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"RAIN FOLLOWS THE PLOW" AND DRYFARMING DOCTRINE: THE CLIMATE INFORMATION PROBLEM AND HOMESTEAD FAILURE IN THE UPPER GREAT PLAINS, 1890-1925

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ABSTRACT

In the late 19th and early 20th centuries, the North American agricultural frontier moved for the first time into semi-arid regions where farming was vulnerable to drought. Farmers who migrated to the region had to adapt their crops, techniques, and farm sizes to better fit the environment. But there was very incomplete information for making these adjustments, and ultimately they were insufficient: too many small, dry land wheat farms were founded, only to be abandoned in the midst of drought. In this paper, we examine why homestead failure occurred in the Great Plains, by analyzing two episodes in western Kansas in 1893-94 and in eastern Montana in 1917-21. We focus on the weather information problem facing migrants to the region. We examine the learning process by which migrants mis-interpreted new rainfall information and failed to adequately perceive drought. Homesteaders had neither an analytical framework nor sufficient data for predicting fluctuations in rainfall. Knowledge of the climate was primitive and the underlying mechanisms triggering droughts were not understood. Long-term precipitation records did not exist. Homesteaders gambled on the continuation of previous wet periods due to a possible climate change because of cultivation, and on the optimistic opinions of dryfarming "experts." Dryfarming doctrine argued that moisture could be saved in the soil, allowing small wheat farms to endure any dry period. Accordingly, homesteaders discounted new information that indicated drought. The subsequent waves of homestead busts that swept the region during severe droughts were part of the adjustment toward agricultural techniques, crops, and farm sizes more appropriate for a semi-arid region.

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“No one need be in doubt about the sharp change in climate that occurs somewhere between the 96th and 100th meridians. It can be felt on the lips and skin, observed in the characteristic plant and animal life, seen in the clarity and/or dustiness of the atmosphere, determined by measurements of rainfall and evaporation, tested by attempts at unaided agriculture. Practically every western traveler in the early years remarked the facts of aridity, though not all used the word ‘desert’..”[1]

“Dame Nature of the West holds out most alluring charms, and those who woo and win her smile reap a reward beyond compare. The one thing most needed is correct and accurate information.”[2]

“That dry-farming is a system of agricultural practice which requires the application of high skill and intelligence is admitted; that it is precarious is denied. The year of drought is ordinarily the year in which the man failed to do properly his share of the work.”[3]

I. Introduction.

In this paper, we examine the climate information problem facing homesteaders who migrated to the semi-arid Great Plains between 1880 and 1925. When migrants crossed the 100th meridian, running through the Dakotas, Nebraska, and Kansas (Figure 1), they encountered climatic conditions that were quite different from what they had experienced in the East or in Europe. It was dry. The area had been known in the 1840s and 50s as the Great American Desert.[4] While average precipitation in eastern states, such as Ohio, was almost 38 inches, in western Kansas, it was 25 inches and in eastern Montana, about 14. And rainfall was more variable than in the East, with precipitation in some years falling well below the 20 inches thought necessary for unirrigated farming. In the Great Plains, then, rainfall was to be the critical factor in agricultural success, and drought was to take a toll.[5]

Figure 1

We show how a lack of understanding of appropriate farm sizes, cultivation techniques, and crops for a semi-arid region resulted in two waves of farm failures or "homestead busts" in western Kansas and Nebraska and eastern Colorado and later, in eastern Montana and the western Dakotas. The droughts of 1893 and 1894 in Kansas and of 1917 through 1921 in Montana caused farm yields and incomes to collapse. Small, wheat-growing homesteads were deserted and the population moved away. Between 1890 and 1900, the number of farms and population in the 24 counties of western Kansas fell by 37 percent and 27 percent, respectively.[6] In eastern Montana, perhaps 60,000 of the191,965 original homestead claims filed between 1900 and 1920 were abandoned.[7] Failures of this scale were unusual in the American frontier experience, and they dominated the historiography of the Great Plains.[8] Agricultural experts and historians searched for an explanation. In the 1930s, USDA and agricultural experiment station officials criticized past federal land policies for encouraging the wrong people (non-farmers) to plant the wrong crops (drought-sensitive ones and not sufficiently diversified) on the wrong farm sizes (too small).[9] Historians castigated homesteaders for attempting to transplant farming practices that were only appropriate for more "humid" regions and for failing to recognize that any cycle of wet years was certain to be followed by ones of drought. Homesteaders were asserted to have been misled by the false claims of railroads, developers, and other promoters.[10]

We examine the learning process by which migrants mis-interpreted new rainfall information and failed to adequately perceive drought.[11] Homesteaders had neither an analytical framework nor sufficient data for predicting fluctuations in rainfall. Knowledge of the climate was primitive and the underlying mechanisms triggering droughts were not understood. Long-term precipitation records for most sites in the region did not exist. Homesteaders in western

Kansas gambled on the continuation of previous wet periods and were encouraged by a belief in climate change due to cultivation, “rain follows the plow.” Homesteaders in eastern Montana relied upon the optimistic opinions of dryfarming “experts,”who claimed that certain cultivation methods could store sufficient moisture in the soil to endure any drought.

We analyze the homestead failure in eastern Montana to determine why farmers did not adequately respond to the semi-arid conditions of the upper Great Plains. They settled the region during an (ex post) unusually wet period between 1906 and 1916 and discounted the appearance of the drought in 1917 that was to last for five years. Over 50,000 additional homestead claims were filed between 1917 and 1925 and the total number of farms grew, even as yields plummeted and farm bankruptcies began to occur. Homesteaders interpreted the observed drier weather within the context of dryfarming doctrine that downplayed the significance of annual variation in rainfall for agricultural success. As such, it fueled homesteader optimism. Dryfarming, or scientific soil culture as it was labeled by its advocates, appeared after 1900 during the settlement of northern Great Plains. It outlined methods for storing moisture in the soil, and made understanding the climate of the region and its fluctuating rainfall seem less critical. According to the doctrine, short-term droughts could be offset by past moisture conservation, and failures would occur only if farmers failed to follow prescribed procedures. Dryfarming was enthusiastically promoted to homesteaders by agricultural experiment stations, state and local governments, the region’s railroads, Dry Farming Congresses and to a lesser degree, by USDA officials.

The climate information problem led the Great Plains to be settled too densely in farms that later were found to be too small, under capitalized and insufficiently diversified to be sustainable. The subsequent waves of homestead busts that swept the region during severe droughts were part of the adjustment toward agricultural techniques, crops, and farm sizes more appropriate for a semi-arid region.

II. Homesteading on the Great Plains and the Information Problem Facing Settlers Regarding the Weather.

Between 1863 and 1880, the northern U.S. agricultural frontier moved across the Midwest from Ohio, Indiana, and Illinois through Iowa, Wisconsin and Minnesota to the eastern parts of Kansas, Nebraska, and the Dakotas.[12] In following the frontier, migrants encountered similar climatic and growing conditions. This situation allowed settlers to use similar cultivation techniques, crops, and farm sizes as in their places of origin.[13]

By 1880, however, much of the remaining government land for claiming was in the Great Plains.[14] Between 1880 and 1925, 1,078,123 original homestead entries were filed to 202,298,425 acres in western Kansas, Nebraska, and the Dakotas and eastern Colorado and Montana, 45 percent of all homestead filings and 48 percent of all government land claimed during the period.[15] Because of their relative aridity, the Great Plains were very different from what confronted settlers on earlier frontiers.[16]

The Great Plains were then, and remain today, a climatic transition zone where most North American droughts have taken place.[17] During periods of high precipitation, the area took on the characteristics of sub-humid climates, becoming superficially attractive for the kinds of agriculture more appropriate for such regions.[18]When droughts returned, those agricultural practices were placed at risk.

Drought is a meteorological phenomenon, an extended period of below normal levels of precipitation. We define a severe drought as annual rainfall one standard deviation below the mean. Drought is due to an aberration in atmospheric circulation, but the precise triggering mechanisms are not well identified or very accurately predicted.[19] Until the Great Plains were settled, droughts were not of overriding concern. In the eastern Midwest dry months could reduce yields and agricultural income in affected areas, but they usually did not mean complete crop failures.[20] Temperatures were followed more closely because frosts were important in determining growing seasons.

The Army Signal Corp began to systematically collect temperature and precipitation data from weather stations and voluntary reporters in 1870 with creation of the U.S. Weather Bureau.[21] By 1890 there were 178 weather stations in the U.S., mostly east of the Mississippi.[22] The major emphasis of early weather data collection was for the Great Lakes, Atlantic and Gulf Coast shipping, which was vulnerable to storms. Agriculture made use of frost and growing season length predictions. Weather services were created in Iowa, Nebraska, Missouri, and Ohio between 1875 and 1882, and by 1891 a special weather and crop service was in operation in most states. The first Weather Bureau crop bulletins began in May 1887.[23] The Weather Bureau was transferred from the Signal Corp to the Department of Agriculture in 1891. Following this move, special forecast services for corn and wheat, cotton, sugar, rice, tobacco, fruit, and truck farms were established. A Division of Agricultural Meteorology to analyze weather patterns was not established until1916.[24]

A particular problem encountered in the late 19th and early 20th centuries in studying droughts was that the mid to upper atmosphere, which housed the jet stream and other key meteorological forces affecting precipitation, was barely accessible to observation. Kites and balloons could go as high as 20,000 feet, but required very favorable conditions to do so. Further, there was no established analytical framework for analyzing the data that were collected.[25] The Weather Bureau's Bulletin D, issued in 1897 outlined the primitive state of knowledge about precipitation and admitted that there were few observed patterns regarding droughts:

> "It is true that suggestions of a faint periodicity have been found in some regions of the globe, but it is still the general belief that the vicissitudes of rainfall, if not wholly fortuitous, are so intermingled with the variations of pressure, temperature, etc., that no satisfactory solution of the problem will be reached until the greater problem of the general circulation of the atmosphere has been solved...We can do not more than present the facts as they exist. The treatment of this subject has necessarily, been superficial, and, in a measure, unsatisfactory. It has not been possible, nor is it believed to be desirable to undertake, with the data available at present, a systematic investigation of the underlying causes of rainfall variation, but rather to carry along such an investigation in connection with other studies of the general atmospheric circulation."[26]

Migrants to the Great Plains after 1880 had especially limited information about the climate of the region. Although the Weather Bureau collected precipitation data for the Great Plains, the data generally were intermittent and incomplete for most of the 19th century.[27] Precipitation and temperature records often were collected at military posts, but the stations were widely scattered and temporary. Many areas had no precipitation records until the 20th century.

Under these conditions, "folk" theories emerged regarding the weather of the Great Plains. "Rain follows the plow" was the most influential model for explaining the weather of the region. The theory argued that rainfall was endogenous to human activity. Very early observations suggested that the frequent movement of transcontinental trains stirred the atmosphere and changed the flow of moisture, increasing precipitation in the plains that otherwise would have traveled further east before falling.[28] Planting trees with settlement also was hypothesized to make the air more humid with the release of oxygen and water vapor and hence, more likely to support rainfall. But the most critical factor was cultivation, whereby the hard prairie soil which previously caused water to run off, was broken down to become more absorptive and a subsequent source of moisture for evaporation and following the cycle, for rainfall.

Chroniclers of western settlement conditions commented on the proliferation of springs, larger stream and river flows, and new, more luxurious vegetation that accompanied the plowing of the plains. As early as 1844, Josiah Gregg reported that droughts were becoming less oppressive in the West and that rains had increased in New Mexico where he lived. He attributed the climate change to civilization and associated cultivation, including the planting of "shady groves."[29] In1867 Ferdinand Hayden, Director of the U.S. Geological Survey of the Territories informed the Secretary of the Interior that the climate could be changed if each settler planted 10 to15 acres of trees on each 160-acre plot.[30] Bayard Taylor of the New York Tribune wrote in June 1866 that "cultivation" would "subdue" the arid belt between Kansas and Denver.[31] In Nebraska, Samuel Aughey (1880, 40, 42) claimed with rising rainfall that nowhere in North American did circumstances exist for "genuine desert conditions"and concluded that "the proofs, therefore, that the rainfall of Nebraska is steadily increasing, are manifold."[32] Charles Francis Adams, editor of The Nation in 1887 stated: "Consequently, there seems no good reason for doubting that the entire area of county west of the Missouri and east of the Rockies will within a few years enjoy a rainfall sufficient to admit of raising of crops without any considerable degree of artificial irrigation."[33]

The notion that rainfall would increase with settlement fit nicely with the optimism and sense of manifest destiny that were associated with the western frontier. The civilizing taming of the wild prairies would lead not only to the establishment of small farms for the "home seeker," but to the benevolent transformation of the climate and the creation of a breadbasket from what had been a desert.[34]

By the late 19th and early 20th centuries, the idea that cultivation would affect precipitation was dismissed by many, but not by all. Some Weather Bureau officials concluded that the climate did not change perceptively due to human activity.[35] In the 1896, irrigation proponent, F. Newell argued that "farmers have deluded themselves with the belief that with the breaking the soil...and bringing civilization, the climate was becoming more favorable to their operations."[36] In 1901 Willard D. Johnson of the United States Geological Survey cautioned against "fruitless and demoralizing movements of population" into the Great Plains under the mistaken belief that "a radical change of climate" was taking place.[37] E.C. Chilcott, Chief of the Office of Dry Land Agriculture in the Department of Agriculture rejected the argument that the climate was changing.[38]

These skeptics, however, offered no alternative explanation for precipitation fluctuations, such as the relatively high levels of rainfall enjoyed in western Kansas in the early 1880s and in eastern Montana between 1906 and 1916. Moreover, there was never a concerted effort to change the views of homesteaders who might have thought that rainfall was increasing.[39] As late as the 1909 Dry Farming Congress held in Cheyenne, Wyoming, the issue of a permanent climate change due to cultivation was still debated.[40]Even in the 1930s, it was concluded that there was no simple rainfall pattern that lent itself for drought predictions in the Great Plains.[41]Accordingly, migrants to this semi-arid region did not perceive the precarious condition of the farms they founded or the crops they planted.[42]

Figure 2 illustrates climatic conditions facing homesteaders. It shows precipitation levels for Ohio, western Kansas, and eastern Montana, from 1895 through 1947, a period where we have comparable data.[43] The figure shows the disparities that existed between an area of origin for homesteaders and their frontier destination. Notice that precipitation was not only always higher in Ohio, but that when it fell, it remained above that found in western Kansas and eastern Montana. In Ohio, even in dry period, rainfall generally was sufficient for crops at lower yields. But in western Kansas and eastern Montana agriculture was always on the margin. When rainfall was at or above the mean, yields would be plentiful, but when rainfall was below the mean, yields and agricultural income would fall. Table 1 reports the mean precipitation levels for the three regions, the coefficient of variation, and the correlation coefficients between the regions. Not only did western Kansas and eastern Montana have lower average precipitation than Ohio, but the coefficient of variation measures show that rainfall was more variable, making weather prediction more difficult in those states. Further, the correlation coefficients indicate that the weather experience a farmer might have had in Ohio provided little useful information for predicting rainfall patterns in either frontier area.

