Plants and Animals as Economic Assets

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In 2007, I estimate that US farmers invested $9.9 billion in long-lived working animals and $3.7 billion in orchards and pastures. In addition, urban landowners invested $31 billion in decorative landscaping plants. The international guideline for national accounts, System of National Accounts 2008, considers all of these items to be capital assets. However, BEA currently does not include any of these items in capital stock. In this paper, I estimate investment, prices and capital stock for each asset category back to 1929. I then recalculate GDP statistics if long-lived working animals, long-lived farm plants and urban landscaping are all capitalized.

To preview, my paper found three important results:

1) Nominal investment in farm animals and plants has grown slower than overall GDP. Therefore, nominal GDP growth falls by 0.011% annually if cultivated farm assets are capitalized. In contrast, landscaping investment roughly tracks overall GDP and capitalizing landscaping has no significant impact on nominal GDP growth.
2) Investment prices for long-lived plants and animals have roughly tracked overall GDP prices. Accordingly, average inflation rates do not change much when cultivated assets are capitalized.
3) Measured total factor productivity (TFP) growth in agriculture falls from 1.42% to 1.31% when long-lived farm animals and farm plants are treated as capital assets in the accounts. Even after adjustments, agricultural TFP growth is still much higher than overall TFP growth.

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Section 1: Introduction

SNA 2008 refers to the items covered in this paper as 'cultivated biological resources'. This phrase includes both plants and animals. In this paper, I will focus on three separate categories of cultivated assets: a) long-lived working animals; b) long-lived farm plants and c) urban landscaping. This paper summarizes my research on each category of cultivated assets. More detail on each category is available in my papers 'Long-Lived Working Animals as Capital Assets'; 'Long-Lived Farm Plants as Capital Assets' and 'Urban Landscaping as Construction Investment'.

Long-lived working animals are defined as animals which yield repeat products (SNA Section 10.92). For example, a dairy cow gives milk 300 days a year from age two until ten. Animals raised for meat are not considered capital assets even if they are more than one year old when slaughtered. Egg-laying chickens typically live for less than two years, so they are not counted as a capital asset in this paper. In this paper, I examine four separate animal categories: a) farm horses, farm mules, race horses and other equines; b) dairy cows; c) breeding beef cows and bulls; d) miscellaneous working livestock (breeding hogs, sheep, goats, honey bee hives and exotic livestock). I considered including non-farm animals like bomb-sniffing dogs or zoo animals, but I could not find any reliable data. I believe that these categories are relatively small and would not impact results if they were included. Dogs, cats and other pets are not counted as capital assets because they do not provide services counted in GDP.

Long-lived farm plants are defined as farm plants which yield repeat products (SNA Section 10.95). For example, an apple orchard may produce apples annually for fifty years. Trees raised for wood are considered work-in-progress inventories because their wood is only useful once. When discussing long-lived plants, the SNA handbook is focused on orchards. However, the stated definition of plant capital applies equally well to farm pastures. It is true that individual grass stems are very short-lived and should not be considered capital assets. But the underground pasture roots survive for decades. In this paper, I examine four separate long-lived farm plant categories: a) orchards and bushes producing fruit, nuts or syrup; b) alfalfa pastures; c) clover pastures; d) grass pastures.

Urban landscaping plants are defined as trees and lawns planted surrounding residential housing, golf courses, parks and other urban areas. At first glance, one might think that beautiful landscaping is too abstract to measure in GDP. It is true that the SNA's discussion focuses on farm orchards which provide fruit or nuts every year. However, residential landscaping contributes to home values. A beautiful backyard is no more abstract than granite countertops or other interior improvements. I will measure landscaping capital based on investment costs, without attempting to value aesthetics over time.

Because urban landscaping has a service life of more than a year and used, along with other structures, to provide services such housing and recreation that are within the production boundary, it meets the SNA's criteria to be classified as a fixed asset. It is less clear, however, where urban landscaping should be classified in the SNA's classification of non-financial assets. The SNA's definition of cultivated biological resources appears to emphasize animals and plants that yield repeat products in agriculture. Alternatively, landscaping could be classified as part of dwellings or other building and structures. I note that the SNA recommends that the costs of clearing and site preparation should be included in the value of these structures, and landscaping is not dissimilar from these costs. Another alternative would be to classify urban landscaping as part of land improvements.

The main section of this paper is divided into three parts. In section 1, I discuss why the treatment of cultivated assets matters for the national income and product accounts (NIPA's). In section 2, I describe my results for animals and long-lived farm plants. In section 3, I describe my results for urban landscaping plants.

Section 1: Changes to the National Income and Product Accounts when Cultivated Assets are Capitalized

In 2007, I estimate that farmers invested $9.9 billion raising long-lived working animals and $3.7 billion planting long-lived crops. I also estimate that property owners invested $31 billion in urban landscaping. Right now, BEA classifies that $45 billion in a variety of ways. Some categories of working farm animals are currently included in farm inventory. The rest of cultivated assets are not tracked as assets in the National Income and Production Accounts (NIPA's).

This paper recommends that BEA treat production costs for cultivated assets as an investment activity. In that case, breeding and planting costs for cultivated assets are treated as investment and directly included in the calculation of GDP. The investment costs are added to the pre-existing capital stock of cultivated assets to get the total capital stock of cultivated assets. This stock of cultivated assets generates a flow of capital services to its owners. The owners use that flow to produce food products like milk and services like rental housing. The proposed measure of GDP will not break out the flow of capital services from cultivated assets, [2] but it will continue to account for consumer spending on products like milk and services like rental housing. Therefore, the flow of services from long-lived cultivated assets will be implicitly counted in GDP.

Finally, depreciation (which is known as consumption of fixed capital or CFC) is deducted to calculate the new capital stock of cultivated assets. The new capital stock of working animals equals the pre-existing capital stock plus new investment minus CFC. In addition to the well-known GDP, BEA also estimates net domestic product (NDP); NDP = GDP – CFC. Because NDP reflects a charge for the cost of using capital, it is generally viewed as a better long-term measure of the total sustainable consumption made possible by an economy.

Unlike most capital assets, working farm animals have a large scrap value. Working cows culled from the herd and sent to slaughter contribute 10% of the US beef supply. I will treat those slaughtered animals as a disposal of animal assets from the capital stock and as an addition to the supply of meat for consumption. Reported investment in animal assets is the breeding investment in new animals **minus** the revenue from slaughtered animals (SNA Section 12.71). Similarly, farm pastures have scrap value because the plowed-up roots fertilize the soil.

Reclassifying production costs from current expenses to capital expenditures has important ramifications beyond raising measured GDP and capital stock. For example, the United States Department of Agriculture's (USDA) total factor productivity statistics are also affected by capitalizing working animals. Later in this paper, I will recalculate TFP growth from 1948 to 2011 when working animals and long-lived farm plants are treated as capital assets. Balance sheets, published jointly by BEA and Federal Reserve Board as part of the integrated macroeconomic accounts, are also affected by capitalizing cultivated assets.

[2] For government and nonprofit institutions, capital services from cultivated will be explicitly included in the estimates of GDP. Those sectors do not sell products on the market, so BEA uses expenses as the measure of output. Depreciation (or "consumption of fixed capital") is included as one of those expenses and can be thought of as a partial measure of the services of capital. In practice, neither sector owns many long-lived working animals or farm plants. However, governments and non-profits do own significant amounts of urban landscaping.

Section 2: Nominal Investment, Prices and Capital Stock of Long-Lived Working Animals and Long-Lived Farm Plants

In order to measure investment and capital stock of cultivated assets, I need time series data on nominal investment and price indexes from 1929 to 2011.[3] I also need a depreciation rate for animals in each category. I can then calculate real investment and real capital stock in Year t:

$$\text{Real Investment}_t = \text{Nominal Investment}_t/\text{Price Index}_t$$

$$\text{Real Capital Stock}_t = \text{Real Capital Stock}_{t-1} - \text{Real Depreciation}_{t-1} + \text{Real Investment}_t$$

In the remainder of section 2, I will give information on nominal investment, price indexes and depreciation rates for each cultivated farm category. Animals raised for meat are not candidates for capitalization – so I did not measure investment or capital stock. However, I did recalculate **changes** in farm inventories if only those animal categories are included.

