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Revising the Dust Bowl: High Above the Kansas Grasslands

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Abstract

This article reconstructs land cover patterns in Depressionera Kansas from historical aerial photos and compares the locations of crop fields to areas of submarginal land identified in modern digital soil survey maps. The analysis argues that New Deal land retirement programs overestimated the degree of bad land use because they lacked the basic science to make comprehensive assessments. The findings demonstrate that the misuse of land unfit for cultivation was relatively rare across the central plains but especially in the Dust Bowl region.

Introduction

The visual framework is usually established with ground-level photographs. On one page, a group of harvesters waded into an endless horizon of wheat. On another, dust clouds rise against the barren earth and envelop nearby farmhouses. Captured in faded grayscale photographs, the condition of treeless landscapes suggests only a trying future. With good reason, little in the conventional narrative of the Dust Bowl shades this visual framework away from a story of endangerment.¹

The consequences of encroachment on the American grasslands remain inescapable. The loss of wildlife habitat, native biodiversity, and soil biomass has been enormous.² But for most historians and ecologists, the footprint of agricultural change extends further. The outcomes of the period—the plowing of marginal soil, dust storms, and outmigration—are interpreted as evidence that plains farmers were little different from other smallholders in the American past. Like farmers in colonial or antebellum times, settlers in the plains took advantage of the sheer abundance of land. When the soil was exhausted in one place, farmers moved on to the next.

These themes are not new. Abundance and waste are common to the history of the environment in the United States, as elsewhere.³ However, while some historians of other regions, such as colonial New England, have begun to reinvest agriculture with more of the complexity and ambiguity inherent in early transformations of the North American environment, histories of the Great Plains have made less room for the idea that farmers were careful stewards of the land.⁴

In particular, the literature leaves the widespread impression that farmers extensively cultivated poor soils in the Dust Bowl region. This judgment flows mainly from an

interpretation of short-term gain. Historians have argued that farmers essentially ignored the natural barriers placed in their way, seduced by the incentives offered by new machinery, industrial methods, and an aggressive capitalist ethos. Some historians have acknowledged that farmers recognized the biological limits to cultivation, and they discuss when and why farmers chose to plow marginal soil, and when they chose to save it for grazing land. The awareness of limits begins with agricultural historians like Doug Hurt who emphasize that wheat production peaked by the beginning of the 1930s, well before new machines like the combine harvester were widely adopted.⁵ Geoff Cunfer's prizewinning book *On the Great Plains* extends this recognition of peak production to the entire region, arguing emphatically that less than a third of the western plains was ever plowed in the twentieth century.⁶ We also know that agricultural policy has constrained postwar levels of cultivation through various allocation schemes, set-asides and conservation programs—all designed to deal with persistent overproduction and low farm prices.

The conviction that most farmers were making poor choices prior to the Dust Bowl has never been examined in great physical detail. The task of reconstructing historical patterns of land use is daunting and uninviting, particularly in view of the mountains of archival evidence from the Soil Conservation Service, Land Utilization Program, and the Agricultural Adjustment Administration attesting to poor practice by plains farmers. As anyone who has sifted through the archival holdings of these New Deal agencies is aware, case files compiled by field staff convey the urgency of implementing various relief measures. In the midst of drought, it is understandable that negative assessments of farm practice underwrote field surveys and reports. Nevertheless, some of the physical evidence, and the science that emerged from the period, points in a different direction, at least after recovery began.

This article reports on an effort to reconstruct patterns of cultivation in twenty-five historical landscapes in Kansas. It compares aerial photographs from the 1930s, and the land use visually interpreted from those 1930s air photos, to digital soil surveys maps completed long after recovery began. The picture of Dust Bowl farms that emerges from this spatially defined information is quite different from the conclusion of the traditional historiography. In the twenty-five locations chosen for this study, the view from high above the earth indicates that cultivation was largely limited to good soils, and that, in fact, encroachment on poor land was less likely in the heart of the Dust Bowl than elsewhere in the state.

New Deal Soil Surveys

The New Deal represented an enormous leap forward for physical science, and the need for accurate and comprehensive soil surveys was widely recognized. Early work focused on reconnaissance surveys in the worst affected drought regions, first in 1933 through an agency in the Department of the Interior, known as the Soil Erosion Service, and then, via a wider scientific mission of conservation and classification under the Department of Agriculture, in a permanent agency known as the Soil Conservation Service. It was created by statute in 1935. The initial attempts to select land for retirement from farming were based on surveys of wind erosion, rather than on surveys of actual soil types. Better surveys were needed, soil scientists believed, to plan which lands should be used for which purposes. Two

major initiatives in the physical sciences combined to meet these needs: aerial photography and the development of Land Capability Class Ratings. During the New Deal, a national aerial photography program was created to monitor crop allocations. After the Depression, soil scientists worked to develop more accurate survey maps, allowing them to classify the structure and composition of soils with an eye to their long-term use.

