow	Max	4400	medium peat	48.0	3.8	deep	.10	6.86	5/31	57	26.5	33.46	1.470	.0554	2628	2877
	Ave.	..	.. ..	..	..	..	..	7.91	5/31	..	19.2	27.11	1.940	.1010	3488	1756
28-33S.-19E.	Min	..	.. ..	..	..	..	..	8.64	5/31	..	8.5	17.14	1.245	1452	2273	1703
Alsike clover and timothy	Max.	4400	peaty si. loam	10.0	2.5	deep	.10	2.64	5/11	57	4.25	6.89	2.560	.602	4245	367
	Ave	..	.. .. ..	..	..	..	..	2.63	5/11	..	3.10	5.73	2.080	670	3648	355
28-33S-19E	Min	..	.. .. ..	..	..	..	..	2.56	5/11	..	2.25	4.81	2.400	1.066	4195	459
Alsike clover and timothy (tanks)	Max	4400	peaty si. loam	10.0	2.5	2'	sq. ft. 1.39	3.60	5/11	57	14.0	17.60	2.560	1820	4245	937
	Ave	..	.. .. ..	..	..	..	..	3.92	5/11	..	8.5	12.42	2.080	244	3648	769
28-33S.-19E	Min	..	.. .. ..	..	..	..	..	5.39	5/11	..	5.0	10.39	2.400	480	4195	560
Sugar grass	Max	4400	medium peat	48.0	3.8	2'	1.39	8.92	4/29	120	32.0	40.92	2.395	.074	2395	3864
(in tanks)	Ave	..	.. ..	..	..	..	..	9.50	4/29	..	16.0	25.50	1.960	.122	1960	2940
	Min	..	.. ..	..	..	..	..	11.30	4/29	..	12.0	23.30	1.306	1088	1306	4032
Natural meadow	Max	4400	silt loam	7.6	2.1	deep	acres .10	6.12	5/9	57	26.2	32.37	.600	0239	931	7843
	Ave	..	.. ..	..	..	..	..	5.86	5/9	..	14.5	20.36	.430	0296	729	6309
19-33S.-19E.	Min	..	.. ..	..	..	..	..	4.50	5/9	..	5.75	10.25	.570	0991	991	2338
Nat. meadow 19-33S-19E							27.0		5/1	63	12.8	20.95	.850	.0660	1482	3194

TABLE VIIc. SUMMARY, CHEWAUCAN VALLEY, DUTY OF WATER TRIALS
Soil and weather conditions, water used, crop yields, 1917.

Crop and location	Plot	Altitude	Soil Type	Percent humus	Usable water Cap In.	Soil depth	Plot area	Rain and soil water Used Inch	Date of First Irrigation	Irrigation Season in days	Total depth irrigation in inches	Total water used in inches	Yield per acre in bu or Tons	Yield per acre inch bu. or Tons	Total yield marketable dry matter	Pounds water per pound Total D.M.
Marsh Grass (Tanks)	Max	4300	Med Peat	48	2.5	Med deep	1.4 Sq ft	1.50	May 5	75	33.48	34.98	grams in plot 2159	grams in plot 64.45	—	1273
	Ave	"	" "	"	"	"	" " "	1.27	" "	"	18.63	19.28	889	47.71	—	1493
	Min	"	" "	"	"	" "	" " "	1.49	" "	"	13.77	15.26	379	27.45	—	1952
Marsh Grass	Max	4300	Med Peat	48	3.8	Med deep	1/10 A.	4.65	May 13	53	27.9	32.55	Tons per A. 1.03	Tons per acre .037	—	3579
	Ave	"	" "	"	"	"	" "	3.18	" "	"	14.78	17.96	.92	.062	—	1820
	Min	"	" "	"	"		" "	3.48	" "	"	3.00	6.48	.945	.315	—	361
Alsike & Clover (Tanks)	Max	4300	Med Peat	48	3.8	Med deep	1.4 Sq ft	4.33	May 5	70	21.46	25.79	grams per plot 1132.1	grams per plot 53.1	—	1110
	Ave	"	" "	"	"	"	" " "	3.03	" "	"	12.97	16.00	901	69.6	—	867
	Min	"	" "	"	"	" "	" "	348	" "	"	3.07	6.55	650	21.15	—	458
	Ave (mowed)	"	" "	"	"	" "	" " "	3.09	" "	"	8.49	11.58	1178	138.54	—	464
Beans	Max	4300	Silt loam	7.6	2.1	deep	1/30 A	.86	July 9	—	13.2	14.06	bu per A 24	1.8	—	2075
	Ave	"	" "	"	"	"	" "	.72	" "	—	12.6	13.32	24	1.9	—	1985
	Min	"	" "	"	"	"	" "	1.00	" "	—	4.4	5.40	15	3.41	—	601