2a. Nominal Investment in Farm Animals

According to the 2007 Census of Agriculture, US farmers owned 4.3 million horses, 9.3 million dairy cows, 32.8 million breeding beef cow, 6.3 million breeding hogs, 3.5 million breeding sheep, 3.1 million goats, 0.8 million exotic animals and 2.9 million honeybee hives. I estimate that these animals had an aggregate value of $72 billion. The Census of Agriculture does not track annual investment. I calculate investment from a population model. In 2007, I estimate that farmers bred $1.9 billion of horses, $6.4 billion of dairy cows, $3.3 billion of breeding beef cattle and $1.3 billion of miscellaneous livestock in 2007. I also estimate that farmers also slaughtered $1.8 billion worth of dairy cows, $1.0 billion worth of breeding beef cattle and $0.3 billion worth of miscellaneous livestock. I will report animal investment = breeding investment minus slaughter.[4]

Figure 1 shows the nominal GDP share of animal investment by category. The most striking thing about Figure 1 is the shrinking GDP share over time. This decrease is mainly caused by the much

[3] In order to calculate initial capital stock, I estimated investment prior to 1929. My earlier investment numbers are available upon request, but they are more speculative than the numbers after 1929.

[4] If the culling rate is high enough, reported investment may be negative. This may have happened for cows in 1934 and 1935, when drought and government purchase programs reduced the dairy cow herd dramatically. I also count imports as positive investment and exports as negative. In practice, imports and exports are small.

slower growth for the overall farm sector. In 1929, farm output equaled 12.5% of total GDP and consumers spent 21% of their income on food at home. By 2011, farms only accounted for 2.5% of US output and consumers spent only 8% of their income on food at home. Working animals have also shrunk relative to the overall farm sector. In 1929, animal investment in long-lived working animals equaled 6.3% of farm output. By 2011, animal investment dropped to only 2.0% of farm output. From 1929 to 2011, nominal GDP growth drops by 0.009% annually when working animals are capitalized.

Figure 2 shows the change in gross farm output from capitalizing long-lived working animals. For the interest of readers, I split the GDP changes from capitalizing working animals into four separate parts: a) The impact of using new datasets and new population models to measure livestock inventories; b) The impact of new quality adjustments for livestock inventories. The new quality adjustments mean that a decrease in the number of animals does not always cause a decrease in the quality-adjusted inventories; c) The impact of including new animal categories like horses in farm inventories; d) The impact of reclassifying all these animals from inventory to capital stock.

2b. Nominal Investment in Long-Lived Farm Plants

According to the 2007 Census of Agriculture, US farmers owned 5 million acres of orchards, 25 million acres of alfalfa pasture, and 134 million acres of other pasture. I estimate that these long-lived plants had an aggregate value of $58 billion. This $58 billion is for the plants alone. The farmland underlying the plants is worth at least double the long-lived plants contained in the land. However, that land value would remain even if farmers planted another crop.

In 2007, I estimate that farmers planted $1.4 billion of orchards, $0.7 billion of alfalfa pastures, $0.1 billion of clover pastures and $3.3 billion of grass pastures. I also estimate that farmers plowed up $0.2 billion of alfalfa pastures, $0.03 billion of clover pastures and $1.6 billion of grass pastures. I consider those plowed-up acres to be negative investment. In this paper, I will report pasture investment = planting investment minus plowing up rates.

Figure 3 shows the nominal GDP share of plant investment by category. Just like Figure 1, Figure 3 shows a shrinking GDP share over time. From 1929 to 2011, nominal GDP growth drops by 0.002% annually when long-lived farm plants are capitalized.

2c. Price Indexes for Long-Lived Working Animals

It is surprisingly difficult to measure livestock prices over time. The USDA has wonderful data on livestock prices per animal, and I have used those prices as a starting point for my price indexes. However, I believe that those prices need to be adjusted for livestock quality. Modern dairy cows give four times as much milk as dairy cows did in 1929. Breeding beef cattle produce heavier calves and breeding sows produce more piglets. Most of these changes are due to genetic improvement in livestock, and therefore should be counted as a quality improvement in the capital stock.

Figure 4 shows livestock prices by category from 1929 onwards. Dairy cow prices have grown much slower than other livestock prices because that category experienced the biggest quality improvements. Dairy cows are also much more likely to be artificially inseminated than other livestock. I do not know if the high artificial insemination rate causes the rapid quality improvement by itself, or if the potential for rapid quality improvement makes artificial insemination more worthwhile.[5] Going forward, beef cattle ranchers are starting to artificially inseminate their breeding cows. We will see whether this leads to faster quality improvement in the beef cattle herd.

2d. Price Indexes for Long-Lived Farm Plants

The University of Iowa has published several cost estimates for planting alfalfa pasture and grass pasture. I use those cost estimates when available. When planting costs are not available, I use wholesale prices for fruits, nuts and hay as a proxy for investment costs. I then adjust those planting costs for quality improvement over time. Long-lived farm plants have improved much slower than short-lived crops like corn, so the quality adjustments do not change prices much.

Figure 5 shows long-lived plant prices by category from 1929 onwards. Plant investment prices have grown much faster than grain prices and other farm output. This is mostly caused by faster productivity improvement in major crops like corn, wheat or soybeans. Accordingly, prices for farm output grow faster when plant investment is added to farm output. On the other hand, plant investment prices track overall GDP prices. Therefore, the overall GDP deflator does not change much when plant investment is capitalized.

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[5] Thoroughbred racehorses are not allowed to compete if they are produced from artificial insemination.

2e. Depreciation Schedules

Even after they are placed into service, cultivated assets require a few years to mature fully. Dairy cows are first bred at 15 months and they start giving milk when they calve 9 months late. But they do not reach peak milk production or market value until a few years later.[6] Fruit trees typically start producing significant amounts of fruit around age 4 but do not reach full maturity until age 12. These age-productivity profiles seem to be a natural biological process, and are not caused by changes in farmer inputs. Human workers also start out less productive and become more productive as they mature and gain experience.

In this paper, I only count value increases before cultivated assets enter service as investment. Value increases after cultivated assets enter service are considered negative depreciation. The negative depreciation on young animals and trees are almost always balanced out by positive depreciation on older animals and trees, so overall depreciation is still positive. I have also experimented with treating the value increases after animals enter service as new investment. This technique produces identical estimate of aggregate capital stock and net savings (investment minus CFC), but investment and CFC are both lower with the second technique. Those alternative statistics are available upon request.

Figure 6 shows the value profile for each animal category over time. The longest lived animal category is equines (horses and mules). Farm mules often worked more than 30 years before dying of old age. Breeding beef cattle can produce calves for about ten years before they become infertile or too frail to survive the outdoor range. Dairy cows have a less healthy lifestyle than breeding beef cows and they generally are slaughtered by age six.

Figure 7 shows the value profile for each plant category. Clover pastures have the shortest lifespan. They are ready for grazing within a few weeks and then depreciate rapidly. Alfalfa pastures and grass pastures require about a year to mature and then provide grazing for a decade or more. Finally, orchards require years to mature and last for decades. The typical tree enters service at age 4.5

[6] In 1916, dairy cows peaked in value around age 6 (McDowell 1916). Modern dairy cows peak in nominal value earlier, but some of this may be associated with overall quality improvements for new heifers rather than depreciation.

and peaks in value at age 12. However, a few long-lived species do not enter service until age 9 and peak in value at age 24.[7] In contrast, berry bushes typically mature quickly and live for only a few years.

When calculating capital stock, I use a geometric depreciation schedule for each cultivated category. Equines depreciate at 8.4% per year, dairy cows depreciate at 12.0%, breeding beef cattle depreciate at 7.2% and miscellaneous livestock depreciates at 18.2%. On average, orchards depreciate at 3.3% per year, alfalfa pastures depreciate at 14.5% per year, clover pastures depreciate at 38.4% per year and grass pastures depreciate at 6.1% year. These geometric depreciation rates are not accurate for individual plants or animals. Figures 6 and 7 generally show that 'middle-aged' plants and animals have lower depreciation rates than very old plants or animals. However, it is too difficult to implement the non-geometric depreciation rates every quarter. In practice, aggregate capital stock is very similar when I use a geometric depreciation rate or the complex depreciation schedules. The results with complex depreciation schedules are available upon request.

