Carbon is the Cash Crop

Does Paying Farmers to Plant Trees Really Work?

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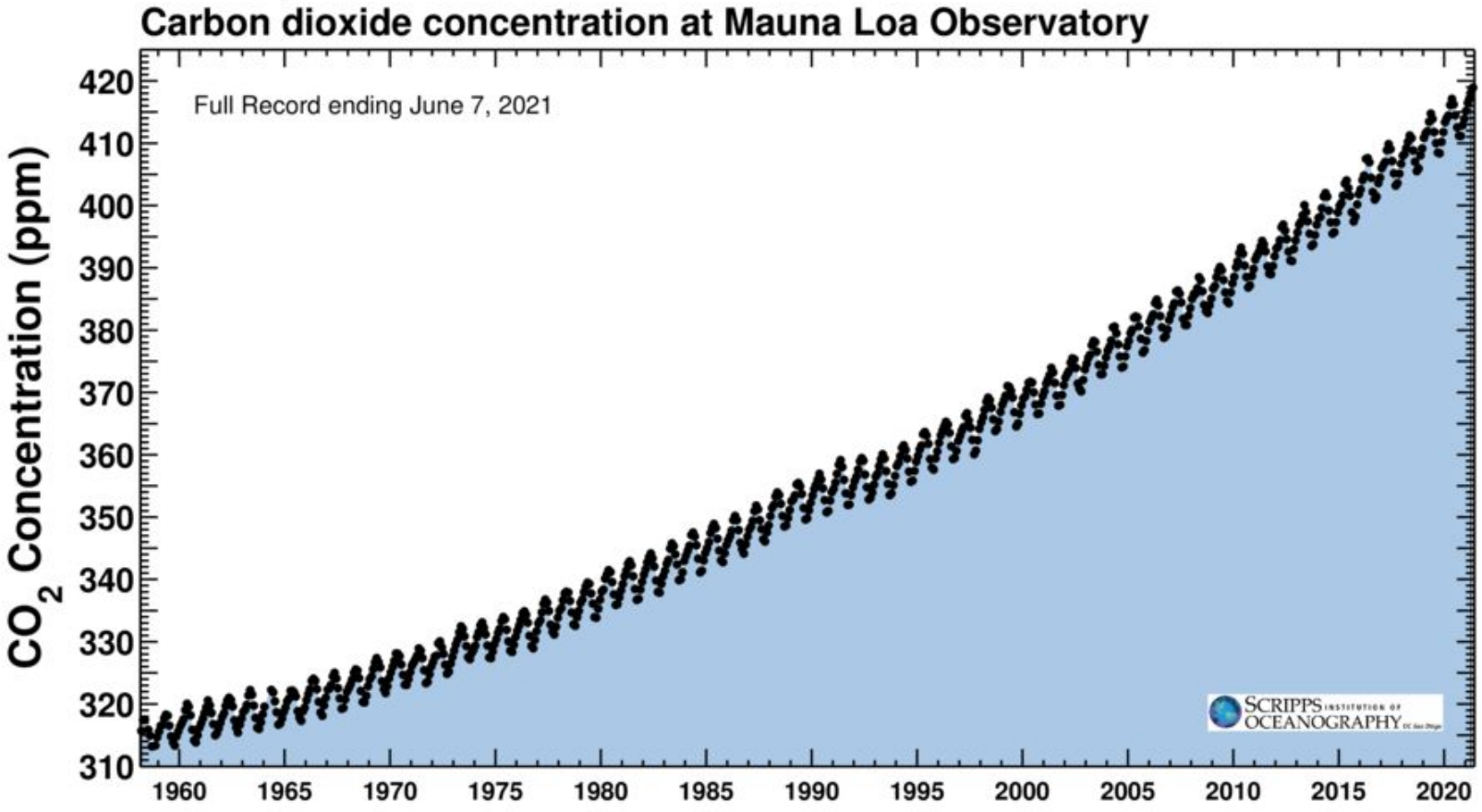
Carbon dioxide concentration at Mauna Loa Observatory
Full Record ending June 7, 2021
CO_2 Concentration (ppm)
