Prevailing Myths About Agricultural Abandonment and Forest Regrowth in the United States

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The classic story of historical land-cover change in the United States suggests that agricultural clearing in the 1800s was followed by agricultural abandonment at the turn of the twentieth century and subsequent forest regrowth—often referred to as a forest transition. Most descriptions present statistical data from historical censuses and surveys to make this case. Here we show that the historical data on cropland and forest area change for the United States need to be interpreted with care. Some earlier studies have exaggerated the extent of cropland abandonment and forest regrowth by failing to account for changes in definitions of croplands over time and changes in political boundaries in the case of forests. We reexamined the historical data to find that cropland and forest area for the United States as a whole have not undergone large-scale abandonment and regrowth but rather stabilized around the mid-twentieth century. Moreover, we find that, consistent with local and regional case studies, croplands were indeed abandoned in the eastern portions of the continent accompanied by forest regrowth, but there was compensating cropland expansion and forest clearing in the west. Our study suggests the need to exercise caution when using historical data to understand land-cover change and for developing theories such as forest transition. [Supplemental material is available for this article. Go to the publisher's online edition of *Annals of the Association of American Geographers* for the following free supplemental resource: (1) a table of cropland harvested area for the states of the United States from 1879 to 2002.] *Key Words: farmland abandonment, forest transition, historical data, land-cover change, United States.*

美国历史上土地覆盖变化的经典故事表明，在 19 世纪发生了农业清算，紧接着是 20 世纪的农田废弃，以及其后的森林再生，这一现象通常被称为森林过渡。目前支持该案例的大多数描述是基于历史普查和统计数据的。在本篇文章里，我们的分析研究显示，对于美国的耕地和森林面积变化，研究者需要特别小心对待历史数据。一些早期的研究实际上夸大了农田废弃和森林再生的范围，因为没有考虑到耕地的定义，以及森林的政治性边界随着时间推移而产生的变化。我们重新检查了历史数据，发现作为一个整体，美国的耕地和森林面积并没有发生大规模的遗弃和再生，围绕 20 世纪中叶，其变化是相对稳定的。此外，我们还发现，在大陆东部的部分地区，确实存在着农田废弃和相伴随的森林再生，但是，这一结果被发生在大陆西部的耕地扩大和森林减少所补偿，这一发现在局域和区域尺度的案例研究中是一致的。我们的研究表明，在使用历史资料试图了解土地覆盖变化和发展的时候，例如建立森林过渡理论这一个例，研究者需要加以特别的小心。【本文所用的参考材料可从下述地址获得：美国地理学家协会年鉴网络版有该出版者提供的免费补充材料：（1）1879 年至 2002 年，美国各州农田收割面积表格。】 *关键词：农田废弃，森林过渡，历史数据，土地覆盖变化，美国。*

El clásico recuento de los cambios históricos en la cobertura del suelo en los Estados Unidos sugiere que al desbrozo agrícola ocurrido durante el siglo XIX le siguió a la vuelta del XX el abandono de las tierras de cultivo y el subsiguiente recrecimiento del bosque—proceso al que a menudo se le conoce como transición forestal. La mayoría de las descripciones presentan datos estadísticos de censos y levantamientos de campo históricos en soporte de sus puntos de vista. En nuestro estudio mostramos que los datos históricos sobre el cambio de área de tierras cultivadas y bosques para los Estados Unidos deben interpretarse con cuidado. Algunos de los estudios anteriores han exagerado la extensión de campos de cultivo abandonados y de los bosques que las reemplazaron, al no tener en cuenta cambios en la propia definición de tierra de cultivo y las modificaciones que ocurrieron en los límites políticos en lo que se refiere a bosques a través del tiempo. Examinamos los datos históricos para así establecer que el área de tierras cultivadas y bosques de los Estados Unidos, en conjunto, no ha experimentado abandono en gran escala y recrecimiento forestal, sino que por el contrario se estabilizó a mediados del siglo XX. Aun más, encontramos que, consistente con estudios de casos locales y regionales, tierras cultivadas de las regiones orientales del continente en verdad fueron abandonadas y acompañadas de recrecimiento del bosque, pero que, en compensación, ocurrió una expansión del área cultivada y reducción de los bosques en el oeste. Nuestro

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estudio sugiere obrar con cautela cuando se utilizan datos históricos para entender los cambios de la cubierta del suelo y para desarrollar teorías como la de la transición forestal. [Hay disponible material suplementario para este artículo. Acceder a la edición *online* del publicista de *Annals of the Association of American Geographers* para el siguiente recurso suplementario gratuito: (1) una tabla del área de las tierras de cultivos cosechados en los estados de EE.UU. de 1879 a 2002.] *Palabras clave*: abandono *de tierras de cultivo, transición forestal, datos históricos, cambio de la cobertura de la tierra, Estados Unidos.*

The classic story of historical land-cover change in the United States is well known. European Americans initially cleared and settled the forests along the eastern seaboard. As the settlers moved west, agriculture migrated with them, resulting in agricultural abandonment along the eastern seaboard and southeast. Today, much of the intensive agriculture is located in the midwestern United States and the forest has returned in the eastern United States and other areas not well suited to agriculture.