Figure 8 shows the nominal capital stock of farm animals relative to total fixed capital. The capital share of farm animals has declined even faster than the investment share shown Figure 1. Farm horses are the main reason for the faster declines. By 1929, farmers had mostly stopped breeding new farm horses because tractors were better (Olmstead and Rhode 2000). But farmers still had a large capital stock of existing horses that they used until after World War 2.

Figure 9 shows the nominal capital stock of farm plants relative to total fixed capital. In contrast to animals, the capital share of farm plants has declined slightly slower than the investment share shown in Figure 2. The main reason for the difference is a shift away from alfalfa pastures and clover pastures. In 1929, those two pasture types accounted for 34% of annual investment. By 2011, their investment share had fallen to only 16%. Alfalfa pastures and clover pastures are also shorter lived than orchards or grass pastures. As a result, the average depreciation rate for long-lived farm plants has fallen over time and the capital stock has increased relative to annual investment.

2f. Livestock Inventory

Inventory changes are one component of total GDP, so measured GDP will increase when livestock inventories increase. BEA currently takes its numbers for the change in farm inventories from

[7] The long-lived species in this paper are: date, hazelnut, maple syrup, olive, pistachio, pecan, pear and walnut.

the USDA. Those USDA statistics include dairy cows, breeding beef cattle and other livestock that this paper reclassified to be capital assets. If BEA continued to use the same numbers for livestock inventory, we would double-count changes in those animal categories. Instead, I estimated entirely new numbers for livestock inventory. My numbers only count animal categories not capitalized.

Figure 10 shows the nominal value of livestock inventories relative to nominal capital stock. Like animal capital stock, animal inventories have been growing much slower than overall capital stock. In 1929, livestock inventories equaled 0.82% of total capital stock. By 2011, livestock inventories were only 0.15% of total capital stock. Most of this decline comes from the steadily shrinking GDP share for farms. However, animals raised for meat are also maturing faster – so farmers require less work in progress inventories to produce the same amount of meat as before.[8]

2g. Total Factor Productivity (TFP) in Agriculture

BEA does not currently publish productivity statistics, so there is no official BEA table to revise. However, the USDA's Economic Research Service (ERS) does publish their own estimates of farm inputs and output back to 1948. For the interest of readers, I studied how the ERS's published table might change if they capitalized farm animals and plants like this paper recommends.[9]

I decomposed the measured productivity changes into three separate components:

1) **Livestock Inventories:** I collected new data on livestock inventories and developed new price indexes for livestock inventories. Also, I changed the methodology to account for livestock when measuring TFP. Even if long-lived working animals are not capitalized, these changes could potentially influence measured TFP.

2) **Capitalizing Long-Lived Working Animals**: This step reclassifies long-lived farm animals from inventory to capital stock. Livestock investment is added to gross value-added and livestock CFC is added to capital services. The impact on net value-added and productivity change over time is theoretically ambiguous.

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[8] I treat this faster growth as quality improvement over time. Chickens have improved in quality much faster than cows or pigs, so quality adjusted chicken prices have barely increased since 1929.

[9] I thank Jon Samuels for helping me run a back of the envelope calculation estimating how this paper could affect measured TFP growth. My numbers are much simpler than his detailed procedure. In particular, I assume a constant rate of return for livestock inventories and capital. This allowed me to easily calculate capital services.

3) **Capitalizing Long-Lived Farm Plants**: ERS does not currently track long-lived farm plants in capital stock. This step calculates TFP if long-lived farm plants are tracked as capital investment. Plant investment is added to gross value-added and plant CFC is added to capital services. The impact on net value-added and productivity change over time is theoretically ambiguous.

Figure 11 shows the changes to measured TFP from each step. The changes to livestock inventories have little impact on TFP growth. In contrast, measured TFP growth declines modestly when cultivated farm assets are capitalized. Average TFP growth rates fall from 1.42% to 1.31%. Even with the slower growth rate, TFP in the agriculture sector still increases much faster overall.

Section 3: Nominal Investment, Prices and Capital Stock of Urban Landscaping

3a. Nominal Investment

My main dataset for trees is the Census of Agriculture, which is conducted every five years. The Census of Agriculture tracks commercial tree nurseries along with more conventional crops. According to the 2007 Census of Agriculture, commercial tree nurseries produced $6.6 billion worth of young trees, vines and shrubs. In the same year, young tree imports were $0.38 billion and exports were $0.18 billion. So, total young tree usage in the United States was $6.8 billion. The Census of Agriculture does not split production by type, so I supplement with the 2009 Horticultural Census. In 2009, tree nurseries earned 10% of their revenue from fruit trees probably used in farm orchards. I estimate they earned another 5% of their revenue from small saplings sold to forests or other nurseries for further growth.[10] Based on the numbers above, I calculate that US households and businesses planted $5.2 billion worth of young trees in 2007. Between census years, I use payroll data from the Quarterly Census of Employment and Wages (QCEW) to interpolate annual sales.[11]

[10] I include the categories ‘ornamental grasses’ and ‘other woody ornamentals, vines and ground covers’ with trees. Like trees, ornamental grasses and vines live a very long time once established properly.
[11] I focus on NAICS code 111421, nursery and tree production. This NAICS code includes sod for lawns and short-lived flowers, so it is not a perfect proxy for trees. As a robustness check, I tried using annual sales data from the Oregon Tree Survey. That survey shows a similar pattern overall, but it peaks in 2005 rather than 2007.

Tree investment is much larger than young tree sales. Commercial tree nurseries generally sell their young trees wholesale to landscaping companies and retail stores. Landscaping companies typically charge 200%-300% of the initial young tree cost to plant a tree and care for it over the first two years (Thompson and Sorvig 2007). When calculating annual investment, I will assume that a tree planted one year ago is worth 250% of its wholesale price and tree planted two years ago is worth 350% of its wholesale price. After age 2, I assume that trees are ready to enter service and no more investment is necessary. Just like farm orchards, landscaping trees continue to increase in value after they enter services. I consider this value increase to be negative investment.

My main data source for lawns are two USDA surveys on lawn investment. The USDA surveyed Maryland property owners in 2005 and Virginia property owners in 2004.[12] I have not been able to find any national data on lawn planting, so I use those two states as a proxy. Maryland property owners planted 30,890 acres in 2005 and Virginia property owners planted 50,000 acres in 2004. According to the National Resource Inventory, those two states account for 4% of the newly developed land in the United States. Therefore, I calculate that property owners planted approximately 2.1 million acres of lawns nationwide in 2004. The USDA survey also reports that Maryland and Virginia businesses spent $5,200 per acre of lawn established.[13] Based on that, I calculate that total investment in lawns was $10.3 billion in 2004. This $10.3 billion includes out-of-pocket spending on purchased materials, hired labor and do-it-yourself home-owner labor.

My historical data on lawns is taken from a variety of sources. The Census of Agriculture tracks commercial sod production back to 1969.[14] Between 1945 to 1969, I use total residential acreage estimated by the Census of Agriculture to impute lawn investment. Before 1945, even that data is unavailable. I assume that real lawn planting is proportional to real investment in single family housing. I then multiplied real lawn investment by my price index to get nominal lawn investment. Regardless of how I model data, lawn investment was small before 1969. Between Census years, I use payroll data from the QCEW to impute annual investment.

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[12] The USDA also surveyed New York, but their survey reported a completely implausible value for turfgrass acreage planted. I do not know why New York's results were so far from the other two surveys.

[13] I focus on businesses because home-owners might have contributed do-it-yourself labor. According to the SNA, I should impute a market value for this do-it-yourself labor – but I have no data on time use or tasks performed. Landscaping wages are not constant across the US. Maryland and Virginia are roughly in the middle, so adjusting for wage differences has little impact on my results.

[14] It might seem that I could use sod sales from the Census of Agriculture directly. However, many property owners plant lawns from seed without purchasing any sod. When measuring historical investment, I assume that the ratio of sod sales to total investment has been fixed over time. I welcome suggestions to improve my estimates.

Figure 12 shows tree landscaping investment relative to nominal GDP. In the short term, tree and lawn investment generally investment generally tracks other forms of residential investment. During the housing bubble, landscaping rose significantly and then dropped. Over the long term, lawn investment has grown much faster than tree investment. I believe that main cause of this increase is the growth of suburbs. Houses in central urban areas generally don't have much space for lawns, and houses in rural areas have enough greenery without lawns. Americans have been gradually moving out to suburbs since World War 2, and lawn investment has risen in response.

