Cash for Carbon:
A Randomized Controlled Trial of "Payments for Ecosystem Services" to Reduce Deforestation

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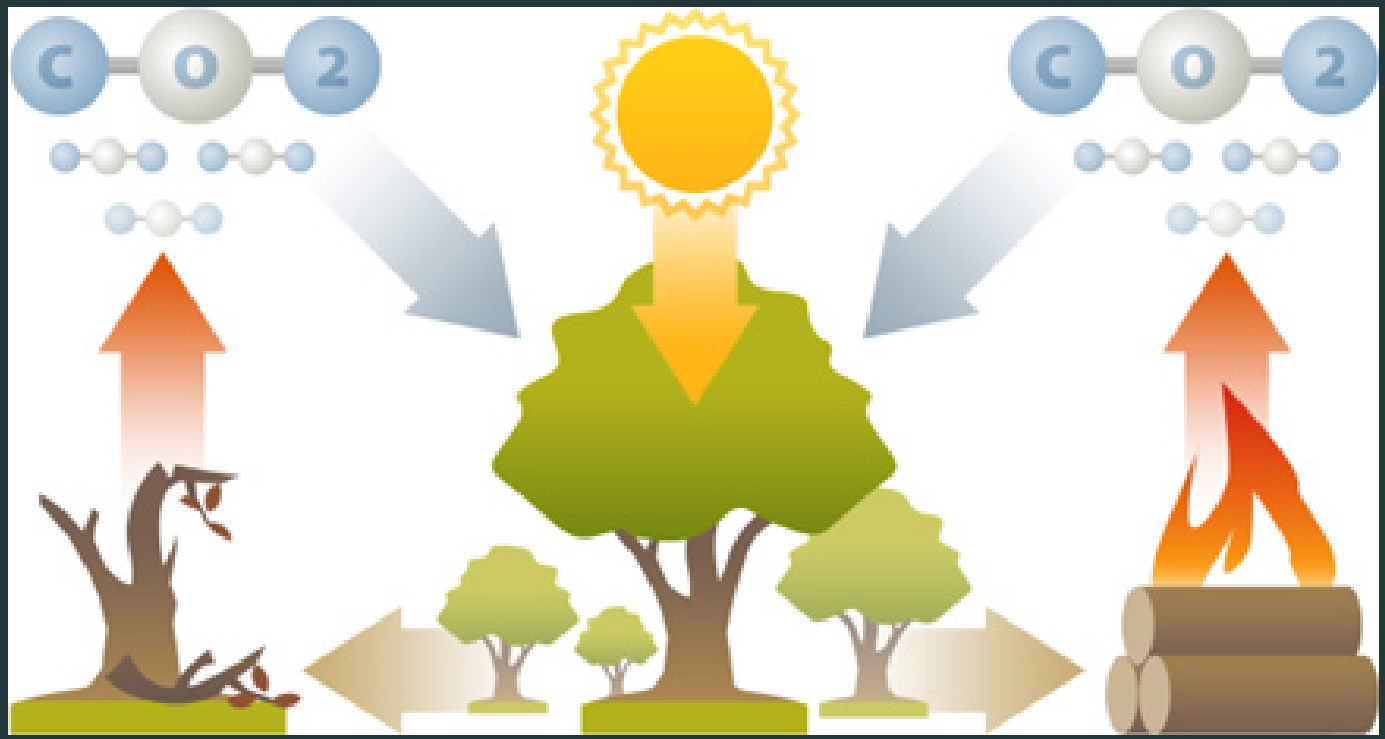
- Mostly in developing countries
- Reducing deforestation in poor countries is potentially one of the most cost-effective ways to reduce carbon emissions (Stern Report, 2006; IPCC, 2007)

Forests and the carbon cycle



Payments for Ecosystem Services (PES)

- PES = Payment to individual or group in exchange for specified pro-environment behavior
  - Conditional cash transfer
- Example: Pay forest owners an amount each year if they do not clear their forest