This story of the rise and fall of agriculture (or deforestation followed by forest recovery) has been told numerous times, by numerous authors, quantitatively and qualitatively, and with a focus on either agriculture, forests, or both (e.g., Hart 1968; Clawson 1979; Williams 1989; Foster 1992; Waisanen and Bliss 2002; W. B. Smith et al. 2004; Kauppi et al. 2006). Indeed, the United States is often presented as an example of the forest transition theory, which suggests that the process of economic development in countries often begins with forest clearing but then undergoes a turnaround whereby agriculture is abandoned and the forests recover (Mather and Needle 1998; Rudel 1998; Rudel et al. 2005). In this article, we present an in-depth investigation of the historical land-cover data for the United States. Our study reveals critical nuances in the story that are often overlooked. In particular, we demonstrate that the dominant story applies only to the eastern United States and not across the country as a whole as normally portrayed.

In perhaps the earliest quantitative assessment, Hart (1968) examined changes in cleared farmland from 1910 to 1959 in thirty-one states across the eastern United States and argued that loss and abandonment of farmland "has been more widespread than is commonly recognized" (417). Hart pointed out that although farmland acreage across the entire conterminous United States had not changed substantially, farmland in the thirty-one eastern U.S. states was lost rapidly while the west continued to gain farmland. Hart argued that for the eastern United States as a whole, poor land quality hindering agriculture was perhaps the single most important factor influencing abandonment.

In a classic article titled "Forests in the Long Sweep of American History," Clawson (1979) examined trends since 1800 in forest inventory data (acreage, standing timber volumes, annual wood growth, wood utilization, and price of forest products) to present an optimistic outlook for the future of American forestry. In this article, he also summarized changes in forest (and area of "cropland in farms") across the United States from 1630 to 1977 from numerous sources. Figure 1 from Clawson (1979) is adapted and reproduced here (Figure 1) and suggests that farmland area across the United States increased and forests decreased until the early twentieth century, but the trend then reversed as farmlands were abandoned and the forests grew back. Although Clawson only argued in his article that the area of forests had stabilized and did not proclaim a large forest regrowth, his data have since been used by other authors to suggest a forest transition in the United States (e.g., Williams 1989; Kauppi et al. 2006). Indeed, Clawson included the following caveat in the introduction to his article:

> A quantitative history of forest land use, timber stands, timber growth, and timber harvest from 1800 to date, as presented in this article, is, like many other histories, limited by the paucity, suspected inaccuracy, and noncomparability of the available data. The best available data have been used in this article and are sufficient to sustain the interpretations drawn. (Clawson 1979, 1168)

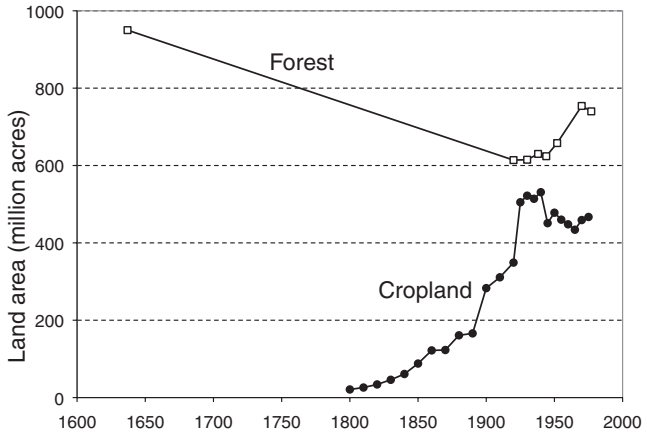

Figure 1. Reconstruction of historical cropland and forest areas for the United States from Clawson (1979). Data were taken from Tables 1 and 2 of Clawson, to reproduce an adapted version of his Figure 1. The data suggest large-scale cropland abandonment and forest regrowth in the United States since the mid-twentieth century.

Although Clawson's conclusions about the state of American forestry were not based solely on the acreage data, those data have been used since to tell the story of the return of the American forest. Williams (1989), in his authoritative volume, "Americans and Their Forests," used the same data as Clawson (see his Table 13.3) to say:

> Whatever measure is taken, the conclusion seems unavoidable that the forest is building up today rather than declining. The trends of the last three-and-a-half centuries have been reversed so that the conclusion seems unavoidable that the forest is being reborn. The amount of land in commercial forest (see Table 13.3) has risen from a low point of about 461 million acres in 1944 to 483 million acres in 1977. The amount of land in noncommercial forest has increased even more, from a low point of 120 million acres in 1930 to 254 million acres in 1977. (Williams 1989, 467)

Williams did go on, however, to acknowledge that relating forest regrowth statistics to agricultural abandonment is difficult because of lack of appropriate measures in the agricultural census. Sedjo (1999), in a discussion paper titled "Marion Clawson's Contribution to Forestry," wrote,

> In . . . "Forests in the Long-Sweep of American History" (1979), Clawson showed how the nation's forests had recovered, far beyond what had been anticipated even by the most optimistic analysts, from earlier logging and land-clearing abuses. His argument was that the American forests were in far better condition than was commonly supposed, in large part due to their natural resiliency, which he felt was consistently underestimated. (Sedjo 1999, 3)

The notion of agricultural abandonment and forest regrowth in the United States is also consistent with local experience of this change, as evidenced through numerous case studies across the eastern United States (Hart 1980; Foster 1992; B. E. Smith, Marks, and Gardescu 1993; Matlack 1997; Flinn, Vellend, and Marks 2005). Photographs showing agricultural structures from the past hidden in present-day forests lend further credence to this idea (e.g., Russell 1998; Thorson 2002; Van Valkenburgh 2004; see also the Web sites of the Harvard Forest Museum at http://harvardforest.fas.harvard.edu/museum.html and the Center for Rural Massachusetts at http://www.umass.edu/ruralmass).

