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Pastures and Cash Crops: Biomass Flows in the Socio-metabolic Transition of Twentieth-Century Colombian Agriculture

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1. Summary

This supplementary document aims to introduce the whole data used in the elaboration of the article. In the second section, we describe the sources and procedures applied to figure missing values for crop production and harvested area. Additionally, we provide details for the most important crops: maize, sugarcane, and coffee. In the third section, we present the scientific literature to estimate the harvest index, root-shoot ratio, weeds in traditional, low-input and conventional agricultural systems, and NPP for pastures and tropical forest. The fourth section is devoted to forest and pasture covers; we show the data on pasture, cattle and cattle density employed to estimate pastureland and discuss the available data for permanent pastures, meadows and shrubland. Regarding forest, the annual rates of change in clearing are presented. The fifth section describes the methodological procedure to estimate the average weight and the nutritional requirements of the livestock, including a sensitivity analysis of the animal feed requirements and the biomass extracted. Finally, we show the series of NPP, extraction and uses resulting from our research.

The dataset is part of a broader project on the physical analysis of Colombian agriculture in the long-run, aimed to appraise the evolution the sustainability, the energetic efficiency and socio-ecological impact of the agricultural transition during the twentieth century in the country. The primary goal of the project is to place the experience of a peripheral country into the socio-metabolic transition of western agriculture. This research is funded by the projects "Sustainable Farm Systems: Long-Term Socio-Ecological Metabolism in Western Agriculture" (Canadian Social Sciences and Humanities Research Council Partnership Grant 895-2011-1020), and "Sustainable Farm Systems and Transitions in Agricultural Metabolism" (Spanish Ministry of Science grant HAR2012-38920-C02-02) which has also funded the cost of this publication in Open Access.

2. Crops Production and Crop Area Missing Values

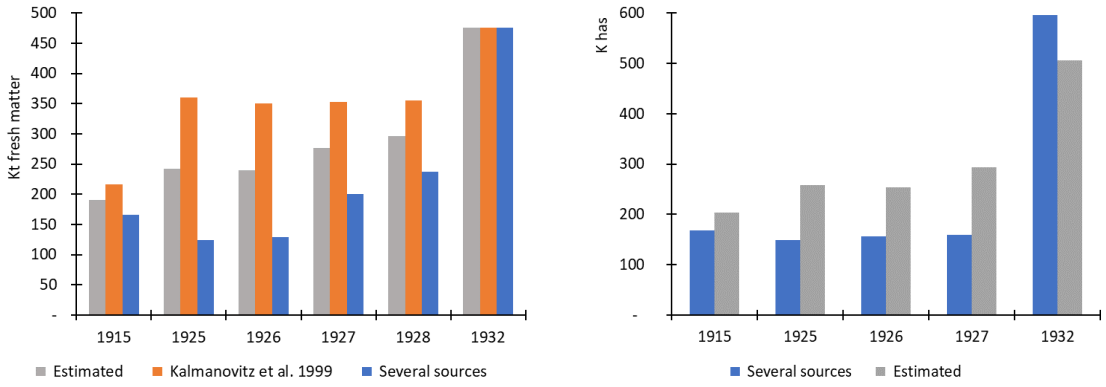
Before 1961 there is information at the national level, but not all years are available. Kalmanovitz et al. [1] provide annual production series for twelve crops, namely: maize, wheat, barley, rice, potatoes, beans, tobacco, sugar cane, cocoa, banana, and coffee. We contrast these series with data on production and area from other national sources for 1915, 1925, 1928–1930, 1932–1946, 1948–1950, with yields from other countries in the region (see section 2.2 in the text) and introduce some modifications accordingly. Moreover, we add information for cassava, coconuts, agave, cotton, fifteen vegetables, and one aggregate category for fruits other than banana and plantain. Regarding the area in 1915, we adjust the data from the Yearbook [2] according to the production data from Kalmanovitz et al. [1]. Missing years, both in production and area, were estimated employing linear interpolation or assuming steady yields. In the case of vegetables, the figures follow from the per capita production of 1961 for each crop. As for fruits, we have used total fruit supply from FAO in 1935-39 and 1946 [3], except for banana and plantain, to obtain per capita supply. The ratio and the population series [4] were used by periods to figure the fruit production. We describe the cases of

maize, sugar cane, and coffee below, as they are the most relevant crops concerning their physical and economic weight.

2.1. Maize

In the case of maize, the data of Kalmanovitz et al. [1] exceeds by a factor of two the production of the Yearbook in 1915 and Wylie, K. H.'s [5] estimates for 1925–1928, but the difference with the Yearbooks disappears after the 1930s (Figure S1 (a)). When we cross production data from Kalmanovitz et al. [1] with the available for the area (Figure S1 (b)), the difference entails yields higher than 1500 kg/h and even 2000 kg/h (Figure S2 (a)). By contrast, the yields obtained with the data from Wylie, K. H. [5] are consistent with the yields in 1932–1940 (800-1000 kg/h) and with those of countries like Ecuador (1280 kg/h between 1938–1942) [6], Cuba (916 kg/h in 1945) [7], or Venezuela (1000 kg/h in 1949) [8].

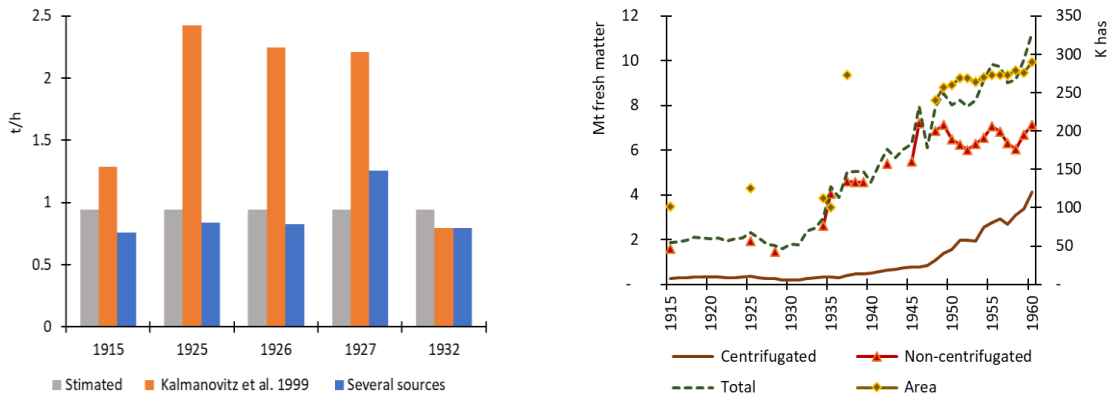
These differences could derive either from the occultation of the harvested area or the overestimation of production in the series by Kalmanovitz et al. [1], but we are unable to identify which one of them is behind the issue. Therefore, we estimate production as the average between the information in Kalmanovitz et al. [1] and the information from the other sources [2,5,9]. Regarding the area, the missing values were obtained by assuming that average yields in 1915, 1925–1927, and 1932 (941 kg/h) remained constant during the period 1915–1932.



(**a**) (**b**)

Figure S1. (**a**) Maize production in thousands of tonnes (Kt) of fresh matter from our estimation, Kalmanovitz et al. [1], and other sources [2,5,9]. (**b**) The area under maize in thousands of hectares (Khas) from several sources [2,5,9] and our estimation for 1915, 1925–1928, and 1932.