420
410
400
390
380
370
360
350
340
330
320
310
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
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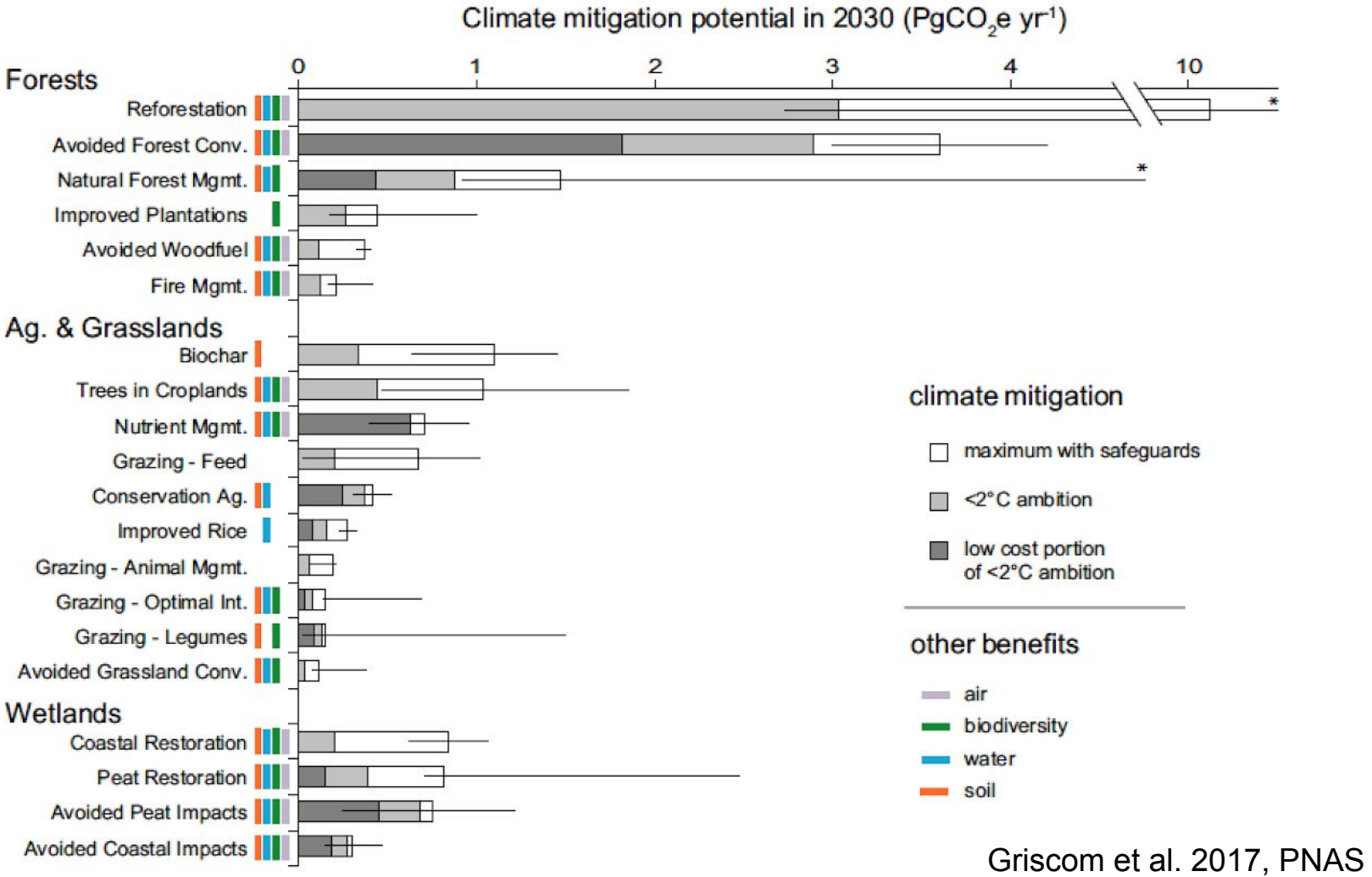
Can paying farmers to produce **carbon offsets** by planting trees…..