Figure 3 provides additional information on the critical nature of the precipitation distribution in the upper Great Plains relative to the Midwest. The Figure shows the percent of annual rainfall in Ohio and Montana over the period 1895-1982 that was one standard deviation below the mean, our definition of a severe drought. Over the 88 year period, such a shortfall in precipitation occurred in Montana 16 percent of the time, whereas in Ohio, it occurred 12.5 percent of the time. But these figures alone do not reveal the differential threat to agriculture in the two regions. In Montana, rainfall one standard deviation below the mean meant at most 12.9 inches of rain, while in Ohio it meant 33.4 inches, more than enough for crops. The variation in rainfall, then, was much more threatening for agriculture in upper Great Plains than in the

Midwest.

Figure 2
Table 1
Figure 3

III. The Kansas Homestead Bust, the First Major Homestead Failure on the High Plains.

Eastern Kansas, Nebraska, and the Dakotas were settled beginning in the late 1850s and early 1860s, largely by emigrants from Ohio, Indiana, and Illinois. Rainfall and soil conditions were relatively similar to what they had experienced before and the settlers "felt at home."[44] Farmers could use familiar farming techniques and grow quite similar crops of corn and small grains. The agricultural frontier continued to move westward across Kansas through the early 1890s. A major drought, however, led to an exodus of homesteaders as their crops and farms failed. This was the first major homestead "bust" on the Great Plains.[45]

Figure 4 presents rainfall data for western Kansas, beginning in 1883. Mean precipitation for the region was 24 inches, and although 1890 was a dry year, with 17 inches, 1891 and 1892 were wet with 35 and 23 inches, respectively. But 1893 and 1894 were very dry, with rainfall at 19.6 and 15.9 inches, and these were the years that brought about farm failure.[46] As yields collapsed, farm families migrated from the region. The population of the 24 counties of Kansas that lie west of the 100th meridian fell from 68,328 in 1890 to 50,118 in 1900, a decline of 26.7 percent and the number of farms declined from 14,311 in 1890 to 8,952 in 1900, a drop of 37.4 percent.[47]

Figure 4

By the end of the drought, western Kansas was less attractive to new homesteaders. There were 2,385 original homestead entries in 1892, the year before the drought, and even more, 3,083, in 1893, the first year of the drought. But then they fell to 907 in1894 and averaged only 471 new entries annually through the end of the century.[48] The drought also brought agricultural adjustment in western Kansas through farm consolidation and production diversification. Between 1890 and 1900 average farm size in the region doubled from 221 acres to 468 acres and rose to 504 acres by 1920. Farm consolidation in eastern Kansas where rainfall was higher was much more modest. Average farm size in eastern Kansas was 169 acres in 1890, 186 acres in 1900, and 197 acres in 1920, only a 17 percent increase between 1890 and 1920.[49] Farmers also added livestock to grain production. Since after the drought many no longer believed that there had been a permanent climate change bringing more rainfall, they adopted dryfarming techniques to conserve soil moisture.[50]

The homestead failure of western Kansas and Nebraska following the drought of 1893-94 did not deter subsequent migrants from settling on small farms in other parts of the arid Great Plains, especially in eastern Montana and the western Dakotas between 1905 and 1920. The Kansas experience does not appear to have loomed large in the information set used by settlers. Relatively few homesteaders to eastern Montana came from Kansas or Nebraska, so that most settlers did not have direct experience with the drought. Further, there was little systematic means of communicating information to prospective settlers about droughts. Although the USDA published bulletins on farming in the Great Plains, it does not appear to have actively disseminated the publications to migrants, nor did it or any other agency strongly warn of droughts. Cautions were limited and buried in the optimism about the prospects for settlement in the region. Indeed, most organizations were stressing a different factor, dryfarming technology, that promised to limit the impact of any future drought on agricultural prospects on the Great

Plains[51]

IV. Dryfarming or "Scientific Soil Culture" as a Progressive Era Solution to Drought: 1900-1916.

Dryfarming, or scientific soil culture, gained prominence after 1906. Dryfarming was an agricultural doctrine for cultivation of land in semi-arid regions. The most prominent communicator of dryfarming techniques was Hardy Webster Campbell who published a series of monographs (1902, 1907, 1914, 1916). Besides Campbell, there were other advocates of the new, practical science of dryfarming, including John Widtsoe, (1911), President of the Utah Agricultural College and formerly head of the Utah Experiment Station; B.C. Buffin (1909), Professor of Agriculture at the Universities of Wyoming and Colorado Agricultural College and Director of the Wyoming Agricultural Experiment Station; E.R. Parsons, (1913), who was credited with 40 years of experience and scientific training; Thomas Shaw (1911), Professor of Animal Husbandry at the University of Minnesota; V.T. Cooke (1907), whose work was published by the Wyoming Dry Farming Commission, and Professor Murray E. King (1911).[52]

These writers emphasized their academic credentials and experience, and presented their recommendations with references to the use of experimental techniques, control plots, precise measurement, data collection, and practical testimonials.[53] Their prescriptions for arid regions were repeated in agricultural experiment station bulletins and circulars, state and local government publications, proceedings of Dry Farming Congresses, and railroad immigration pamphlets. Further, dry farming principles were examined in USDA bulletins and an Office of Dry Land Agriculture was created in 1905.[54]

Dryfarming was a manifestation of the Progressive Era. It stressed an evolutionary march of progress made possible through the practical adoption of science to advance human welfare: "dry-farming was moving onward to conquer the waste places of the earth."[55] With the introduction of dryfarming, vast areas could be opened for settlement, not only in America, but throughout the world. Arid regions previously thought too hostile for crops without irrigation could be transformed so that farmers could grow wheat and other crops in "the natural habitat of cactus."[56] Food production could be increased at a time when there were concerns of impending shortages of food and various raw materials.[57] Finally, because it was so labor intensive, but promised such high yields, dryfarming encouraged formation of small family farms.[58]

The emergence of dryfarming principles occurred at a time of political conflict over the distribution of the remaining federal estate and whether the land laws should be relaxed sufficiently to allow very much larger homesteads of 1,250 acres or more as advocated by John Wesley Powell.[59] Those who promoted Campbell's dry farming techniques strongly supported the maintenance of the small farm homestead and successfully fought major changes in the land laws. Minimal adjustments were made in 1909 and 1912 to allow for 320 rather than 160 acres and to reduce the residency requirement from 5 to 3 years.[60]The question subsequently encountered was whether such small farms of 160 or 320 acres could be viable during serious drought.

Although the identification and use of adaptable plant varieties were part of dryfarming, the key notion was the use of the soil to store water, some times four to ten feet under ground. The stored water was hypothesized to percolate upward via capillary action toward the surface to nourish plant roots.[61] Water was to be captured through persistent cultivation, deep fall and spring plowing to capture moisture, surface mulching with a harrow after every rain to create a 2 ½ to 3 inch mulch to retard evaporation, subsurface soil packing to promote percolation, and summer fallow and tillage on alternating years to build up moisture and nutrients.[62] The subsurface packer and other specialized implements were recommended by dryfarming advocates.[63] Too much evaporation, rather than too little rainfall was asserted to be the critical problem in semi-arid regions.[64] Diligent adherence to these practices would increase yields in wet years by providing plants with the right amount of moisture and sustain reasonable yields during droughts.[65]

Through the use of scientific dryfarming techniques, sharp fluctuations in agricultural yields were no longer to be the natural consequence of the vagaries of rainfall, but rather the result of a failure of farmers to follow the proscribed practices. It was a choice variable. To achieve the success that could be possible, dryfarming advocates stressed that "eastern farmers must *'unlearn'* what he knows of farming."[66] Close attention to the doctrines promised mastery over nature. The occasional dry year was not considered serious for those who practiced proper farming methods: "the farmer will always have a crop: in the wet years his crop will be large; in the driest year it will be sufficient to sustain him."[67]

The assertions of dryfarming proponents might have been dismissed at an earlier time, but at the turn of the century there was an optimistic faith in the ability of science and technology to remove natural constraints and to eliminate waste and inefficiency in the economy.[68] Dryfarming also was introduced at a time when there were no serious droughts, but rather, relatively abundant rainfall, at least in the upper Great Plains. Hence, its doctrines were not put to test until 1917. Dryfarming principles were so attractive that they were emphasized by virtually every organization supplying information to homesteaders on the Great Plains between 1900 and 1920.

Agricultural Experiment Stations and Dryfarming.

Dryfarming appeared just as the big homestead boom in eastern Montana and the western

Dakotas was getting under way. Its principles were extended and communicated to farmers by the agricultural colleges and their experiment stations in the upper Great Plains.[69] The Montana Agricultural Experiment Station organized Farmers' Institutes to bring together farmers and experiment station personnel. At least one meeting was held in each county annually.[70] During 1901-2, 17 institutes were held, and by 1907, 154 were convened across Montana, with 12,000 farmers in attendance.[71]The Farmers' Institute assured prospective homesteaders that even in eastern Montana where annual rainfall was about 13 inches irrigation was "not necessary" in many places and that good crops could be grown with dryfarming. During droughts, lower, but adequate yields could be maintained.[72] Besides Farmers' Institutes, demonstration farms were set up to showcase new crops, equipment, and cultivation practices, and by1910,13 dry farm substations had been set up to conduct dryfarming tests.[73] The Northern Pacific, Great Northern, Chicago, Burlington and Quincy, and Milwaukee railroads provided demonstration trains and contributed funding for dryfarming investigations.[74] State and railroad support for dryfarming experiments continued to rise between 1909 and 1914.[75]

Publications of the Experiment Stations in Montana, North and South Dakota, Nebraska, Wyoming, and Colorado provided specific information to settlers about precipitation levels in various areas, crop types to plant, new varieties under consideration, cultivation and tillage techniques, the best timing for cultivation and planting in each region, results of crop rotation experiments, expected yields and costs, returns from use of summer fallow, and necessary farm equipment.[76]The publications were optimistic in their prescriptions for the success of small dry land homesteads, and they repeated or closely followed the principles advocated by Campbell, Widtsoe, Buffin, and others.[77] Climatic information for Montana stations through 1913 was listed by Cooley (1912) and Linfield (1914). Most of the time series reported began in 1898 or thereafter so that the information record for precipitation was fairly short, ten years or less. Even so, rainfall was taking secondary importance because of the emphasis on moisture conservation through the use of dryfarming technology. Changes in rainfall due to cultivation were not emphasized in experiment station reports, although some other sources of information continued to point to the possibility of a permanent change in climate.

Prospective settlers commonly wrote to the experiment station requesting information on the availability of lands to homestead, land values, the types of crops to plant, cultivation practices, the weather (especially rainfall), the capital requirements to start a new farm, and the location of other sources of information. Judging by the volume of letters in the archives, correspondence was a major activity of agricultural extension station personnel. They not only answered questions, but referred homesteaders to dryfarming books, such as the one by Buffin (1909), the publications of the Dry Farming Congresses, and periodicals like *Dakota Farmer*, *Scientific Farmer*, *Montana Farmer*, and *Western Farmer*, all of which published dryfarming articles.[78] The experiment station also distributed copies of its bulletins describing dryfarming practices as part of its correspondence.[79] Because they actively supplied basic data on the climate and dry farming options, the experiment stations were the most important source of information for homesteaders on the upper Great Plains.

The U.S. Department of Agriculture and Dryfarming.