TABLE VIIIa. SUMMARY, HARNEY VALLEY, DUTY OF WATER TRIALS
Soil and weather conditions, water used, crop yields, 1916.

Crop and location	Plot	Altitude	Soil type	Percent humus	Usable water cap-in	Soil depth	Plot area acres	Rain and soil water used. Inch.	Date of first irrigation	Irrigation season in days	Total depth irrigation in inches	Total water used in inches.	Yield per acre bu. or tons	Yield per acre inch bu. or tons	Pounds yield marketable dry matter	Pounds water per pound total D M
Natural meadow (tanks)	Max.	4120	silt loam	2.41*	2.1	2'	sq. ft 1.39	6.33	5/11	56	11.0	17.33	grams 76.5	grams 6.95	grams 34.5	1647
	Ave.	"	" "	"	"	"	"	7.00	5/11	"	6.0	13.00	85.0	14.10	40 0	1066
	Min.	"	" "	"	"	"	"	6.32	5/23	49	3.5	9.32	77.9	22.20	37.0	869
	Max.	"	" "	"	"	"	"	5.94	5/11	56	11.0	16.94	88.8	8.07	37.0	1502
	Ave.	"	" "	"	"	"	"	6.88	5/11	"	6.0	12.88	77.7	12.90	34.5	1224
21-23S.-31E.	Min.	"	" "	"	"	"	"	5.55	5/23	49	4.5	10.05	67.0	12.60	28.0	1177
Field peas (tanks)	Max.	"	" "	"	"	"	"	7.62	6/7	"	7.5	15.12	281.0	37.46	76.5	617
21-23S.-31E.	Min.	"	" "	"	"	"	"	6.96	6/7	"	3.75	10.71	205.0	54.66	56.0	670
Natural meadow.	Max.	4120	silt loam	2.41*	2.1	deep	100.0	12.50	5/6	56	21.50	34.00	tons 2.178	tons .101	—	—
	Ave.	"	" "	"	"	"	"	14.98	5/6	"	10.75	25.73	2.178	.202	—	—
	Min.	"	" "	"	"	"	"	10.03	—		0.00	10.03	2.178	—	—	—
	Max.	"	" "	"	"	"	"	6.85	5/6	"	24.50	31.35	1.960	.080	—	—
	Ave.	"	" "	"	"	"	"	9.94	5/6	"	12.25	22.19	1.960	.160	—	—
	Min	"	" "	"	"	"	"	6.03	—		0.00	6.03	2.613	—	—	—
	Max	"	" "	"	"	"	"	11.14	5/6	"	28.00	39.14	2.831	.101	—	—
	Ave	"	" "	"	"	"	"	10.96	5/6	"	14.00	24.96	2.831	.202	—	—
21-23S.-31E.	Min	"	" "	"	"	"	"	12.51	—		0.00	12.51	1.960	—	—	—

*Extraction method used

TABLE VIIIb. SUMMARY, HARNEY VALLEY, DUTY OF WATER TRIALS
Soil and weather conditions, water used, crop yields, 1916.