- help farmers transition to more productive resilient agroecosystems?
- encourage provision of co-benefits?
- diversify cropping systems and income streams?
- improve household livelihoods?
- mitigate CO_2 emissions through carbon sequestration?
- enlist farmers as co-collaborators in climate change solutions?

A carbon offset is one ton of carbon dioxide that has not been released into the atmosphere as the result of some on-the-ground activity

Or one ton of carbon dioxide that has been “recaptured” and “sequestered” or stored

Tree planting is considered one of the most cost effective “natural” means of sequestering carbon



Griscom et al. 2017, PNAS

Some co-benefits of trees

- Carbon sequestration
- Soil stabilization
- Temperature regulation
- Watershed protection
- Efficient nutrient cycling
- Soil microbiome support
- Habitat supports biodiversity
- Animal fodder
- Non-timber forest products
- Fiber and fuel

Haitian Tree by Eileen Schaffer (C'2013)

Farmers face high **opportunity costs** for maintaining trees, despite the benefits of trees and the consequences of deforestation

Limited land is cleared to grow annual subsistence crops

Charcoal, the most commonly used fuel, sells for a high price

Charcoal sells for ~$50/sack

Watershed protection has no market value

Can paying farmers in Haiti help restore degraded lands and raise household incomes?

University of Texas Libraries: http://www.lib.utexas.edu/maps/americas/haiti_rel99.pdf

The border between Haiti and the Dominican Republic. (NASA Scientific Visualization Studio 2002)

Zanmi Kafe: A collaboration between Association Zanmi Agrikol (AZA), Bois Joly famers and Sewanee

2012 - AZA organizes meetings with Bois Joly farmers

2013 - Tree nursery establishment

2014 - Tree planting begins to establish agroforests

2015 - Annual tree surveys begin (survival, height, diameter)

Carbon payments made to farmers “upfront” based upon tree number

2018 - First coffee harvests

2019 - Carbon offsets calculated, purchased and retired

2021 - Second round of carbon offsets calculated

2013
tree
nurseries
established

2014
trees
planted

Kajou peyi (*Swietenia mahogani*)

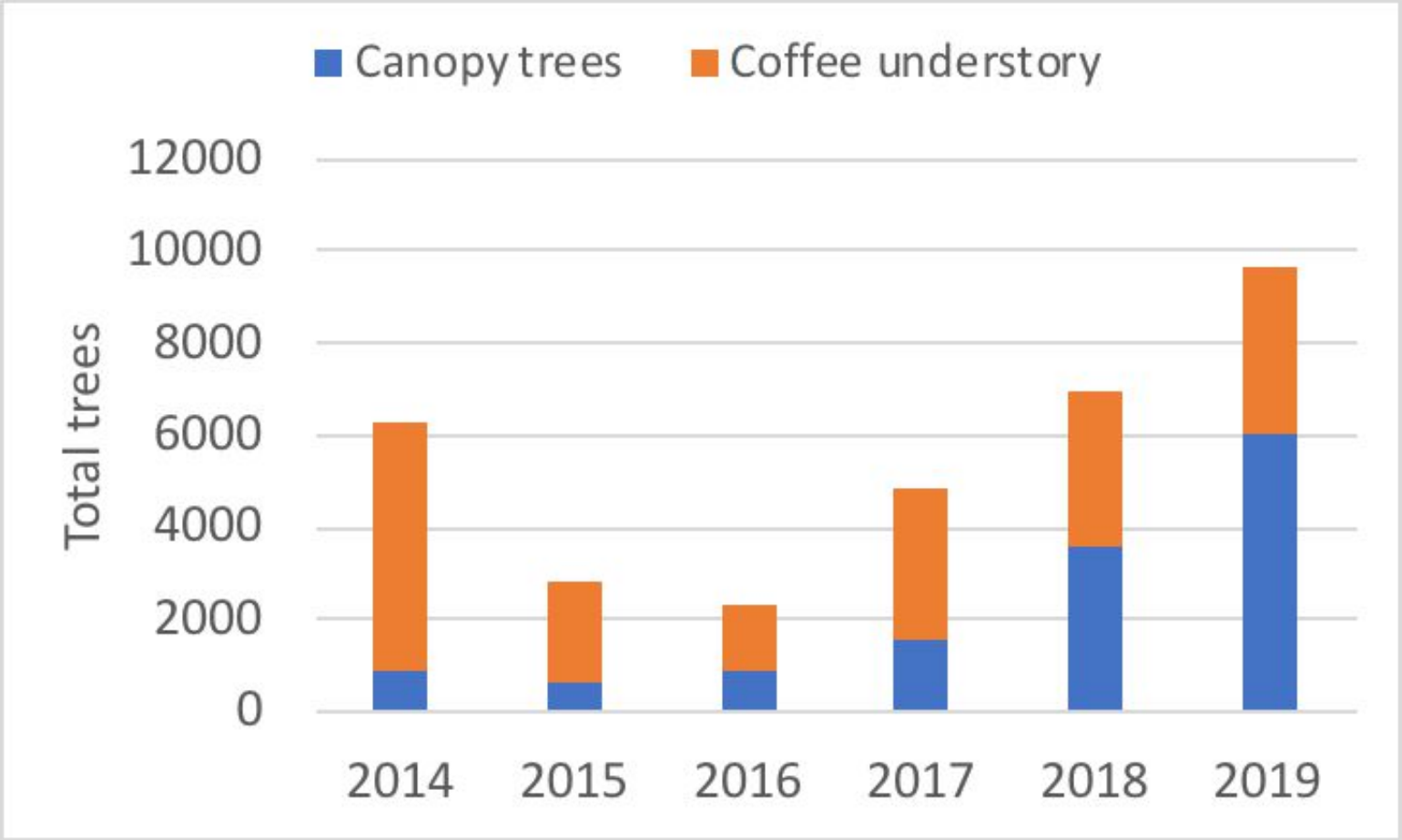
Sèd (Cedrela odorata)

