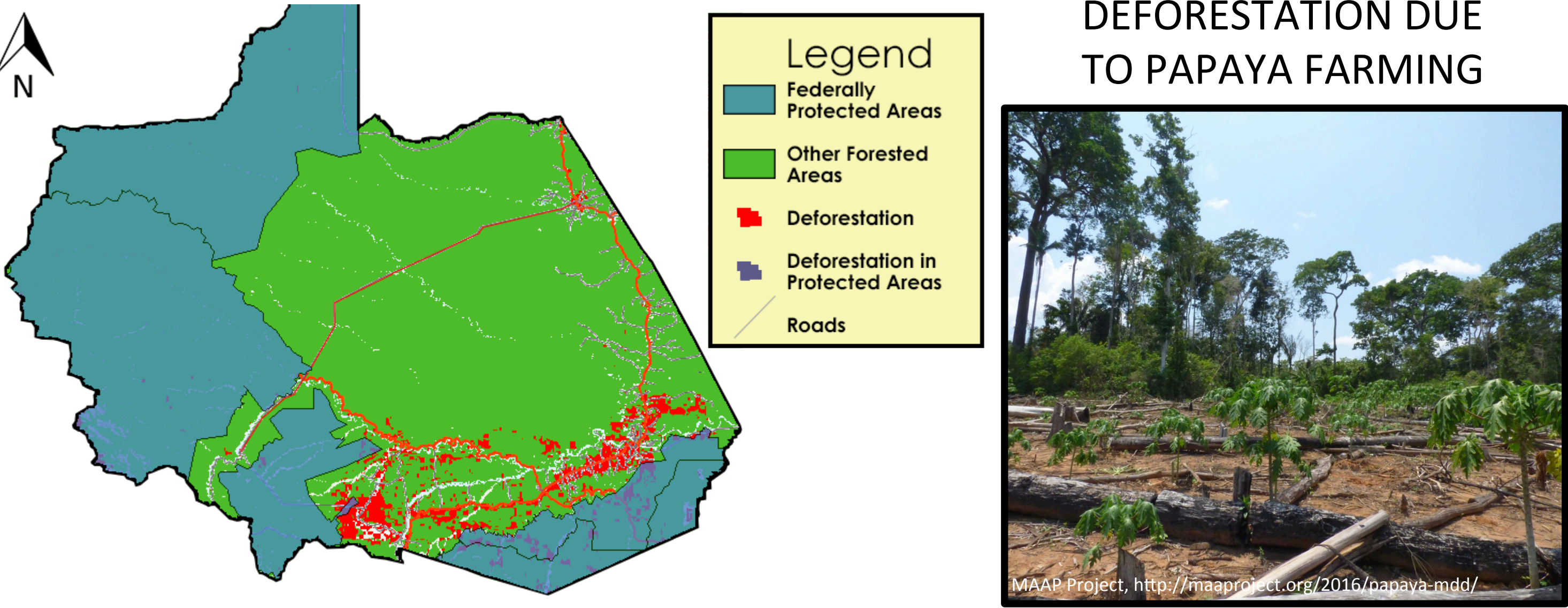# INCORPORATION OVER DEFORESTATION: CACAO (*Theobroma