The Department of Agriculture was more cautious than were the experiment stations in prescribing particular dryfarming practices or crops. Department personnel argued that regional differences had to be considered before making broad recommendations, and they criticized Hardy

Webster Campbell's assertion that dryfarming techniques could be applied everywhere to improve yields. For example, summer fallow, which was a central part of dryfarming doctrine, was argued to be costly, effective only under certain circumstances, and conducive to blowing.[80] Further, some USDA experiments did not locate appreciable movement of water in the soil, which was a key claim of dryfarming advocates. E.C. Chilcott, head of the Office of Dry Land Agriculture was Campbell's chief critic.[81] Chilcott, Cole, and Burns (1915) summarized results from 14 field stations in North Dakota, Montana, Nebraska, Colorado, Kansas, and Texas and concluded that unfavorable climatic conditions could result a major yield decline, regardless of crops planted or cultural methods used, a conclusion contrary to the most optimistic claims made by Campbell and others. Even so, the conclusion does not appear to have been widely circulated. Alfred Atkinson of the Montana Experiment Station urged the USDA to be more active in disseminating its studies and to attend the 1910 Dry Farming Congress in Spokane. He argued that the experiment stations and USDA had "not made full provision for getting into the hands of these new farmers the statements regarding the best known methods. Unlike humid agriculture, dry land agriculture demands that the essentials must be observed if success is gained."[82]

Further, the Department did not strongly counter dryfarming assertions, and other USDA publications described the results of dry farm experiments and recommended cultivation to enhance water storage in a manner consistent with Campbell's arguments.[83] Even Chilcott (1910) released the results of USDA dry land investigations conducted after 1906 that recommended alternate cropping and summer tillage. Small homesteads of 160 acres were supported. Hence, the USDA lacked a consistent position on dryfarming, and any homesteader who read the technical reports would have seen little that differed from experiment station publications.[84]

Dry Farming Congresses and Dryfarming.

Dry Farming Congresses were organized to disseminate information about dryfarming techniques and the opportunities they created for homesteaders and to lobby Congress and the states for supportive land policies.[85]They were most active during homestead migration to the upper Great Plains, 1906-1916, which was also a time of high rainfall and success for dryfarming doctrine. Congresses were held in Denver, 1907, Salt Lake City, 1908, Cheyenne, 1909, Billings, 1909, Spokane, 1910, Colorado Springs, 1911, Lethbridge, 1912, Wichita, 1914, Denver,1915, and El Paso, 1916. They were popular. 500 delegates attended the third Congress in Cheyenne, February 23-25, 1909, and in 1912, the Dry Farming Congress was alleged to have 15,000 members.[86]

The information-sharing objective of the congresses was outlined at the Fourth Dry Farming Congress in Billings, Montana, October 26-28, 1909: "to discuss and compare methods by which the great area of arid land can be profitably utilized under thorough tillage by which the natural rainfall can be conserved; to encourage the use of methods by which in districts where rainfall is slight, or irrigation water is limited, the actual productive acreage can be increased, to create closer co-operation between the government and state experts in charge of Dry Farming Experimental work and the actual farmers of the arid districts."[87]The assemblies were addressed by experiment station personnel, leading dry farm proponents like Hardy Webster Campbell and Thomas Shaw, and local politicians, such as the Governors of Colorado, Montana, and Wyoming. The presenters outlined the opportunities afforded through dry farming, new crops to plant, practical information regarding cultivation, the results of experiment station studies, and testimonials from "experienced"dry farmers.[88]As such, the Dry Farming Congresses were another important source of information about dryfarming techniques for homesteaders.

Local Government Agencies and Institutions and Dryfarming.

Prospective homesteaders on the upper Great Plains also received publications from state agencies, such as the Montana Bureau of Agriculture, Labor and Industry, later the Department of Agriculture and Publicity. Until 1904 and the shift of emphasis to dryfarming, the Montana agency stressed irrigation opportunities in the state. With the publication of the 1904 report and the inauguration of a section titled, "Dry Land Farming" and thereafter through 1918, however, the agency promoted the opportunities provided by dryfarming. The 1906 report noted that in 15 years of wheat farming in Cascade County in eastern Montana there had never been an entire crop failure on non-irrigated farms, although droughts could cut yields in half.[89]Beginning in 1908, dryfarming was advertised as the poor man's alternative to expensive irrigation in federal reclamation projects.[90]The agency also provided lists of monthly precipitation, county population, land values, spur railroad lines, and crops to plant, including winter and spring wheat, oats, rye, barley flax, peas, "prolific potatoes,"watermelon, alfalfa, sugar beets, all of which "could be grown without the hazard of failure even in a dry year, providing they have been planted in season and properly prepared land."[91]Practical information for homesteaders regarding the use of the federal land laws, location and amounts of available federal land, and lists of recent homestead entries were included. Additionally, the reports announced the results of experiment station dryfarming tests, included primers on how to use the Campbell method to conserve soil moisture, and described the prizes won at international agricultural fairs, such as the Panama-Pacific International Exposition in San Francisco where Montana won the grand prize for cereals.[92] Specific reference to recent experiment station publications on dryfarming was made.[93]

Any prospective homesteader who had examined the experiment station and USDA publications and attended or read material from the Dry Farming Congresses would have found confirmation in the agency's publications. There were similar state agencies elsewhere in the Great Plains, such as in North Dakota and Kansas.[94]

Besides state agencies, local communities, land developers, and professional homestead locators advertised the advantages of their dry farming regions to migrants. For example, the Glasgow (Montana) Commercial Club claimed that the local land was "very productive without irrigation and the increased yields by irrigation makes it one of the richest valleys in the world." Developer W.M. Wooldridge's circulated a two-page flier for Hindsdale, Montana, "a new town on the main line of the Great Northern Railway" in April 1904, and E.B. Milburn's flier, "Eastern Montana Farm Lands" summarized crops grown, comparative yields, rainfall, private and government land availability, agricultural prizes won, and testimonials from satisfied farmers "who are glad they came to Montana."[95]

The Railroads and Dryfarming

Most historical accounts of homesteads and their subsequent failure point to the railroads as having misled settlers with extravagant claims about dryfarming prospects.[96] The railroads, however, could not have been mere publicists, indifferent to the outcome of homestead migration. The railroads adopted agricultural development in order to promote the settlement of their service areas, and in the case of the Northern Pacific, to sell land. They had to address the difficult conditions of the region if a sustained population were to be promoted. Widespread failure of agriculture would have reduced the attractiveness of the area and hence, the value of railroad investment in the upper Great Plains. Trains, and particularly, tracks and yards were site-specific capital investments with little alternative uses. Hence, the railroads had a stake in the permanent, not temporary, success of the region. And they had no better information about the weather or dryfarming prospects than did the experiment stations or USDA. Dryfarming offered a solution to the problem of settling their lands, and they invested in experiments, demonstration farms and trains, and publicized its advantages. And through 1916, with abundant rainfall, dryfarming experiments continued to show promise. Only with the drought after 1917, was dryfarming doctrine shown to be an insufficient solution, and after that, railroad promotion was much more cautious.[97]

The Northern Pacific argued in 1911 that "Good farming, good methods of cultivation, intelligent tillage of the soil, should be the slogan of the Northwest. Investigations demonstrate that thorough and intelligent cultivation means *more* than the particular amount of rainfall in regions which are classed as sub-humid or semi-arid. The fact has been demonstrated beyond any reasonable doubt that the yields of the various grains can be greatly increased and often doubled, by the intelligent cultivation of the soil, and not only increased in amount but the yield rendered sure."[98]

The railroads relied upon both private demonstration farms and the state experiment stations to conduct dryfarming investigations. They hired dryfarming experts like Hardy Webster Campbell and Thomas Shaw to perform experiments and to establish a rapport with farmers for the transfer of practical dryfarming techniques.[99] The Rock Island named Henry M. Cottrell, authority on dry farming and director of the Colorado Agricultural Experiment station and who had been involved in the Colorado Farmers' Institutes to head its agricultural development department in 1914. The results of dryfarming investigations and testimonials from farmers were advertised throughout the Midwest, East, and Europe to substantiate claims that were made about the advantages of homesteading the upper Great Plains.

The railroads provided farmers with cuttings and crop seeds that seemed suited to the northern plains at cost.[100] Immigration departments were created, and immigrant trains provided a low-cost means of transporting household goods and farm equipment and animals for settlement.[101] Free transportation to Farmers' Institutes and demonstration trains were sent out to spread the word about moisture-saving techniques. For example, the Chicago, Burlington, and Quincy sent out a Better Farming Special train to 65 towns in Montana, Wyoming, South Dakota, and Nebraska. Finally, the railroads lobbied Congress to liberalize the land laws for the adjustments in the land laws to allow for shorter residences and somewhat larger homestead claims.[102]

We argue that the limited knowledge of the climate of the Great Plains and the optimistic assertions of dryfarming doctrine critically affected how homesteaders interpreted information about rainfall and agricultural prospects in the region. A lack of experience with semi-arid agriculture and the assurances of dryfarming experts that moisture could be stored in the soil, mitigating any dry period, led homesteaders to discount drought signals. Before examining this phenomena, we turn to homestead record on the upper Great Plains.

V. Homestead Settlement and Drought on the Upper Great Plains, 1900-1925.

The homestead boom in the northern Great Plains began gradually after 1900 with the major increase in settlement occurring in 1910 and thereafter through 1921. Original homestead entries that had averaged 3,495 between 1900 and 1909, jumped to 21,982 in 1910 and remained well above the pre-1910 average through 1921. After that, homesteading declined considerably so that in 1925 there were only 1,180 new homestead entries. All told, between 1900 and 1921 some 197,388 original homestead claims were filed.[103] With 67,963,057 acres of available government land in 1900, Montana alone had over 7 percent of all unappropriated federal property that could be claimed by homesteaders. And they did so rapidly, reducing unappropriated federal land to only 5,659,879 acres by 1922.[104] As a result the rural population of Montana grew from 158,775 in 1900 to 376,878 people in 1920, with the eastern counties growing from 83,762 in 1900 to 250,330 in 1920.[105] Figure 5 describes original homestead entries in Montana per 100,000 acres of available federal land during the period 1903 through 1930.[106] Homesteading rises sharply in 1910 and continues through 1922. After that year, homestead entries relative to available federal land fall and do not recover.

Figure 5

The timing of the homestead boom seems due to both the federal land law changes in 1909 and 1912 that doubled the homestead allotment and reduced the waiting period for receiving title, as well as the gradual extension of railroad lines. Although the Northern Pacific and Great Northern Railroads had crossed Montana in the 1880s, they added track after 1900 and the Chicago, Milwaukee, and St. Paul Railroad entered Montana in 1907 and 1908. In 1900 there were 2,932 miles of mainline track in Montana. By 1915 there were 4,589 miles of mainline and 1,384 miles of branch track.[107] Railroads were the primary mode of transportation. They provided access to potential homesteads and linked those homesteads to markets. New towns along the main and branch lines were founded for the anticipated growth in population.[108] Wheat prices (the crop most likely to be grown by homesteaders) rose moderately from 1900 to 1914 and then doubled from their 1914 level by 1917. Wheat acreage expanded from 72,555 acres in 1900 to

3,621,000 acres in 1919.[109] Most of the agricultural expansion occurred in the eastern two-thirds of the state.

The attractiveness of Montana also was stimulated by very high wheat yields, which remained above 20 bushels per acre from 1891 through 1914, well above the approximate 15 bushels possible in the Midwestern states of Ohio, Illinois, and Kansas.[110]Yields were high because soils had accumulated nutrients that had not been leached away by precipitation in the dry climate. Further, the period 1906 through 1916 was one of unusually abundant rainfall. Figure 6 describes rainfall from 1895 through 1925 in eastern Montana where most homesteads were located.[111] Except for one-year droughts in years 1904 and 1910, most of the period through 1916 is one of precipitation at or above the mean.

Figure 6

To have a sense of what a homesteader might have expected to earn from wheat production in 1916, the year before the drought, we have identified 15 homestead farms of 320 acres or less in Hill County in northern Montana that were surveyed in 1921 by the Montana State Agricultural Experiment Station. This was a region of wheat farms that was heavily homesteaded from 1910 through 1922. The survey collected data on farm size, crop acres, production, sales, and expenses.[112] Using these survey data, the1916 Montana average wheat yield of 19.3 bushels per acre and wheat prices of $1.43, and converting 1921 expense estimates to 1916 values, we estimated gross and net wheat income for the mean homestead in 1916, the year prior to the drought. The exercise is shown in Table 2. As indicated, the mean gross wheat income for a homestead was $2,622, wheat income net of current expenses was $2,387, and net of total expenses were $2,273.[113]Although these are only suggestive figures, they compare very favorably with average U.S. per farm gross income of $2,104 in 1920 or mean total farm receipts for the western U.S. of $2,322 in 1922.[114] The sample data indicate why homesteading in the upper Great Plains was such an attractive prospect in the early part of the twentieth century, given the very high wheat yields that were possible from untapped soil.

Table 2

To further examine the motivating factors underlying homesteading we estimated two equations for the period 1895 to 1925 for Montana:

(1) $\text{Yields}_t = c_1 + c_2\,\text{Land Quality}_t + c_3\,\text{Rain}_{t,\,t-1} + e$,

where land quality is represented by available surveyed federal land. Of the total federal land available for claiming there was surveyed and unsurveyed land. Absent a measure of soil quality, we assume that General Land Office surveyors would survey the best or most productive lands first because those would be most desirable to homesteaders. We included current rainfall and rainfall from the previous year to test dryfarming claims that past rainfall could be stored to plant use.

(2) $\text{Original Homesteads}_t = b_1 + b_2\text{Available Surveyed Federal Land}_t + b_3\,\text{WheatYields}_{t,\,t-1} + b_4\text{Wheat Price}_{t,t-1} + b_5\text{Federal Law Change} + e$,

where a dummy for changes in federal land laws to reduce the costs of acquiring land is entered beginning in 1909.

Table 3

Table 3 provides the results of the OLS estimation. Wheat yields are strongly influenced by land quality as proxied and current rainfall. The previous year's rain had little impact on current production, undercutting the dryfarming notion that rainfall could be stored from year to year.[115] For annual original homesteads filed, changes in federal land law that reduced the occupancy requirement and doubled the amount of land that could be claimed to 320 acres and lagged wheat yields, reflecting information on expected returns from wheat farming have the expected positive signs and are significant at approximately 95 percent. Surveyed federal lands available for homesteading and real wheat prices, both current and previous year's, also encouraged new entries although at lower levels of significance.[116] Migrants, then, were attracted to the region by the availability of government land, which after 1909 could be claimed more easily, by knowledge of previous high wheat yields, and the price of wheat.