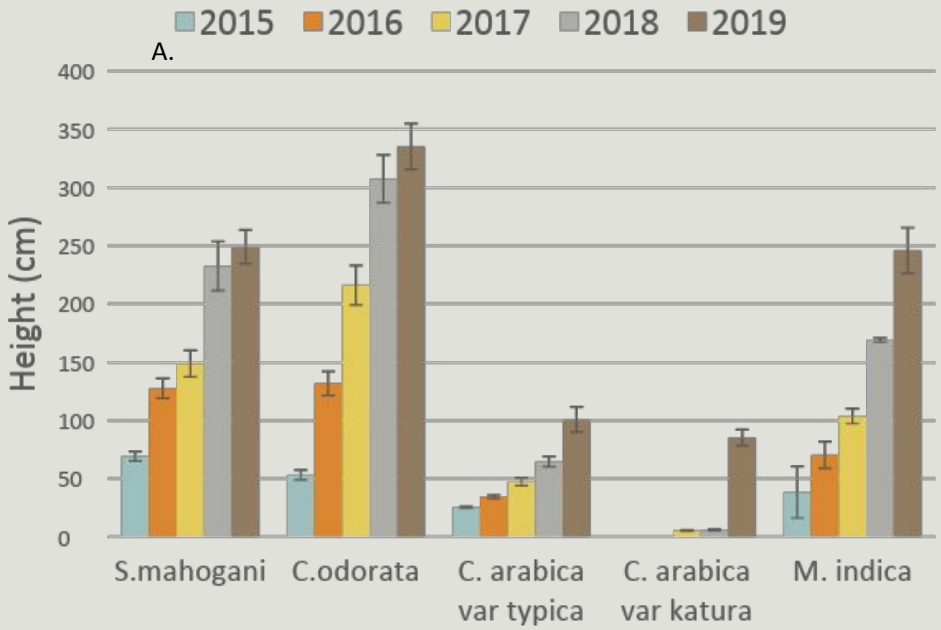
Mango (*Mangifera indica)*

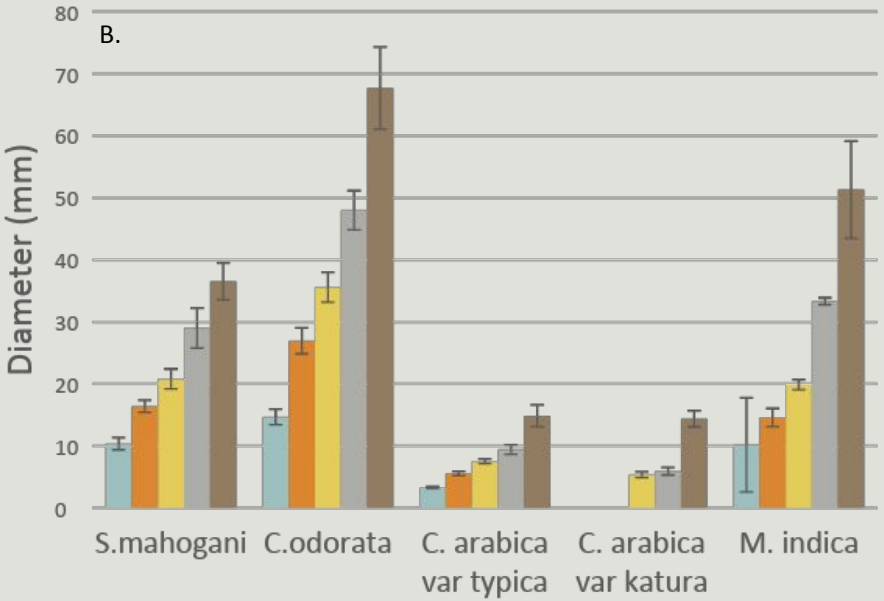
Measured survival and growth of 4 species for 5 years (2014-2019)

Kafe (*Coffea arabica)*

Students monitor seedling survival, growth and health while they conduct verification surveys


Canopy trees
Coffee understory
12000
10000
8000
6000
4000
2000
0
Total trees
2014
2015
2016
2017
2018
2019


2015
2016
2017
2018
2019
A.
Height (cm)
400
350
300
250
200
150
100
50
0
S.mahogani
C.odorata