Crop and location	Plot	Altitude	Soil type	Percent humus	Usable water cap.-in.	Soil depth	Plot area. acres	Rain and soil water used.-Inch	Date of first irrigation	Irrigation season in days	Total depth irrigation in inches	Total water used, in inches.	Yield per acre. bu. or tons	Yield per acre inch bu. or tons	Pounds yield marketable dry matter	Pounds water per pound total D.M.
Spring wheat	Max.	4125	v.f. sandy loam	2.49*	1.8	deep	1/13	11.12	6/29	21	9.0	20.12	29.25	3.25	1527	1176
	Ave.	..	.. ..	..	..	..	..	8.35	6/30	21	6.0	14.35	26.66	4.44	1467	903
	Min.	..	.. ..	..	..	..	..	9.87	7/1	—	3.0	12.87	22.40	7.47	1238	906
	Dry.	..	.. ..	..	..	..	..	12.44	—	—	0.0	12.44	18.85	—	1060	1304
	Ave. Manure	..	.. ..	..	..	..	..	9.03	7/1	21	6.0	15.03	frosted out	—	—	—
7-235.-32E.	Dry Manure	..	.. ..	..	..	..	..	9.03	—	—	0.0	9.03	.. ..	—	—	—
Field peas.	Max.	4125	v.f. sandy loam	2.49*	1.8	deep	1/13	3.64	6/24	21	12.0	15.64	Tons. 1.690	Tons. .140	2658	1329
	Ave.	..	.. ..	..	..	..	..	1.39	6/28	21	8 0	9.39	1.690	.211	2490	852
	Min.	..	.. ..	..	..	..	..	4.65	6/28	—	4.0	8.65	1105	.276	1794	1089
	Ave. manure	..	.. ..	..	..	..	..	+0.39	7/2	21	8.0	7.61	1.365	.170	2422	710
7-235.-32E.	Min. manure	..	.. ..	..	..	..	..	0.30	7/3	—	4.0	4.30	1.235	.308	1673	580
Alfalfa (in rows 32" apart)	Max.	4125	v.f. sandy loam	2.49*	1.8	deep	1/12	1.01	6/22	42	18.0	19.01	2.156	.119	3665	1172
	Ave	..	.. ..	..	..	..	..	4.39	6/21	28	12.0	16.39	2.641	.220	4489	821
	Min.	..	.. ..	..	..	..	..	6.36	6/14	..	6.0	12.36	2.077	.346	3531	791
	Ave. manure	..	.. ..	..	..	..	..	4.92	6/13	..	12.0	16.92	2.746	.228	4669	819
7-235.-19E.	Dry	..	.. ..	..	..	..	..	9.59	—	—	0.0	9.59	2.050	—	—	H.B.H.

* Extraction method used.

TABLE VIIIc. SUMMARY, HARNEY VALLEY, DUTY OF WATER TRIALS
Soil and weather conditions, water used, crop yields, 1917.