V. Limited Climate Information, Dryfarming Doctrine and Decision Making: Drought and Homestead Failure.

Because settlers were moving into a very different region from what they had experienced, they would not know the "true" conditions for agricultural prospects at the time of the migration or farming decision. When making their decisions, they would have to decide how to weigh observed conditions, relative to their prior beliefs about the area. A Bayesian decision process would involve updating prior assessments whenever new information about precipitation, yields, and prices appeared, leading homesteaders to form new posterior judgements about the true state of agricultural opportunities in the upper Great Plains. Hence, settlers would begin with limited information about farming opportunities obtained from previous homesteaders or advertisements from railroads, state and local governments or other sources, and after migration, they would annually update their prior opinions based on their actual experiences leading to a more complete judgement about farming opportunities. This Bayesian process has been described as adaptive learning.[117] If the possibility of serious drought in the region had been appreciated and the linkage between precipitation and farm production well understood, observations of very dry weather in 1917 would have led homesteaders to modify their prior opinions, formed during years of relatively high rainfall, and adjust farming practices–delaying or changing migration plans for prospective migrants and reducing planting by existing farmers. Larger farms would have been preferred because they could have produced more and supported the diversified crops and livestock that could better withstand drought.

But, the climate was not understood and appropriate farm practices and sizes had not been determined. Dryfarming doctrine argued that annual rainfall was not essential and that small farms could be successful under adverse conditions. This limited and ultimately faulty information was used in the assessment of weather conditions and their implications for agriculture. Given a high degree of uncertainty, homesteaders relied upon heuristics that heavily weighed past information in making judgements about farming prospects when they received new rainfall information.[118] We argue that the previous wet period and the strong claims of dryfarming experts led homesteaders to discount observations of dry weather and to place more weight on past opinions about the ability of the region to withstand droughts. Discounting drought prospects would lead to continued migration and farming, even in the face of currently observed unattractive returns. This decision rule would be reinforced if the dry year were followed by a rebound in rainfall and production. If a dry year, however, were followed by two or more periods of drought and poor harvests, then prior beliefs would be adjusted toward a more pessimistic view of homesteading opportunities. Accordingly, a migration and farming decision rule strongly influenced by the past assertions of dryfarming doctrine would result in a lagged response to a serious drought.

As Figure 6 shows, the drought of 1917-1921 stands out both for the severity of the precipitation shortfall and for its length. For five years, precipitation remained below average, and in 1917 and 1919 rainfall was more than one standard deviation below the mean. Nothing like this had been experienced in Montana since 1895, the period in which historical data were available for consideration by homesteaders.[119] The drought appeared with a dry spring in 1917.[120] Optimism remained high, however, and there was no initial adjustment in farming practices or settlement.

The data in Figure 5 illustrate the lagged response to the drought. Original homestead entries continued at their high level through 1922. 53,366 additional new homestead entries were filed between 1917 and 1925, with most between 1917 and 1922. 15,197 original homestead entries were made in 1917 (more than in 1916), and they gradually declined, but even 1920 and 1921, the last two years of the drought, 13,235 homestead claims were entered.[121] The number of farms in Montana grew by 7,700 between 1916 and 1920 before declining gradually by 1925.[122]

Dryfarming doctrine encouraged a disregard of drought conditions and urged continued migration and settlement. For example, in July 1917 Alfred Atkinson of the Montana Experiment Station and later, President of Montana State College of Agriculture and Mechanical Arts, warned a prospective homesteader that the supply of good land was dwindling. He also suggested that the homesteader bring $2,500 to $3,000 to start a farm. In an August 1917 letter to another homesteader, Atkinson claimed that "Dry land crops are raised successfully in practically all parts of Montana....The great dry farming area in Montana lies in the eastern part of the state. There is practically no place in the state where they do not receive sufficient rainfall in normal years to produce a crop."And in December 1917, the experiment station claimed that: "there are very few points in Montana where they cannot raise crops successfully."[123] The drought would continue and become even more severe, yet Atkinson examined available precipitation data from 1898 through 1916 and concluded that there was "a tendency for two dry years, but in very few cases for three dry years in succession."[124]

The two short-term droughts in 1904 and 1910 in eastern Montana had been accommodated with little hardship, and this experience validated the claims of dryfarming advocates that the new techniques could successfully store enough water in the soil to carry a small farmer through a drought year. In commenting on the potential for dry-land agriculture in Cascade County in eastern Montana, the Montana Department of Agriculture, Labor, and Industry (1906, 311) minimized the effects of drought, claiming that in 15 years there had never been a complete crop failure. A Milwaukee Railroad publication (1912) included a testimonial from a settler in Musselshell, County in the eastern part of the state, who commented on the success of dryfarming after the drought of 1910 : "…Taking into consideration the remarkable dry season we just passed through I am now perfectly satisfied that good paying crops can be raised on the dry land principle…"[125]

Dryfarming doctrine did not begin to change until 1919. By that year the unusual duration of the drought was finally acknowledged by the experiment station: "Weather conditions beyond the expectation of any student of weather reports the past 40 years in this state have fallen upon Montana..." For the first time, the experiment station indicated doubt about the ability of dryfarming techniques to guarantee at least a moderately successful crop.[126] In a further shift, by 1920 the experiment station claimed that drought could be expected "rather frequently, "and by

1921 dryfarming doctrine was called into question.[127]Small dry-land homesteads were criticized for having been inappropriate. Experiment Station Director Linfield claimed that the distribution of marginal lands via the homestead acts was a mistake and that much larger farms, "two to four times the area of the land named in the National Homestead Acts" were necessary for successful farming in dry areas.[128]

By 1920, after three years of drought and after average wheat yields had dropped to 2.7 bushels per acre in 1919, down from 26.5 bushels in 1915, prior beliefs about the viability of small homesteads were finally revised. Homestead abandonment began. Between 1919 and 1925, some 60,000 homesteaders are claimed to have left the state, with over 11,000 farms failing (one out of five) and approximately 2,000,000 acres of land going out of production.[129] The impact of the drought on farm incomes was devastating, and it undercut the viability of small homesteads in particular.

Returning to Table 2 and the mean farm from the sample of 15 homestead farms in Hill County surveyed by the Montana Experiment Station in 1921, we report gross and net wheat income in 1919 at the peak of the drought, using the lower yields of 1919 at 2.7 bushels per acre, the higher 1919 wheat price of $2.16, and converting 1921 reported expenses to 1919 values. As indicated, 1919 net wheat income was $182, a drop of 92 percent from the $2,387 calculated for 1916. Wheat income net of current expenses, mortgage costs and depreciation was $1.00. This exercise reveals how devastating the drought was for homestead earnings, relative to the U.S. per farm gross income of $2,104 in 1920.

Larger farms in the upper Great Plains could better withstand the drought. Turning to the experiment station survey, there were 50 farms larger than 320 acres, and we report surveyed production and 1921 expense data for them in the table, converted to 1919 values. Using 1919 yields wheat prices, gross mean wheat income for these larger farms was $1,171, income net of current expenses was $496, and net of mortgage and depreciation costs, $175. The drop in yields hurt farms of all sizes, but larger farms still had two to three times the income of homesteads and had positive earnings to service mortgage debt and other loans.[130]

Data assembled by the experiment station to analyze foreclosures on farm loans made between 1911 and 1932 also shows the vulnerability of small homesteads to the drop in yields that occurred with the drought. The data are described in Table 4.

Table 4

Of the 381 loans examined, 107 were to homesteaded farms with an average size of 291 acres. 70 percent of the loans to homesteaded farms were foreclosed, by far the largest percentage of all farm categories. By comparison, the 127 farms acquired through purchase from non-relatives with an average size of 544 acres had foreclosure rates of 28 percent, the next highest category. All larger farms had lower foreclosure rates. They were less likely to default on loans during drought because they had more production to draw from and other products beyond wheat to sell.[131] Homesteads, by contrast, were smaller, had lower appraised values, and were less diversified than were other farms.

Survey data from later in the 1920s and early 1930s reinforce the conclusion that small homesteads were not viable on the Great Plains. Halcrow's (1938) study of 503 "unsuccessful" farms in eastern Montana, using data for 1928-1935, found that they were undiversified and small, two-thirds were below 360 acres, when at least 700 to 800 acres were deemed necessary for minimum cost production.[132] Cochrane's (1938) examination of 314 farms, using data for 1934-

36, found that the most productive farms (measured by net income) were twice the size of the average farm at approximately 1,100 acres, focused on wheat cultivation with diversification into livestock production, did not invest appreciably more in buildings, but used more machinery, and were more likely to practice summer fallow than were their less productive counterparts. With limited acreage, small farms could not afford to leave much land in fallow and lacked the economies of scale necessary for effective use of machinery.[133]

VI. Conclusion.

In the late 19th and early 20th centuries the North American agricultural frontier moved for the first time into semi-arid regions where farming was vulnerable to drought. Farmers who migrated to the Great Plains had to adapt their crops, techniques, and farm sizes to better fit the environment. But there was very incomplete information for making these adjustments. The use of decision rules that gambled on the continuation of previous wet periods and the optimistic opinions of dryfarming "experts" led too many to migrate to the region and settle on too many small dry land wheat farms. Our sample homestead data indicate that so long as rainfall remained high, early homesteads were viable, providing farm incomes comparable to what could be earned elsewhere. But when rainfall declined, farms of 320 acres or less were especially vulnerable to the drop in yields. Most appear to have been abandoned subsequently in the midst of drought. Two waves of major homestead failures took place, first in the central Great Plains of western Kansas and Nebraska and eastern Colorado and then, almost 25 years later in the northern Great Plains of eastern Montana and the western Dakotas. These homestead failures and corresponding farm consolidation were part of a necessary transition process toward larger, more viable farms in the Great Plains. Although it is beyond the scope of this paper to estimate the costs of this transition, they surely included the lost opportunity income of homesteaders during the five-year drought period, redundant farm buildings, cultivation of submarginal lands that subsequently contributed to wind erosion and the Dust Bowl of the 1930s, excessive county infrastructure that was designed for larger populations, and disruption to the banking system by wide-spread mortgage defaults by small farmers and corresponding bank failures.[134]

The transactions costs, however, were probably unavoidable given the limited information available about the climate of the Great Plains and appropriate agricultural techniques and farm sizes for a semi-arid region. Homesteaders, migrating during periods of relatively more rainfall, tended to discount new information that suggested drought. In western Kansas, there was the belief that the climate had been changed by cultivation, "rain follows the plow,"so that drought was a thing of the past. In eastern Montana, dryfarming doctrine assured homesteaders that moisture could stored in the soil and that dry periods could be successfully endured on small wheat farms. Both judgements were incorrect. Had homesteaders better understood the weather they might not have accepted the claims of a changing climate or of dryfarming advocates. And had dryfarming tests occurred under less favorable circumstances, its doctrine might have been more circumspect. Land laws might have been revised and fewer homesteaders might have gone to the Great Plains around the turn of the century.

Census data provide a glimpse of the adjustment in farm size that was necessary to bring about more sustainable agricultural establishments. In 1910, during the midst of the homestead boom in the upper Great Plains, average farm size in eastern Montana was 612 acres, a figure that included homesteads of 160 to 320 acres and larger established farms and ranches. By 1920, average farm size was 696 acres, and by 1925, after the effects of the drought had been felt and farm consolidation had occurred, average farm size was 783 acres, an increase of 28 percent from 1910.[135] Moreover, the share of small farms, 499 acres or smaller, declined between 1910 and 1925 from 84 percent of total farms to 59 percent, whereas the share of larger farms, 500 acres and up, increased from 16 percent to 41 percent. The dispersion of observed farm sizes also declined. The coefficient of variation for farm sizes in eastern Montana fell from 1.35 in 1910 to 1.01 by 1925.[136] Farm sizes continued to expand after 1925 with adoption of mechanization and associated changes in economies of scale in grain production. The droughts of 1893-94 in the central region and 1917-21 in the north, however, dashed the small-farm ideal of the homestead acts and initiated the move to more viable, larger farms on the semi-arid Great Plains.

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1. Stegner (1954, 399).

2. Buffin (1909, 16).

3. Widtsoe (1911, 412).

4. The classic description of the Great Plains is by Webb (1931). Ranges of mean annual precipitation, calculated 1941-1970 for western Kansas are provided in Self (1978, 58).

5. For an assessment of the critical importance of precipitation on the Great Plains, see Starch (1939, 114). When rainfall occurred also was critical. Rainfall during the growing season, April-June, was most important. For discussion, see Burke and Pickney (1919) and Johnson and Saunderson (1936)..

6. Calculated from Fite (1966, 131). The role of weather in on agricultural yields and prices in the 17th and 18th centuries in Europe is discussed in de Vries (1980).

7. Calculated from the Annual Reports of the Commissioner of the General Land Office for the Fiscal Years, 1900-1920. The data are state levels, but most homesteading was in the east. Homestead failure figures from Howard (1959, 207-8) and Fulton (1977, 69).

8. For analysis of some American frontier experiences, see Conley and Galenson (1998), Herscovici (1998), and Ferrie (1994).