We did not use the series of Kalmanovitz et al. [1] or the area data from the other sources without adjustment since it entailed assuming an incredible rise in yields, a significant recovery of the area harvested after the food crisis in 1927, and a negation of the reduction in the area under basic grains. Instead of that, we have made a conservative estimation considering the limitations of yields during the period and allowing for the expansion of commercial crops (like coffee) over staple crops described by the historiography of the country [9–11].



(**a**) (**b**)

Figure S2. (**a**) Yields of maize in tonnes per hectare in fresh matter from Kalmanovitz et al. [1] and several sources [2,5,9] in 1915, 1925–1927, and 1932. (**b**) Centrifuged, non-centrifuged, and total sugarcane in millions of tonnes of fresh matter (left axis) and the area under sugarcane (right axis) in thousands of hectares (Khas) during 1915–1960.

2.2. Sugarcane

The data on sugar cane before 1961 is usually the amount of centrifuged sugar produced (Figure S2 (b)). non-centrifugated sugar and molasses, very relevant during the first half of the twentieth century, are not taken into account in the studies. We standardize the values before 1961 with the information in FAOSTAT. The yield of centrifuged, non-centrifuged sugar and molasses in the 1940s ranged between 10–11% of cut sugarcane [12] (p. 85), so we apply 0.1 to the data in Kalmanovitz et al. [1] and to the whole sugarcane production in several sources for 1915, 1925, 1928, 1934–1935, 1937–1939, 1942, 1945–1946, 1948–1950 [2,5,9,12–17]. For the years in between, we use the value of the ratio of centrifuged over non-centrifuged sugarcane. This ratio moved from 0.18 in 1915 to 0.58 in 1960, but during 1915-1950 the amount of centrifugated sugar remains almost constant (Figure S2 (b)). The average for 1915-1950 during the 1960s is 0.14 (sd. 0.05) Regarding the area, the missing values were estimated by linear interpolation. The values for 1934-35 were rejected as yields were closer to the mid-1960 than 1925 or 1937. Finally, the estimated average yield between 1941–1945 is 23 tonnes per hectare; very close to the yield of 27 tonnes per hectare in Cuba in 1945.

2.3. Coffee

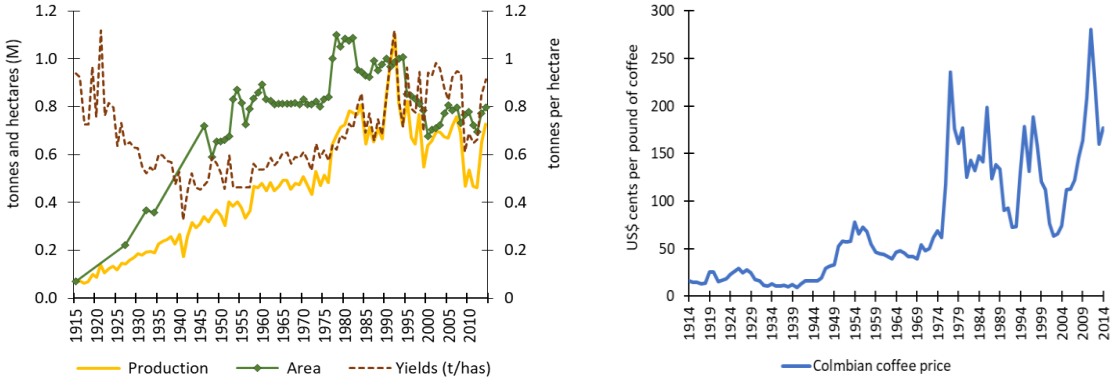
Data for coffee production between 1915 and 1947 is from GRECO [18] These series shows the effect of the Great Depression and WWII better than Kalmanovitz et al. [1]. We used the data in Kalmanovitz et al. [1] for 1948–1950, as it is consistent with figures in Atkinson [13]. The latter was also used between 1950 and 1960. After 1960 the information comes from FAOSTAT, as usual [19]. Regarding the area in the 1915 Yearbook, there is no information for Caldas. The area under coffee in this source is 46,295 has. However, Caldas was the primary producer with a share of 30% of the total coffee production in the country. Due to its relevance, we estimated this area by applying the average yield of the other departments (830 kg/h). This leads to an area of 25,370 has, so the total national area under coffee in 1915 is 71,665 has (see table S1). There is information on area for 1925/27 [9,14], 1932/34 [15,16], 1946 [12], and 1948–1960 [13], and FAOSTAT as of 1961 [19]. The years in between were figured by linear interpolation.

Table S1. Coffee area and production in Colombia by departments 1915.

Department	Area (has)	Production (kg)	Yields (kg/has)
Antioquia	2416	1,777,988	736
Atlántico			
Bolivar	151	85,075	563
Boyacá	30	18,742	625
Caldas	25,370 [1]	21,057,152	830[1]
Cundinamarca	15,517	20,060,475	1293
Cauca	1781	760,660	427
Huila	2175	821,874	378
Magdalena			
Nariño	443	635,120	1434
Santander N.	10,515	13,476,400	1282
Santander	4163	1,433,700	344
Tolima	3500	3,677,670	1051
Valle	5604	5,604,000	1000
Total	71,665	69,408,856	

[1] The yield is the average yield of the other departments were used to calculate the area. Source: 1915 Yearbook and our calculation.

Regarding the yields, we observe a decreasing trend during the first half of the century from 930 kg/has in 1915 to 450 kg/has on average during IIWW (Figure S3 (a)). This is read by Cárdenas et al. [20] as a weakening of the coffee economy that began after the Great Depression. They argue that after 1945 prices grew (Figure S3 (b)), but the area and the production did not. Plantations deteriorated, and the productivity per hectare fell to 1% [20]. However, our data on exportations and area does not fit well with this story.



(**a**) (**b**)

Figure S3. (**a**) Coffee production in millions of tonnes and its area in millions of hectares (left axis). Coffee yields in tonnes per hectare (right axis). (**b**) Colombian coffee prices in US$ cents per pound of Excelso coffee (453.6 gr.). Sources: for the coffee area and production see the text. Excelso coffee prices are from the Federación de Cafeteros de Colombia [21].

Based on the series of GRECO, between 1915 and 1955 the production and the area under coffee, in physical terms, rose on average at 6% annually. Production increased four-fold and the area ten-fold. Coffee production grew from 67 Mt to 377. The area increased from 71 Khas in 1915 to 360 Khas in 1932/34 and to more than 800 Khas in 1955. After 1955 the expansion in production and area slowed down until the 1970s when the coffee production and the international prices rose again (Figure S3 (b)).

Our interpretation of the decline in yields is related to the expansion of the agrarian frontier, instead of the loss of dynamism in coffee production. The land ploughed for coffee expanded at 5%

annually until 1946, but the population growth in the coffee zone was slower. We gathered data for the population in Antioquia and Caldas for 1918, 1928, 1938, and 1951 to test this [22–25]. The average rate of growth of the population during these years was 2.5%. In the case of the rural population, the average growth rate was 1.6%, but only data for 1928, 1938, and 1951 is available. If we look at the evolution in Caldas, the most dynamic zone, population growth (3.1%) remained lower than the area expansion. The greater dynamism of the frontier expansion over the available labor could explain the decrease of the yields during the first half of the century. After 1955 the production grew slowly, while the area stabilized. This is partly related to advances in intensification during the 1960s. However, the increase in yields took off with the rise of international prices during the 1970s (Figure S3). The spread of new technologies (i.e., new species, management, and fertilizers) allowed to reduce the land devoted to cultivating coffee.