The conviction that submarginal cultivation was a very large problem gained wide currency during the many experiments in conservation policy set in motion by the Roosevelt administration. The Land Utilization Program lent the greatest authority to the idea that submarginal land was routinely cultivated and needed to be retired from farms. In 1935 Lewis Cecil Gray, a Wisconsin-trained agricultural economist, was put in charge of a repurchase program, run out of the newly established Land Policy Section of the Agricultural Adjustment Administration.⁷ Gray had long favored land use planning, and he supervised the early selection of lands for retirement (taking private farmland out of active use) by the federal government. The US Department of Agriculture (USDA) was authorized to spend \$25 million on the program, and half of these funds were eventually spent in the plains states.⁸

Unlike the demonstration work of the Soil Conservation Service or Civilian Conservation Corps, the Land Utilization Program remained controversial. Although the science of erosion and soil classification were still at a very formative stage, local USDA officials were asked to make judgments about which lands were submarginal. Usually they relied on driving and walking surveys of wind erosion to make assessments about which private lands had been misused in the period prior to the drought. The scale of the proposed purchases simply reinforced the idea, expressed widely in the literature ever since, that “drought and extensive cultivation of submarginal lands created the Dust Bowl.”⁹

Aerial Surveillance

Soil scientists recognized the need for better survey tools. In the midst of drought, to keep up with the demand for comprehensive assessment, a shift from ground to aerial surveillance gained momentum. When agriculture secretary Henry Wallace decided to combine production controls and conservation measures in 1938, he directed officials in the Agricultural Adjustment Administration to carry out a nationwide program of aerial photography. Some method of ensuring compliance with acreage reduction targets was needed. The Agricultural Adjustment Administration and the Soil Conservation Service both demonstrated the accuracy of field measurements on individual farms in missions flown in 1935 and 1936, comparing the area of fields measured in air photographs to ground-level transects.¹⁰

Convinced of the precision of aerial surveillance, New Deal planners decided to expand the program to all agriculturally important areas of the country. By 1941, when air surveillance work shifted to wartime purposes, over 90 percent of agricultural land had been already surveyed. Although the focus of the Agricultural Adjustment Administration was squarely on obtaining accurate measurements of field size, the scientific legacy of the program extended to soils mapping, land use classification, and other geographic research. After

World War II, the USDA continued to monitor croplands in the same way. The Soil Conservation Service would also use the early aerial photographs to improve the accuracy of its most detailed soil classification maps. In fact, the soil survey continued to evolve as it accumulated more information and worked to devise a common taxonomy.

The Land Class Capability Ratings

Like the wind erosion surveys, the early ground reconnaissance work conducted by the newly formed Soil Conservation Service was designed to provide a quick assessment of drought conditions.¹¹ But the new work in improving indicators of soil erosion also led to the adoption of a novel assessment tool for the comprehensive survey: the land capability rating. Hugh Hammond Bennett, who had begun his career as a soil surveyor for the USDA, had become increasingly concerned about declining crop yields and soil erosion prior to assuming the directorship of the Soil Conservation Service. His publication, *Soil Erosion: a National Menace*, a USDA bulletin coauthored in 1928, was a manifesto for like-minded soil scientists who wanted more investigation of farm practices and soil erosion. By the late 1930s, the Soil Conservation Service began research on developing indicators of land capability that would be useful in farm planning. As American soil science shifted to a more organic conception of soil formation, moving away from the older notion that the soil was a relatively static container for plant nutrients toward the modern idea that the soil is a natural body, with a living history, the Land Class Capability rating emerged as a logical choice for inclusion in the general survey.¹² Now known as the Land Capability Classification, this system originated in a large collaborative study between the USDA and the University of Georgia to study conditions in Georgia's lower piedmont, where half of all farms were reportedly abandoned during the 1920s.¹³ Bennett embraced the Land Capability Classification system because it conformed to his idea that soil science should not merely be involved in developing soil taxonomies, but provide guidance for correcting farm practice.

The working interpretation of land capability was eventually published in the *Soil Conservation Survey Handbook* in 1939. The Land Capability Classification system used eight land capability classes (originally given in Roman numerals) with the first four classes considered suitable for cultivation, under progressively greater constraint. First-class soils were identified as those with few limitations on their annual cultivation, needing no special practices. Class 2 soils, the *Handbook* directed, should be used with simple soil-building practices, Class 3 soils with more complex or intensive restoration practices, and Class 4 soils were not recommended for continuous cultivation. The remaining four classes were not recommended for cultivation at all. Class 5 soils were considered unfit for cultivation because of uneven terrain, poor drainage, stoniness, or some other feature that suggested even temporary cultivation was harmful. Classes 6 through 8 were reserved for grazing regions. Class 8 soils were considered unsuitable even for commercial grazing and were recommended for recreation, aesthetic, or wildlife use.

After the Land Capability Classification system was published in 1939, field workers from the Soil Conservation Service and the state soil surveys began the herculean task of rating soils across the United States. Published soil surveys, based on older criteria, already existed in many counties across the country. But the new soil surveys were the first comprehensive

surveys in many areas, and the first surveys to use the newly developed land capability ratings. In most cases, the postwar soil surveys were not published until the early 1960s, and in some areas, not until the early 1990s.¹⁴ The ratings are remarkable from a historical perspective because they are based on this ongoing fieldwork, much of it conducted shortly after the Dust Bowl. No comprehensive updates of the ratings have been undertaken since the postwar soil maps were published in print form.¹⁵ The Land Capability Classification ratings therefore embody a historically representative assessment of soil capability following the Dust Bowl. In geological time, the soil surveys are nearly contemporary with the air photos taken in the late 1930s.

Comparing Cultivation and Soils

The comparisons that follow rely heavily on these twin legacies: aerial surveillance and the Land Capability Classification system. Together, they provide the geographic and biological evidence necessary to assess, retrospectively and explicitly, the traditional view that poor land use choices contributed substantially to the severity of the Dust Bowl. The conclusions are drawn from a sample of study areas in the central plains. Kansas was chosen not merely because of its location at the heart of the Dust Bowl region but because the state conducted its own censuses of agriculture and population. Household level census returns from the federal agricultural census were destroyed in the 1960s as a cost-saving measure. But the state of Kansas has preserved all of its manuscript censuses. The Kansas records allow researchers to examine household-level land use into the 1930s while also allowing reconstruction of detailed change reaching back a generation or more before the drought. James Malin made use of these documents a half century ago, compiling statistics by hand and linking lists of farm households over time, to make the case that plains farmers were adapting to the aridity of the region.¹⁶ A modern effort like ours is made much easier by the use of computers, and the evolution of geographic and ecological science, which permit more detailed assessment of biological variation.