9. Criticisms of land policy, homesteading, and dry land farming are summarized in the USDA Yearbook of Agriculture, 1938, Soils and Men. In particular, see Hambridge (1938, 9); Bennett, Kenney, and Chapline (1938, 69-72); Gray, Bennett, Kraemer, and Sparhawk (1938, 111-13); Cooper, Roth, Maddox, Schickele, and Turner (1938, 146-7); Clapp, Munns, Sims, Wehrwein, and Clayton (1938, 235); Mathews and Cole (1938, 241). See also Thornthwaite (1936, 202-50) for critical discussion of homestead settlement of the Great Plains under the land laws. He notes (219) the lack of a drought model for prediction. Nevertheless he is critical of farmers who ventured into the region for being "unable or unwilling to consider, realistically, the odds against them" (235). The failure of homesteaders to perceive the drought risk is stressed throughout the literature. For example, see Thornthwaite (1941, 177-85), Saarinen (1996). M.L. Wilson of the Montana Extension Service (1923, 28-31) cited the adoption of inappropriate techniques and cultivation of land not suited to agriculture, and the failure of farmers to adapt to the requirements of the region as contributing to farm failure. The importance of diversification and larger farms is noted by the USDA in Oakley and Westover (1924). Kifer and Stewart (1938, 21) point to the inadequate size of farms in the Great Plains that were at drought risk in the 1930s. The development of farms that were too small for efficient operation due to the homestead acts is stressed in Saunderson, Haight, Peterson, and Willard (1937, 15, 19). A general inditement of past land policy for encouraging farms that were too small and for promoting wasteful land use practices is outlined in Great Plains Committee (1936, 27-44; 63-4).

10. Howard (1959, 189-6) blames a frenzy of unskilled homesteaders settling and farming the region. Malone, Roeder, and Lang (1991, 238) emphasize the over promotion of land by the

railroads and others. See also Toole (1959, 228-42) and White (1991, 142-53). For discussion of Alberta and Saskatchewan and a similar discussion of inept farmers, promotion, failure to perceive drought, excessive promotion, is found in Jones (1986, 1987).

11. For discussion of decision making under uncertainty, the use of heuristics, and the biases that can result, see Kahneman, Slovic, and Tversky (1982), El-Gamal and Grether (1995), and Camerer (1995).

12. Between 1863, the year after the Homestead Act was passed, and 1880, 469,882 original homestead entries were filed covering 55,667,035 acres of federal government land. These figures were compiled from the Annual Reports of the Commissioner of the General Land Office for the Fiscal Years1863-1880. The average claim size was 118 acres. 59 percent of the claimed acreage was in the Midwest, in Ohio, Indiana, Illinois, Michigan, Iowa, Wisconsin, Minnesota, eastern Kansas and Nebraska. During this period homestead entries include those made under the Timber and Stone Act.

13. For instance, 1880 census data show similar agricultural patterns across northern states: Average farm size was 99 acres in Ohio, 124 acres in Illinois, and 134 acres in Iowa; Ohio, Illinois, and Iowa devoted 13 percent, 29 percent, and 27 percent of farm land to corn and 10 percent, 10 percent, and 6 percent, respectively, in wheat. See U.S. Department of the Interior, Census Office (1883, 26-7, 102-3, 177, 212, 250-1). Farmers did have to make adjustments for different temperatures and soil types. Olmstead and Rhode (2000) examine the process of biological innovation that occurred in American agricultural development that was in part stimulated by migration to new areas with different growing conditions.

14. The 100th meridian also ran through the panhandle of Oklahoma and across west Texas. Because Oklahoma was largely Indian reserve and Texas was governed by different land policies, these areas generally were not the focus of northern homesteaders.

15. <u>Annual Reports of the Commissioner of the General Land Office</u> for the Fiscal Years, 1880-1925. The calculations are for state totals.

16. Laskin (1996, 92-3) referred to the weather of the high plains as “shockingly different.”

17. Bark (1978, 11), Riefler (1978, 66), Diaz (1983), Karl and Koscielny (1982).

18. Warrick (1975, 11-27; 1980) points out that although there is no general agreement on how normal circulation patterns are disrupted to cause droughts, the arid Southwest and Great Plains are most susceptible in North America. There are no well-defined drought cycles. Smith (1920b, 81-2, 101) provides an early discussion of the climate of the Great Plains, giving charts of climate types according to annual rainfall and charts of crops.

19. Felch (1978, 25-42). Felch distinguishes between droughts and aridity. The latter is a permanent characteristic of low average precipitation, while drought is temporary. Arid regions may have fewer droughts. The American Meteorology Society defines drought as a period of abnormally dry weather sufficiently prolonged for a lack of water to cause serious hydro-logic imbalance in the affected area. Schneider (1978, 163) states that although drought is a recurrent

feature, it is difficult to forecast. Warrick (1975, xiii, 3-11) states that drought is when there is deficiency of moisture that seriously damages crops in a large area. He notes a general disagreement as to the primary meteorological causes of prolonged precipitation deficiencies and claims that there is little statistical evidence of drought cycles. The arid Southwest and semi-arid Mid Continent are most vulnerable. Smith (1920b, 25) indicates that the study of weather was still relatively new early in the twentieth century. The agricultural meteorology division was not organized in the USDA Weather Bureau until 1916. Bradley (1976, 2-15) comments that even today the climatic characteristics of the area are not well understood For a similar assessment, Trewartha (1961, 259-61, 279-87) who describes the arid conditions that characterize the interior just east of the Rocky Mountains and who points out that this is an area where prediction of climatic conditions is difficult.

20. See U.S. Department of Agriculture, Weather Bureau (1897, 18) for observations about drought duration. On page 39 the agency reported that "..in years of scant rainfall there may be partial failure of crops throughout its whole extent. So varied are its capabilities, however, that it rarely happens that there is total failure of all crops except in the Far West."

21. Smith (1920a, 281), Whitnah (1961, 4-8) describes early crude mapping of storm movement, theories of wind and pressure formation in the 1840s-70s. He notes (page 23) that the original focus of the weather service was on Gulf and Atlantic Coasts and the Great Lakes. See Craft (1998) for discussion of the use of weather information in Great Lakes shipping.

22. The location of weather reporting stations is shown in the Annual Reports of the Chief Signal Officer through 1890. For example see map and lists in The Report of the Chief Signal Officer of the Army, (Chief Signal Officer,1881, 304). The reports also provide summaries of the year's weather at observation posts.

23. Smith (1920a, 281); Hughes (1970, 36-9) also notes that in the 19th century most Weather Bureau activity involved storm warnings. Weekly weather forecasts began in 1910.

24. Smith (1920a, 281); Weber (1922, 7-12) describes early weather activities in the 1870-80s that included limited forecasts, river observations, flood warnings, and some meteorological investigation.

25. See Abbe (1908, 1909) for discussion of the state of meteorological science at the turn of the 20th century.

26. U.S. Department of Agriculture, Weather Bureau (1897, 18, 24). The analysis presented in the bulletin relied on patterns observed from constructing ratios of the wettest and driest years relative to mean annual precipitation. Beginning on page 18 it describes droughts in the U.S. from 1860 on. These are one-year droughts, or ones covering several months during a growing season. The bulletin admits that little was known about how to predict droughts.

27. U.S. Department of Agriculture, Weather Bureau (1897, 18-19) noted that "the local distribution of rainfall is exceedingly erratic," so that individual registers "often afford doubtful and conflicting information respecting the yearly fall of one and the same region." A few stations

had longer term data. Johnson (1901, 46) notes precipitation data existed for Dodge, Kansas from 1874. See U.S. Department of Agriculture, Bulletin C, (1894) for data on annual precipitation, beginning with the earliest records, in the U.S. at various cities. Data for Montana are shown on pages 44-5 and these are mostly from forts in western Montana and are irregular until1881 when some complete series for the eastern part of the state begin. This same pattern also is true for Kansas and Nebraska with early observations in the eastern "wet" area until 1881. Riefler (1978, 63-77) discusses the drought in the early 1890s in western Kansas and Nebraska and notes that records on the drought are sparse. Even after the turn of the century, the was inadequate climatology and limited analytical use of available weather data for western land use.

28. Scott (1985, 8) claims that the railroads were no better informed about the nature of the high plains than were other observers. "Even as sober an authority as the *Army and Navy Journal* announced that the coming of the railroad had altered the electrical condition of the atmosphere and increase the rainfall, and many other spokesmen were thoroughly convinced that rain followed the plow."

29. A classic discussion of rain follows the plow and the alleged transformation of the Great Plains is in Smith (1947, 169-93). Malin (1953, 211) notes that after the Civil War there was a growing notion that the climate was becoming more favorable because of settlement. See also, Laskin (1996, 105),

30. Laskin (1996, 105-6).

31. Smith (1947, 175).

32. Aughey (1880, 44, 45) described the theory that linked cultivation with greater rainfall: "It is the great increase in the absorptive power of the soil, wrought by cultivation, that has caused, and continues to cause an increasing rainfall in the State." Cultivation breaks the soil, rain is absorbed "like a huge sponge." Soil gives this absorbed moisture back by evaporation, which increases rainfall. He was a professor of natural science at the University of Nebraska and he cast his arguments in the same scientific manner used for dry farming discussions by claiming to have tested this theory with experiments. See Bark (1978, 16). Given the state of knowledge about precipitation in the late 19th century, the Weather Bureau was skeptical but did not dismiss the possibility that human activity could affect precipitation patterns: "There was a popular notion a few years ago that the rainfall of the plains was steadily increasing. Such an opinion was based, in all probability, upon the fact that from 1881 to 1885 heavy rains fell in parts of western Kansas and Nebraska and other portions of the sub humid region. A climatic change of such vast economic importance was naturally widely heralded" (U.S. Department of Agriculture, 1897, 39).

33. Hargreaves (1957, 54).

34. As Stegner (1953, 215-9) describes, with greater rainfall the Great American Desert was advertised not as a barrier to settlement, but as a potential garden, ready for hardworking farmers to reap flourishing crops. See also Smith (1950, 174).

35. See Sullivan (1909, 289-300) who warned that dry seasons will inevitably reoccur in semi-arid regions with more devastating results than in other areas.

36. Newell (1896, 172).

37. Quoted in Smith (1947, 171).

38. See Chilcott (1908, 451) and Sullivan (1909, 289-90) who dismissed the notion that there had been a permanent change in the climate.

39. There was an unsuccessful effort to persuade Chilcott and other USDA staff members to be more active in the Dry Farming Congresses. See exchanges involving F.B. Linfield and Alfred Atkinson of the Montana Agricultural Experiment Station and E.C. Chilcott and other USDA officials during 1910 and 1911 regarding USDA involvement in the congresses and in disseminating USDA publications and views. Merrill G. Burlingame Special Collections, Montana State University, 00004, Box 3, Files AA-F6, AC-F4, AF-F4, AF-F4A, AF-F4B, AF-F5.

40. The issue was debated with differing viewpoints. In the opening address, Governor Brooks of Wyoming asserted that rain patterns would change with cultivation. Dry Farming Congress, Board of Control (1909a, 9). In the midst of the 1930's drought, there remained debate as to how much human factors might impact rainfall. See Letter to M.L. Wilson, Montana Agricultural Experiment Station from P.G. Perry, Canadian National Railways, January 26, 1932, Merrill G. Burlingame Special Collections, Montana State University, 00002, Box 5, D-82.

41. In his study of how western Kansas farmers between 1952 and 1964 perceived drought, Saarinen (1966, 3, 138) argued in that the greatest factor affecting the expectation of drought hazard was aridity and previous drought experience. By the 1950s, of course, Kansas farmers had the benefit of much more information about weather patterns in the high plains than was available to homestead settlers in western Kansas in the 1880s or eastern Montana in 1910s. See also Thornthwaite (1936, 219).

42. Ausubel and Biswas (1980, 93-123) discuss the impact of droughts on agricultural yields.

43. National Climatic Data Center (1983) for Ohio. Eastern Montana precipitation data through 1913 from Burke and Pinckney (1914) and for 1914-47 from USDA Weather Bureau, "Summary of the Climatological Data for the United States by Section, published annually. Our classification of eastern Montana follows that used by Hargreaves (1957). Western Kansas data from a website: cdiac.esd.ornl.gov/r3d/ushcn/state/KS. These data are for stations in the western 24 counties. Stations were identified from NOAA, National Climatic Data Center, Asheville, 1983, "Climatological Data Annual Summary, Kansas" Vol 97 (13), map, p. 34. We selected Ohio because it was one of the states of origin for Great Plains homesteaders, but we could have chosen any of the Midwestern states to make the point.

44. Fite (1966, 13).

45. Fite (1966, 131), Self (1978, 58), Baltensperger (1977), Riney-Kehrberg (1989), and Emmons (1971). (Stegner (1954, 296) argues that drought conditions began to appear in 1886. Rainfall data, however, indicate a series of one-year droughts in the 1880s with rebounds in precipitation. The 1893-94 drought was not only deeper but lasted longer.

46. Self (1978, 58) notes that west of 100th meridian, the normal rainfall is less than 22 inches, west of 98th meridian the normal rainfall is less than 24 inches. Fite (1966, 126-31) discusses earlier droughts and the homestead bust of 1893-94.

47. 21 of the 24 counties lost population. Calculated from U.S. Agricultural and Population Censuses 1890, 1900. See also Fite (1966, 131).

48. Homestead entries are for the entire state of Kansas, but most settlement was in western Kansas. The average is for 1895-1899. Annual Reports of the Commissioner of the General Land Office.

49. Calculated from U.S. Agricultural Census, 1880, "Report on the Production of Agriculture," 115-6; 1890, "Report on the Statistics of Agriculture," 209-9; 1920, Vol. 6, Pt. 1, 732-41. Western Kansas counties are those west of the 100th meridian and eastern Kansas counties were those to the east.

50. Fite (1966, 131-4). Other discussions of drought adaptation in Kansas are provided by Saarinen (1966). Malin (1944) discusses the introduction of spring and winter wheat into Kansas and modifications in production of the two in the late 19th and 20th centuries.