Crop and location	Plot	Altitude	Soil type	Per cent humus	Usable water cap. in	Soil depth	Plot area acres	Rain and Soil water used Inch	Date of first irrigation	Irrigation Season in days	Total depth irrigation in inches	Total water used in Inches	Yield per acre bu. or Tons	Yield per acre inch bu. or Tons	Pounds yield marketable dry matter	Pounds water per pound Total D.M.
Field Peas Hay	Min	4125	v.f. sandy loam	2.49	1.8	deep	1/10	5.56	June 25	21	3	8.56	.186	.062	—	5200
	Ave.	"	"	"	"	"	"	5.56	"	"	6	11.56	.607	.101	—	2152
	Max	"	"	"	"	"	"	4.86	"	"	10	14.86	.885	.0885	—	1907
	Ave (Manure)	"	"	"	"	"	"	4.86	"	"	6	10.86	.493	.0821	—	2496
Field Peas Hay	Min	"	"	"	"	"	"	6.14	"	"	3	9.14	.832	.2775	—	1240
	Ave	"	"	"	"	"	"	5.45	"	"	6	11.45	1.076	.1790	—	1202
	Max	"	"	"	"	"	"	4.25	"	"	10	14.25	1.975	.1975	—	815
	Ave (Manure)	"	"	"	"	"	"	5.45	"	"	6	11.45	.966	.1610	—	1338
Field Peas Grain	Min	"	"	"	"	"	"	5.56	"	"	3	8.56	.1978	.0659	—	4890
	Ave	"	"	"	"	"	"	5.56	"	"	6	11.56	.5970	.0999	—	2148
	Max	"	"	"	"	"	"	4.86	"	"	10	14.86	.8374	.0837	—	2005
	Ave (Manure)	"		"		"	"	4.86	"	"	6	10.86	.7360	.1226	—	1737
Field Peas Grain	Min	"	"	"	"	"	"	6.14			3	9.14	.2024	.0675	—	5103
	Ave	"	"	"	"	"	"	5.45		"	6	11.45	.6624	.1104	—	1953
	Max	"	"	"	"	"	"	4.25		"	10	14.25	.8970	.0897	—	1795
	Ave (Manure)	"	"	"	"	"	"	5.45	"	"	6	11.45	.5014	.0835	—	2580

TABLE VIIId. SUMMARY, HARNEY VALLEY, DUTY OF WATER TRIALS
Soil and weather conditions, water used, crop yields, 1917.

Crop and location	Plot	Altitude	Soil Type	Percent humus	Usable water cap-in	Soil depth	Plot area acres	Rain and soil water used-inch	Date of first irrigation	Irrigation Season in days	Total depth Irrig in inches	Total water used in inches	Yield per acre bu. or Ton	Yield per acre inch bu. or ton	Pounds yield marketable dry matter	Pounds water per pound total D.M.
Barley	Min	4125	v.f. sandy loam	2.49	1.8	deep	1/10	3.08	June 25	—	3	6.08	.565	187	—	1235
	Ave	"	" " "	"	"	"	"	2.86	"	—	6	8.86	1.410	.236	—	710
	Max	"	" " "	"	"	"	"	4.25	"	—	10	14.25	2.422	.242	—	665
	Ave (Manure)	"	" " "	"	"	"	"	2.86	"	—	6	8.86	1.695	.283	—	591
Barley	Min	"	" " "	"	"	"	"	4.60	"	—	3	7.60	343	.114	—	2504
	Ave	"	" " "	"	"	"	"	4.20	"	—	6	10.20	.417	.0695	—	3253
	Max	"	" " "	"	"	"	"	3.94	"	—	10	13.94	.742	.0744	—	2123
	Ave (Manure)	"	" " "	"	"	"	"	3.47	"	—	6	9.47	.762	.127	—	1404
Alfalfa	Min	125	v.f. sandy loam	2.49	1.8	deep	1/10	3.37	June 22	64	6	9.37	.2335	.0389	—	4534
	Ave	"	" " "	"	"	"	"	3.34	"	"	12	15.34	.5085	.04235	—	3409
	Max	"	" " "	"	"	"	"	2.83	"	"	18	20.83	.5330	.03970	—	4416
	Ave (Manure)	"	" " "	"	"	"	"	2.45	"	"	12	14.45	.4765	.0397	—	3426
Alfalfa	Min	"	" " "	"	"	"	"	3.34	"	60	6	9.34	.444	.0740	—	2384
	Ave	"	" " "	"	"	"	"	3.34	"	"	12	15.34	.8125	.0677	—	2133
	Max	"	" " "	"	"	"	"	2.83	"	64	18	20.83	.9685	.0542	—	2430
	Ave (Manure)	"	" " "	"	"	"	"	2.45	"	"	12	14.45	.7865	.0655	—	2069

TABLE VIIIe. SUMMARY, HARNEY VALLEY, DUTY OF WATER TRIALS
Soil and weather conditions, water used, crop yields, 1918.