2. Sources for Conversion Factors

Table S2. Literature review for factors of harvest index, root-shoot ratio, weeds in traditional, low-input and conventional agricultural systems, and NPP for pastures and tropical forest.

Harvest index and root-shoot ratio	**Weeds**			**NPP**	
	Traditional system	**Low-input system**	**Conventional system**	**Pastures**	**Forest**
Guzmán et al. [26]	Begna et al. [27]	Bradshaw & Lanini [28]	Begna et al. [27]	Borda & Ramirez [29]	Álvarez-Sánchez [30]
Funes et al. [31]	Bradshaw & Lanini [28]	Begna et al. [27]	Bradshaw & Lanini [28]	Moreno & Padilla [32]	Gómez & Gallopin [33]
Kyle et al. [34]	Guzmán et al. [26]	Guzmán et al. [26]	Chauhan et al. [35]	Padilla [36]	Raich et al. [37]
Madden et al. [38]	Khanthavong et al. [39]	Khanthavong et al. [39]	Cheema et al. [40]		Scurlock and Olson [41]
Montero [42]	Liebman et al. [43]	Liebman & Davis [43]	Cierjacks et al. [44]		
Robinson et. al. [45]	Marambe & Sangakara [46]	Liebman et al. [47]	Guzmán et al. [26]		
Sethuraj [48]	Mohler & Liebman [49]	Papamichail et al. [50]	Khanthavong et al. [39]		
	Papamichail et al. [50]	Ryan et al. [51]	Liebman & Davis [43]		
	Ryan et al. [51]	Tixier et al. [52]	Liebman et al. [47]		
	Tixier et al. [52]	Wilson et al. [53]	Mohler & Liebman [49]		
	Wilson et al. [53]		Ryan et al. [51]		
			Tixier et al. [52]		
			Zafar et al. [54]		

3. Crop Categories from FAO and Our Aggregations

Table S3. Crop categories and aggregations

FAO categories	Aggregation 1	Aggregation 2
Barley	Barley	Cereals
Buckwheat	Cereals, nes	Cereals
Canary seed	Cereals, nes	Cereals
Cereals (Rice Milled Eqv)	Cereals, nes	Cereals
Cereals, nes	Cereals, nes	Cereals
Cereals,Total	Cereals, nes	Cereals
Coarse Grain, Total	Cereals, nes	Cereals
Fonio	Cereals, nes	Cereals
Grain, mixed	Cereals, nes	Cereals
Maize	Maize	Cereals
Millet	Cereals, nes	Cereals
Oats	Cereals, nes	Cereals
Quinoa	Cereals, nes	Cereals
Rice, paddy	Rice, paddy	Cereals
Rye	Cereals, nes	Cereals
Sorghum	Cereals, nes	Cereals
Triticale	Cereals, nes	Cereals
Wheat	Wheat	Cereals
Agave fibres nes	Agave fibres nes	Fibre Crops
Bastfibres, other	Fibre crops nes	Fibre Crops
Cotton lint	Fibre crops nes	Fibre Crops
Fibre crops nes	Fibre crops nes	Fibre Crops
Fibre Crops Primary	Fibre crops nes	Fibre Crops
Flax fibre and tow	Fibre crops nes	Fibre Crops
Hemp tow waste	Fibre crops nes	Fibre Crops
Jute	Fibre crops nes	Fibre Crops
Kapok fibre	Fibre crops nes	Fibre Crops
Manila fibre (abaca)	Fibre crops nes	Fibre Crops
Ramie	Fibre crops nes	Fibre Crops
Rubber, natural	Fibre crops nes	Fibre Crops
Sisal	Fibre crops nes	Fibre Crops
Almonds, with shell	Fruits, other	Fruits
Apples	Fruits, other	Fruits
Apricots	Fruits, other	Fruits
Avocados	Fruits, other	Fruits
Bananas	Bananas	Fruits
Berries nes	Fruits, other	Fruits
Blueberries	Fruits, other	Fruits
Brazil nuts, with shell	Fruits, other	Fruits
Carobs	Fruits, other	Fruits
Cashew nuts, with shell	Fruits, other	Fruits
Cashewapple	Fruits, other	Fruits

Cherries	Fruits, other	Fruits
Cherries, sour	Fruits, other	Fruits
Chestnut	Fruits, other	Fruits
Citrus Fruit,Total	Fruits, other	Fruits
Cranberries	Fruits, other	Fruits
Currants	Fruits, other	Fruits
Dates	Fruits, other	Fruits
Figs	Fruits, other	Fruits
Fruit Primary	Fruits, other	Fruits
Fruit, citrus nes	Fruits, other	Fruits
Fruit, fresh nes	Fruits, other	Fruits
Fruit, pome nes	Fruits, other	Fruits
Fruit, stone nes	Fruits, other	Fruits
Fruit, tropical fresh nes	Fruits, other	Fruits
Fruits, total	Fruits, other	Fruits
Gooseberries	Fruits, other	Fruits
Grapefruit (inc. pomelos)	Fruits, other	Fruits
Grapes	Fruits, other	Fruits
Hazelnuts, with shell	Fruits, other	Fruits
Kapok fruit	Fruits, other	Fruits
Kiwi fruit	Fruits, other	Fruits
Kola nuts	Fruits, other	Fruits
Lemons and limes	Fruits, other	Fruits
Mangoes, mangosteens, guavas	Fruits, other	Fruits
Nuts, nes	Fruits, other	Fruits
Oranges	Fruits, other	Fruits
Papayas	Fruits, other	Fruits
Peaches and nectarines	Fruits, other	Fruits
Pears	Fruits, other	Fruits
Persimmons	Fruits, other	Fruits
Pineapples	Fruits, other	Fruits
Pistachios	Fruits, other	Fruits
Plantains and others	Plantains and others	Fruits
Plums and sloes	Fruits, other	Fruits
Quinces	Fruits, other	Fruits
Raspberries	Fruits, other	Fruits
Strawberries	Fruits, other	Fruits
Tangerines, mandarins, clementines, satsumas	Fruits, other	Fruits
Treenuts,Total	Fruits, other	Fruits
Walnuts, with shell	Fruits, other	Fruits
Castor oil seed	Oilcrops, Other	Oil crops
Coconuts	Coconuts	Oil crops
Cottonseed	Oilcrops, Other	Oil crops
Groundnuts, with shell	Oilcrops, Other	Oil crops
Hempseed	Oilcrops, Other	Oil crops
Jojoba seed	Oilcrops, Other	Oil crops