51. This "failure" to learn from the Kansas experience has been criticized by observers who have commented on the riskiness of agriculture in the Great Plains. For example, see Johnson (1901), Thronthwaite (1936), Great Plains Committee (1936), and Warrick (1980).

52. Campbell (1902,19) referred to King as Professor King of Wisconsin. For discussion of dryfarming, see Merk (1978, 484-94).

53. For example, a model farm was established in March, 1900 in Graham County, Kansas to demonstrate the Campbell method of soil culture. Winter wheat sown in 1901 with the Campbell method had yields that were presented as 300 percent greater than those on adjoining (control) farms. Similarly, in his 1914 soil culture manual, Campbell (1914, 20-24) discussed soil moisture in a very scientific, yet practical manner, with unlikely precision in outlining the effects of failure to use his method--only 25 percent of the precipitation became available for the plants, and the rest was lost if soil cultivation techniques were not followed. Finally, a very detailed case study of a farm practicing the Campbell method owned by G.W. Hahn in Yuma, Colorado is described (Campbell, 1916, 25-7).

54. As we describe below, the USDA was less promotional and more cautious in its conclusions about dry farming prospects. But this difference was only a matter of degree or intensity of enthusiasm. The Department did not strongly caution homesteaders about the risks of settling the Great Plains. In the 1930s, USDA publications were more critical of homestead settlement, but not before 1920. See Hargreaves (1948).

55. Widtsoe (1911, 361). Notice also, Buffin (1911, 11-2): “Evolution always leads towards greater perfection.”

56. Quoted in Scott (1985 33); Campbell (1914, 9-10) claimed that the one time American desert will be the *greatest* agricultural region of the world.

57. Widtsoe (1911, vii-ix), (Olson, 1961), Campbell (1914, 5).

58. There was a considerable bias toward small homestead farms in the dryfarming literature because they offered an alternative to more costly irrigation or larger-scale ranching. Larger farms were also considered wasteful. Campbell (1902, 5) opposed larger farms, claiming that they were not family farms and were not productive. He repeated the argument in (1907), (1914), (1916). Buffin (1909, 36) argued that 160 acres with summer tillage was sufficient for a successful farm on the Great Plains. Roeder, (1992, 15), discusses Montana promoter, Paris Gibson’s emphasis on dense farm settlement. Gibson uged maintaining the 160 acre homestead against even the 320 or 640 acre enlargements against those who would lock up the land.

59. See Stegner (1953, 219-42) and Pfeffer (1951, 8-62, 135-68) regarding the political controversy over homestead farm size and efforts to adjust the federal land laws.

60. New homestead laws and provisions were described for prospective migrants in U.S. Department of the Interior, General Land Office (1913, 1915).

61. See Campbell (1902, 6) for discussion of percolation and capillary action. Campbell argued that water must percolate to a greater depth and be stored as in a reservoir for later tapping by plant roots during dry periods. Capillary action was asserted to move the deep moisture upward. See also Campbell (1914, 66-83) for additional discussion of the principles of moisture storage. Further, Campbell claimed that dryfarming cultivation in arid areas actually could result in yields of three times those found in humid areas because nutrients were not leached from the soil. Campbell (1914, 6), Widtsoe (1911, 283). Hargreaves (1948, 1958) discusses the linkage between dry farming and scientific soil culture as it was called and Harvey Webster Campbell’s role as a promotionist.

62. Parsons (1913, 17, 44), Campbell (1902, 34; 1914, 57-65).

63. Campbell (1902, 12-5), Widtsoe (1911, 301), Buffin (1909, 35-7), Hargreaves (1977).

64. Campbell (1902, 42).

65. Widtsoe (1911, 399-410) described how a drought was successfully handled by those who practiced dryfarming. On page 400 Widtsoe claimed that “The failure of 1894 was due as much to a lack of proper agricultural information and practice as to the occurrence of a dry year.”

66. Buffin (1909, 15-18).

67. Widtsoe (1911, 402).

68. See Sullivan (1928, 6105), Noble (1958, 5-6), Hays (1959, 265-6; 1995, 15-8), Diner (1998, 3-4) for discussion of the ideology of the Progressive Age and the optimistic assessments of the role of science and technology for human progress. Jones (1986) describes the spirit of the time and the use of scientific techniques to control nature.

69. At the turn of the century, the diffusion of scientific knowledge came not so much through formal education as through adult education media, such as Scientific American and Popular Science Monthly, through publications of organizations, such as the agricultural extension service and the Department of Agriculture, and through congresses that focused on the practical adoption of technology, Hays (1995, 28-30). By the late 19th century, Washington D.C. had become a scientific center, particularly for the study of the natural sciences, such as geology, and their application for analysis and use in the West, Stegner (1953, 117). For example, John Wesley Powell's reports on the physical features of the Colorado basin and his assessment of the agricultural opportunities in the dryland area were published in Popular Science Monthly, Stegner (1953, 151). The application of the new opportunities provided by science and technology to rural areas and agriculture was advanced by the Country Life Movement Hayes (1995, 136-7). The Hatch Act of 1887 created the agricultural experiment stations and the Smith Lever Act of 1914 created the agricultural extension service to promote the adoption of technology. Montana legislation in 1913 provided some funding for county agricultural extension agents. Bertino (1976, 153-70), in describing a homestead experience, emphasizes the role of the extension service in providing information on summer fallow, dry farming techniques, crops, and shelter belts. Widtsoe (1911, 365) discusses the role of experiment stations in transmitting information about dryfarming.

70. Montana Farmers' Institutes (1905).

71. Montana Agricultural Experiment Station (1902, 17), Montana Farmers' Institutes (1908, v).

72. Montana Farmers' Institutes (1903, 201-3). Montana Farmers' Institutes (1904,198) describes the role of experiment stations as providers of information, introducers of new crops and livestock, and developers of new products. Criticisms of dry farming were dismissed. Even in severe drought, dryfarming practices were thought to prevent complete failure–there would be lower yields but not complete collapse. See correspondence from the Montana Agricultural Experiment Station to G.H. Carroll, January 5, 1911 (Merrill G. Burlingame Special Collections, Montana State University, 00004, Box 1, File AC-F4) and to S.H. Hanson, June 12, 1919 (Merrill G. Burlingame Special Collections, Montana State University, 00004, Box 3, File AC-F6).

73. As of July 7, 1910 the Montana Agricultural Experiment Station had 13 dry farming substations across eastern Montana. The actions of the county agents and the extension service in disseminating dryfarming principles are described in Merrill G. Burlingame Special Collections, Montana State University, 00004, Box 1,AA-F8, 00002, Box 22, File T-10, and collection 78036.

74. The role of demonstatation farms is noted in correspondence from the Montana Agricultural Experiment Station to A.C. Bailey, June 11, 1918 (Merrill G. Burlingame Special Collections,

Montana State University, 00004, Box 1, File AC-F4). Dryfarming investigations by the Montana Experiment Station were extended with contributions from the Great Northern Railroad for $2,000 and the Northern Pacific for $2,500 in 1905 and in 1906 for "cooperative tests on dry bench lands" (Montana Agricultural Experiment Station, 1906, 236). Montana Agricultural Experiment Station (1908, 163) claimed that the agency started examining dry farming problems in 1904 because "the demand for definite information on this subject during the past years, both from the older settlers, and especially from the newer settlers of the state, has shown conclusively that we took up this work none too soon." The agency noted that the arrival of the Milwaukee railroad brought "thousands of people to Montana, many of whom are spreading out over the dry bench lands. Thse people are meeting with a type of agriculture in which the emphasis has to be put on moisture and water supply for the soil, rather than upon fertility which is the prominent feature in the east."

75. In 1909, state appropriations were $11,000 for dry farm stations with the Northern Pacific providing an additional $5,000 and the Great Northern and Milwaukee Railroads each granting $2,000 (Montana Agricultural Experiment Station, 1910, 65). By 1911, state appropriations and railroad contributions rose from $16,250 for 1911-12 to $22,750 for 1913 and $7,500 from the Northern Pacific and $4,000 from the Milwaukee (Montana Agricultural Experiment Station (1912, 115).

76. Linfield and Atkinson (1907) identified the Montana regions, some 12 to 14 million acres where dryfarming promised the greatest success. Atkinson and Nelson (1908), described viable grain types and cultivation practices and concluded that dry farming would be successful in many parts of Montana. Testimonials from established dry farmers were provided. Other experiment results from demonstration farms and suggestions for crops and techniques were provided in Atkinson and Nelson (1911), Atkinson and Cooley (1910), Atkinson (1911, 1915), Atkinson and Wilson (1915), Atkinson and Donaldson (1916), and Currier (1918). Although the Montana Experiment Station publications are described here, similar ones are found for North Dakota and elsewhere. Thysell, McKinstry, Towle, Ogaard (1915) discussed the moisture needs of crops, provide charts of moisture regions, list yields from dryfarming investigations, outline tillage methods, and dismiss disputes over dry farming. They claimed that such disputes were due to the imperfect understanding of the principles governing the storage, movement, and use of water in the soils. Shepperd and Ten Eyck (1901) described conservation of moisture by cultivation, crop rotation, summer fallow, and wheat crop experiments. Waldron (1912) discussed the structure of soil, water conservation, cultivation techniques, machinery, and crops to plant.

77. For example, see the correspondence between Agricultural Experiment Station personnel and prospective homesteaders in the Merrill G. Burlingame Special Collections, Montana State University, 00004, Box 1, File AC-F4. In one letter to B.D. Bundy from Alfred Atkinson of the experiment station, May 30, 1916, Atkinson asserted that 160 acres could give fine returns. Atkinson went on to describe the crops that were possible. In another letter, February 3, 1916, Atkinson claimed that prompt surface tillage after a rain would conserve 20-35 percent of the rainfall, and he disputed claims to the contrary made by the USDA.

78. See letters, Alfred Atkinson to Eunice Keidel, February 6, 1915, 00004, Box 1, File AC-F4; Atkinson to Cochshutt Plow Co, March 3, 1910, 00004, Box 1, File AC-F4; letter to Julie

Bender, February 1, 1916, 00004, Box 1, File AB-F9A; to Ivers Smith Coal Co, August 8, 1910, 75010; to W.L. Irvine, February 22, 1911, 75010; letter from Atkinson to Owen Faulkner, March 21, 1911, 00004, Box 1, File AB-F6, and letter to H.H. McKimmey, November 10, 1090, 00004, Box 1, File AB-F9, Merrill G. Burlingame Special Collections, Montana State University.

79. For example, see letter to Gillam, Bellows, and Pierce Loan Co, October 4, 1909, 00004, Box 1, File AB-F9, Merrill G. Burlingame Special Collections, Montana State University.

80. The experiments with summer fallow reported by Briggs, Beltz (1910) indicated that there was little benefit from the practice if rainfall were above 10 inches, which described most of the region. Other USDA experiments refined, rather than contradicted dryfarming principles. See Cardon (1915).

81. Chilcott (1908, 1910, 1912) and Chilcott, Cole and Burns (1915) objected to what was viewed as a lack of careful scientific testing by Campbell and inappropriately broad generalizations that were drawn from his work. Chilcott believed that the USDA and the experiment stations should teach principles, but not practices. However, see Hargreaves (1948) who concludes that the differences between Chilcott and dryfarming promoters were more of degree than of substance.

82. The dispute over USDA involvement in the Dry Farming Congress of 1910 in Spokane is outlined in correspondence in the Merrill G. Burlingame Special Collections, Montana State University. See letter from Chilcott to Atkinson, September, 7, 1910, letter, May 28, 1910, from J.T. Burns, Secretary of the Dry Farming Congress to Atkinson. 00004, Box 3, File AF-F4B. The Dry Farming Congress was considered more promotional than the USDA liked. There also may have been bureaucratic turf issues as the agency saw the Congress growing in popularity. The experiment station criticized the USDA for being too cautious in its interpretation of dry farming experiments, even when the results supported dryfarming doctrine. See letter from Chilcott to Atkinson, February 23, 1911, Atkinson's response, March 15, 1911, and Chilcott's reaction, March 21, 1911, 00004, Box 1, File AC-F4. Others criticized the USDA for being too technical and not addressing the specific issues of concern to homesteaders: "so technical that they do not see the problem from a broad and comprehensive standpoint." (Letter, E.A. Burnett to M.F. Greeley, no date, 00004, Box 3, File AF-F3). Chilcott was not equally critical of experiment station studies that were more narrow in focus with controlled experiments, even though their findings supported dry farm homesteading. Allen (1905, 167-82) discussed how the USDA and local experiment stations supplemented one another in collaborative research and dissemination of information. USDA, Bureau of Plant Industry (1908) is a summary of papers read at the second annual meeting of the cooperative experiment association of the Great Plains area, June 26-27, 1907. The presentations stressed points similar to those raised by Campbell--the importance of storing water and use of proper tillage methods to do so.

83. For example, in a USDA bulletin, Failyer (1906) makes arguments very similar to those outlined by Campbell, with less emphasis on drought resistant plants and more on cultivation methods, water movement, storage, equipment, soil packing. Champlin (1914) describes the yields from experiments with dryfarming techniques for grain production in South Dakota 1903-12.

84. After the homestead failures of 1917-1925, the USDA became much more critical of homestead settlement. Small farms and inappropriate techniques are blamed. There is no recognition, however, of the Department's implicit role in attracting homesteaders. See Oakley and Westover (1924) and Mathews (1926).

85. Gates (1977) describes the lobby activity of the Dry Farming Congress to secure more funds for investigations into dry farming. Widtsoe (1911, 374) claimed that the Dry Farming Congresses were established to promote the exchange of ideas regarding agriculture in semi-arid regions.