Crop and location	Plot	Altitude	Soil Type	Percent humus	Usable water cap-in	Soil depth	Plot area acres	Rain and soil water used Inch	Date of First Irrigation	Irrigation Season in days	Total depth Irrig in inches	Total water used in Inches	Yield per acre bu. or Ton	Yield per acre inch bu. or Tons	Pounds yield marketable dry matter	Pounds water per pound Total D.M
Barley	Max	4125	v.f. sandy loam	2.49	1.8	deep	1/10	5.62			12	17.62	20.20	1.68		1228
	Ave	..	..	..	..	..	..	9.49			8	17.49	17.91	2.24		1673
	Min	..	..		..	..	..	8.03			4	12.03	16.25	4.06		1444
	Ave (Manure)	..	..			..	..	8.34			8	17.98	9.47	1.18		1802
Barley	Max	..	..		..	..	..	10.06			12	22.06	35.52	2.96		1363
	Ave	..	..			..	..	11.37			8	19.37	27.60	3.45		1193
	Min	..			..	..	..	10.32			4	14.32	32.91	8.22		1126
	Ave (Manure)	..	..		..	..	..	8 34			8	16.34	25.10	3.14		1324
Field Peas	Max	4125	vf. sandy loam	2 49	1.8	deep	1/10	5 62			8	16.52	1.975	.247		1134
	Ave	..	..	..	..		..	9.49			4	6.14	1.072	.268		776
	Min	..	..	..	..	..	..	8.03			0	4.65	.185			3412
	Ave (manure)	..	..	..	..	..	..	8.34			4	16.33	1.230	.307		1832
Field Peas	Max	..	..	..	..	..	..	10.06			8	17.41	.915	.113		2577
	Ave	..	..	..	..	..	..	11.37			4	14.56	430	.108		4596
	Min	..	..	..	..	..	..	10.32			0	10.51	.0975			14660
	Ave (Manure)	..	..	..	..	..	..	8.34			4	11.89	.915	.208		1760
Ruta Bagas	Ave	4125	vf sandy loam	2.49	1.8	deep	1/10	6.86			14	20.86	10.414	.4997		974

TABLE VIIIf. SUMMARY, HARNEY VALLEY. DUTY OF WATER TRIALS
Soil and weather conditions, water used, crop yields, 1918.

Crop and location	Plot	Altitude	Soil type	Per cent humus	Usable water cap in	Soil depth	Plot area acres	Rain and soil water used inches	Date of first irrigation	Irrigation Season in days	Total depth Irrigation in inches	Total water used in Inches	Yield per acre bu or Ton	Yield per acre inch bu. or Ton	Pounds Yield marketable dry matter	Pounds water per pound Total D. M.
Beets	Max	4125	V. f. sandy loam	2 49	1.8	deep	1/10	4 30			9	13.30	13 742	1 527		563
	Ave	"	"					6.62			6	12 62	14.557	2 426		518
	Min	"	"		"	"	"	13.42			3	16 42	7 650	2.550		1217
	Ave (Manure)	"	"			"	"	7 45			6	13 45	14850	2 475		525
Beets	Max	"	"		"	"	"	2.49			9	11.49	6 365	.707		1057
	Ave	"	"		"	"	"	10 59			6	16.59	7.950	1 325		1234
	Min	"	"		"	"		10 54			3	13 54	3 680	1 226		2105
	Ave (Manure)	"	"			"	"	9.18			6	15.18	6.055	1 009		1488
Alfalfa	Max	4125	V. f. sandy loam	2 49	1.8	deep	1/10	5.89			18	23.89	1.645	.0915		1786
	Ave	"	"		"	"	"	12.53			12	24 53	1.640	.1366		1842
	Min		"	"	"		"	9.18			6	15.18	.635	1060		2942
	Ave (Manure)		"			"		4 57			12	16.57	1.260	.1050		1618
Alfalfa	Max	"	"		"	"	"	6.24			18	24.24	4.000	.2222		746
	Ave	"	"	"	"	"		4 42			12	16.42	3.435	.2862		588
	Min	"	"		"			8 71			6	14.71	1.475	.2458		1225
	Ave (Manure)	"	"		"	"	"	6 83			12	18.83	2.825	.2354		804
Sweet clover	Ave	"	"	"	"	"		6.67			12	18.67	2.923	.2435		807