In this article, we suggest that this dominant story requires refinement. Although we do not dispute that agriculture was abandoned in the eastern United States and that these forests grew back, presenting the data at a national scale obscures important regional differences, with implications for theories such as forest transition. Moreover, historical land-cover change data for the United States are fraught with problems related to changes in definitions and changes in administrative boundaries and therefore need to be interpreted with care. Well-known recent studies (e.g., Waisanen and Bliss 2002), although acknowledging problems with definitions, have continued to present the data without addressing these inconsistencies. Ramankutty and Foley (1999b) attempted to correct for these inconsistencies but did not present a detailed analysis of the source of inconsistencies and their implications. In this article, we carefully reexamine the historical data on land-cover change across the United States, addressing the inconsistencies and their implications for our understanding of land-cover change and for theories such as forest transition.

Data Sources

Cropland

Clawson estimated and compiled data on "cropland in farms" from 1800 to 1975 (Figure 1). From 1800 to 1880, he estimated this variable based on the relationship of total farm area to population and of cropland area to total farm area.[1] From 1890 onward, Clawson obtained data from a compilation titled *Historical Statistics of the United States: Colonial Times to 1970* (U.S. Bureau of the Census 1975).[2] More recent estimates are available from table Da14-27 of the updated edition of *Historical Statistics of the United States* (Carter et al. 2006). We henceforth collectively refer to these compilations as HisStatUS. The primary sources of data for HisStatUS were the individual U.S. censuses that are described further later.[3]

Historical changes in U.S. agricultural area are available from censuses taken roughly every ten years from 1879 to 1919 and roughly every five years since then (Table 1). From 1879 to 1919, the census reported the following variables related to agriculture: "improved land" (vs. unimproved land) and "harvested area" of several crops. Starting in 1924, more detailed agricultural land-use information was collected by the censuses and, in addition to "cropland harvested,"[4] included area in "crop failure," "cropland idled or fallow,"[5] and "ploughable pasture." From 1945 onward, the ploughable pasture variable was replaced with "cropland used for pasture."

Table 1. Data sources for cropland measurements

Source	Years	Variables reported related to cropland	Cropland area as reported by HisStatUS
U.S. Bureau of the Census	1879, 1889, 1899, 1909, 1919	Improved land; harvested area of individual crops	Sum of harvested area of individual crops
U.S. Bureau of the Census	1924, 1929, 1934, 1939	Cropland harvested; crop failure; cropland idle/fallow; ploughable pasture	Cropland harvested + Crop failure + Cropland idle/fallow + Ploughable pasture
U.S. Department of Agriculture	1944, 1949, 1954, 1959, 1964, 1969, 1974, 1978, 1982, 1987, 1992, 1997, 2002	Cropland harvested; crop failure; cropland idle/fallow; cropland used for pasture	Cropland harvested + Crop failure + Cropland idle/fallow + Cropland used for pasture
U.S. Department of Agriculture	Annual estimates from 1910–2005	cropland harvested; cropland used for crops (includes harvested, failure, and fallow)	

From the U.S. censuses since 1879, we compiled state-level data on "cropland harvested," a variable that is more or less consistently reported. For the decades from 1879 to 1919, cropland harvested was not directly reported; however, the area under each crop was reported and we summed them to estimate cropland harvested. The number of reported crops increased between 1879 and 1919 to progressively include additional minor crops. For all years after 1919, a cropland harvested category is reported by state in the censuses. Data for Alaska, Hawaii, and the District of Columbia were available from the censuses for the more recent time periods, but not for the past. However, the area of cropland in these administrative units is insignificant to the analysis.

The U.S. Department of Agriculture's (USDA) Major Land Uses database provides annual estimates from 1910 to 2005 (national totals for the forty-eight U.S. states) on "harvested cropland" and "cropland used for crops" (the latter includes cultivated summer fallow and crop failure, in addition to harvested area; USDA 2008). It is not clear how annual estimates were derived even though censuses were only taken every five years at best. We gathered these annual data for additional comparison to the censuses.

Forest

To analyze change in forest area over time, we obtained state-level data on forest area from W. B. Smith et al. (2004). These data were predominantly based on forest surveys conducted by the USDA Forest Service. However, the data were adjusted to include estimates of forest area in regions that were later to become states within the United States, thus producing a data set that maintains a constant geographic definition throughout all years.