3c. Price Indexes

I use wage data for nursery workers to create a price index. According to the QCEW, average wages for nursery workers were $24,808 in 2005 and $27,479 in 2012. The QCEW data is available back to 1984. Before then, I use USDA data on farm labor costs to get wages back to 1901.

I then adjust the wages series for productivity growth. I could not find any sources estimating labor productivity in the landscaping. The best I could find was two careful breakdowns of farm fencing costs. In 2005, Iowa State University estimated that a worker can set-up 31 feet of fence an hour. In 1916, Harold Humphrey estimated that workers can set up 28 feet of fence an hours.[15] This small increase represents only 12% productivity growth over 89 years, an annual rate of 0.13% per year. I believe that landscaping requires similar inputs as farm fences, so productivity for that investment has also grown at 0.13% per year.

Figure 13 shows my landscaping price index over time. As a robustness test, I check the created landscaping prices against quantity data from the Census of Agriculture.[16] In general, my landscaping price index matches the Census of Agriculture data reasonably closely. There is some short-term variation, but the long-term trend is almost identical.

[15] Humphrey gives many possible production rates, depending on the type of fence choses and technique used. I took his estimates for woven wire 1 barbed wire strand, with the posts set 13 to 16.5 feet apart. The pamphlet gives daily productivity without reporting hours worked. I assume a 10 hour day.

[16] The Census of Agriculture does not report output consistently. Instead, it reports acreage of open land for tree nurseries and sod nurseries. It also reports square feet of greenhouse space for tree nurseries. I believe that land use data is a reasonable proxy for real work in progress inventory. I assume that real sales are proportional to work in progress inventories in the long run.

3c. Depreciation Rates and Capital Stock

For trees, I use a model of mortality and tree values over time to calculate depreciation. My model assumes that trees increase in value until age 14 and then depreciate at 3% per year afterwards. The earlier value increase is caused by natural growth between planting and full maturity. The later value decrease is caused by mortality. My mortality numbers are based on mortality rates for a sample of mature trees in Baltimore (Nowak, Kuroda and Crane 2004).[17]

Between 1970 and 2010, the average tree depreciation rate was 0.98% per year. This average is much lower than the 3% depreciation rate for mature trees because the aggregate capital stock includes many young trees which are still growing. That growth is considered negative depreciation and subtracted from the positive depreciation for mature trees. The exact depreciation rate calculated changes over time, depending on the fraction of young trees relative to old trees. For simplicity, I will use a fixed depreciation rate of 0.98% from 1901 onwards. This fixed depreciation rates gets very close to the capital stock estimated using a more complex model.

For lawns, I use a depreciation rate of 4% per year. This 25-year lifespan is much longer than the recommended replacement rate for heavily used turf. For example, the US Golf Association recommends that courses resurface their grass every 15 to 20 years (White 2006). The San Francisco Park District recommends resurfacing playing fields every 10 years (Morrison 2005).[18] However, most lawns are located on residential property and receive far less traffic than golf courses or sports playing fields. In addition, homeowners are generally willing to tolerate a few weed and minor irregularities in their lawns. So, a 25 year lifespan for home lawns seems reasonable.

Figure 14 shows my estimates of tree and lawn capital stock relative to the aggregate capital stock. Since 1950, the capital share of landscaping has been almost constant. In contrast, the capital shares for long-lived working animals and long-lived farm plants have both fallen dramatically. The main reason for this difference is changing industry shares. Most urban landscaping is used for residential housing, and landscaping investment tracks overall housing investment quite closely. Over the past century, residential housing has grown at approximately the same rate as the overall economy. Farm animals and farm plants track the farm sector, which has grown much slower than the overall economy.

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[17] I define mature tree as trees more than 15.3 centimeters in diameter. Newly planted trees have a much higher mortality rate than mature trees, but I assume the value increase from their growth more than balances out the value decrease from ordinary mortality. Baltimore trees may not be representative of the total tree population.

[18] This paper argues for using synthetic grass, so the author may have picked a low lifespan to help his case.

Conclusion

SNA 2008 recommends that countries include 'cultivated assets' in capital stock. This paper studies three separate categories of cultivated assets: a) long-lived working animals; b) long-lived farm plants and c) urban landscaping. All three categories fit the SNA's criteria laid out in Sections 10.88-10.96. However, BEA does not currently capitalize any of them. This paper recalculates the NIPA's if all three categories are treated as capital assets.

To review, my paper found three important results:

4) Nominal investment in cultivated farm assets has grown slower than overall GDP. Therefore, nominal GDP growth falls 0.007% per year if cultivated farm assets are capitalized. In contrast, cultivated landscaping assets have roughly tracked overall GDP. When landscaping is capitalized, nominal GDP growth is almost unchanged.
5) Investment prices for cultivated assets have roughly tracked overall GDP prices. Accordingly, average inflation rates do not change much when cultivated assets are capitalized.
6) Measured TFP growth in agriculture falls from 1.31% to 1.26% when cultivated farm assets are included in capital stock. But agriculture still has very rapid TFP growth even after revision.

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Figure 1: Livestock Investment Relative to GDP