86. Quisenberry (1977, 220) claimed that 20,000 attended the 1912 Dry Farming Congress in Lethbridge. Other sources claim that the Dry Farming Congress had 15,000 members at the time Says that dry farming congress has 15,000 members (Merrill G. Burlingame Special Collections, Montana State University, 00004, Box 3, File AF-F4A). Given the population of the region, the numbers are indicative of the movement's popularity.

87. Dry Farming Congress (1909b, 3-4).

88. See Dry Farming Congress (1909a) for a list of presenters and topics covered.

89. See the 10th Annual Report of the Montana Bureau of Agriculture, Labor, and Industry (1906, 311).

90. 11th Annual Report of the Montana Bureau of Agriculture, Labor, and Industry (1908, 3).

91. Montana Department of Agriculture and Publicity (1916, 34-6).

92. Montana Department of Agriculture and Publicity, (1916, 77, 81-93) for a list of all Montana prize winners in various categories at the Panama-Pacific International Exposition. Other discussion of prizes won at fairs, new rail lines planned by the Soo rail line and experiment station dryfarming exhibits, see Montana Bureau of Agriculture, Labor, and Industry (1912, 32-149).

93. See 11th Annual Report, Montana Bureau of Agriculture, Labor and Industry (1908, 27, 105).

94. For example, see Emmons (1971, 47-77) on promotional agencies in other Great Plains states.

95. Glasgow Commercial Club, 1914 3, Montana Historical Society Collections. Hinsdale flier, April 1904; E.B. Milburn flier, no date, Merrill G. Burlingame Special Collections, Montana State University, 00004, Box 4, File AB-F6.

96. For example, see Howard (1959, 167-82; Toole, 1959, 233-5) for a discussion of the actions of the promotional actions taken by railroads, such as the Great Northern and Northern Pacific. Malone, Roeder and Lang (1991, 240) for discussion of excessive promotion by the Milwaukee Railroad. Mickelson (1993) describes the promotional actions of the Northern Pacific. Scott (1985) provides a useful assessment of the settlement policies of the railroads.

97. See Scott (1985, 9, 12, 31) for discussion of railroad objectives. There is a marked shift in the tone of railroad pamphlets after 1920. For example, see the Northern Pacific pamphlet "Montana: Fallon and Carter counties in the New Corn Belt, in the Pacific Northwest," no date, but probably 1925 given the data in the document, Montana Historical Society Collections.

98. Northern Pacific pamphlet (1911), "Western North Dakota: Being a Description of a Land of Great Promise and the Opportunities it Holds for Homeseekers," Montana Historical Society Collections. Italics added.

99. Scott (1985, 12-3). See also documents of support of the railroads for the experiment station and dry farm substations in Montana (Merrill G. Burlingame Special Collections, Montana State University, 00004, Box 1, Files, AA-F8,AB-F1,AC-F1, AC-F4.

100. Scott (1985, 8).

101. Great Northern Railway, 1913 describes the climate, fertility of the soil, urgent need to file for claims quickly, tables of yields by crop for Montana and various states.

102. Overton (1965, 283-85). Scott (1985, 35) notes that in 1911 the Great Northern, Northern Pacific and Soo railroads contributed $15,000 to the Better Farming Association which would promote the kind of techniques that the railroads believed would be successful in the Great Plains. They also participated in and helped to fund the Dry Farming Congresses. At the American Land and Irrigation Exposition in 1911 the Northern Pacific awarded 160 acres of Montana farm land and $500 for the best display of apples, while Great Northern awarded a silver cup worth $1,000 for the best 100 lbs of wheat.

103. Annual Reports of the Commissioner of the General Land Office.

104. Annual Reports of the Commissioner of the General Land Office, 1900, 1920. The data are for total unappropriated and unreserved federal lands.

105. 1900 and 1920 U.S. Population Census.

106. We scale the number of homestead entries by total federal land available for claiming in order to control for the effect of the declining federal estate. Original homestead claims and total federal land available for claiming are compiled from the Annual Report of the General Land Office for the years of 1903-1930.

107. Railroad mileage data for the state and county-level assessed value data are found in the Montana State Board of Equalization, Annual Reports for 1900, 1903, 1905, 1910, and 1915.

108. See Montana Bureau of Agriculture, Labor, and Industry (1912, 145) for discussion of line building activities. New railroad town construction is described in the Montana Department of Agriculture and Publicity (1915, 22). See also Rabin (1996) for discussion of the Milwaukee Railroad. The Northern Pacific had considerable properties from the federal land grant to sell in eastern Montana and marketed the lands aggressively after 1904. The Annual Reports of the State Board of Equalization provide data on state wide railroad track mileage and railroad

assessed value by county, at least through 1916.

109. Wheat prices, acreage, and yields are provided in Montana Department of Agriculture, Labor, and Industry (1928, 125).

110. Yields are from the USDA Yearbook of Agriculture, 1900, 769; 1910, 516-7;1920, 565-6; 1925, 746; 1930, 600-1.

111. Rainfall data compiled from Burke and Pinckney (1914) and USDA, Weather Bureau, "Summary of the Climatological Data for the United States, by sections, Montana," various years. Eastern Montana counties included follow the designation used by Hargreaves (1957), Big Horn, Blaine, Carbon, Carter, Cascade, Chouteau, Custer, Daniels, Dawson, Fallon, Fergus, Garfield, Golden Valley, Hill, Judith Basin, Liberty, McCone, Meagher, Musselshell, Park, Petroleum, Phillips, Pondera, Powder River, Prairie, Richland, Roosevelt, Rosebud, Sheridan, Stillwater, Sweet Grass, Teton, Toole, Treasure, Valley, Wheatland, Wibaux, Yellowstone.

112. Farm Survey Records, 73039, Box 12, Files A-28, T-27, T-42, T-43, T-89, Merrill G. Burlingame Special Collections, Montana State University, Bozeman. The "Farm Survey Record" for each farm included county; date; operator; address; acres--owned, operated, in crops, fallow, pasture, in various types of crops; crop sales; livestock; livestock sales; livestock product sales; other sources of income; seed; current expenses– for hired labor, machinery repairs, seeds, fertilizers, taxes, and horseshoeing, and other miscellaneous costs; machinery and equipment (number, type, value); depreciation rates on machinery; real estate; farm finance; unpaid labor; and demographic data.

113. Current expense reported in the table is that described in the survey. Total expense includes current expenses plus depreciation on machinery and buildings and the interest cost on mortgages and short term loans. The survey reported the value of machinery and buildings, mortgage and other loans, loan interest rates, and depreciation rates. Since some farmers did not report depreciation rates, we used the mean rates for them, which were 7 percent for buildings and 10 percent for machinery. The table reports only wheat sales revenues using reported wheat acreage, 1916 Montana yields (USDA, Yearbook of Agriculture, 1920, 555-6), and wheat prices (U.S. Department of Commerce, Historical Statistics, 1976, 208).

114. The average U.S. farm income figure for 1920 was calculated by using 1920 gross farm income as reported in the USDA, Agricultural Statistics (1936, 338-39) $13,566,000,000 and total number of farms in 1920 of 6,448,343 (USDA, 1922 Agricultural Yearbook, "Agricultural Statistics," 1923, 1008). The 1922 USDA Agricultural Yearbook, "Agricultural Statistics" (1923, 1160) report $2,322 as gross receipts for western farms.

115. Descriptive statistics:

Variable	Mean	Std. Deviation	Min	Max
Surveyed Land	12,472,154	6,231,027	3,335,963	21,024,719
Montana Annual Rainfall	15.77	2.39	10.88	21.12

116. We converted nominal wheat prices to real prices using the CPI index (1967 base year) from U.S. Department of Commerce, U.S. Historical Statistics (1976, 211). Descriptive statistics:

Variable	Mean	Std. Deviation	Min	Max
Surveyed Federal Land	12,472,154	6,231,027	3,335,963	21,024,719
Montana Wheat Yield	20.89	7.35	2.7	32.5
Real Price of Wheat	2.91	0.81	1.82	5.34

117. See Cyert and DeGroot (1989).

118. See Kahneman, Slovic, and Tversky (1982, 11) for discussion of the "availability" heuristic. Basically, individuals assess the probability of an event by the ease in which previous instances can be brought to mind. Past experiences or information are relied upon in decision making, especially if they have credibility. El-Gamal and Grether (1995) also discuss undue reliance on past information as "conservatism"whereby decision makers require more evidence to update their priors than the Bayesian rule would imply.

119. There were longer precipitation time series for some stations, such as Havre in north central Montana, where data went back to 1882. Beyond these isolated series, there were no general data for the region until approximately 1895. See Letter to M.L. Wilson, Montana Agricultural Experiment Station from M.A. Bell of the Havre Branch Station, November 16, 1931, Merrill G. Burlingame Special Collections, Montana State University, 00002 Box 5, File D-81.

120. Bertino (1976, 34, 137-41); Guldborg (1963, 31). See also Devore's (n.d) discussion of the impact of the drought.

121. Annual Reports of the Commissioner of the General Land Office.

122. Http://www.nass.gov/mt/historic/general/farmnumber.htm. The numbers do not correspond with those for original homesteads. Some new homesteads were combined with existing farms. Moreover, as new homesteads were being entered, farms were being abandoned by 1919. The number of farms rose from 50,000 in 1916 to 57,700 in 1920, declining gradually to 50,000 once again in 1925.

123. Letters by Alfred Atkinson to Gibson McKneight, July 9, 1917; Atkinson to J.L. Ambrose, August 21, 1917, both in 00004, Box 1, File AF-F0. Letter to B.H. Hibbard, December 4, 1917, 00004 Box 1, File AB-F1, Merrill G. Burlingame Special Collections, Montana State University.

124. Alfred Atkinson, "The Agricultural Outlook," 00004, Box 1, File AB-F1, Merrill G. Burlingame Special Collections, Montana State University.

125. Lewis Cameron, Sr., Martingsdale, Montana Aug 20, 1910. Quoted in Chicago, Milwaukee and Puget Sound Railroad pamphlet, "The Musselshell Country," Montana Historical Society, Helena. See also, "An Address by Howard Elliott, President of the Northern Pacific Railway Company, Delivered at the Interstate Fair, Bozeman, September 1, 1910" Montana Historical Society, Helena.

126. Reported in the Denton Recorder, September 1, 1919, p. 2, Montana Historical Society, Helena; Montana Agricultural Experiment Station (1920, 8). Bertino (1976, 155-60). The Fairview News, July 14, 1919 p. 2 says that the drought is "without precedent in the weather records of this state." Montana Historical Society, Helena.

127. Montana Agricultural Experiment Station (1921, 7; 1922, 57).

128. Montana Agricultural Experiment Station (1924, 8; 1926, 6). Snedecor (1969, 27) notes that by the time of failure, farmers realized that they needed more than 160 or 320 acres. Small dry farmers were chastised for not listening to the experts, although the record is clear that they did. It was the experiment station's assessment of the success of dryfarming that had changed between 1920 and 1925. See Gray, Bennett, Kraemer, and Sparhawk (1938, 113-14).

129. Toole (1959, 238), Howard (1959, 207-8) Malone, Roeder, and Lang (1991, 283), Fulton (1977). See also Jones (1987, 100-14) for a description of farm failure in Canada. The impact of precipitation on wheat yields is discussed along with the influence of geography in Johnson and Gustafson (1962, 15-57). With crops weakened by the drought they were more vulnerable to insect (grasshopper) infestation. See Wilson (1923, 26).

130. 1921 current expenses plus mortgage and depreciation expenses for homesteads averaged \$572; for the larger farm sample, 1921 mean total expenses averaged \$1031. 1919 Montana yields from USDA, Yearbook of Agriculture, 1920, 555-6) and wheat prices (U.S. Department of Commerce, Historical Statistics, 1976, 208). In related work, we are attempting to determine the characteristics of farms that survived versus those that failed.

131. Data on relation of farm operator's method of acquirement of farm to foreclosure, Montana State Experiment Station, Bozeman, Merrill G. Burlingame Special Collections, Montana State University, 73039, Box 12. Homesteaded farm loans tended to be made later, during 1917 or after, than were loans to other farms in the sample, which is understandable since homesteads had to be titled before they could be used as collateral. It took at least three years to receive title. According to the survey, 80.4 % of homestead loans were made between 1917 and 1932, whereas13.4% for farms purchased from non-relatives, 3.1% from farms acquired from relatives, 15.9% for farms acquired through homestead and purchase, and 9.1% for farms acquired through other means were made during that period. The survey also categorized farms according to production categories and size: wheat farms, general and mixed farms, livestock farms, and all farms. Small wheat farms of 399 acres or less had foreclosure rates of between 57 and 77%, larger than any other category of farm (mixed crop or livestock) or size group. Small wheat farms also had the smallest number of livestock.

132. Halcrow (1938) defined unsuccessful farms as those with less than \$1,000 average annual gross farm income and whose operators received relief assistance from the Farm Security Administration. He also found that unsuccessful farms were on less productive soil, and used less summer fallow than did other farms in the area.

133. For further analysis of the relative disadvantage of small farms during this period see Starch (1935), Renne (1938, 1939), Montana Agricultural Experiment Station, 1939, Bulletin 367, and

Clawson, Saunderson, and Johnson (1940).