C. arabica var typica
C. arabica var katura
M. indica


B.
Diameter (mm)
80
70
60
50
40
30
20
10
0
S.mahogani
C.odorata
C. arabica var typica
C. arabica var katura
M. indica

Estimating carbon sequestration using allometric equations

We compared estimates from 3 equations:

Y_{total} (kg) = 1.163 + 0.017 dbh^2H (Cole and Ewel 2006)

Y_{total} (kg) = EXP(-2.187+0.916*LN(p* dbh^2*H (Chave et al. 2005)

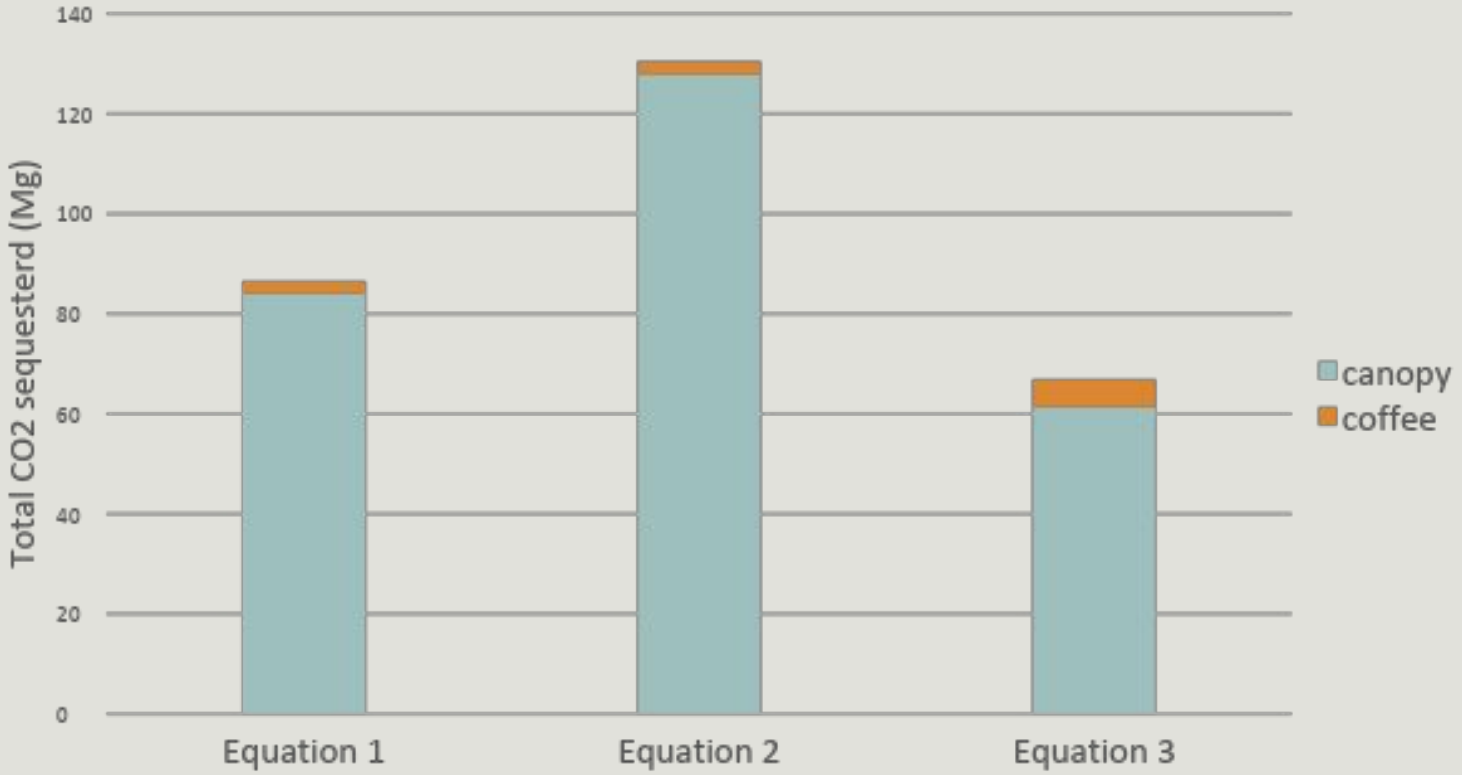
Y_{total} (lbs) = 0.25 (dbh^2H) (Trees For the Future)