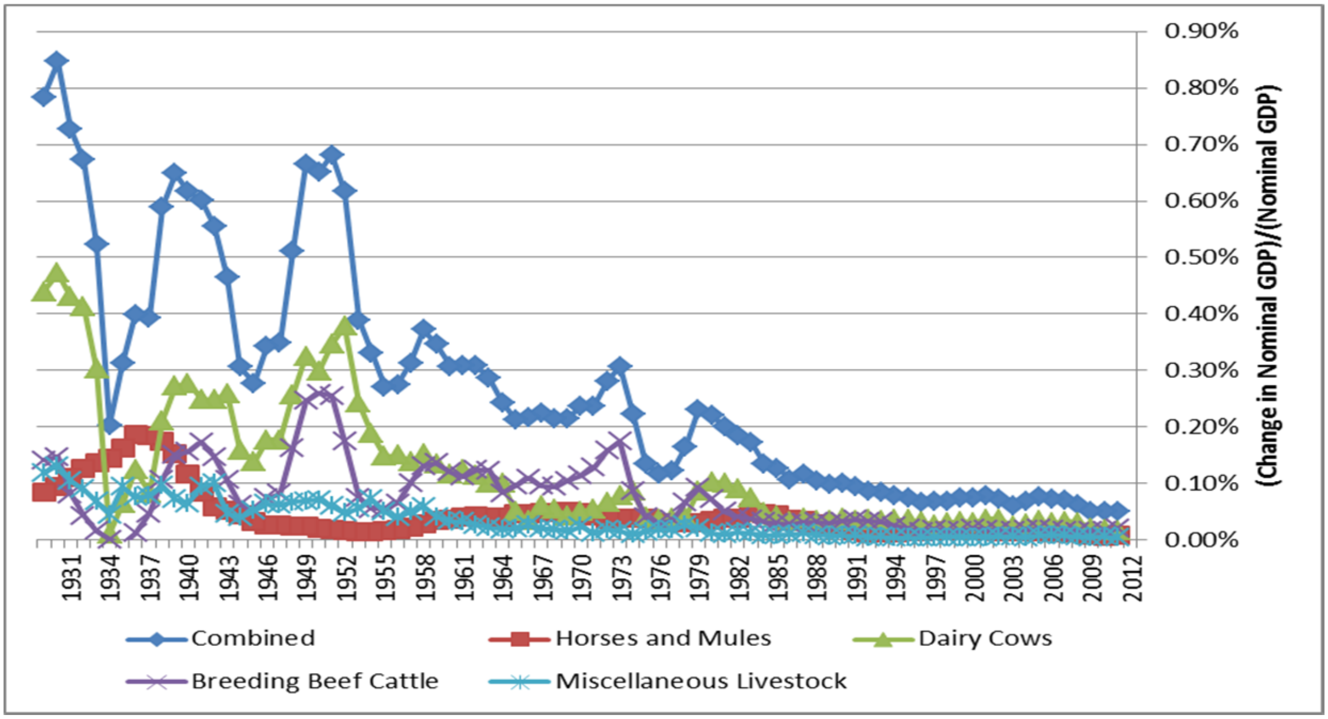

Figure 2: Changes to Farm Output from Capitalizing Animals

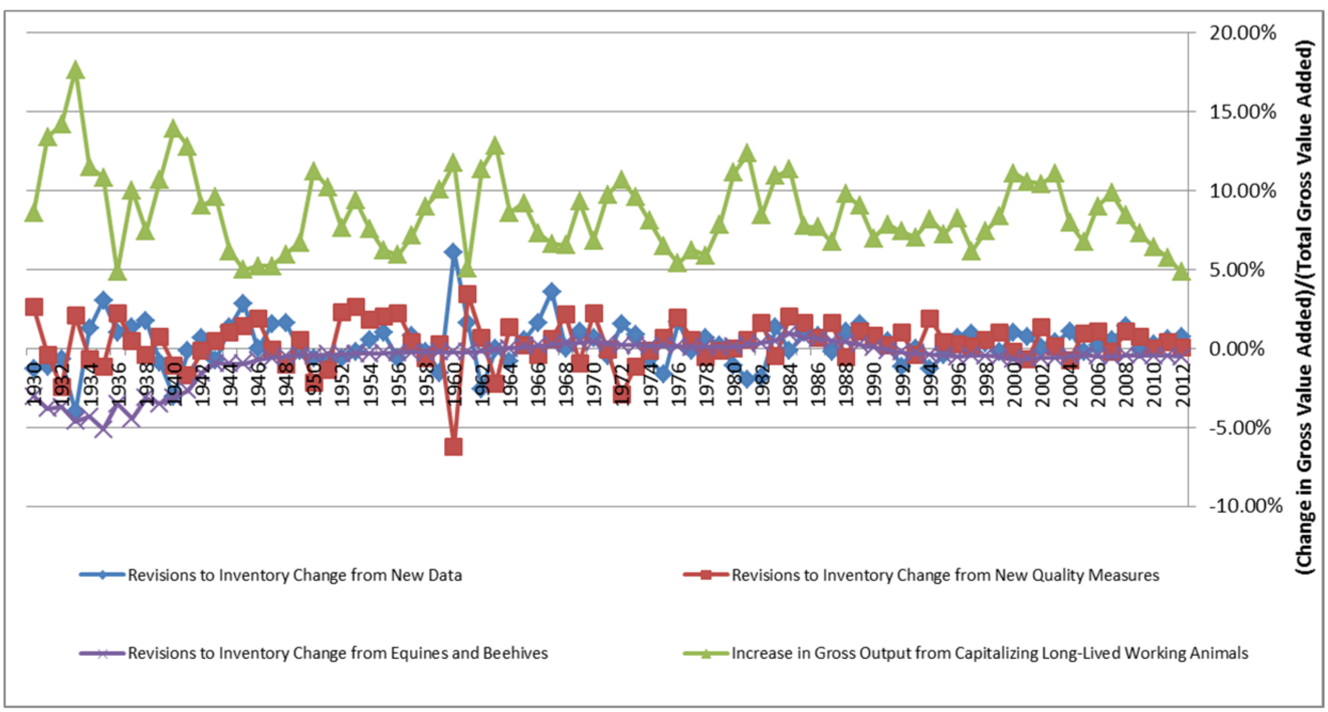

Figure 3: Long-Lived Farm Plant Investment Relative to GDP

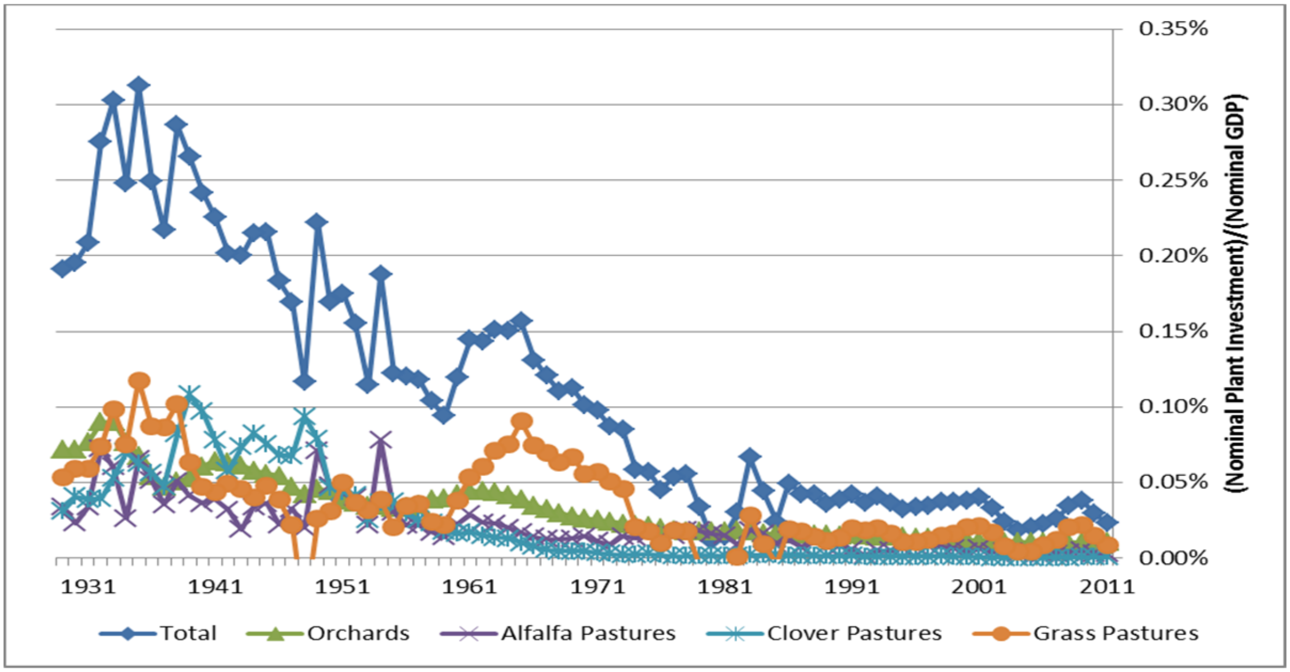

Figure 4: Price Indexes for Long-Lived Working Animals