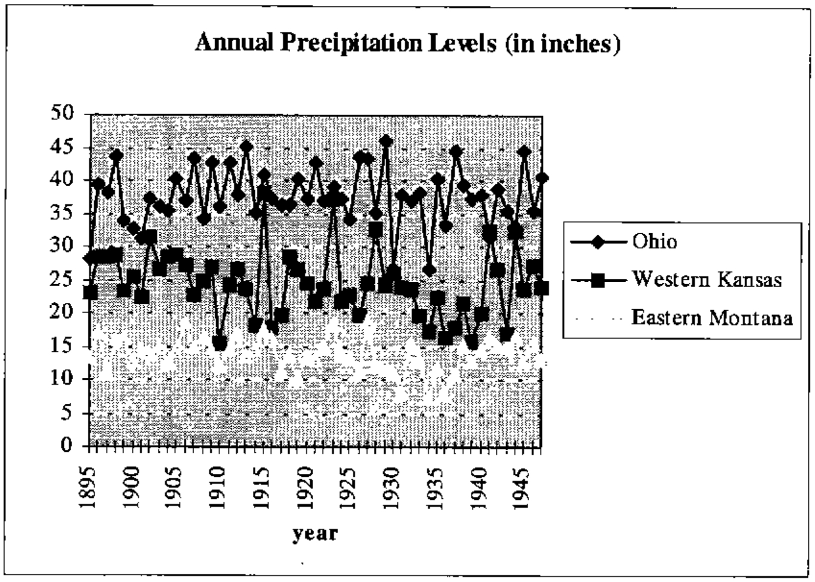
134. The sample of 15 Hill County homesteads is small, but it appears to be representative of conditions. The income data from that sample indicate that homesteaders earned what they might have made elsewhere in agriculture. Not all homesteaders lost their investments. Most homesteading occurred between 1910 and 1917. Those who arrived earlier had access to the best land and a longer opportunity to earn on their investment during favorable conditions. Most likely, these were the homesteaders who are included in row 4 of Table 4, homesteaders who were in a position to purchase the property of their less fortunate neighbors. On-going research is examining the characteristics of those homesteaders who survived and those who failed. With regard to bank failures, the Minneapolis Federal Reserve Bank (Rich, 1923) reported widespread bank failures in eastern Montana and the western Dakotas in the early 1920s. By contrast, there appears to have been no serious bank failure in southeastern Alberta and southwestern Saskatchewan where wheat farms also failed during the drought. This difference may be due to the existence of branch banking in Canada. For a broader analysis of bank failure in the U.S. following the collapse of agricultural prices and the differential experience of branch banking systems in the early 1920s, see Calomiris (1990, 1992).

135. Data from 13th U.S. Census, 1910, Volume VI Agriculture, 958-60, and 15th Census of the U.S., 1930, Agriculture, Volume II, Part 3, 118-22. We included the counties listed in footnote 111, which are the counties identified by Hargreaves as eastern Montana. Average farm size is the mean of the average farm sizes by county.

136. Data are from 13th U.S. Census, 1910, Volume VI Agriculture, 958-60; 14th U.S. Census, Agriculture, Volume IV Part 3, The Western States, 106-110; and the 1925 U.S. Census of Agriculture, Part III, The Western States, 82-89. The farm size categories listed in the census were combined to 0-99, 100-259, 260-499, 500-999, 1,000-4,999, and 5,000 and larger. To calculate the coefficient of variation, the number of farms in each size category was assumed to have the mid point size. A weighted mean was calculated and a standard deviation around the mean for 1910, 1920, and 1925.

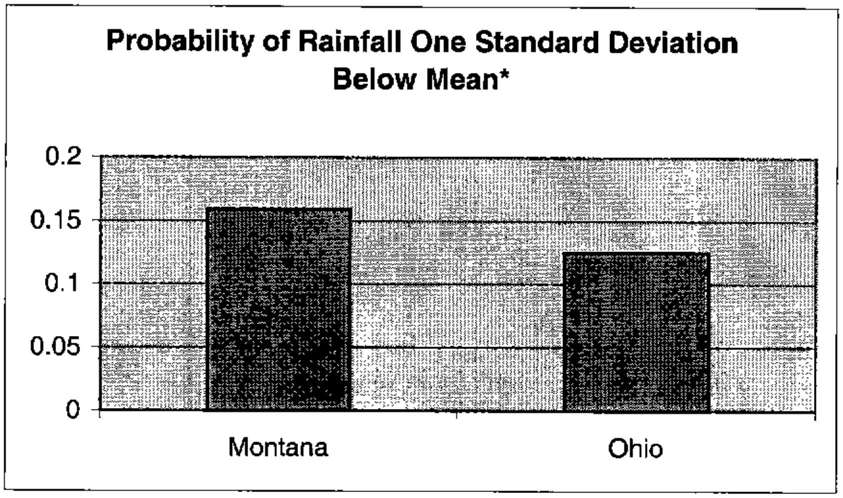
Figure 1
100th Meridian and the Start of the Great Plains

Figure 2



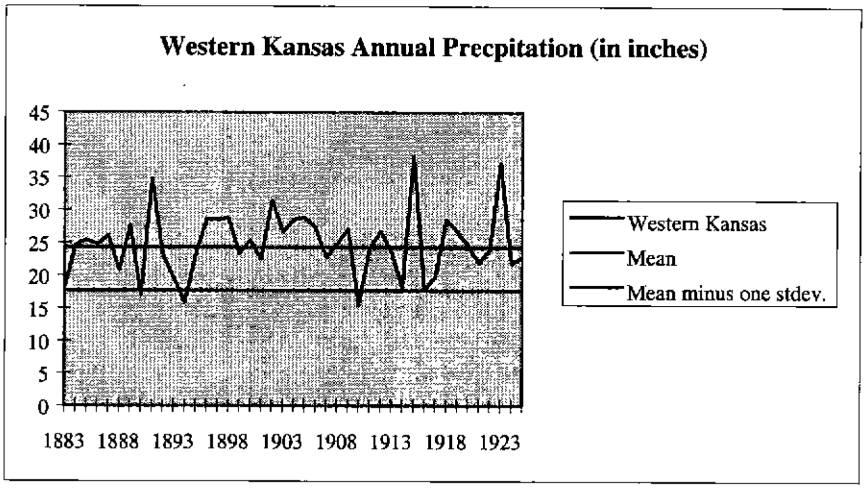
Annual Precipitation Levels (in inches)
50
45
40
35
30
25
20
15
10
5
0
1895
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
year
Ohio
Western Kansas
Eastern Montana

Figure 3



*Montana: mean precipitation=15.36 inches. Mean – 1*stdev = 12.93 inches
Ohio: mean precipitation = 37.77 inches. Mean – 1*stdev = 33.43 inches

Figure 4



Western Kansas Annual Precpitation (in inches)
45
40
35
30
25
20
15
10
5
0
1883 1888 1893 1898 1903 1908 1913 1918 1923
Western Kansas
Mean
Mean minus one stdev.

Figure 5

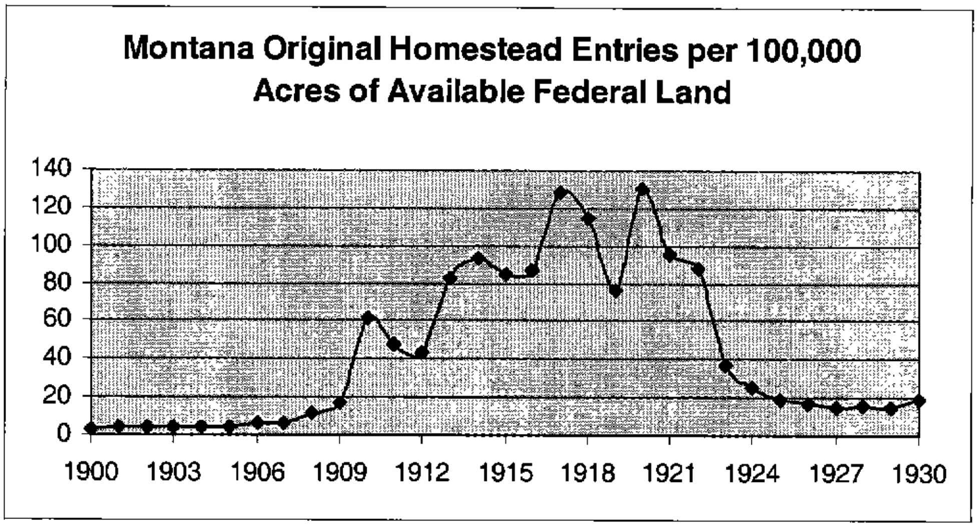

Montana Original Homestead Entries per 100,000 Acres of Available Federal Land
140
120
100
80
60
40
20
0
1900
1903
1906
1909
1912
1915
1918
1921
1924
1927
1930

Figure 6

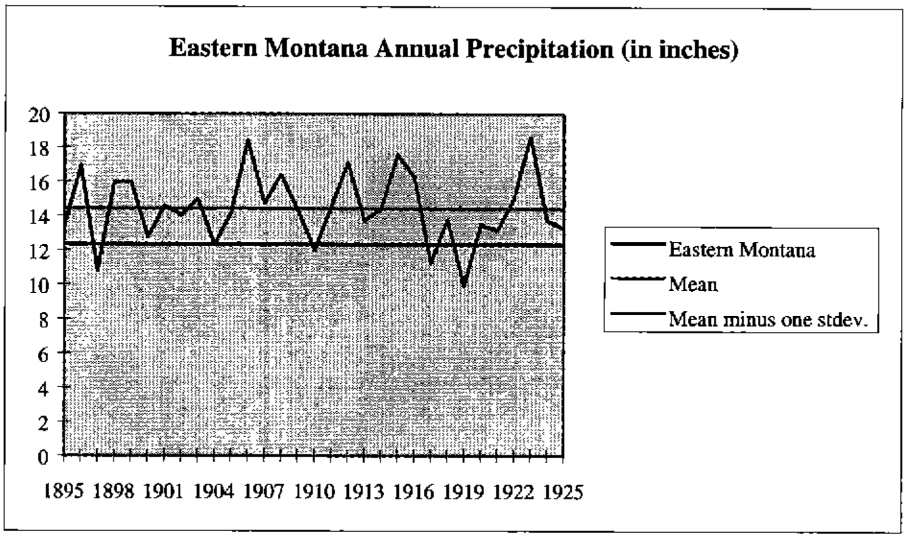

Eastern Montana Annual Precipitation (in inches)
20
18
16
14
12
10
8
6
4
2
0
1895 1898 1901 1904 1907 1910 1913 1916 1919 1922 1925
Eastern Montana
Mean
Mean minus one stdev.

Table 1
Rainfall Patterns

	Western Kansas	Eastern Montana	Ohio
Mean	24.5	13.8	37.7
Coefficient of Variation	0.207	0.18518	0.11783
Correlation Coefficient with	1	0.45425	0.04192
Correlation Coefficient with	0.45425	1	0.1411
Correlation Coefficient with	0.04192	0.1411	1

The precipitation data are for the years of 1895 through 1947

Table 2
Estimated Farm Income, 1916 and 1919

Sample of 15 Homestead Farms, 320 Acres or Smaller							
	Mean Farm Size (acres)	Mean Wheat Acres	Mean Current Expenses	Total Expense*	Gross Wheat Income	Income-current expenses	Income-total expense
1916 Montana Wheat Yield (19.3 bu/acre) and Price ($1.43/bu)	319	95	$235	$349	$2,622	$2,387	$2,273
1919 Montana Wheat Yield (2.7bu/acre) and Price ($2.16/bu.)	319	95	$372	$553	$554	$182	$1.00
Sample of 50 Farms Larger than 320 Acres							
1919 Montana Wheat Yield (2.7 bu/acre) and Price ($2.16/bu)	749	201	$675	$996	$1,171	$496	$175

*Mean Expenses + Mortgage and Depreciation. 1921 expense data are converted to 1916 and 1919 values using the cost of living index in U. S. Department of Commerce, Historical Statistics (1976, 211).

Table 3
Yield and Migration Analysis

Dependent Variable: Montana Wheat Yield		
Variable	Coefficient	t-ratios
Constant	-6.75	-1.30
Land Quality (Proxy)	0.93 E-03	9.58
Montana Annual Rainfall, t	0.76	2.87
Montana Annual Rainfall, t-1	0.24	0.96
Durbin-Watson: 1.71		
Adjusted R-squared: .79		
Number of Observations: 34 (1895-1929)		

Notes: The proxy that is used for the land quality is available surveyed land in Montana (in terms of 1,000 acres)

Dependent Variable: Original Homestead Entries in Montana		
Variable	Coefficient	t-ratio
Constant	-24032.60	-5.20
Available Surveyed Federal Land	0.19	0.54
Montana Wheat Yield, t	153.81	0.78
Montana Wheat Yield, t-1	366.24	1.94
Price of Wheat, t	1564.71	1.13
Price of Wheat,t-1	1850.09	1.32
Dummy (Law change of 1909)	11680.06	4.70
Durbin-Watson: 1.41		
Adjusted R-squared: .61		
Number of Observations: 34 (1895-1929)		

Notes: Montana wheat yields relative to the annual wheat yields in Ohio give similar results. Total available federal land is in terms of 1,000 acres. Real wheat prices are calculated using nominal prices and the consumer price index (U.S. Department of Commerce, 1976, Historical Statistics, 211).

Table 4
Analysis of Loan Foreclosures According to Method of Farm Acquisition

Method of Acquisition	Number of Loans (Farms)	Percent Foreclosed	Average Amount of Loan	Farm Appraisal	Farm Size (Acres)
Homestead	107	70%	$2,023	$5,636	291
Purchase from Non-Relatives	127	28	5,621	14,522	544
Purchase from Relatives	32	22	6,753	16,709	788
Homestead and Purchase	82	27	5,741	15,894	826
Other	33	24	7,079	21,100	1,102

Source: Montana State Experiment Station, Bozeman, Merrill G. Burlingame Special Collections, Montana State University Bozeman, Group 73039, Box 12.