TABLE IXa. SUMMARY, KLAMATH BASIN, DUTY OF WATER TRIALS
Soil and weather conditions, water used, crop yields, 1917.

Crop and location	Plot	Altitude	Soil Type	Percent humus	Usable water cap in	Soil depth	Plot area acres	Rain and soil water used in.	Date of First Irrigation	Irrigation Season in days	Total depth Irrigation in inches	Total water used in inches	Yield per acre bu or Ton	Yield per acre inch bu or Tons	Pounds yield marketable dry matter	Pounds water per pound Total D.M.
Wire Grass (Tanks)	Max.	4100	Med. Peat	43		Medium	Sq. Ft 139	39.98	June 4	80	20	59.98	3.47	.1735		1938
	Ave	"	" "	"		"	"	8 46	" "	"	11	19.46	1.39	.126		6341
	Min.	"	" "	"		"	"	6 79.	" "	"	7	13.79	.75	.107		2077
Alsike & Timothy (Tanks)	Max.	"	" "	"		"	"	9.16	" "	"	17	26.10	3.58	.210		824
	Ave	"	" "	"			"	6.45	" "	"	11	17.45	3.08	.280		643
	Min	"	" "	"		"		12.37	" "	"	8	20.37	1.95	.243		1180
Alsike on Timothy	Max	4100	Deep Peat	43		deep	Acres 1/10	11.65	July 12	30	6.5	18.15	3.4	.524		603
	Ave	"	" "	"		"	"	11.65	" "	"	Subbed thru dyke		3.0	---		----
	Min	"	" "	"		"		11.65	" "	"	"	"	2.8	----		-----
Sugar Beets	Max	"	" "	"		"	"	11.65	July 16	"	3.34	14.99	12	3.61		
	Ave	"	" "	"		"	"	11.65	" "	"	Subbed thru dyke		10	----		----
	Min	"	" "	"		"	"	11.65	" "	"	"	" "	8	----		----

TABLE IXb. SUMMARY, KLAMATH BASIN, DUTY OF WATER TRIALS
Soil and weather conditions, water used, crop yields, 1918.

Crop and location	Plot	Altitude	Soil Type	Percent humus	Usable water cap in	Soil depth	Plot area Sq. ft.	Rain and soil water used inch	Date of first irrigation	Irrigation season in days	Total depth irrigation in inches	Total water used in inches	Yield on plot grams	Yield per acre inch grams	Pounds yield marketable D.M.	Pounds water per pound total D.M.
Sugar grass	Max	4100	Med. Peat	43		Medium	139	909	May 15	80	25	34.09	30	12		4680
(tanks)	Ave	"	" "	"		"	"	4.80	June 9	"	13	26.10	42	3.23		2560
	Min	"	" "	"		"		1372	" "	"	7	21.72	26	37		3441
Sugar Grass	Max	"	" "	"		"		9.03	May 15	"	25	3403	30.6	122		4580
(Tanks)	Ave	"	" "	"		"	"	9.94	June 9	"	13	2694	44	315		2550
	Min	"	" "	"				16.29	" "	"	7	22.29	18	257		5100
Alsike & Timothy	Max	4100	Med Peat	43		Medium	1.39	9.17	May 15	80	25	3417				
(Tanks)	Ave	"	" "	"		"		1475	June 9	"	13	2775	23	172		3464
	Min	"	" "	"		"		1733	" "	"	7	24.33	12.6	18		8016
Alsike & Timothy	Max	" "	" "	"			"	9.01	May 15	"	25	34.01				
(tanks)	Ave	"	" "	"		"	"	15.52	June 9	"	13	2852	51.6	3.9		2276
	Min	-	" "	"		"		16.86	" "	"	7	23.86	9.0	397		10920

TABLE IXc. SUMMARY, KLAMATH BASIN, DUTY OF WATER TRIALS
Soil and weather conditions, water used, crop yields, 1919.