To reproduce Clawson's estimate, we also obtained, from Table 1 of Clawson (1979), the area of commercial forest and noncommercial forest from 1630 to 1977. We obtained similar data from Williams (1989; Table 13.3) to reproduce his estimates.[6]

Results

Cropland

Previous reconstructions of historical agricultural data are plagued by problems of inconsistent definitions. As mentioned earlier, Clawson's (1979) cropland in farm area statistics (Figure 1) were derived from HisStatUS. These data, which were compiled from individual censuses beginning in 1890, use inconsistent definitions through time (Figure 2), as noted in some instances in the HisStatUS footnotes[7] (Table 1). In particular, the census data from 1879 to 1919 reported total "harvested area," but this acreage was reported under the category of croplands by HisStatUS and used by Clawson as such. Starting in 1924, the additional variables of crop failure, cropland idled or fallow, and ploughable pasture were added to cropland harvested area to represent total cropland area in HisStatUS. From 1945 onward, the ploughable pasture variable was replaced with "cropland used for pasture." The definition of ploughable pasture used from 1924 to 1939 was broader (and therefore of greater acreage) than the term cropland used for pasture.[8] Figure 2 shows that the cropland area from HisStatUS from 1924 to 1939 is the highest over the entire time series. It is commonly assumed that these values are high because this period was the peak of agriculture but it is more likely an overestimate because of the use of "ploughable pasture" instead of cropland used for pasture as just described. Moreover,

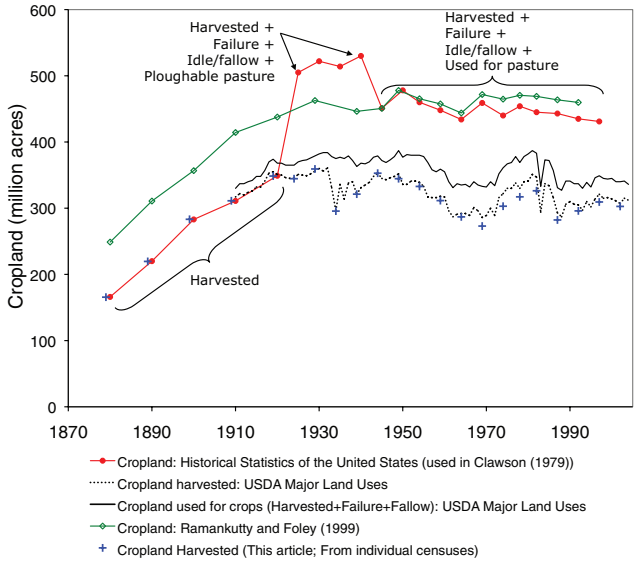

Figure 2. An intercomparison of various interpretations of cropland area change in the United States. The time series from the *Historical Statistics of the United States* is clearly influenced by changes in definition. The other time series do not show large-scale cropland abandonment. Note that a couple of time series are mismatched by one year because of discrepancies in whether they report data for the year in which they were collected or for the year in which the report was published. In the post-1945 time period, Ramankutty and Foley (1999a) is slightly different from the *Historical Statistics of the United States* even though they use the same definitions of croplands. This is because the Ramankutty and Foley data after 1945 are taken from the USDA Major Land Uses database that provides a "consistent accounting of all major uses of public and private land" in the United States, and therefore had adjusted the census data further.

the cropland areas from 1879 to 1919 are likely also underestimates of the real extent of total cropland area because of the use of a narrower definition of cropland.

The one variable that can be consistently gleaned from primary sources since 1879 is cropland harvested area. We first examine the annual historical data compiled by the USDA (2008) for "harvested cropland" as well as "cropland used for crops" (the latter includes cultivated summer fallow and crop failure, in addition to harvested cropland) for the forty-eight U.S. states from 1910 to 2005. These variables suggest a small gradual decline in croplands since the peak in 1930s instead of a large decrease[9] (Figure 2). Across the entire United States, the peak cropland harvested area was 361 million acres in 1932, decreasing to 321 million acres in 1997, a decline of 11 percent relative to the 1932 peak. Total cropland from HisStatUS shows a 19 percent decrease from 530 million acres in 1940 to 431 million acres in 1997. Ramankutty and Foley (1999b) made an attempt to adjust the data to account for change in definitions over time (see their article for details); their estimated change in total cropland area (including cropland harvested, crop failure, cultivated summer fallow, cropland idled, and cropland used for pasture) is also shown in Figure 2. According to this data set, cropland areas peaked at 478 million acres in 1949 and declined to 460 million acres in 1992, a mere 3.8 percent decline, showing no large decrease in cropland area since the mid-twentieth century but rather that cropland areas have mainly stabilized.

Forests

Previous reconstructions of historical forest area are also misleading. The first time-series reconstruction of historical changes in U.S. forest extent was by Clawson (1979), which Williams (1989) later reproduced using some of the same data sources (Figure 3). It is not clear from the descriptions of the data whether the definitions were consistent through time. Here, however,