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- Example: Pay forest owners an amount each year if they do not clear their forest
- Deforestation PES programs have been implemented in Costa Rica, China, Mexico, Colombia, Panama, Mozambique, etc.
- PES could grow under UN's REDD+ (reducing emissions from deforestation and forest degradation) mechanism
  - Paris Agreement in December 2015 bolstered role of REDD+

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- People could just shift their tree-cutting to nearby land ("leakage")

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- Randomized experiment of a PES program in Uganda
- Individuals who owned natural forest in 60 treatment villages offered money if they left their forest intact
- Measure impacts on tree cover via high-resolution satellite imagery
- Cost/benefit analysis based on value of delayed CO_2 emissions
- Measure economic outcomes as well as forest-related behaviors

Preview of results

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- Cost-effectiveness
  - Benefit of delayed CO_2 emissions exceeds program costs
  - Many assumptions needed for cost-benefit analysis
  - Cannot examine all behavioral responses

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- A lot of money is flowing into deforestation PES; this study is the first randomized evaluation
  - Best existing studies match enrollees to non-enrolles on observables
- Adds to literatures on deforestation and on conditional cash transfers

Outline

- Study design and PES program
- Data and empirical specification
- Results
- Cost-benefit analysis and policy implications

Study design and PES program

Study area

Uganda's forests

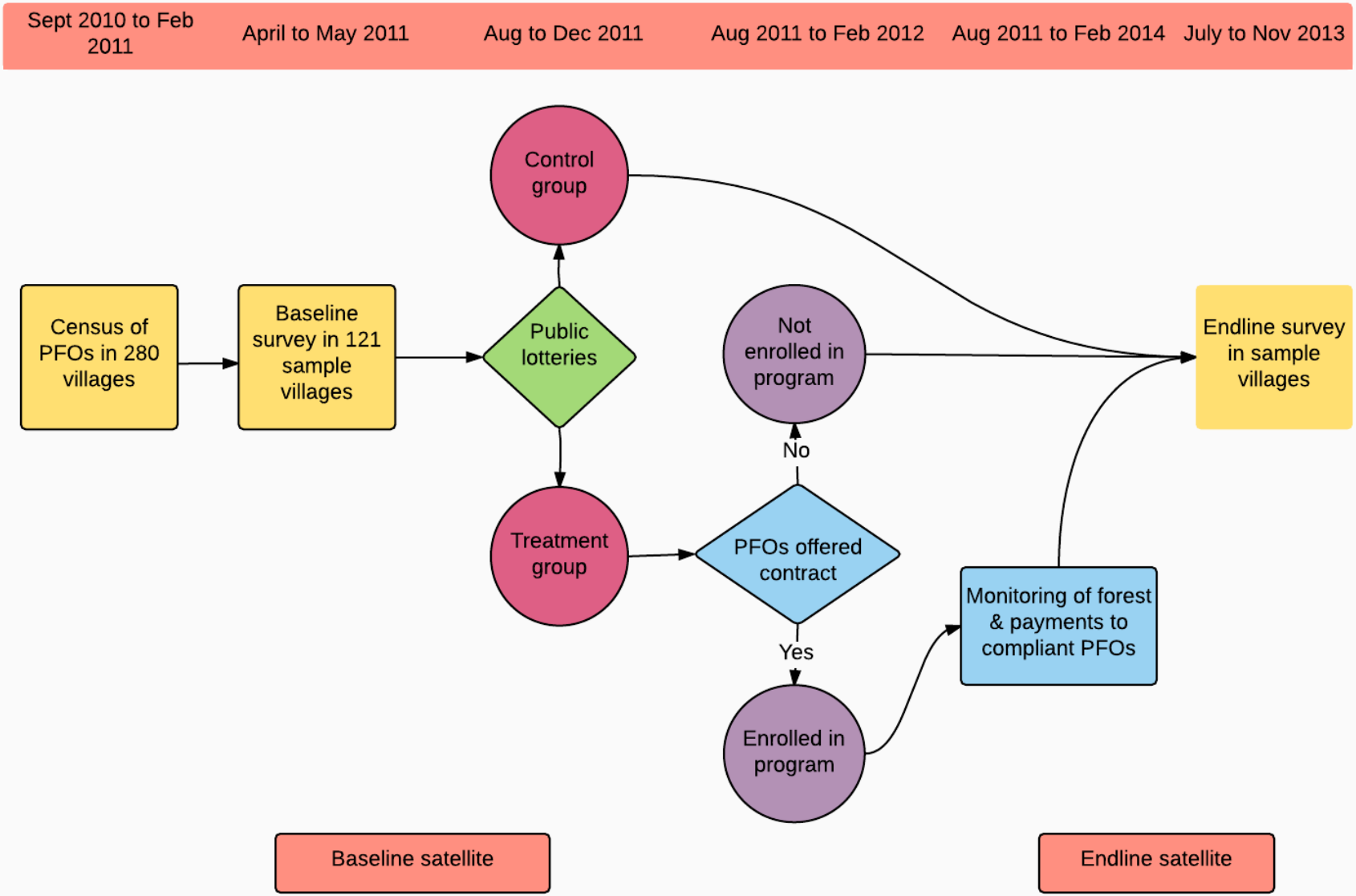
- Forest loss in Uganda is 2.7% per year, 3rd highest rate in world
- 70% of forested land in Uganda is privately owned
- Forest is important for biodiversity too: Habitat of chimpanzees, an endangered species, and other flora and fauna