The geographic design of our sample, shown in figure 2, is less familiar to social research, but ecologists would recognize the approach because the sample examines change in specific places rather than across a whole society.¹⁷ Because the entry point is the civil township, a local unit of government that is the basic minor civil division in Kansas, a spatially defined political unit serves as the sample frame. In some cases, these municipal units were based on a single 6-mile by 6-mile public land survey township. But in the western part of the state, as the maps illustrate, the civil townships were often larger. Rather than drawing random observations, we gathered data on every farm and every person listed within each civil township at every available time point. We targeted counties for inclusion based on the availability of census records and geographic location across the state.¹⁸ The spatial distribution of the townships was designed to be sufficiently broad to capture the presence of poor soils in each subregion of the state, especially the Dust Bowl areas in the west, which are overrepresented in the sample.¹⁹

The study areas represent a balanced selection of the major land use areas in the state, already well known by the 1930s. Five broad regions, described in a state extension bulletin published in 1933, are illustrated in figure 2, together with the twenty-five study areas or

townships.²⁰ The groupings remain relevant today. The first region included a tier of counties along the state's northern boundary with Nebraska, which was known for its corn production.²¹ Typically, crops in the loess hills of the northern counties are planted crops in bottomlands.²² South of the Kansas River, the second region includes counties in the eastern part of the state. These lands lie in a series of east-facing ridges or escarpments, the Osage Cuestas, combining flat uplands, open meadows, and wooded ravines.²³ In this area farms practiced mixed livestock and small grain farming. Further to the west is the third region, known as the Bluestem Pastures or Flint Hills area, which is situated on Permian age limestone and shale. The numerous hills and bluffs contain bands of chert or flint, and the weathering of the parent material has left behind a thin clay soil full of stones and gravel. Arable land is typically found in silted floodplains along streams and rivers. West of the Flint Hills the landscape rises into the High Plains, the fourth region. Relief is rare as the elevation rises across the western half of the state, but the predominant tableland is covered by dark, rich, well-drained soils.²⁴ The deep surface horizons of these permeable soils are the product of organic matter accumulation, from short and mixed grasses, with deep root systems. The transition away from the center of the state brings an observer to the final region, the semiarid far west. Here trees are scarce and the dominant vegetation is composed of short grasses, chiefly drought-resistant buffalo grass and blue grama.

Several assumptions underlie the use of sources and choice of study areas. One is that land use interpreted from 13,000 feet above the earth, in seventy-year-old aerial photographs, provides a better reading of the physical extent of cultivation than driving and walking surveys conducted by the Soil Erosion Service or the Land Utilization Program in the middle of the drought. Another is that the land capability ratings that developed after the period, between the 1950s and 1980s, are more reliable as an indicator of the long-term productivity and quality of the soil because they are based on surveys conducted after the return to normal vegetation and climate conditions in the central plains. Finally, the biggest assumption may be that the sample of twenty-five study areas is sufficiently representative of the human and natural variation in the central plains.

Trends in Census Data

Because of the differences in climate and vegetation, the western plains were settled much later than the eastern plains. This sequence is captured well in the household-level census returns from our study areas. Initially, the semiarid west struggled with its perception as a "Great American Desert." Then when the drought of the 1890s subsided, Euro-American settlers began to move into the region to stay. Environmental historian Donald Worster notes that the number of farms held steady in the 1890s but more than doubled in the High Plains between 1900 and 1910.²⁵ Wheat prices also doubled (to \$2 a bushel) under the price controls introduced by the Wilson administration during World War I. By 1919 an extended boom took hold, and farmers in the High Plains of Kansas, Nebraska, Colorado, Oklahoma, and Texas expanded the wheat crop by 13.5 million acres, mainly at the expense of native grassland.

The expansion of cropland described in the literature is also captured in the sample data. But the emphasis on continued growth in the 1920s is less clear. The manuscript censuses in the

selected townships suggest the expansion was largely complete by the 1920s. Figure 3 offers region-by-region summaries of cropland, pasture, and the number of farms reported in the state-run censuses of agriculture between 1875 and 1940. On the left axis, acres of cropland and pasture are reported (in thousands) and displayed as lines in the graph. On the right axis, the number of farms are reported (in hundreds) in each region, and represented as bars. Comparing the process of land transformation in this way suggests that cultivation peaked soon after farm numbers in every region of the state. No matter when settlement arrived, the expansion of cultivation reached local maxima as the number of farms peaked and then began to slow or decline. Even in the far west the expansion of cropland slowed noticeably in the early 1920s, the proportion of pasture held steady, and the numbers of farms did not collapse during the worst of the drought that followed.²⁶ But even if the persistence of pasture and rangeland hints at the more careful use of land, it does not provide an assessment of whether the expansion of cropland led to extensive plowing of marginal soil.

Spatial Methods

To compare historical land cover to soil quality, we first had to create a series of air photo maps using the imagery commissioned by the Agricultural Adjustment Administration in the late 1930s. After the Second World War, the USDA resumed its program of monitoring crop reduction using airborne cameras, giving a substantial boost to the commercial aviation sector and the young science of photogrammetry. As natural resource managers and planners discovered the benefits of more accurate measurement of vegetation cover and condition, the applications of aerial photography widened to include forestry, wildlife management, landscape ecology, and urban planning.²⁷ Today the most common use of aerial photography is in forestry, where management agencies rely on the existence of a record of landscape change that reaches back to the 1930s to provide historical baselines for current management plans. Although satellite imagery is used more often in global change analysis, aerial photography has retained its role in the analysis of vegetation health and human impacts because of its time depth and spatial resolution.²⁸ Typically black-and-white panchromatic air photos taken at scale of 1:24,000 on negative film can resolve ground objects smaller than a meter.