cacao*) AGROFORESTRY AS AN ALTERNATIVE TO PAPAYA (*Carica papaya*) MONOCROP IN MADRE DE DIOS, PERU
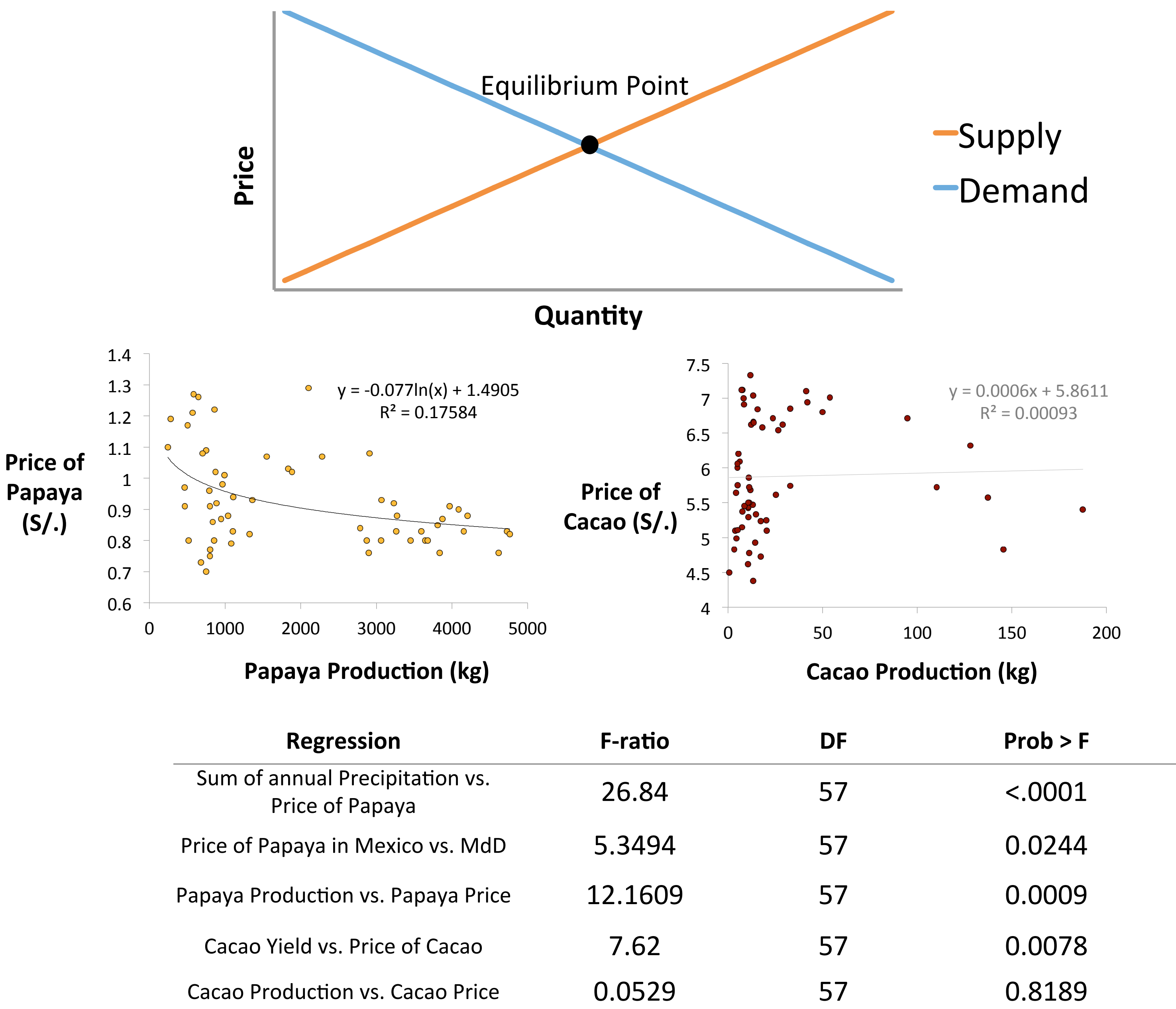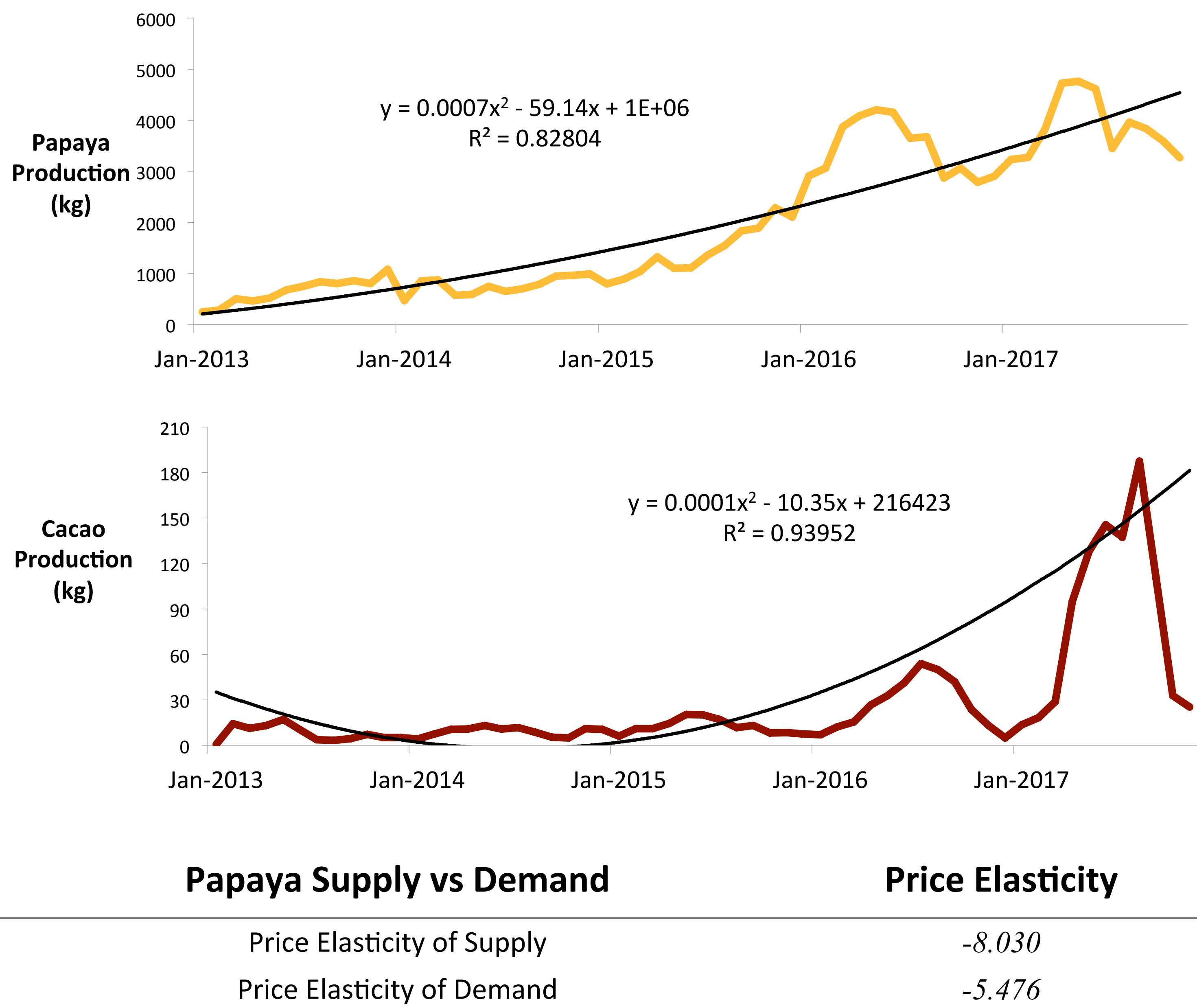
David H. Klinges, Geoff Gallice