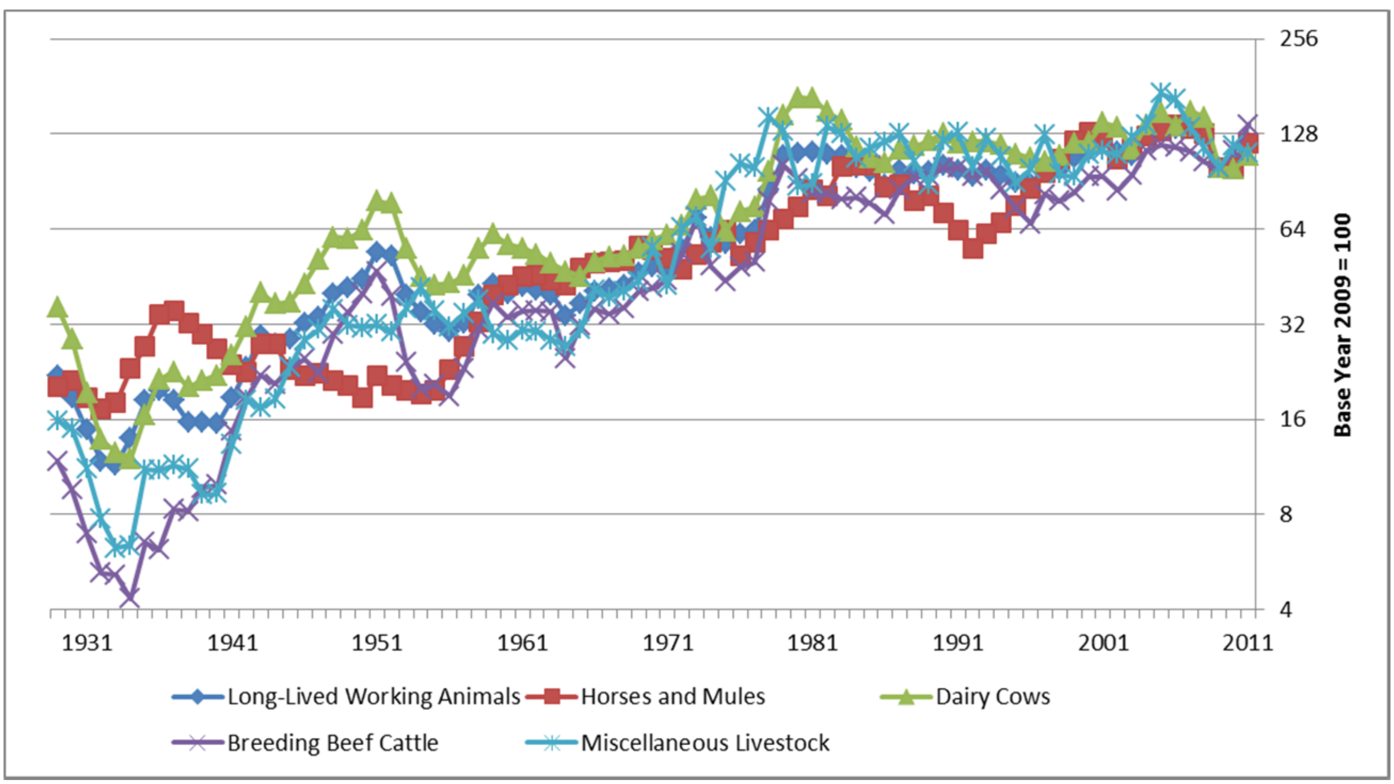

Figure 5: Price Indexes for Long-Lived Farm Plants

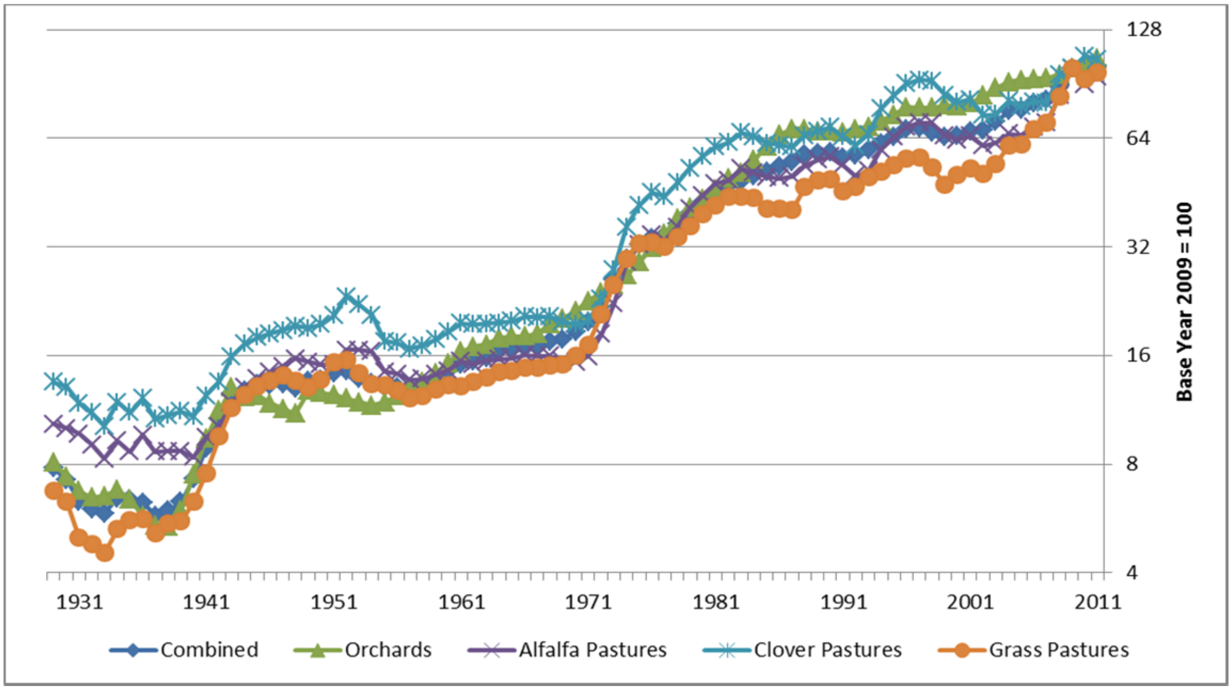

Figure 6: Livestock Values by Age

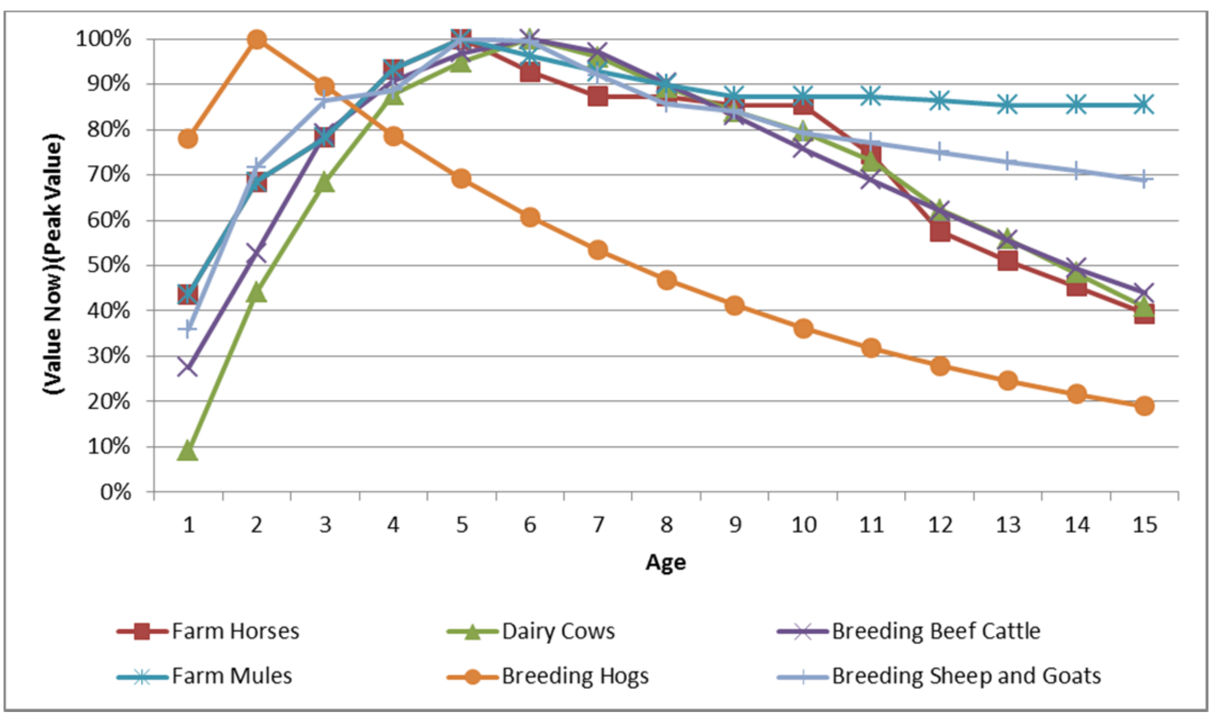

Figure 7: Plant Values by Age

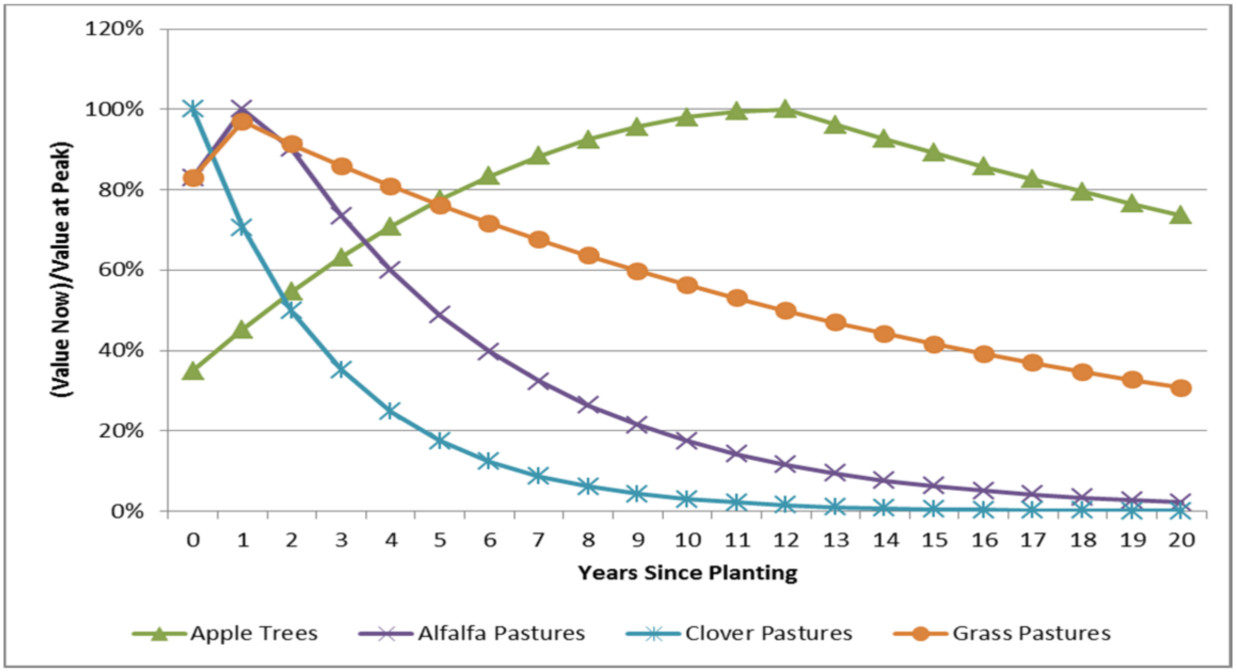