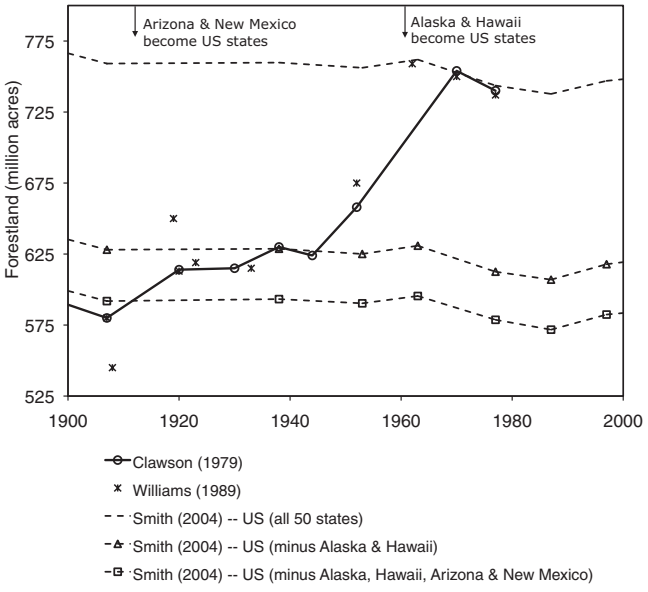

Figure 3. Data on forest area change in the United States from different sources. Smith (W. B. Smith et al. 2004) has the most consistent reconstruction of changes over time. Clawson (1979) and Williams (1989) did not consider the changes in territorial boundaries over time and therefore overestimated forest regrowth. Note that Williams had an estimate for total forest area in 1962, whereas only commercial forest area was reported by Clawson. Williams reported different forest extent values, from two different sources, for the adjacent years 1907 and 1908 and again for 1919 and 1920; because these differences should not be interpreted as a real progression in forest area between those years, we do not connect the Williams points in the figure with a line.

we raise another important issue: inconsistent political boundaries. Endnote 3 in Clawson (1979, 1174) says:

> It is not clear when data on the forested area of southeastern Alaska were first included in the various data sources. Such data were clearly included by 1953, at which time the commercial forest area in southeastern Alaska was slightly in excess of 4 million acres. Data on commercial forests in central Alaska are included only in the 1977 data.

This endnote has enormous implications for interpreting total forest change in the United States.

The most comprehensive survey of historical changes in U.S. forest extent has recently been done by the U.S Forest Service (W. B. Smith et al. 2004), providing consistent estimates for all fifty states in the United States from 1630 to 2002. Overlaying these total forest area estimates for both the forty-eight conterminous U.S. states (excluding Alaska and Hawaii) and all fifty U.S. states on top of the estimates from Clawson and Williams (Figure 3) reveals the artifact of including Alaska (and Hawaii, although its contribution is small) in the Clawson and Williams estimates. The rapid increase from 624 million acres of forest in 1944 to 759 million acres in 1962 (an increase of 135 million acres) was clearly due mainly to the inclusion of Alaska (with 130 million acres of forest, with forests in southeastern Alaska included first, and the rest of Alaska later) and Hawaii (2 million acres of forest) and not a result of regrowing forests. Furthermore, Figure 3 shows that the inclusion of Arizona and New Mexico in 1912 introduced yet another artifact in the reconstruction of Clawson and Williams, although less significant in extent compared to the influence of Alaska. Indeed, the data from W. B. Smith et al. (2004) show that for the country as a whole, forest extent has stabilized since 1907, and no significant regrowth has occurred.

We should acknowledge that not all studies have so strongly portrayed the story of the returning forests. Indeed, the literature from the USDA Forest Service, which carefully reconstructed the forest area data (W. B. Smith et al. 2004), only discusses a slowing down or termination of clearing of forests for agriculture. For example, W. B. Smith et al. (2004) said, "Nearly two-thirds of the net loss of forest to other uses occurred between 1850 and 1900. By 1920, the clearing of forests for agriculture had largely subsided" (3). Birdsey and Lewis (2003, 18) said,

> The total area of forestland in the conterminous United States has been remarkably stable over the last century, with a net loss of just 4.2 million ha. However, significant regional changes have occurred. The Northeast and North central region have gained forestland, 43 percent and 7 percent respectively, while all other regions have lost forestland.

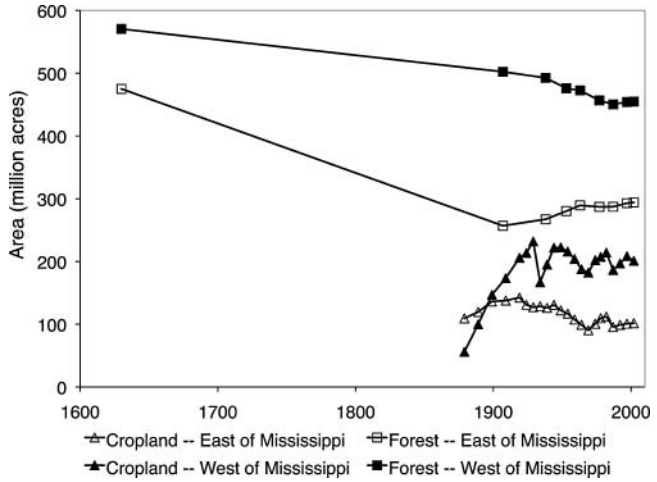

Figure 4. Historical time series of cropland harvested area and forest area grouped by states to the east and west of the Mississippi River.