Alliance for a Sustainable Amazon, Madre de Dios, Peru. 2018.

Background

- The Madre de Dios region, enshrined into Peruvian law as the "Capital of Biodiversity," contains some of the largest stretches of forest in the Western Amazon, and high concentrations of endemic and endangered flora/fauna[1]
- The region has experienced a large amount of land-use change, largely due to illegal gold mining, cattle ranching, and rapidly expanding agriculture[3]
- Much of the agricultural expansion due to **papaya**: ~600% increase in papaya production in the last 4 years, which has been one of the driving forces of deforestation and degradation[4]
  - Papaya necessitates high fertilizer/fungicide application and open canopy[4]
- Conversely, **cacao** has become one of the cornerstones of agroforestry systems
  - Shade-tolerant, and with high profit/ton yields, cacao has potential as a cash crop and generator of biodiversity.[4,5,6] Peru has become a global contender for cacao production, but Madre de Dios lags behind.

Legend
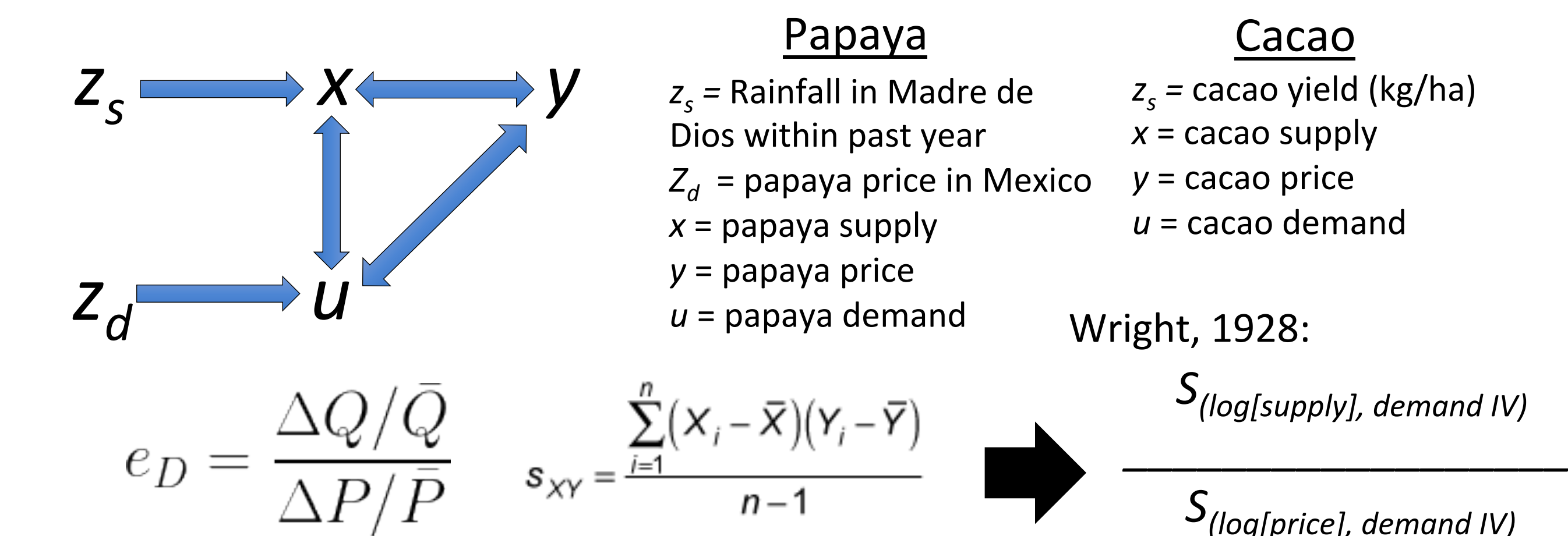- Federally Protected Areas
- Other Forested Areas
- Deforestation
- Deforestation in Protected Areas
- Roads

DEFORESTATION DUE TO PAPAYA FARMING

MAAP Project, http://maaproject.org/2016/papaya-mdd/

Case Study Results

$y = 0.0007x^2 - 59.14x + 1E+06$
$R^2 = 0.82804$

Papaya Production (kg)

$y = 0.0001x^2 - 10.35x + 216423$
$R^2 = 0.93952$

Cacao Production (kg)

Equilibrium Point

Price — Supply / Demand — Quantity

$y = -0.077\ln(x) + 1.4905$
$R^2 = 0.17584$

Price of Papaya (S/.) — Papaya Production (kg)

$y = 0.0006x + 5.8611$
$R^2 = 0.00093$

Price of Cacao (S/.) — Cacao Production (kg)