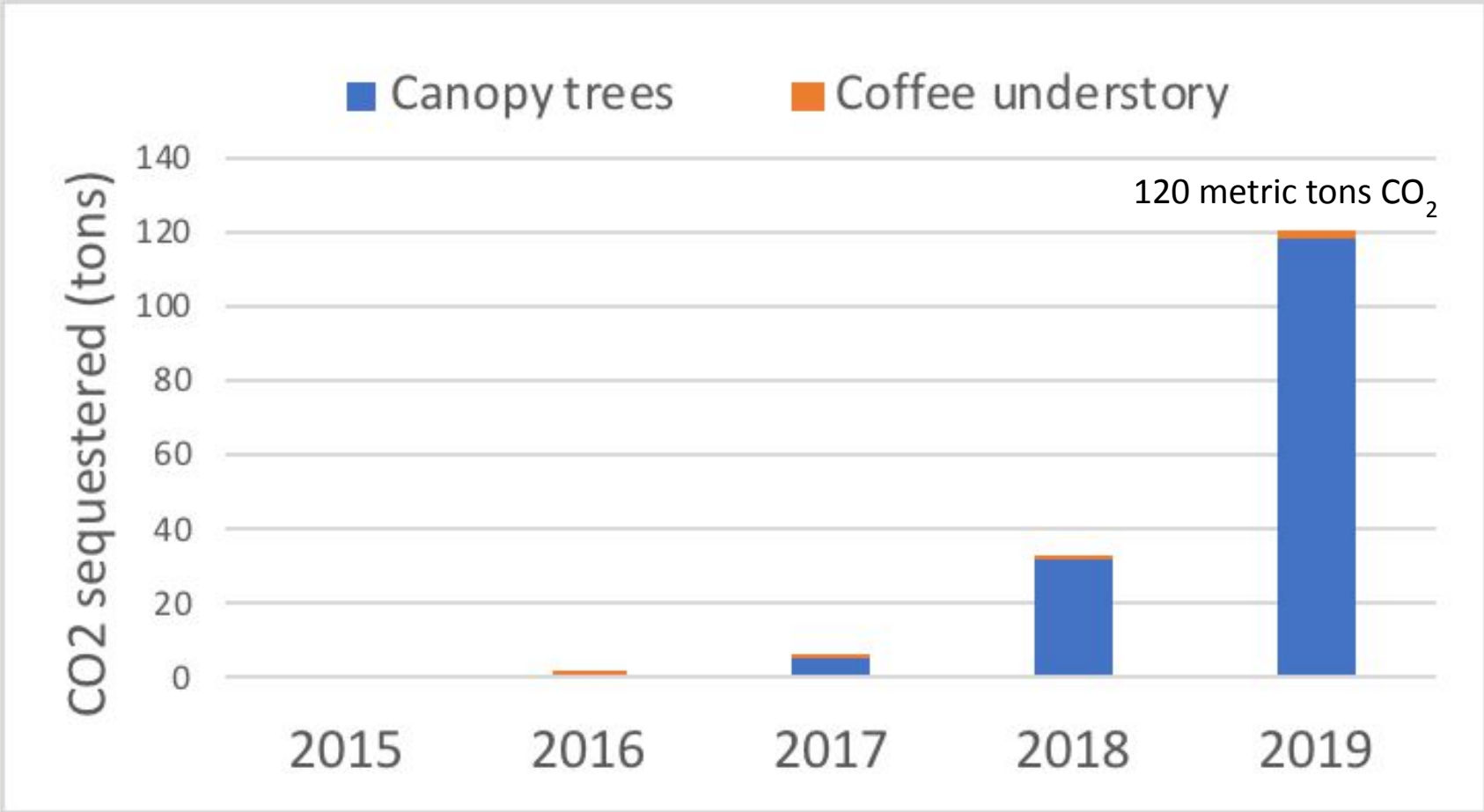
Y = above ground mass; dbh = diameter; H= height