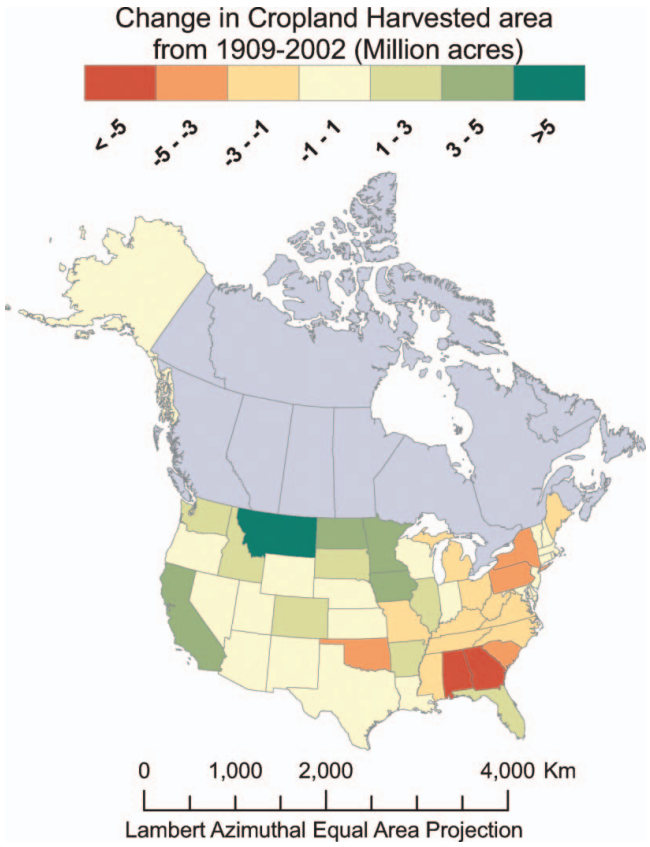

Figure 5. Changes in cropland harvested area from 1909 to 2002. The map clearly shows cropland abandonment in the eastern United States but expansion in the western United States and Florida.

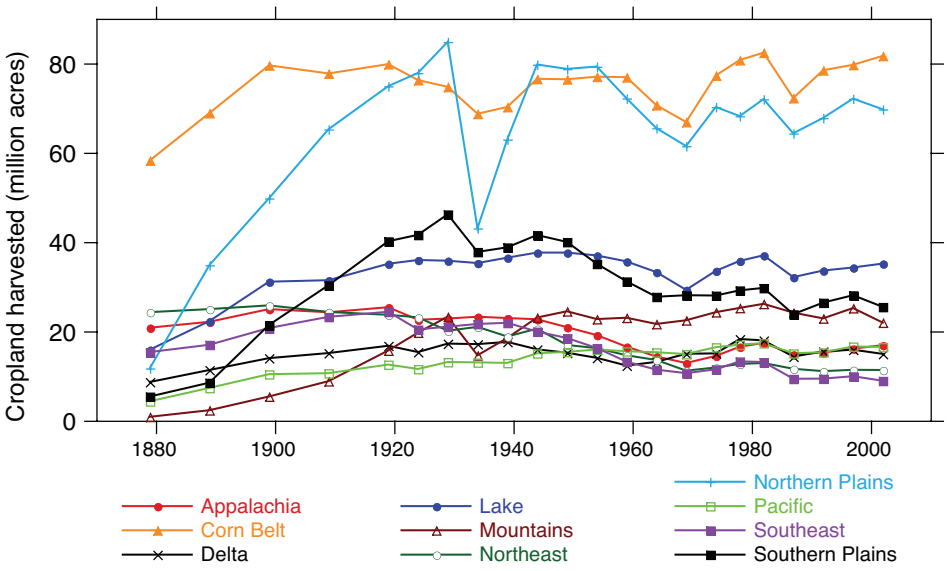

Figure 6. Time series of cropland harvested area from 1879 to 2002 for ten major regions of the United States. The regions are defined as follows: *Northeast:* Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont; *Appalachia:* West Virginia, Virginia, North Carolina, Kentucky, Tennessee; *Lake:* Wisconsin, Michigan, Minnesota; *Southern Plains:* Oklahoma, Texas; *Pacific:* Washington, Oregon, California; *Delta:* Arkansas, Louisiana, Mississippi; *Corn Belt:* Illinois, Indiana, Iowa, Missouri, Ohio; *Northern Plains:* Kansas, Nebraska, North Dakota, South Dakota; *Mountains:* Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming; *Southeast:* Alabama, Florida, Georgia, South Carolina. Alaska and Hawaii are not shown because cropland area is negligible.

Regional Changes

We have thus established that, for the United States as a whole, the story of large-scale cropland abandonment and forest regrowth does not apply. However, there are also several detailed studies of agricultural abandonment and forest regrowth in the eastern United States (Hart 1980; Foster 1992; B. E. Smith, Marks, and Gardescu 1993; Matlack 1997; Flinn, Vellend, and Marks 2005), suggesting that there must be compensating loss of forests and agricultural expansion elsewhere in the United States. We first look at the historical data on harvested cropland and forest area, separated by states to the east and west of the Mississippi River (Figure 4). Even as cropland harvested area declined somewhat in the eastern United States, it expanded greatly in the western United States until the early to mid-1900s and then stabilized. Similarly forests recovered somewhat in the eastern United States, but forest area continued to decline in the west.