Several steps were necessary to prepare imagery for classification. These methods are described in more detail in the endnotes and in other publications. Briefly, arriving at classification scheme that focused on the distinction between cropland and other forms of vegetation presented the greatest challenge. Manual interpretation can be subjective, and interpretation accuracy improves with training and experience and the use of decision rules that constrain the choices facing interpreters. The quality of many of the 1930s images is also an issue because of variation in the aerial cameras used by the many vendors contracted by the USDA and the storage of the images afterward.

We based the development of a classification scheme on the key distinction between grassland and cropland, and relied on central findings of grassland ecology about vegetation recovery. Several transect and repeat photography studies indicate that the signatures of tillage systems remain in the vegetation profile of grassland landscapes for some time after plowing activity has ceased.

For instance, Herbert Shantz's pioneering work early in the twentieth century found that full Clementsian succession to presettlement vegetation can take as long as fifty years in short grass environments.²⁹ More recent studies of grassland restoration in abandoned farmland have confirmed that recovery times range from thirty-five to fifty years.³⁰ The characteristic patchiness or uneven appearance of dominant perennial grasses is generally not evident until the end of the recovery period. Vegetation during early succession—following the abandonment of a plowed field—appears more homogeneous because the species that colonize disturbed sites are more likely to be mixed and tall grass species, like big bluestem (*Andropogon gerardii*) and sideoats grama (*Bouteloua curtipendula*), which are known for more rapid seed dispersal. The dominant perennial shortgrasses, like buffalo grass (*Buchoe dactyloides*) and blue grama (*Bouteloua gracilis*), are more tolerant to grazing and drought and will eventually dominate the composition of recovering grassland in dryland settings.

Recent studies of abandoned farmland using aerial photography from the late 1930s note that the signs of tillage in fields idled by the drought were quite pronounced. Coffin, Lauenroth, and Burke report a sharp contrast between abandoned fields and unplowed vegetation in adjacent fields in the historical images, and the distinct coloration of abandoned fields in the 1930s images allowed the grassland ecologists to identify abandoned cropland sites fifty-three years later. These ecologists caution that it is not possible to estimate the length of cultivation prior to abandonment in the 1930s.³¹ But the length of the recovery period is consistent with other studies. For an historical study, these well-known patterns of succession suggest that the imprint of tillage visible in 1930s aerial photos represent a history of soil disturbance that reaches back to the beginnings of settlement, particularly in the far west of Kansas where extensive plowing did not begin until around 1900.

Photo Mosaics

To reconstruct a spatially complete record of cultivation, we located Agricultural Adjustment Administration aerial imagery for our sample areas at the National Archives and Records Administration in College Park, Maryland. Near-complete inventories of the aerial surveys were ceded by the USDA to the National Archives in the 1980s.³² The USDA only intended the photographs for simple measurements, suitable for monitoring crop reduction and allocation programs.³³

Once the individual photos were joined in mosaics, a team of student interpreters began the classification work. Manual interpretation was keyed to the distinction between cropland and grassland, and land covers were assigned according to a common scheme developed in the 1970s.³⁴ Interpreters were asked to use a series of identification rules to proceed from five basic types of land cover (impervious or developed land, grassland, trees, water, and barren land) to eleven more detailed classes.³⁵ To distinguish between cropland and grassland, for example, the interpreter was instructed to note the absence of trees, developed land, water, or barren soil. If there were signs of tillage in the vegetation (plowing, mowing, parcel lines, and rectangular or geometric shapes with sharp tonal edges), the interpreter was asked to classify the land as cropland. If the grassland cover showed no signs of tillage, the interpreter was asked to distinguish whether the land cover was homogeneous enough to

suggest that it had been fertilized or seeded. If it looked richer than the surrounding vegetation, with no signs of tillage, the interpreters were asked to classify it as pasture. If it did not look richer than the surrounding vegetation, but instead looked uneven, or contained areas of bare soil (up to 40 percent of the land area), they were instructed to classify it as grassland.³⁶ These classifications were assigned to nonoverlapping parcels in map layers delineated by students in ArcGIS, the industry standard mapping software developed by the Environmental Systems Research Institute (ESRI).³⁷

Soil Survey

The other major data source in the analysis was already available for download from the USDA's Natural Resources Conservation Service (NRCS). The Soil Survey Geographic (SSURGO) Database provides digital versions of original countywide soil survey maps, considered accurate at scales that range from 1:12,000 to 1:63,000. As the most detailed soils information provided by the NRCS, the SSURGO data are designed for local use by landowners and natural resource managers. Because they arrive in relational form, the most difficult aspect of working with the SSURGO data is extracting the necessary information for display in standard mapping software. Users must make decisions about how to aggregate the underlying information in several data tables to individual map units. We chose a method called dominant condition, which assigns values to map units based on the key physical conditions.³⁸

In practice, many factors influenced where the soil scientists mapped soil unit boundaries, including the properties of the soils and the contemporary land use practices. Both informed their judgment of whether soils were at risk of erosion and their assessment of Land Capability Ratings. The ratings were meant to go beyond the classification of soil types and offer practical guidance as to the capabilities of the soil. In identifying the classes according to use capability, the surveyors were asked to consider four factors: (1) permanence of the soil if cultivated (susceptibility to erosion); (2) productivity of the soil as conditioned by native fertility, capacity for retention and movement of water, salt content, aeration, or other factors; (3) the presence of any factor that would interfere with cultivation, such as stoniness or a hardpan layer; and (4) the climatic environment, particularly temperature and precipitation.³⁹

Analysis

In the 1930s, federal officials did not have access to this information in any comprehensive sense. A new conceptual framework for soil survey was still taking shape, and the fieldwork was still several years from completion. But, in time, recovery of the worst affected areas and the advance of the basic science allowed for a more rigorous baseline for assessing land use practice. In digital map form, comparisons of the soil quality ratings and the physical extent of plowing from aerial photographs suggest marginal land was used cautiously. Only a small portion of the land classified as having a land capability of five or below was cultivated in the photos we analyzed. The areas that soil scientists eventually rated as nonarable were the areas still mainly in grassland cover during the late 1930s.