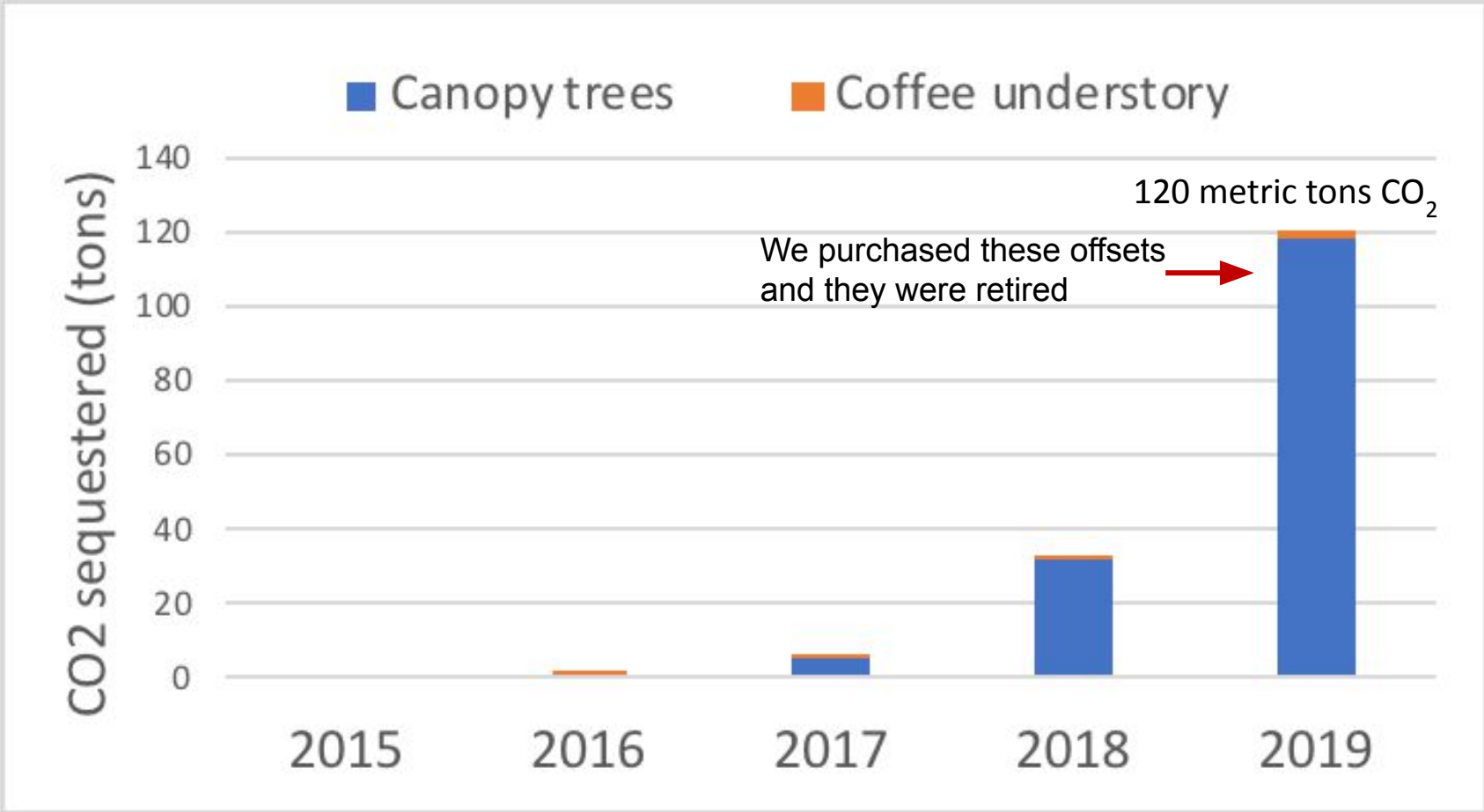
P= wood density (0.42); Mass *1.2 = above + belowground per tree;