At the state level, changes in cropland harvested area over the twentieth century in the United States show that although croplands were indeed abandoned across the eastern United States, compensating cropland expansion occurred during this time period in the Midwest, Mountain states, Pacific states, and Florida (Figure 5). A time series of cropland harvested since 1879, over twelve major regions of the United States (Figure 6), shows that cropland was abandoned since

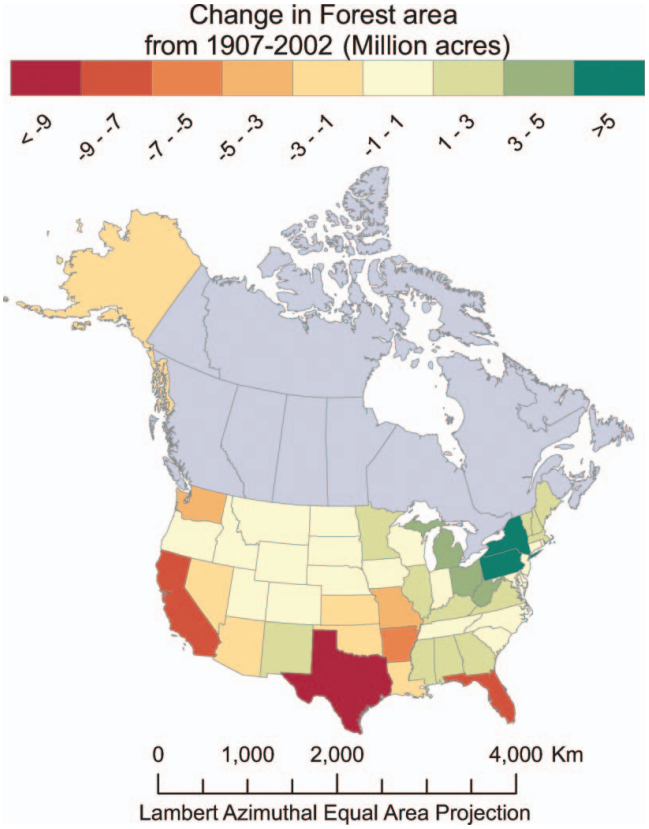

Figure 7. Changes in forest area from 1907 to 2002. The eastern United States (particularly the Northeast) witnessed forest regrowth, but forest area declined in the western United States (particularly Texas and California) and Florida.

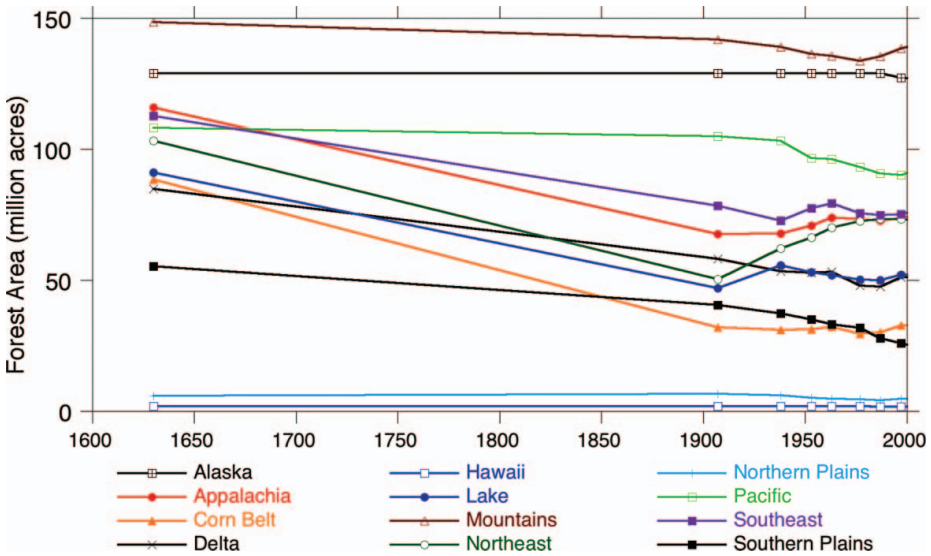

Figure 8. Time series of forest area from 1630 to 2002 for ten major regions of the United States, as well as Alaska and Hawaii. The regions are defined as follows: *Northeast:* Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont; *Appalachia:* West Virginia, Virginia, North Carolina, Kentucky, Tennessee; *Lake:* Wisconsin, Michigan, Minnesota; *Southern Plains:* Oklahoma, Texas; *Pacific:* Washington, Oregon, California; *Delta:* Arkansas, Louisiana, Mississippi; *Corn Belt:* Illinois, Indiana, Iowa, Missouri, Ohio; *Northern Plains:* Kansas, Nebraska, North Dakota, South Dakota; *Mountains:* Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming; *Southeast:* Alabama, Florida, Georgia, South Carolina. Alaska and Hawaii are not shown because cropland area is negligible.

the early to mid-1900s, mainly in the Northeast, Appalachia, Southeast, and southern Plains, consistent with the literature on agricultural abandonment in the eastern United States (Hart 1968). However, croplands continued to expand in the Corn Belt, Mountain, Lake, and Pacific states (Figure 6). The most striking feature in Figure 6 is the large decrease in cropland area in the northern Plains, the Corn Belt, southern Plains, and the Mountain region; this is likely associated with the Dust Bowl of the 1930s (Worster 1979).

Change in forest area over the twentieth century for the U.S. states shows that whereas the Northeast region has seen significant forest recovery, and Appalachia and the Lake states have also seen some recovery, there have been continued significant forest losses in the southern Plains and Pacific regions and the Delta states to a lesser extent (Figures 7 and 8). Whereas forest area increased by 21 million acres in Pennsylvania, New York, Michigan, and Ohio (the four states with the greatest increases in forest area), the states with the greatest loss of forests—Texas, California, Florida, and Arkansas—lost 35 million acres. The amount of forest loss in Texas is highlighted by the fact that in 1630, Texas had the third largest forest area in the United States after Alaska and California, whereas in 2002 it was ranked seventeenth. It is clear that the return of the forest is particular to the northeastern United States and not representative of a widespread trend across the country.