Crop and location	Plot	Altitude	Soil Type	Percent humus	Usable watercap Inches	Soil depth	Plot area acres	Rain and soil water used-inch	Date of first irrigation	Irrigation season In days	Total depth irrigation in inches	Total water used in inches	Yield per acre bu. or Ton	Yield per acre inch bu or Ton	Pounds yield marketable dry matter	Pounds water per pound Total D M
Wire grass (Tanks)	Max	4100	Med. Peat	43	4.8	Medium	Sq. Ft. 1.39	-1.605	Apr 27	45	24	22.395	grams per tank 43.85	grams per tank 1.82	grams 35.08	2108
	Ave	"	" "	"	"	"	"	.470	May 13	29	16	16.470	38.75	2.42	31.00	1812
	Min	"	" "	"	"	"	"	1.576	May 24	18	8	9.576	31.62	3.95	25.30	1207
Wire grass (Tanks)	Max	"	" "	"	"	"	"	.484	Apr. 27	75	24	23.516	36.11	1.50	28.88	2681
	Ave	"	" "	"	"	"	"	.484	May 13	29	16	15.516	45.62	2.85	38.50	1120
	Min	"	" "	"	"	"	"	-3.652	May 24	18	8	11.652	33.50	4.19	26.80	1430
Alsike and Timothy (Tanks)	Max	4100	Med Peat	43	4.8	Medium	1.39	9.945	May 5	75	29.5	39.445	24.20	8.20	193.60	670
	Ave	"	" "	"	"	"	"	8.973	May 20	60	16	24.973	231.4	14.46	185.12	444
	Min	"	" "	"	"	"	"	9.112	" "	60	8	17.112	137.0	17.13	109.60	441
Alsike and Timothy (Tanks)	Max	"	" "	"	"	"	"	8.834	May 5	75	29.5	18.334	250.0	8.47	200.00	765
	Ave	"	" "	"	"	"	"	8.000	May 20	60	16	24.000	182.9	11.43	146.32	540
	Min	"	" "	"	"	"	"	9.806	" "	60	8	17.806	153.0	19.13	122.40	479
Alsike and Timothy	Max	4100	Med Peat	43	4.8	Medium	1.020	4.305	May 28	43	9.623	13.928	T. per acre 3.706	T. per acre .385	Pounds 6448	490
	Ave	"	" "	"	"	"	.839	15.190	" "	"	6.168	21.158	2.672	.433	4756	1002
	Min	"	" "	"	"	"	.887	15.330	" "	"	5.280	20.610	2.333	.442	4107	1137
Grain Hay	Max	4100	Med. Peat	43	4.8	Medium	.907	14.710	July 11	35	10.979	13.026	.8568	.0783	1414	2065
	Ave	"	" "	"	"	"	.914	8.921	" "	"	7.500	16.421	.9370	.125	1686	2184
	Min	"	" "	"	.	"	1.019	4.806	" "	"	5.420	10.226	1.0670	.197	1974	1178
Wheat	* Max	4100	Clay loam		3.17	deep	.349	3.726	June 10	60	17.352	21.078	bu per acre *52.27	bu. per acre 3.012	2729	1746
	Ave	"	" "		"	"	.384	7.562	" "	30	9.984	17.546	36.70	3.676	1920	2067
	Min	"	" "		.	"	.356	7.770	July 14	30	6.000	13.770	15.09	2.517	826	3358

*Yield determined from 1/3 of plot. The remainder did not mature due to excess moisture but yielded 1 Ton of hay.