Figure 8: Capital Stock of Long-Lived Working Animals

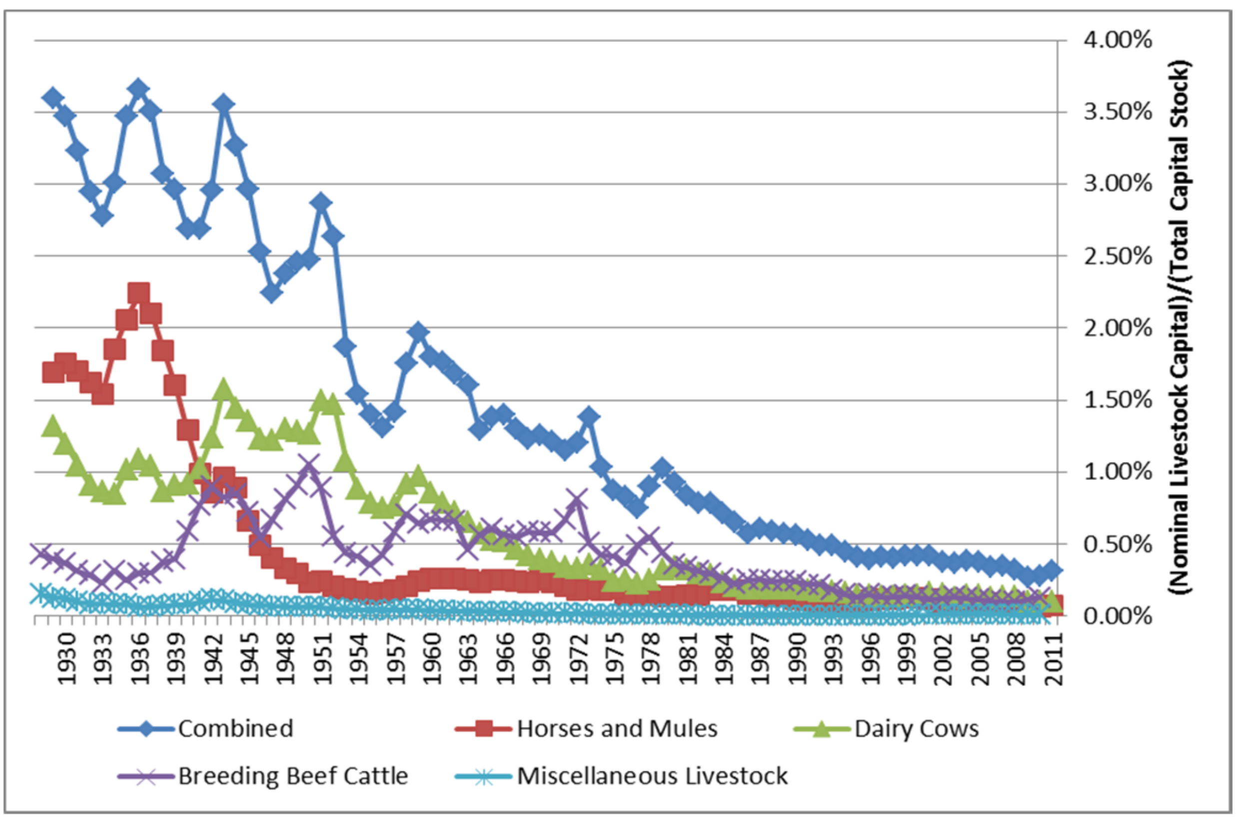

Figure 9: Capital Stock of Long-Lived Farm Plants

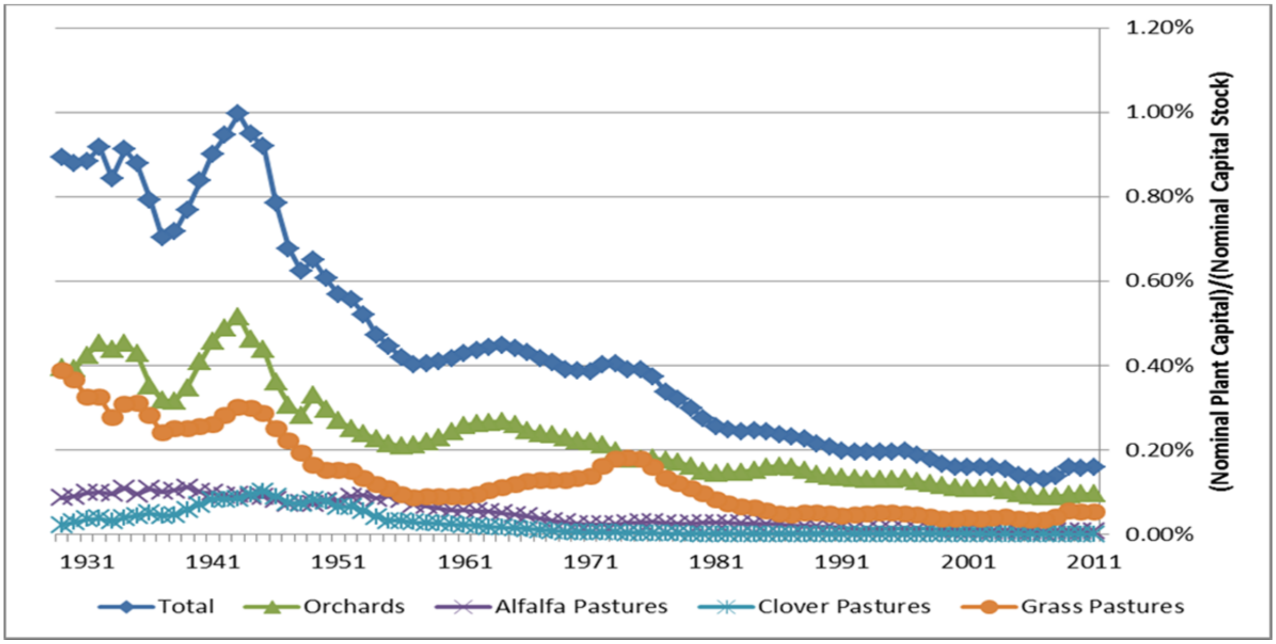

Figure 10: Inventories of Animals Raised for Meat

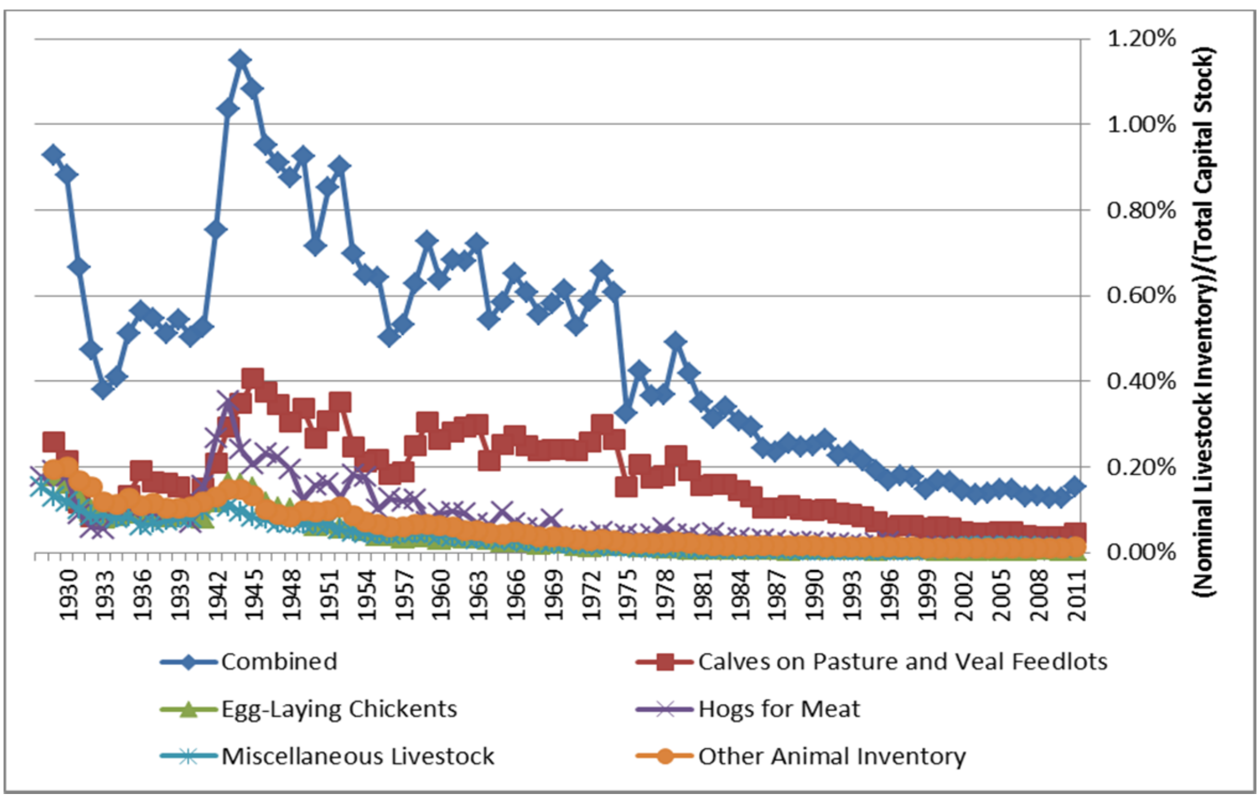