Kg C/tree = 50% dry mass; sequestered CO_2= carbon mass *

Carbon estimates vary considerably depending upon the equation used




Canopy trees
Coffee understory
CO2 sequestered (tons)
140
120
100
80
60
40
20
0
2015
2016
2017
2018
2019
120 metric tons CO_2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140
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40
20
0
2015
2016
2017
2018
2019
120 metric tons CO_2
We purchased these offsets
and they were retired

Carbon sequestered by year five offset Sewanee air travel

Flight	kilometers traveled	CO_2 tons round trip	18 participants CO_2 tons	7 years (2012-2018) CO_2 tons	Source
Flight ATL-PAP direct	4100	0.750	14	95	MyClimate
Flight ATL-PAP direct		0.719	13	91	Co2census
Flight ATL-PAP direct	4232	1.141	21	144	Atmosfair
Flight BNA-MIA-PAP	4900	0.962	17	121	MyClimate
Flight BNA-MIA-PAP		0.839	15	106	Co2census

Payments made in 2015 - 2019 based upon surveys of survival and growth on every farm

Carbon payments came from Sewanee's Green Fund

Year after planting	One 2015	Two 2016	Three 2017	Four 2018	Five* 2019
Total across 50 farms	$1,415	$1,608	$2,252	$3,111	$6,305
Average payment per farm	$32 ± 2	$37 ± 2	$45 ± 5	$65 ± 8	$107 ± 13

Farmers were paid $50 per CO_2 equivalent - "social cost of carbon"

Tree cover tripled over 5 years

Canopy trees increased 10-fold

120 tons CO_2 sequestered
offset 8 years Sewanee airfare

Young trees rapidly sequester
carbon (~200 Mg/year?)

$15K invested in Bois Joly

Farmers are harvesting coffee

Farmers avoided deforestation

Soils are protected & enriched

Paying farmers to sequester carbon works!

- Payments for carbon sequestration incentivized tree planting and maintenance
- CO_2 sequestered in trees in Haiti is highly additional
- Payments avoided deforestation from charcoal selling
- Families are selling products from their agroforestry systems
- Partnering with Sewanee decreased monitoring costs -money goes to farmers
- Sewanee gained powerful experiences for many students and offset air travel

Data analysis and visualization goals:

- **Establish a database** that enables more efficient data collection and analysis
- **Test and compare allometric equations** to better quantify carbon sequestration in trees within and across farms
- **Develop models to predict** carbon sequestration
- **Improve method for carbon payment** calculation, distribution, tracking
- **Establish a dashboard** enabling viewers to track carbon sequestration and other benefits from our website
- **Explore Malde's photo archive** as a means of assessing changes in household wellbeing concurrent with this program
- **Scale up project and monitoring** with aerial imagery (drones)

Appreciation for Our Collaborators and Supporters

Association Zanmi Agrikol:
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Photographs by Pradip Malde, Professor of Art
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Shearwater Foundation
American Colleges of the South
Sommer-Speck Fund for Environmental Internships

Can paying farmers in Haiti help restore degraded lands and raise household incomes?

Agroforestry systems offer models of sustainability