To measure the extent of cultivation precisely, we used a spatial overlay technique known as intersection. The intersect tool in ArcGIS generates a single polygon layer, in effect merging the two datasets (land use and soils) and spatially assigning the attributes associated with both original datasets to a new composite data layer. Everywhere that polygons share overlapping space and everywhere a line segment from either of the original layers crosses the other, the shared attributes for that space are assigned to new, more numerous, polygons generated from the intersection. Then the composite layer can be searched to identify polygons based on the attributes of both original layers. We queried the intersected layer to select polygons with land use identified as cropland and soils identified as unsuitable for cultivation. The analytical results of the map intersections are presented further below in figure 5.

But first the visual reward of the effort to classify land use is presented in the comparison of the six townships in figure 4, displaying the land use data layers over the aerial photo mosaics used to create them. The color scheme in figure 4 emphasizes the contrast between cropland and native grass. Even without stream data layers added to the maps, the flow of waterways and the changes in topography are apparent in the vegetation patterns. In the east, streambeds are lined with trees and woody vegetation, and in the west, streambeds remain in native grass. The two most heavily cropped townships are the ones in Doniphan and Ford. The others still had preserved substantial grassland cover in the late 1930s. The biggest signs of farming on marginal soils, what we call “ecological forcing,” in the landscape are at both ends of the state, as we illustrate later, in Doniphan and Stevens Counties.

Marion Township in Doniphan County is located on the west bank of the Missouri River in northeastern Kansas. In spite of its hilly terrain, virtually all available land was in use for cropland or orchards when the aerial photographs were taken in October 1941. This was partly a feature of the township’s location, just across the river from St. Joseph, Missouri. Over time the many small farms in the community sold fruit and vegetables into markets at St. Joseph and Kansas City. By contrast, the generally large farms in Voorhees Township in Stevens County, in the southwestern part of the state, were far from markets and concentrated on sorghum and cattle raising, with smaller crops of wheat. The soils in both locations presented several challenges. In Doniphan County, steep slopes encouraged farmers to plant orchards, and in Stevens, substantial sand hills rose above the otherwise flat terrain, making the terrain more suited to grazing.

Elsewhere farms faced fewer limitations. In Allen County, grassland was preserved in Cottage Grove Township because of the need for pasture on mixed farms. Soils were generally good, but farms maintained significant fields of grass and meadow, creating the diverse mosaic of land cover seen in photographs taken in July 1938. Further north and west in Wabaunsee Township, in Wabaunsee County, the limestone bedrock of the Flint Hills discouraged encroachment on thin upland soils. While there was significant cropping in the floodplain along the Kansas River in the north of the township, elsewhere tilled fields were located in the bottomlands. In the far west, townships in Ford and Cheyenne counties provide examples of rich soil conditions. Located just north of the Arkansas River, Wheatland Township in Ford County is nearly all composed of rich dark soils, with distinct grassland corridors along its stream network. In Cherry Creek Township, in Cheyenne

County, long arroyos or gullies (typical of the Republican River Basin) punctuate the otherwise rich flatland soils, ensuring reserves of grass for the area's livestock.

The signs of ecological forcing we expected to see, based on the literature, are distinctly absent from these landscapes. No matter when these communities were settled, and the unique circumstances each faced, farmers did not extensively cultivate submarginal land. Figure 5 provides an explicit spatial comparison of the same six townships. This time, instead of land cover, the maps present the Land Class Capability ratings, illustrating the distribution of soil classes in the same landscapes. The color scheme shades arable soils from light to dark green. The more challenging soils are displayed on a scale from yellow to red. A final data layer added to the map identifies the patches of cropland located on poor soils, that is, soils with a land capability class of 5 or greater. These polygons are shaded in black. They were identified by querying the intersected data layer combining the soil and land cover data.

A few observations stand out from inspection of their location. One is that these pockets of poor land use were more extensive where the local supply of poor soil was greater. The domain for bad farm practice was larger in places like Doniphan County and Stevens County because the resource endowments were poorer and more varied. But at the same time, the presence of poor resource endowments did not necessarily lead to inappropriate use. Two other townships in figures 4 and 5, in Cheyenne County and Wabaunsee County, offer evidence of the opposite outcome, where care was taken to preserve grazing land in areas where slopes were steep, and soils, too sandy or thin, for repeated cultivation. The other more salient observation is that the plowing of submarginal land, defined in this way, was far from the norm. Several metaphors have underwritten the narrative of land transformation on the plains, but careful or measured are not part of the standard lexicon. The maps generated by our analysis, however, provide evidence that much greater care was exercised than is typically recognized.