Figure 11: **Changes in Measured TFP from Cultivated Farm Assets, Smoothed**

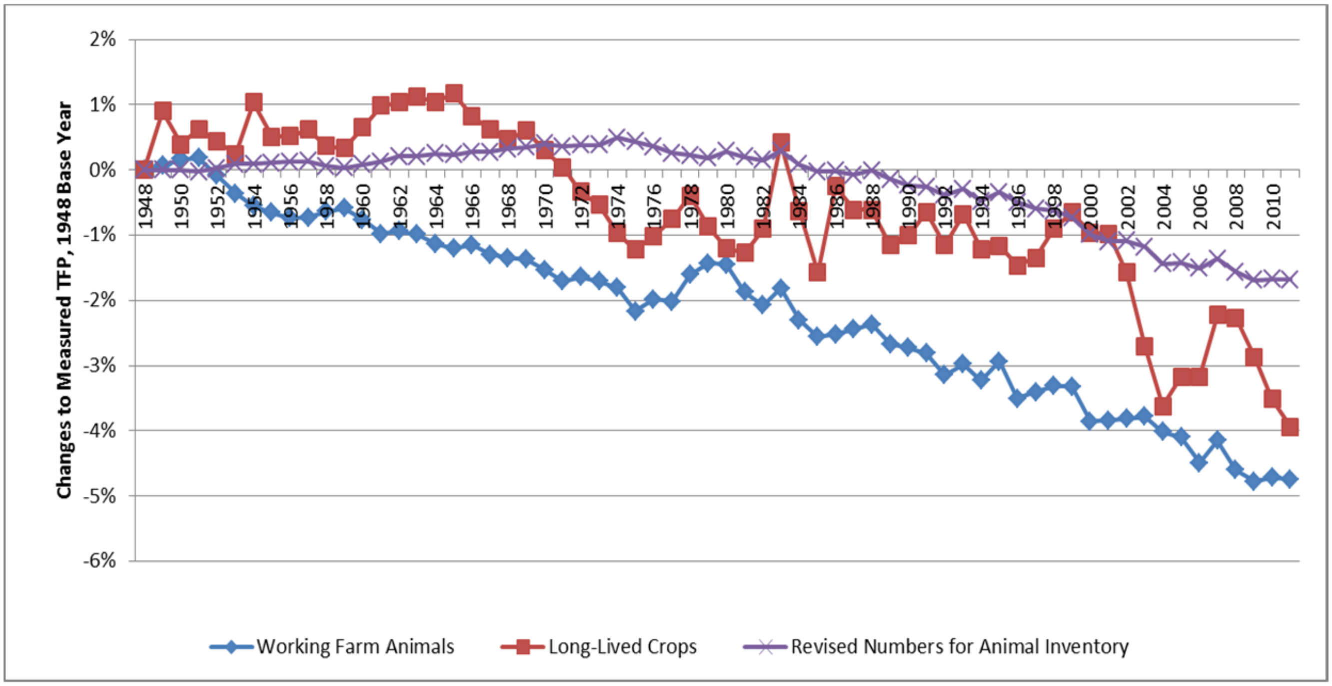

Figure 12: Landscaping Investment Relative to GDP

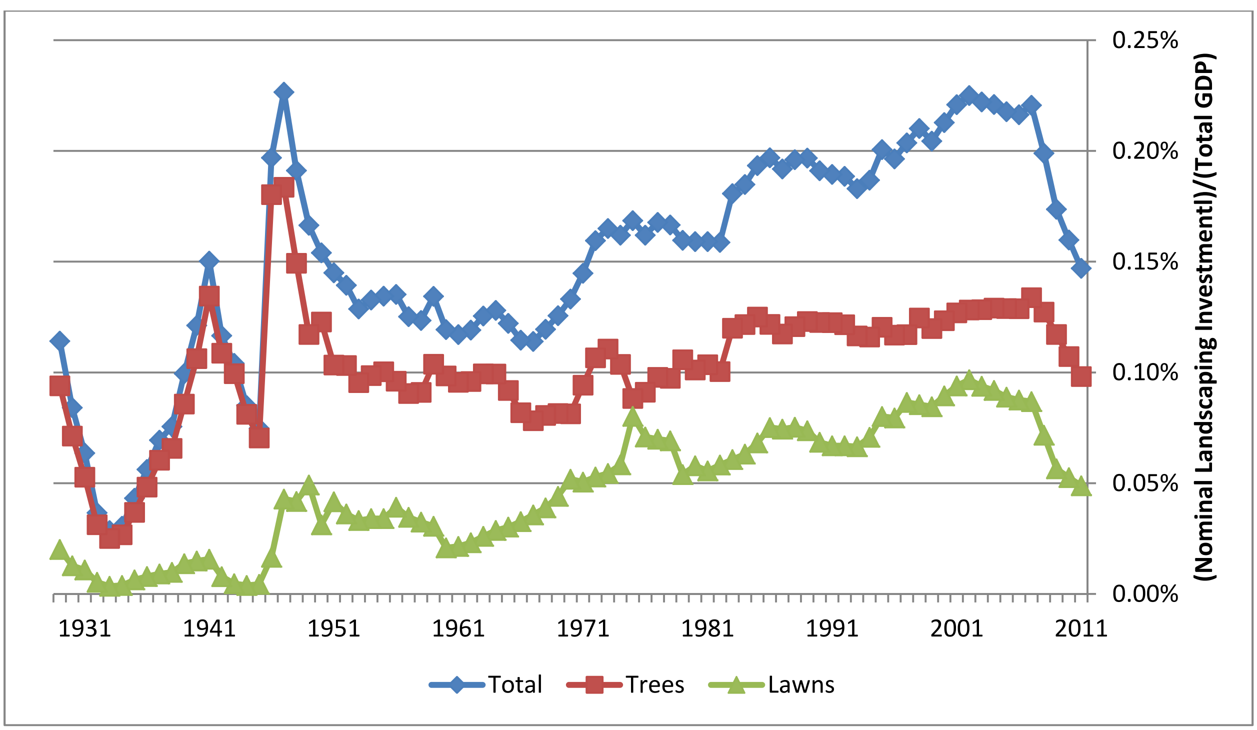

Figure 13: Prices for Landscaping Investment, 1929-2010

Figure 14: Capital Stock of Landscaping, Relative to Overall Capital