Kapokseed in shell	Oilcrops, Other	Oil crops
Karite nuts (sheanuts)	Oilcrops, Other	Oil crops
Linseed	Oilcrops, Other	Oil crops
Melonseed	Oilcrops, Other	Oil crops
Mustard seed	Oilcrops, Other	Oil crops
Oil palm fruit	Oilcrops, Other	Oil crops
Oil, palm	Oil, palm	Oil crops
Oilcrops, Cake Equivalent	Oilcrops, Other	Oil crops
Oilcrops, Oil Equivalent	Oilcrops, Other	Oil crops
Oilseeds nes	Oilcrops, Other	Oil crops
Olives	Oilcrops, Other	Oil crops
Palm kernels	Oilcrops, Other	Oil crops
Poppy seed	Oilcrops, Other	Oil crops
Rapeseed	Oilcrops, Other	Oil crops
Safflower seed	Oilcrops, Other	Oil crops
Seed cotton	Seed cotton	Oil crops
Sesame seed	Oilcrops, Other	Oil crops
Sunflower seed	Oilcrops, Other	Oil crops
Tallowtree seed	Oilcrops, Other	Oil crops
Tung nuts	Oilcrops, Other	Oil crops
Areca nuts	Others	Other plant products
Coir	Others	Other plant products
Gums, natural	Others	Other plant products
Hops	Others	Other plant products
Máte	Others	Other plant products
Others	Others	Other plant products
Pyrethrum, dried	Others	Other plant products
Sugar crops, nes	Others	Other plant products
Tea	Others	Other plant products
Bambara beans	Pulses, nes	Pulses
Beans, dry	Beans, dry	Pulses
Broad beans, horse beans, dry	Pulses, nes	Pulses
Chick peas	Pulses, nes	Pulses
Cow peas, dry	Pulses, nes	Pulses
Lentils	Pulses, nes	Pulses
Lupins	Pulses, nes	Pulses
Peas, dry	Pulses, nes	Pulses
Pigeon peas	Pulses, nes	Pulses
Pulses, nes	Pulses, nes	Pulses
Pulses,Total	Pulses, nes	Pulses
Soybeans	Pulses, nes	Pulses
Vetches	Pulses, nes	Pulses
Cassava	Cassava	Roots and Tubers
Cassava leaves	Cassava	Roots and Tubers
Potatoes	Potatoes	Roots and Tubers
Roots and tubers, nes	Roots and tubers, nes	Roots and Tubers
Roots and Tubers,Total	Roots and tubers, nes	Roots and Tubers

Sweet potatoes	Roots and tubers, nes	Roots and Tubers
Taro (cocoyam)	Roots and tubers, nes	Roots and Tubers
Yams	Roots and tubers, nes	Roots and Tubers
Yams	Roots and tubers, nes	Roots and Tubers
Yautia (cocoyam)	Roots and tubers, nes	Roots and Tubers
Anise, badian, fennel, coriander	Stimulants nes	Stimulants
Cinnamon (canella)	Stimulants nes	Stimulants
Cloves	Stimulants nes	Stimulants
Cocoa, beans	Cocoa, beans	Stimulants
Coffee, green	Coffee, green	Stimulants
Ginger	Stimulants nes	Stimulants
Nutmeg, mace and cardamoms	Stimulants nes	Stimulants
Pepper (piper spp.)	Stimulants nes	Stimulants
Peppermint	Stimulants nes	Stimulants
Spices, nes	Stimulants nes	Stimulants
Tobacco, unmanufactured	Tobacco, unmanufactured	Stimulants
Vanilla	Stimulants nes	Stimulants
Sugar beet	Sugar, Other	Sugar & Sweeteners
Sugar cane	Sugar cane	Sugar & Sweeteners
Artichokes	Vegetables, total	Vegetables
Asparagus	Vegetables, total	Vegetables
Beans, green	Vegetables, total	Vegetables
Cabbages and other brassicas	Vegetables, total	Vegetables
Carrots and turnips	Vegetables, total	Vegetables
Cauliflowers and broccoli	Vegetables, total	Vegetables
Chicory roots	Vegetables, total	Vegetables
Chillies and peppers, dry	Vegetables, total	Vegetables
Chillies and peppers, green	Vegetables, total	Vegetables
Cucumbers and gherkins	Vegetables, total	Vegetables
Eggplants (aubergines)	Vegetables, total	Vegetables
Garlic	Vegetables, total	Vegetables
Leeks, other alliaceous vegetables	Vegetables, total	Vegetables
Lettuce and chicory	Vegetables, total	Vegetables
Maize, green	Vegetables, total	Vegetables
Melons, other (inc. cantaloupes)	Vegetables, total	Vegetables
Mushrooms and truffles	Vegetables, total	Vegetables
Okra	Vegetables, total	Vegetables
Onions, dry	Vegetables, total	Vegetables
Onions, shallots, green	Vegetables, total	Vegetables
Peas, green	Vegetables, total	Vegetables
Pumpkins, squash and gourds	Vegetables, total	Vegetables
Spinach	Vegetables, total	Vegetables
String beans	Vegetables, total	Vegetables
Tomatoes	Vegetables, total	Vegetables
Vegetables Primary	Vegetables, total	Vegetables
Vegetables, fresh nes	Vegetables, total	Vegetables
Vegetables, leguminous nes	Vegetables, total	Vegetables

Vegetables, total	Vegetables, total	Vegetables
Watermelons	Vegetables, total	Vegetables

Source: FAOSTAT and our aggregations

4. Forest and Pasture Covers

4.1. Forest

Table S4. Annual rates of change of the forest clearing by types of forest.

Forest type	1915–1920	1920–1970	1970–2000 [1]
Dry forest	−0.43	−0.75	0.16
Andean forest	−0.21	−0.41	−1.43
Rainforest	−0.03	−0.03	−0.14
Total forest	−0.08	−0.12	−0.49

[1] We apply the same rate to dry, rain, and Andean forest between 2000 and 2015. Source: Source: Etter et al. [55].

4.2. Pasture

Table S5. Pasture, cattle and cattle density

Years	Pasture	Cattle	Density
1950	13,437,000	10,714,246	0.80
1960	14,605,954	13,310,556	0.91
1970	17,464,571	16,391,916	0.94
1992	23,374,004	20,600,437	0.88
2015	24,094,072	22,527,783	0.93

Source: the series on cattle are from Kalmanovitz et al. (1915–1997) and FAOSTAT (1998-2015). Pasture for 1950 is from Varela [56] and 1960/70 from the national agrarian census [57,58]. As of 1992, there is annual data from UCL–CCI in FAOSTAT [19].

We use data from UCCL-CCI in FAOSTAT for pasture (16 Mhas) and shrubland (7.5 Mhas) during 1992–2015 to estimate the area devoted to pastureland for grassing since it fits well with the data in the 2014 agrarian census, and because the "permanent meadows and pastures" series from FAOSTAT is an aggregate category, which makes difficult the cattle density estimation. We are perhaps underestimating the series between 1961 and 1992 and overestimating it between 1992 and 2015 (Figure S4 (b)), however, the data is not conclusive among the sources.

The FAOSTAT series is almost constant between 1961 and 2015, 35 Mhas and 41 Mhas respectively (Figure S4 (a)). In the land cover map of 2010–2012, the addition of pastures (17.5 Mhas), grassland (14.5 Mhas), shrubland (2.5 Mhas), and secondary vegetation (4 Mhas) raises to 38.5 Mhas. Lastly, natural and seeded pastures in the 2014 census amount to 24.8 Mhas, but if we add shrubs (9.6), it reaches 34.4 Mhas. According to these data, the area under pastures and permanent meadows during 2010–2015 ranges between 34.4 and 41 Mhas, and the area for grassing must range between 17 Mhas (pasture) and 24 Mhas (when we add natural grassland for grassing). Our pastureland series match well with these values, but we cannot say the same for shrublands & other since it is our residue. The highest differences between our aggregate data and the FAOSTAT series reach 5% of the total land area, so, if the FAOSTAT series is right, there is some room to improve.