Regression	F-ratio	DF	Prob > F
Sum of annual Precipitation vs. Price of Papaya	26.84	57	<.0001
Price of Papaya in Mexico vs. MdD	5.3494	57	0.0244
Papaya Production vs. Papaya Price	12.1609	57	0.0009
Cacao Yield vs. Price of Cacao	7.62	57	0.0078
Cacao Production vs. Cacao Price	0.0529	57	0.8189

Papaya Supply vs Demand	Price Elasticity
Price Elasticity of Supply	–8.030
Price Elasticity of Demand	–5.476

Hypotheses & Analytic Methods

Hyp_1: Price of papaya in MdD is sensitive to changes in local supply of papaya
  Hyp_0: Price of papaya is not impacted by changes in local supply of papaya

Hyp_2: Price of cacao is not impacted by changes in local supply of cacao
  Hyp_0: Price of cacao is sensitive to changes in local supply of cacao

To test hypotheses: Isolate impact of supply/demand of commodity on price of commodity through use of instrumental variables.

ELASTICITY ANALYSIS USING INSTRUMENTAL VARIABLES

$z_s \rightarrow x \rightarrow y$

$z_d \rightarrow u$

Papaya
z_s = Rainfall in Madre de Dios within past year
z_d = papaya price in Mexico
x = papaya supply
y = papaya price
u = papaya demand

Cacao
z_s = cacao yield (kg/ha)
x = cacao supply
y = cacao price
u = cacao demand

Wright, 1928:

$$e_D = \frac{\Delta Q / \bar{Q}}{\Delta P / \bar{P}}$$

$$s_{XY} = \frac{\sum_{i=1}^{n}(X_i - \bar{X})(Y_i - \bar{Y})}{n-1} \Rightarrow \frac{S_{(\log[supply], demand\ IV)}}{S_{(\log[price], demand\ IV)}}$$

ASA Cacao Agroforestry Initiative

FINCAS LAS PIEDRAS AGROFORESTRY
- 54-hectare property in Madre de Dios, Peru; partially forested
- Cacao-dominant agroforestry complex as tool to reforest degraded agricultural lands
- Rows planted 3 meters apart, trees placed 15 meters apart from each other

Photo credits Geoff Gallice, ASA

The Finca las Piedras agroforestry complex is the first step in a planned local network of cacao agroforestry plots. The near future may hold a transfer of a large portion of the agricultural sector to agroforestry in an economically feasible fashion.

Experimental Plots: Sample Layout

Crop	Contribution	Approx. Quantity
Theobroma cacao	Cocoa seeds	250
Inga edulis	Nitrogen fixer, shade	50
Starfruit	Starfruit	50
Copoazu	Copoazu fruit	50
Anona sp.	Anona fruit	20
Dipteryx sp.	Shihuahuaco wood, shade	20
Prosopis	Prosopis wood, shade	20
Cedrelinga catenaeformis	Tornillo wood, shade	20

Conclusions

- Papaya prices appear influenced by local supply, most demand local
- High supply elasticity for papaya suggests prices will respond to changes in production
  - If papaya production decreased, prices would rebound, stabilizing or reversing the downward spiral
- Cacao production in MdD appears to be not correlated with price; local cacao prices in MdD likely track global cacao prices
- Primary barriers to entry for cacao production are knowledge and capital
  - Domestic and international political/economic incentives urge movement towards cacao production, especially for small farmers (SERVIAGRO)[7]
  - Joint/communal initiatives help finance small-scale farmers
- Cacao production expected to increase in the next 5-10 years
- More involvement in cacao farming will diversify agricultural sector, less vulnerable to localized weather events (intense rain, etc.)
- With an expanding ecotourism sector, and potential for high agroforestry output, Madre de Dios may become an icon of not only immense biodiversity, but also of wholesome human-forest interactions.

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[7] Ministerio de Agricultura y Riego. Estrategia de la Plataforma de Servicio Agrarios del Sector Agricultura y Riego – SERVIAGRO. 2017.

ALLIANCE FOR A SUSTAINABLE AMAZON