Certainly, different levels of risk and caution were exercised as farmers explored the performance of local soils under varying climates. Nevertheless, the gradients were much sharper than we imagined. Until we compared the distributions across all twenty-five study areas, the distinct regional pattern was not evident.⁴⁰ But the bar graphs in figure 6 illustrate the consistency. If we include class 4 soils in the calculation (the threshold illustrated in the maps above), only four townships (Cheyenne, Chautauqua, Doniphan, and Wabaunsee) fall below a threshold of 90 percent of cropland overlaying the best four soil classes.⁴¹ Even if we imposed a stricter definition of arable soils, and include just the three highest soil ratings, only six townships fell below a threshold of having 70 percent of cropland on the best soils. Part of the surprise is that most of the problem cases (in terms of poor land use)—Chase, Chautauqua, Dickinson, Doniphan, Nemaha, and Stevens—were in the east rather than in the west. Therefore, the biggest surprise was the much tighter relationship between the location of cropland and good soil in the western part of the state. Moving down figure 6, as the bar charts progress from east to west, the distribution shifts noticeably to the left, toward the better soil classes.

There were probably several reasons for this so-called dryland effect, in which marginal soils were less likely to be cultivated in the west. One, we think, is that higher precipitation in the east was more forgiving to farmers who cultivated marginal soils. Another is the larger size of western farms, with more cattle and higher grazing needs, reduced the incentive to cultivate marginal land.⁴² But the main reason may be that there was less room for error in the semiarid west. Once marginal soils were plowed and found wanting, awareness of the constraints imposed by local climates and soils conditions became an important component of local knowledge. Some farmers may have intentionally avoided bad soils well before the drought. But others, as we see later, began experimenting with poor soils, and they had to pull back when things went wrong.

Encroachment

In general, the aerial imagery indicates that ordinary farmers were quite good at recognizing land fit for cultivation. But the question remains: Why were plans to retire land so ambitious in the late 1930s? Why do the assessments of misuse appear so far off the mark after the fact? Part of the answer has already been suggested. Before the development of aerial surveillance and the Land Capability Classification rating, the various agencies that oversaw the plans had to rely on assessments of wind erosion to determine how much land to target in the worst affected areas. The social scientists involved in the various stages of the program also saw the aim of the plan to assist the farmers still on the land. The Farm Security Administration in particular saw the land purchase program as a chance to accelerate the restructuring of land tenure patterns and encourage farmers to expand and earn an “adequate level of living” after the drought ended.⁴³ Various agencies in the USDA recognized that the collapse of farm prices and financing exacerbated the environmental problems faced by farmers.

There are many cases in our study areas that fit the social scientists’ interpretation of the factors contributing to poor land use. Many involved in the Agricultural Adjustment Administration regarded bad land use mainly as a product of rural poverty and farm tenancy. Several cases in Doniphan County and Stevens County fit this archetype, at scales closer to what government officials observed. The Kansas census did not typically provide information on the location of farm residences. But in 1940 it is possible to link histories of land use to specific locations because a description of the home parcel was provided. Only further research in ownership records can reconstruct more locational information. Nevertheless, the histories of land use connected to 1940 farm residences are suggestive of the pressures facing small farmers. The themes are familiar to smallholder agriculture in many settings. For communities operating just above the carrying capacity of the land, drought or hard economic times often have disastrous consequences for the environment.

A closer look at one farmer illustrates this point. Alex Gilbert was one of the many small farmers making a living in the Corn Belt of northeastern Kansas. By the time that Agricultural Adjustment Administration contractors were flying over Doniphan County in 1941, Alex was fifty-four years old and living on a 40-acre farm. Most of his land in Marion Township that year was devoted to an orchard and had been since he took over his father’s farm fifteen years earlier. The Gilbert family had arrived in Marion sometime before the

1910 census when Alex was reported as twenty-three years old, married, and living in his parents' home. In 1910 Alex's parents, Nathan age fifty-eight, and Tillie, age forty-seven, told the enumerator they were both born in Missouri. Alex's maternal grandparents were both born in Missouri. In that year Alex's father described the family farm as a "Forest Farm" and Alex's occupation was given as a laborer on the "Home Farm." Listed in the next dwelling in the census was the household of Alex's brother Thomas, age twenty-five, and wife, Jessie, age twenty-five, and their three children. Thomas described his occupation as a laborer on a "Fruit Farm." Alex's father, Nathan, had reported the farm as rented in 1905, and by 1910, he had reported owning a 40-acre farm.

Excluding fruit, little cropland had been cultivated on the small farm. In 1905, 1915, and 1920, Alex's father had reported modest-size hay and pasture fields to the enumerator. But when Alex took over the farm in the 1920s, he began to plant small crops that cut into the pasture on the farm. The crops served as additional fodder for Alex's larger team of mules and two extra dairy cows. Alex may have decided it was cheaper to haul his produce to market, or perhaps he became involved in the carrying trade himself.

Like many farms around it, the Gilbert farm was in the center of Marion Township, where soils were rated as unsuitable for cropping mainly because hills were steep, varying from a slope of between 18 and 32 degrees. While fruit growing was the dominant land use, the slopes were less of an issue. But over time, as farmers began to grow more field crops, the level of soil erosion increased in landscapes like Marion Township. Today, as we see in figure 7, many of the former crop fields are gone, and forests are returning to the hills of northeastern Kansas.

At the opposite end of the state, in the heart of the Dust Bowl, we offer a similar example of a farm under pressure to expand. The farm of Albert and Augusta Mantzke in Stevens County was an equally modest family farm by the standards of western Kansas. Albert was already forty-nine years of age when he and his wife, fifteen years his junior, first appeared in the census for Voorhees Township in 1910. By 1915 the German-born couple was resident on a quarter-section farm with their ten-year-old son, Frank, and two daughters, Emma, age seven, and Marie, age five. All three children were born in Kansas. By the time Albert was ready to retire from active farming in the late 1920s, the Mantzke farm had grown to a half section (320 acres).