Discussion

Land-use and land-cover change is increasingly being recognized as a significant driver of global environmental change (Turner et al. 1990; Foley et al. 2005). With this recognition, numerous efforts have been made to reconstruct historical changes in land use and land cover both regionally and globally (e.g., Ramankutty and Foley 1999a; Klein Goldewijk 2001; Petit and Lambin 2002; Waisanen and Bliss 2002; Hurtt et al. 2006). Such data have subsequently been used extensively in global land change analysis and global modeling studies of the environmental consequences of land-cover change (McGuire et al. 2001; Brown et al. 2005; Gedney et al. 2006).

It is, however, important to bear in mind that these historical "data" are only reconstructions of past changes and contain many inconsistencies. They often combine data on land use that are defined differently by different administrative units, have changing definitions of land use through time, or have not considered shifting political boundaries. Therefore, before using these data sets in global land change studies, it is important to consider carefully the assumptions and caveats underlying those reconstructions. As discussed in this article, even many authoritative assessments and often-cited stories contain inconsistencies.

This study also raises some questions for forest transition theory, because the United States is often

presented as an example (Mather and Needle 1998). Forest transition theory suggests that with economic development, forest area decreases initially but then turns around and forests recover (Mather and Needle 1998; Rudel 1998; Rudel et al. 2005). The classic portrayal of forest change in the United States fits this picture. As this study suggests, however, forest transition in the United States is only applicable to the eastern part of the country and not to the country as a whole. This raises some interesting questions about scale of analysis. For example, a study that only looks at the eastern United States to portray a forest transition will clearly miss the fact that forest clearing has simply shifted to the Pacific Northwest and southern Plains regions. Moreover, there is the possibility of deforestation shifting completely to another region of the world, or "leakage." A recent study suggested that increased forest protection in China, Finland, and Japan has occurred through increasing imports of forest products from Russia (Mayer et al. 2005; Mayer et al. 2006). In addition, one needs to recognize that understanding land-use change and its consequences should involve analysis beyond simple changes in area. For example, Kauppi et al. (2006) introduced the notion of "forest identity" to include forest density, biomass per unit area, and carbon concentrations, in addition to forest area, when discussing forest transitions across the world. Similarly, Rhemtulla, Mladenoff, and Clayton (2007) discussed changes in tree size, biomass, and species composition when discussing forest transitions in Wisconsin.

Conclusion

Here we have demonstrated that the story of large-scale agricultural abandonment and forest regrowth in the United States is mostly confined to the eastern and southern portions of the country. Across the United States as a whole, that story does not hold. Indeed, compensating agricultural expansion and forest loss occurred in the central and western parts of the country. Although some sources accurately represent changes in cropland and forest area by accounting for changes in definitions and political boundaries, many others do not. Thus, our study suggests that careful interpretation of historical data is necessary to avoid false conclusions in relation to trajectories of land-cover change. The use of aggregated data can mask the geography embedded within the data but can also sometimes lead to wrong answers if the aggregation is done carelessly. Particular caution should be exercised when using such historical data to develop theories such as forest transition.

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Notes

1. Historical data on population were available consistently back to 1800. Agricultural data were not available until 1880, so Clawson used the relationship between population and agricultural data from 1880 to 1975 to estimate cropland area between 1800 and 1880.
2. This volume presented data going back to 1880; it is not clear why Clawson did not use the 1880 figure but rather estimated the value.
3. Note that often the census report was issued one year after the data were collected. For example, the 1880 census reported data on agriculture in 1879. HisStatUS (and Clawson) assigned the values to the year of the report, whereas we assigned the values to the year of data collection in this article.
4. Note that cropland harvested denotes the area of land devoted to harvested crops; if a piece of land is multiple cropped, it is not counted more than once. Therefore, our data until 1920 are not entirely consistent because we simply added the harvested area of individual crops to get cropland harvested. However, multiple cropping was likely nonexistent in the early 1900s; even today, only about 4 percent of cropland harvested is multiple cropped (U.S. Department of Agriculture 2008).
5. Cultivated summer fallow.
6. Williams cited his data sources as Clawson (1979) and U.S. Forest Service (1982). It is clear that the legacy of Clawson's first estimates have been reproduced since in other studies.
7. Footnotes to the cropland data in HisStatUS are as follows. Footnote 5: "Cropland harvested only" for the data in years 1880 to 1920; Footnote 4: "Includes Alaska and Hawaii" for data in years 1930, 1940, and 1950; and Footnote*: "Except as indicated by footnote 4, denotes first year for which figures include Alaska and Hawaii." The exclusion of Alaska and Hawaii in some earlier reports, although noteworthy, is insignificant because they contain only 7 percent of the total cropland in the United States currently, and contained less than that in the past.
8. According to a table footnote from the 1945 census, "The 1940 figures are not strictly comparable with those for 1945. The 1945 figures include land used only for pasture, which has been plowed within 7 years. The 1940 figures include land pastured, which could have been plowed and used for crops without additional clearing, drainage, or irrigation. This land may not have been plowed within 7 years prior to 1940" (U.S. Census 1947, as cited in Waisanen and Bliss 2002, 84–4).

9. Indeed, a USDA report suggests that there is an inverse relationship between cropland used for crops and cropland idled because of federal programs (USDA 2008).

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