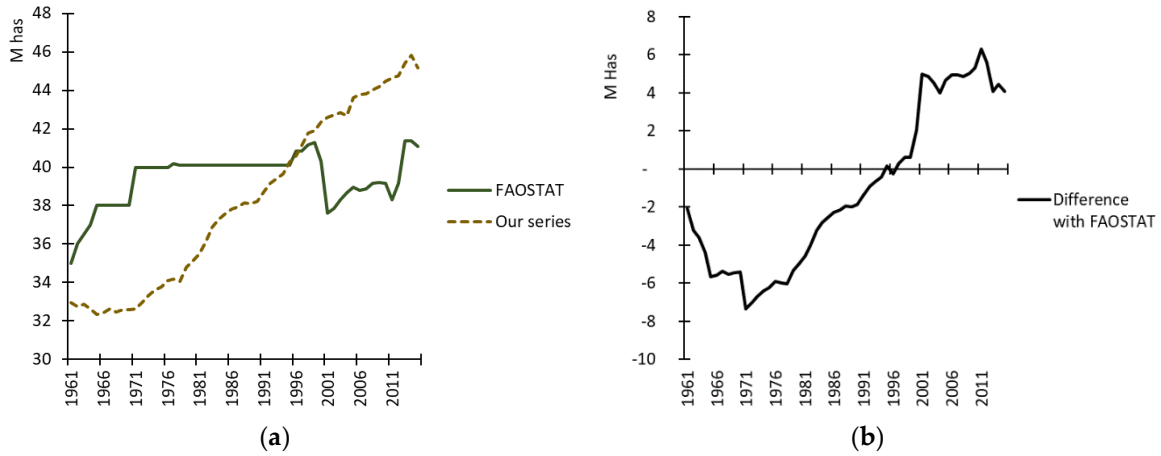


Figure S4. (**a**) Data for pasture and permanent meadows from FAOSTAT and our series of pasture and shrubland & others in millions of hectares and (**b**) The difference between the FAOSTAT series and our series in millions of hectares between 1961–2015.

5. Domestic Extraction of Pasture

5.1. Average Weight of Livestock

The average weight of livestock was estimated tracing the evolution of the most critical animal in pasture extraction: cattle. Additionally, we introduced some historical variation for other species when the data was available. The information on the average weight was compiled from the sources specified in the main text (see section 2.2 in the article). Besides, in the case of cattle, we have adjusted the average weight by accounting the age structure given by Kalmanovitz et al. [1].

Table S6. The evolution of the average weight by species in selected years in kg.

Years	Cattle	Cattle by age	Pigs	Sheep	Goats	Horses [1]	Mules [1]	Donkeys [1]
1916	392.2	330.4				326.0	326.0	172.0
1918	448.0	368.9	70.0	37.0	24.0			
1923	364.9	312.4						
1938	412.2	342.5	81.8					
1942	430.0	352.1						
1945	431.3	349.9						
1950	382.0	316.9	90.0	32.0	26.0			
1965	367.5	300.5						
1969	384.0	311.0						
1980	445.0	342.4						
2010	419.5	324.5	99.4	37.6	30.0	405.7	319.8	319.8
2016	415.9	322.4	108.0	31.8	31.8			

[1] It is the average weight of horses, mules, and donkeys for 1860 and 1999 in Marco et al. [59]. Sources for the other species: see section 2.2 in the article.

5.2. Nutritional Requirements of Livestock

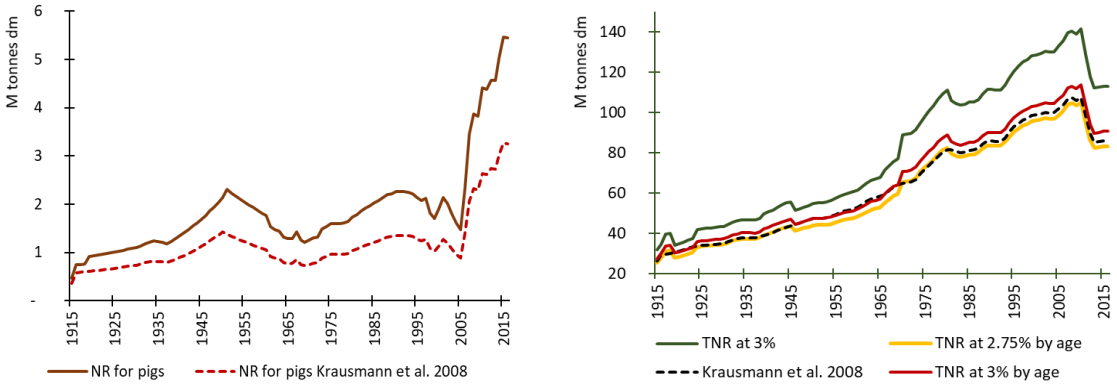
We use animal weight (Table S6) and nutritional requirements to obtain the feed intake (see section 2.1 in the article for sources). We use between 2.5% and 3% of body weight as a yardstick except in the case of pigs since the available information is a diet of corn and soybean [60]. In this case, we estimate a general dry matter equivalent by applying the gross calorific value (GCV) for Maize and legumes used as fodder in Guzmán et al. [26] and the average GCV in Csiro [61] (p. 5) for carbohydrates as cellulose (18.4 Mj/kg). The intake of the pigs as a percentage of the body weight thus obtained ranges between 2.5% and 2.2% for 1916–2016.

Table S7. Livestock feed intake for Colombia in selected years (kg dm per head/day)

Years	Cattle	Cattle by age	Pigs	Sheep	Goat	Horses	Mules	Donkeys
1916	10.8	9.1				8.97	9.78	5.16
1918	12.3	10.1	1.78	1.06	0.63			
1923	10.0	8.6						
1938	11.3	9.4	2.10					
1942	11.8	9.7						
1945	11.9	9.6						
1950	10.5	8.7	2.10	0.92	0.68			
1965	10.1	8.3						
1969	10.6	8.6						
1980	12.2	9.4						
2010	11.5	8.9	2.34	1.08	0.78	11.16	9.59	9.59
2016	11.4	8.9	2.34	0.91	0.83			

5.3. Sensitivity Analysis of Nutritional Requirement of Livestock and Biomass Extraction

The nutritional requirements of the animals were compared with the average feed intake for the Latin American given by Krausmann et al. [62]. This tests confirms the usefulness of our age adjustment for cattle (Figure S5 (b)). For other livestock, we found differences between using our data and using the values from Krausmann et al. [62]. The most relevant case is the difference in the nutritional requirements of pigs (Figure 5 (a)). The gap between the two series increases during the twentieth century despite that the dietary requirement as a percentage of the body weight decreases (see section 5.2). This is due to the exceptional increase in the average weight of pigs, that moved from 70 kg in 1918 to 108 kg in 2016 (Table S7). Moreover, this does not detract from our estimations, since the nutritional requirements of cattle constitute 80% of total needs and that for pigs, although growing since 2006, is less than 8%.