This modest-sized farm concentrated on sorghum, corn, and stock raising. Albert and Augusta appear to have avoided wheat. As the girls grew older, they added dairy cows to their modest operation. Living only about 8 miles east of the town of Rolla, the Mantzke household likely sold a good portion of its dairy production in town. Sorghum was a good choice for the climate in Stevens County because of its heat and drought tolerance. Imported from Africa and Asia, the seeds of the sorghum plant provide coarse grains (millet) for human consumption and abundant fodder for livestock. The cane of sweet varieties was also used in the manufacture of syrup.⁴⁴

The younger Mantzke is the connection to the poor stewardship seen in the landscape in 1942, the year the aerial photos were taken. Although he initially kept the size of his crop

fields below levels established by his father, Frank expanded operations during the Depression. He more than tripled the acreage of sorghum in cultivation between 1930 and 1940. The farm residence reported in his return for the 1940 census was located on the southwest quarter of section 13, township 34, range 39. In figure 8, the location of this residence places him at the northern edge of a sand hill. Highlighted in red outline on the lower panel are areas of submarginal land cultivation. The same area is shown in a recent USDA air photo from 2010. Most of the expansion that young Frank Mantzke undertook in the Depression years appears to have led to further cultivation in the area surrounding his home.

Part of the drive to expand came from Frank's acquisition of farm machinery. By 1935 he had sold off the horses reported in the census five years earlier and acquired a tractor and a harvester. The soil survey would later suggest that most of section 24, south of Frank's residence, be returned to grazing land. The aerial photograph from 2010 indicates that much of this has happened in the intervening years. But even in Frank Mantzke's time, there were already signs of encroachment on poor soil and abandonment of cropland. In the lower right-hand corner of the map, in sections 19 and 30, areas of abandoned cropland were identified. Even though these fields had not been plowed for some time, the signs of tillage visible in the field indicate it was plowed in the decade or so prior to when the photo was taken in 1942.

Conclusion

These are familiar explanations for endangerment of fragile grasslands. At one end of the state, smallholders with few resources exceeded the capacity of the land to sustain a modest living. At the other, similarly modest farms, with more acres, technology, and income, repeated the scenario in fields already abandoned. What is novel in this analysis is the understanding of the wider context in which unsustainable practices took place.

There were many farms like Gilbert's and the Mantzke's that used poorer soils across the whole of Kansas, from the subhumid to the semiarid regions of the state. But the vast majority of farms in our sample did not. While many of the human and environmental consequences of poor land management are part of our iconography of the period, the extent and duration of tragedy have remained obscure.

From the ground, the images of drifting soil and abandoned towns in the photographs of Farm Security Administration photographers Dorothea Lange and Arthur Rostein remind us of the crushing burdens of drought, poverty, and dislocation during the Depression.⁴⁵ But even in the full embrace of ecological disaster, many communities in the heart of the Dust Bowl did not collapse. Among the reasons they were able to recover was that fewer farms had ever encroached on marginal land than officials at the time, and most observers since, have imagined.

From 13,000 feet in the air, and along transects mapped by soil scientists, historic data offer environmental researchers a way to step back in time and reconstruct the practices of the past. When we add these detailed physical dimensions to stories extracted from archival

sources, at the scale of the landscape, farm, or field, the change that preceded the Dust Bowl was more varied. It seems that few farmers followed the conventional script.

Rather than a dramatic expansion driven by new technology, the agricultural change of the 1920s appears more measured. While many grassland farms were certainly spending down the accumulated natural capital around them—releasing carbon from the soil, destroying natural habitat, and abandoning soil building practices—the conversion of grassland was not open ended. Most agents of change in this story understood the consequences of plowing a few more acres, and they did not stray far from the margins of good earth.⁴⁶

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32. National Archives and Record Administration, Record Group 145, Records of the Farm Service Agency, 1904–1978, and Record Group 114, Records of the Natural Resources Conservation Service. Aerial photographs from the AAA were ordered for all the study areas, except Cheyenne and Decatur, which had good imagery from the earliest years of the Soil Conservation Service's aerial survey program. The images were acquired as 650 prints of copy negatives, projected at the original AAA mapping scale of approximately 1:20,000. We ordered a physical coverage with about 30 percent overlap between images in the same flight path. In the transfer from the USDA to NARA, the information on individual camera calibrations and flight lines has not survived. They may never have been indexed with the photographs.
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assumed focal length and an “average” scale of the photos for a given township. In practice, we inferred that altitudes used by aircraft carrying cameras with 8.5-inch focal lengths probably ranged near 13,000 feet above sea level. On interpreting scale in aerial photographs see chapter 4 of Lillesand, Thomas M.; Kiefer, Ralph W. *Remote Sensing and Image Interpretation*. New York: John Wiley, 2000. or Philipson WR. *Manual of Photographic Interpretation*. Bethesda, MD: American Society of Photogrammetry and Remote Sensing, 1997.

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37. The students were asked to use a field of vision that took them no closer to the ground than a scale of 1:4800. At this distance above the earth, the field of vision for the interpreter is limited to a basic public land survey parcel, the 160-acre homestead grant or quarter section. Closer to the surface, pixilation would begin to distort small objects in the scanned AAA images.
38. The downloaded SSURGO data files include ESRI shape files (polygon layers), the related soil survey tables in text form, and a template geodatabase. After the text files have been imported into the database, the tables can be searched for linking to the polygon map file. The rows in the data tables are not necessarily one-to-one matches with the spatial units in the map layers. Our queries were based on a form of aggregation described in the documentation for the dataset as maximum component, which assigns the dominant underlying condition to the spatial units in the soil map. We exported the resulting table with the unique map unit identifiers to a single data table that then reflected a one-to-one relationship to the soil map units.
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40. Aerial photographs were missing for only three townships in Chase, Nemaha, and Smith Counties. In both Chase and Nemaha, the percentage of the total area missing was very small, amounting to 3.2% and 8.5% of the total area of the sample townships in each county. However, in Smith County, only a small fragment of the imagery for Blaine Township was available on the film reels at the National Archives. The bar graph in Figure 6 is based on interpretation of aerial photos for only 12% of Blaine Township's 36-square-mile land surface. The next flight dates for Smith County were not until 1949, and we decided not to acquire imagery from a date so long after the Depression years.
41. This is far from the situation described by Douglas Hurt where USDA officials in Morton County (to the west of Stevens) devised a plan (which was never fully carried out) to retire the majority of farmland.
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Figure 1.