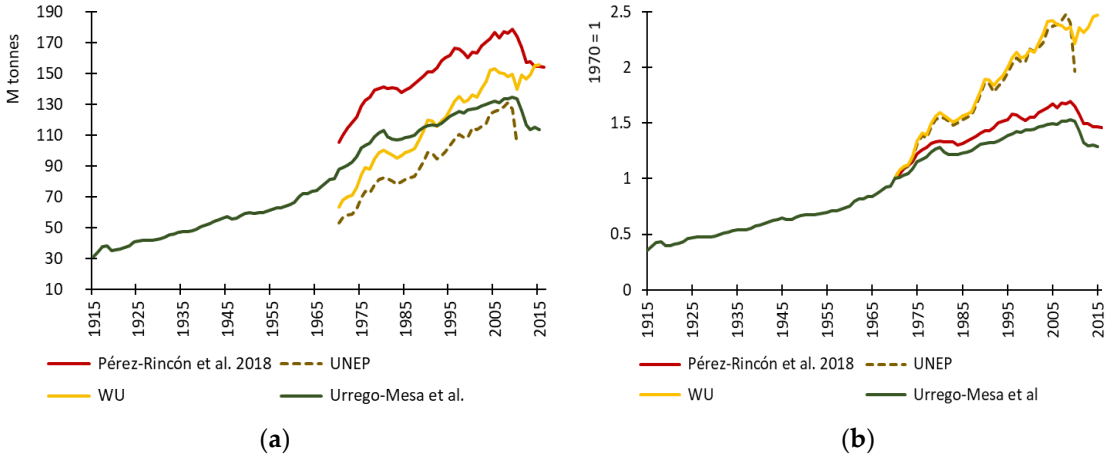


(**a**) (**b**)

Figure S5. (**a**) Nutritional requirements (NR) for pigs. Our estimation and the series with the values from Krausmann et al. [62] (**b**) Total nutritional requirements (TNR) for livestock. Our series (at different percentages of the body weight of cattle and adjusted by age), and the series with the values from Krausmann et al. [62].

There are several series of biomass extraction in Colombia from 1970 until 2015 (Figure 6 (a)), but they are not entirely comparable with ours due to follow the MFA methodology. These series account for pasture in dry matter, while the rest of the biomass remains in fresh matter units (see section 2.1 in the article). The only comparable feature is the intensity of the biomass extraction (Figure 5 (b)). Our series shows lower growth, due to the water content. As we explain in section 3 of

the article, the biomass extracted from cropland has increased more within the cash crops with high water content than within the basic grains. This is the case of fruits, oil crops, and especially sugarcane, in which the water content amounts to more than 25 M tonnes, a fifth of the total dry matter accounted at the end of the period. A point in common among the series is the drop after 2006-08, driven by a shrinking in the cattle population.



(**a**) (**b**)

Figure S6. (**a**) Biomass extraction series in Colombia in millions of tonnes. Our series in dry matter and the others in a mix of dry and fresh matter. (**b**) Index numbers of the biomass extraction series 1970=1.

6. NPP series

Table S8. NPP series in millions of tonnes of dry matter (1915–2015)

Years	Crops [t DM]	Pastures [t DM]	Shrubland & others [t DM]	Dry forest [t DM]	Andean forest [t DM]	Rainforest [t DM]	Other forest [t DM]	Total NPP [t DM]
1915	2.8	57.1	337.2	15.4	434.3	968.7	211.9	2027.5
1916	2.9	58.9	334.2	15.3	433.4	968.4	211.9	2025.1
1917	3.0	60.2	332.1	15.3	432.5	968.1	211.9	2023.2
1918	3.1	61.2	330.6	15.2	431.6	967.8	211.9	2021.6
1919	3.2	62.1	329.2	15.1	430.7	967.6	212.0	2019.9
1920	3.3	62.9	328.0	15.1	429.8	967.3	212.0	2018.3
1921	3.5	64.7	325.2	14.9	428.1	967.0	212.2	2015.6
1922	3.4	66.8	321.9	14.8	426.3	966.7	212.5	2012.4
1923	3.6	68.3	319.7	14.7	424.6	966.4	212.7	2009.9
1924	3.7	69.0	318.8	14.6	422.8	966.1	213.0	2008.0
1925	3.9	69.6	318.2	14.5	421.1	965.8	213.2	2006.3
1926	4.0	69.9	317.9	14.4	419.4	965.5	213.4	2004.7
1927	4.1	70.3	316.6	14.3	417.7	965.2	213.7	2002.0
1928	4.4	70.9	315.1	14.2	416.0	964.9	213.9	1999.4
1929	4.5	71.3	314.6	14.1	414.3	964.7	214.1	1997.5
1930	4.9	71.8	312.1	14.0	412.6	964.4	214.3	1994.1
1931	5.5	72.8	307.1	13.9	410.9	964.1	214.5	1988.8
1932	6.0	74.1	304.2	13.8	409.2	963.8	214.7	1985.8
1933	6.4	75.2	300.7	13.7	407.6	963.5	214.9	1981.9
1934	6.9	75.9	298.8	13.6	405.9	963.2	215.1	1979.4
1935	7.8	76.2	298.4	13.5	404.2	962.9	215.3	1978.4
1936	7.8	76.3	296.9	13.4	402.6	962.6	215.5	1975.1
1937	8.6	76.3	296.6	13.3	400.9	962.3	215.7	1973.8
1938	8.9	76.7	295.9	13.2	399.3	962.1	215.9	1971.8
1939	9.1	77.5	294.7	13.1	397.7	961.8	216.0	1969.9
1940	9.1	78.7	292.7	13.0	396.0	961.5	216.2	1967.2

1941	9.4	80.3	289.8	12.9	394.4	961.2	216.4	1964.4
1942	9.8	82.2	286.2	12.8	392.8	960.9	216.5	1961.2
1943	9.8	83.9	282.8	12.7	391.2	960.6	216.7	1957.6
1944	10.2	85.1	280.1	12.6	389.6	960.3	216.8	1954.8
1945	10.5	86.1	277.9	12.5	388.0	960.0	217.0	1952.0
1946	11.8	87.8	273.4	12.4	386.4	959.7	217.1	1948.8
1947	10.6	89.4	273.5	12.3	384.9	959.5	217.3	1947.5
1948	11.8	90.5	273.5	12.2	383.3	959.2	217.4	1947.9
1949	12.9	91.5	269.7	12.1	381.7	958.9	217.5	1944.5
1950	11.0	92.7	270.6	12.0	380.2	958.6	217.7	1942.7
1951	12.0	101.3	267.8	11.9	378.6	958.3	217.8	1947.7
1952	12.5	101.1	266.4	11.9	377.1	958.0	217.9	1945.0
1953	12.3	101.6	266.7	11.8	375.5	957.7	218.0	1943.6
1954	13.0	102.4	263.7	11.7	374.0	957.4	218.1	1940.4
1955	13.3	104.1	260.0	11.6	372.5	957.2	218.2	1936.9
1956	13.2	106.1	259.6	11.5	370.9	956.9	218.3	1936.6
1957	12.7	107.3	261.2	11.4	369.4	956.6	218.4	1937.1
1958	13.4	107.9	259.4	11.3	367.9	956.3	218.5	1934.7
1959	14.6	108.6	257.0	11.2	366.4	956.0	218.6	1932.4
1960	15.3	110.0	254.3	11.2	364.9	955.7	218.7	1930.1
1961	17.1	112.7	247.8	11.1	363.4	955.4	218.8	1926.3
1962	18.6	115.3	240.5	11.0	362.0	955.2	218.9	1921.3
1963	17.2	117.5	238.3	10.9	360.5	954.9	218.9	1918.2
1964	18.7	118.8	232.4	10.8	359.0	954.6	219.0	1913.3
1965	18.3	120.1	226.3	10.8	357.5	954.3	219.1	1906.2
1966	18.6	121.2	225.2	10.7	356.1	954.0	219.1	1904.9
1967	18.9	123.8	223.1	10.6	354.6	953.7	219.2	1904.0
1968	20.1	127.1	214.8	10.5	353.2	953.4	219.2	1898.3
1969	20.0	130.2	210.7	10.4	351.7	953.2	219.3	1895.5
1970	17.4	131.5	208.4	10.4	350.3	952.9	219.3	1890.1
1971	18.6	140.2	208.5	10.4	345.4	951.5	218.6	1893.2
1972	20.1	140.3	212.7	10.4	340.5	950.2	217.8	1892.1

1973	20.7	142.1	214.3	10.4	335.7	948.9	217.0	1889.1
1974	23.0	147.6	208.8	10.4	331.0	947.5	216.2	1884.6
1975	25.2	152.9	202.3	10.4	326.3	946.2	215.4	1878.7
1976	25.3	157.4	199.1	10.5	321.7	944.9	214.5	1873.4
1977	25.3	162.0	192.0	10.5	317.2	943.6	213.6	1864.1
1978	28.3	167.8	180.4	10.5	312.7	942.3	212.6	1854.5
1979	28.9	172.3	182.7	10.5	308.3	940.9	211.7	1855.3
1980	29.9	175.1	182.6	10.5	303.9	939.6	210.7	1852.3
1981	28.9	175.6	187.0	10.5	299.6	938.3	209.7	1849.7
1982	28.2	172.9	199.6	10.6	295.4	937.0	208.6	1852.3
1983	28.1	171.0	213.6	10.6	291.3	935.7	207.6	1857.9
1984	28.0	172.2	217.5	10.6	287.1	934.4	206.5	1856.4
1985	28.9	173.9	218.7	10.6	283.1	933.1	205.4	1853.7
1986	28.9	174.7	220.7	10.6	279.1	931.8	204.3	1850.0
1987	30.1	176.7	218.7	10.6	275.2	930.5	203.2	1845.0
1988	31.4	182.2	211.6	10.7	271.3	929.2	202.0	1838.3
1989	33.1	186.4	203.9	10.7	267.5	927.9	200.8	1830.3
1990	35.4	187.3	204.1	10.7	263.7	926.6	199.6	1827.4
1991	35.2	187.3	211.1	10.7	260.0	925.3	200.5	1830.1
1992	35.0	187.1	217.6	10.7	256.3	924.0	201.4	1832.2
1993	35.0	187.2	220.7	10.8	252.7	922.7	202.2	1831.3
1994	35.3	187.2	224.1	10.8	249.1	921.4	203.0	1831.0
1995	35.8	188.3	230.5	10.8	245.6	920.1	203.8	1834.9
1996	36.8	188.4	235.0	10.8	242.2	918.8	204.5	1836.5
1997	37.3	188.9	241.5	10.8	238.7	917.5	203.0	1837.7
1998	35.3	189.9	249.0	10.8	235.3	916.3	201.4	1838.0
1999	37.1	191.0	248.7	10.9	231.9	915.0	199.9	1834.5
2000	37.8	191.1	254.8	10.9	228.6	913.7	198.3	1835.1
2001	37.9	195.8	249.6	10.9	225.3	912.4	197.3	1829.3
2002	39.9	191.7	258.7	10.9	222.1	911.1	200.7	1835.0
2003	42.6	192.1	259.4	10.9	218.9	909.9	199.6	1833.4
2004	44.6	194.1	254.0	10.9	215.8	908.6	202.9	1831.0

2005	43.6	194.2	266.6	11.0	212.7	907.3	193.1	1828.4
2006	41.6	194.3	268.7	11.0	209.7	906.0	194.4	1825.6
2007	42.0	193.9	269.7	11.0	206.7	904.8	195.6	1823.7
2008	41.0	193.9	272.7	11.0	203.7	903.5	196.9	1822.8
2009	42.6	193.8	275.5	11.0	200.8	902.2	198.1	1824.1
2010	39.7	193.8	279.2	11.0	197.9	901.0	199.3	1821.9
2011	42.1	193.7	281.5	11.1	195.1	899.7	198.4	1821.6
2012	43.3	193.7	283.5	11.1	192.3	898.5	197.5	1819.9
2013	44.4	193.6	292.8	11.1	189.6	897.2	186.7	1815.3
2014	46.2	192.9	299.4	11.1	186.9	895.9	187.0	1819.4
2015	44.5	192.8	290.2	11.1	184.2	894.7	199.2	1816.8

7. Biomass Extraction and Biomass Use Series

Table S9. Biomass extraction and biomass use in millions of tonnes of dry matter

Years	Extraction			Uses					Total Extraction
	Forestland	Grassland	Cropland	Cash Crops	Staple Crops	Wood & Fuelwood	Animal Feeding	Seeds & other Recycled Biomass	
1915	5.0	24.9	1.5	0.5	0.4	5.0	25.2	0.3	31.4
1916	5.1	27.4	1.5	0.6	0.4	5.1	27.8	0.3	34.1
1917	5.2	30.7	1.6	0.6	0.4	5.2	31.0	0.3	37.5
1918	5.3	31.1	1.7	0.6	0.4	5.3	31.5	0.3	38.2
1919	5.4	27.6	1.7	0.6	0.5	5.4	28.0	0.3	34.8
1920	5.6	28.0	1.7	0.6	0.5	5.6	28.3	0.3	35.3
1921	5.7	28.7	1.8	0.6	0.5	5.7	29.1	0.3	36.2
1922	5.8	29.5	1.8	0.6	0.5	5.8	29.9	0.3	37.1
1923	5.9	30.1	1.9	0.6	0.6	5.9	30.5	0.4	37.9
1924	6.0	32.9	1.9	0.6	0.6	6.0	33.3	0.4	40.8
1925	6.1	33.2	2.1	0.7	0.6	6.1	33.6	0.4	41.4
1926	6.3	33.3	2.1	0.6	0.7	6.3	33.7	0.4	41.7
1927	6.4	33.5	2.0	0.5	0.7	6.4	33.9	0.4	41.9
1928	6.0	33.7	2.1	0.5	0.8	6.0	34.1	0.4	41.9