The Visual Framework: a harvest scene portraying an endless horizon of wheat paired with a dust storm photograph. Image, left: Harvest Scene, Finney County, Kansas, 1924. Credit: Kansas State Historical Society, Item Number 214779. Image, right: Dust storm near Stratford, Texas, April 18, 1935. Credit: National Oceanic and Atmospheric Administration, George E. Marsh Album, Image ID theb1365.

Figure 2.
Agricultural land use zones located in Kansas, 1933. Credit: Malin, *Winter Wheat*, preface.

Figure 3. Major land-use trends reported in sample townships, as derived from historical farm-level agricultural census returns in Kansas between 1875 and 1940. Credit: Kansas State Board of Agriculture, Statistical Rolls, Kansas State Historical Society, 1875–1940.

Figure 4.

Interpreted land use in six of the twenty-five study townships, including: Cottage Grove Township, Allen County, 1938; Cherry Creek Township, Cheyenne County, 1938; Marion Township, Doniphan County, 1941; Wheatland Township, Ford County, 1939; Vorhees Township, Stevens County, 1942; and Wabaunsee Township, Wabaunsee County, 1942. Credit: National Archives and Record Administration (NARA), Aerial Photography of the Soil Conservation Service and the Agricultural Adjustment Administration (AAA), 1938–1942; RG 114 and RG 145.

Figure 5.

Soil Survey Geographic (SSURGO) land capability classes intersected with interpreted land-use, which illustrates the extent of cropland (in black) that is located on poor soils in Allen County, Cheyenne County, Doniphan County, Ford County, Stevens County, and Wabaunsee Township, Kansas, 1938–1942. Credit: NARA Aerial Photography, and Soil Survey Staff, Natural Resources Conservation Service, U.S. Department of Agriculture, Soil Survey Geographic Database, 1998–2004 (Allen, 1998; Cheyenne, 1999; Doniphan, 2003; Ford, 1999; Stevens, 2002; and Wabaunsee, 2002).

Figure 6.
Percent of cropland area by land capability class, 1938–1942. Credit: NARA Aerial Photography and Soil Survey Geographic Database.

Figure 7.

Gilbert Farm located in Marion Township, Doniphan County, Kansas, 1941. Credit: NARA, Aerial Photography of the AAA, RG 145, 1941; Soil Survey Staff, NRCS, USDA, SSURGO Database, 2003; Aerial Photography Field Office, USDA, National Air Imagery Program, 2006.

Figure 8.

Mantzke Farm, Voorhees Township, Stevens County, Kansas, 1940. Credit: NARA, Aerial Photography of the AAA, RG 145, 1942; Soil Survey Staff, NRCS, USDA, SSURGO Database, 2002; and Aerial Photography Field Office, USDA, National Air Imagery Program, 2006.

Table 1

Gilbert farm, Doniphan County, 1905–1940

Name	Age	Year	size	Farm	Wheat	Corn	Oats	Rye	Barley	Sorghum	Hay	Pasture	Horses	Mules	Dairy Cattle	Beef Cattle	Sheep	Swine
NATHAN	49	1905	40		0	0	0	0	0	0	12	0	1	2	1	0	0	7
NATHAN	54	1915	30		0	0	0	0	0	0	5	4	2	2	2	0	0	7
NATHAN	59	1920	40		0	0	1	0	0	0	18	18	3	5	1	2	0	38
ALEX	38	1925	40		0	0	2	0	0	0	14	0	2	2	1	4	0	1
ALEX	43	1930	40		0	0	10	0	0	0	9	0	3	12	3	1	0	2
ALEX	48	1935	40		0	5	0	0	0	0	4	5	0	2	2	0	0	2
ALEX	53	1940	40		0	0	3	0	0	0	7	9	-	-	2	-	-	-

Source: Kansas State Board of Agriculture, *Statistical Rolls*, Kansas State Historical Society, Doniphan County, 1905–1940.

Table 2

Mantzke Farm, Voorhees Township, Stevens County, Kansas

Name	Age	Year	Farm size	Wheat	Corn	Oats	Rye	Barley	Sorghum	Hay	Pasture	Horses	Mules	Dairy Cattle	Beef Cattle	Sheep	Swine
Albert	54	1915	160	0	15	0	0	0	55	0	60	3	6	1	4	0	0
Albert	59	1920	320	0	10	0	0	0	158	0	0	2	3	6	13	0	0
Albert	64	1925	320	0	10	0	0	0	80	0	80	3	2	6	0	0	0
Frank	25	1930	320	0	5	0	0	0	105	0	200	4	0	4	3	0	0
Frank	30	1935	480	0	0	0	0	0	305	0	100	0	0	2	3	0	1
Frank	35	1940	480	0	0	0	0	0	390	0	103	-	-	0	-	-	-

Source: Kansas State Board of Agriculture, *Statistical Rolls*, Kansas State Historical Society, Stevens County, 1915–1940.