1929	6.1	33.9	2.1	0.5	0.8	6.1	34.3	0.4	42.1
1930	6.2	34.0	2.4	0.5	0.9	6.2	34.5	0.4	42.6
1931	6.4	34.7	2.6	0.5	1.0	6.4	35.3	0.5	43.7
1932	6.5	35.6	2.9	0.7	1.1	6.5	36.2	0.6	45.0
1933	6.6	36.2	3.1	0.7	1.1	6.6	36.8	0.6	45.9
1934	6.8	36.6	3.4	0.9	1.2	6.8	37.3	0.6	46.7
1935	6.9	36.5	4.1	1.3	1.2	6.9	37.3	0.8	47.4
1936	7.0	36.4	3.9	1.1	1.2	7.0	37.2	0.7	47.4
1937	7.2	36.2	4.4	1.5	1.3	7.2	37.1	0.8	47.8
1938	7.5	36.9	4.5	1.5	1.3	7.5	37.8	0.8	49.0
1939	7.7	38.2	4.7	1.5	1.4	7.7	39.2	0.9	50.6
1940	7.9	38.9	4.6	1.3	1.5	7.9	39.8	0.9	51.4
1941	8.1	39.7	4.8	1.6	1.4	8.1	40.7	0.9	52.6
1942	8.3	40.6	5.1	1.8	1.4	8.3	41.6	1.0	54.1
1943	8.5	41.3	5.0	1.7	1.4	8.5	42.3	0.9	54.9
1944	8.7	42.0	5.3	1.8	1.5	8.7	43.0	1.0	56.0
1945	8.9	42.5	5.5	1.8	1.5	8.9	43.6	1.0	56.9
1946	9.1	39.9	6.3	2.3	1.6	9.1	41.1	1.2	55.4
1947	9.4	40.9	5.6	1.8	1.6	9.4	42.0	1.0	55.8
1948	9.6	41.3	6.5	2.3	1.7	9.6	42.6	1.2	57.4
1949	9.8	41.8	7.3	2.5	2.0	9.8	43.2	1.4	58.9
1950	10.1	42.6	6.7	2.3	1.8	10.1	43.9	1.2	59.4
1951	9.2	42.7	7.4	2.4	2.1	9.2	44.1	1.4	59.2
1952	9.5	42.6	7.7	2.3	2.3	9.5	44.1	1.5	59.7
1953	9.6	42.8	7.5	2.4	2.2	9.6	44.3	1.4	59.9
1954	9.7	43.0	8.0	2.7	2.2	9.7	44.6	1.5	60.7
1955	9.8	43.7	8.2	2.9	2.2	9.8	45.3	1.5	61.6
1956	9.9	44.5	8.1	2.8	2.2	9.9	46.1	1.5	62.5
1957	10.0	45.1	7.8	2.6	2.2	10.0	46.6	1.5	62.8
1958	10.0	45.3	8.3	2.7	2.4	10.0	47.0	1.6	63.7
1959	10.1	45.6	9.1	2.9	2.7	10.1	47.4	1.7	64.9
1960	10.2	46.3	9.7	3.3	2.7	10.2	48.2	1.8	66.1

1961	12.1	46.9	11.1	4.0	2.5	12.1	49.3	2.2	70.0
1962	11.9	47.9	12.1	4.3	2.7	11.9	50.5	2.4	71.8
1963	11.9	49.2	11.0	3.8	2.6	11.9	51.6	2.2	72.1
1964	12.0	49.5	12.1	4.2	2.8	12.0	52.2	2.4	73.6
1965	12.1	50.3	11.6	3.8	2.8	12.1	52.9	2.3	73.9
1966	12.3	52.4	11.8	3.8	2.9	12.3	55.1	2.4	76.5
1967	12.4	54.0	12.1	3.9	3.0	12.4	56.8	2.4	78.6
1968	12.6	55.6	13.0	4.0	3.3	12.6	58.6	2.6	81.1
1969	12.6	56.3	12.9	4.0	3.3	12.6	59.4	2.6	81.8
1970	12.7	62.2	13.1	3.9	3.4	12.7	65.4	2.6	88.0
1971	12.8	61.8	14.0	4.1	3.3	12.8	65.5	2.8	88.6
1972	13.3	62.1	15.2	4.6	3.5	13.3	66.1	3.0	90.6
1973	13.5	63.3	15.6	4.8	3.5	13.5	67.5	3.1	92.3
1974	13.2	65.5	17.3	5.2	3.8	13.2	70.3	3.5	96.0
1975	15.0	67.4	19.1	6.2	3.8	15.0	72.7	3.8	101.5
1976	14.6	69.4	19.3	6.4	3.8	14.6	74.6	3.8	103.2
1977	14.4	71.3	19.3	6.3	4.0	14.4	76.5	3.8	104.9
1978	14.5	73.1	21.4	6.9	4.3	14.5	79.1	4.3	109.1
1979	14.3	75.1	22.1	7.5	4.3	14.3	81.1	4.4	111.4
1980	13.8	76.2	22.9	7.9	4.4	13.8	82.3	4.5	112.9
1981	13.7	73.0	22.0	7.1	4.5	13.7	79.2	4.4	108.8
1982	13.5	72.4	21.4	7.1	4.2	13.5	78.3	4.2	107.3
1983	13.5	71.8	21.5	7.4	4.2	13.5	77.5	4.2	106.8
1984	13.2	72.4	21.5	7.3	4.4	13.2	78.1	4.2	107.2
1985	13.1	73.2	22.2	7.9	4.2	13.1	78.9	4.3	108.5
1986	13.2	73.2	22.3	7.8	4.3	13.2	79.0	4.3	108.7
1987	13.1	73.8	23.1	7.9	4.6	13.1	80.0	4.6	110.0
1988	13.0	75.7	24.2	8.3	4.8	13.0	82.0	4.8	112.8
1989	12.8	76.9	25.3	8.5	5.1	12.8	83.6	5.0	115.1
1990	12.6	76.1	27.2	9.0	5.3	12.6	83.6	5.4	115.9
1991	12.9	76.1	27.3	9.1	5.5	12.9	83.3	5.4	116.3
1992	13.0	76.0	27.2	9.5	5.3	13.0	83.2	5.3	116.3

1993	12.4	78.0	27.2	9.9	5.0	12.4	85.0	5.2	117.6
1994	12.3	79.7	27.5	10.1	4.7	12.3	87.2	5.3	119.5
1995	11.9	82.3	27.9	10.4	4.8	11.9	89.7	5.3	122.1
1996	11.4	83.4	28.8	11.3	4.6	11.4	90.8	5.5	123.6
1997	10.9	85.0	29.2	11.7	4.6	10.9	92.4	5.5	125.1
1998	11.0	85.9	27.5	11.1	4.3	11.0	92.8	5.2	124.5
1999	10.5	87.0	28.8	11.2	4.8	10.5	94.4	5.4	126.4
2000	10.2	87.1	29.3	11.3	4.9	10.2	94.6	5.6	126.6
2001	9.8	87.9	29.5	11.3	5.0	9.8	95.5	5.5	127.1
2002	10.1	87.7	31.2	12.5	4.8	10.1	95.7	5.9	129.0
2003	10.2	86.5	33.3	13.0	5.2	10.2	95.2	6.3	129.9
2004	9.9	86.3	34.9	13.7	5.6	9.9	95.3	6.6	131.1
2005	9.7	88.0	34.2	13.6	5.3	9.7	96.8	6.5	131.8
2006	8.7	89.5	32.6	11.8	6.1	8.7	97.9	6.2	130.7
2007	8.1	92.6	32.8	11.3	6.9	8.1	101.0	6.2	133.5
2008	8.5	93.3	31.8	10.6	6.9	8.5	101.6	6.1	133.7
2009	9.2	92.0	33.3	11.6	6.9	9.2	100.4	6.4	134.5
2010	8.8	93.8	31.0	11.1	6.4	8.8	101.5	5.8	133.6
2011	8.8	84.3	32.9	12.0	6.7	8.8	92.3	6.2	126.0
2012	8.7	74.3	33.7	11.7	7.3	8.7	82.7	6.4	116.8
2013	8.8	70.2	34.7	12.4	7.4	8.8	78.6	6.5	113.7
2014	8.3	70.3	36.3	13.1	7.7	8.3	79.0	6.7	114.8
2015	8.0	71.0	34.6	13.6	6.7	8.0	79.2	6.2	113.6

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