Why deforest? Clear land for cultivation

Why deforest? Sell trees for timber products

Large mature trees sell for 20 to 40 USD

Project timeline



▸ Randomization

PES program details

- Program implemented by Chimpanzee Sanctuary and Wildlife Conservation Trust (CSWCT)
- Forest owners were offered this contract:
  - Paid 70,000 UGX ($28) per ha per year for compliance
  - Agree not to cut mature trees (defined by trunk diameter)
  - Monitoring by CSWCT to ensure contract conditions are met
  - Must enroll all your forest; can withdraw but cannot re-enroll
  - Optional reforestation component: Plant seedlings in exchange for additional payments
- Program duration was 2 years ▸ Temporary vs. permanent programs

Data

Data sources

- Satellite data
- Household survey
- CSWCT data on program enrollment and payments

Satellite imagery

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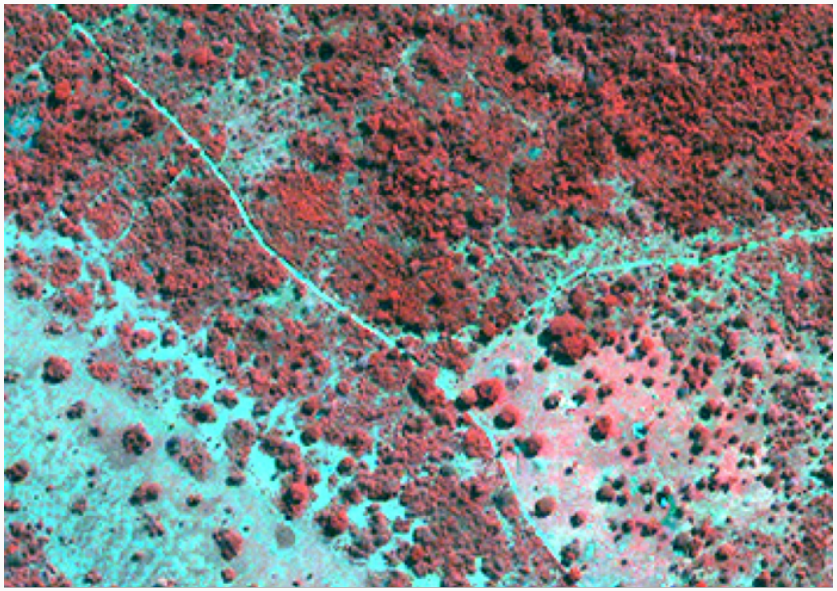
- Image resolution: 2.4m
    - Comparison: Landsat resolution is 30m

Satellite image → Identifying tree cover



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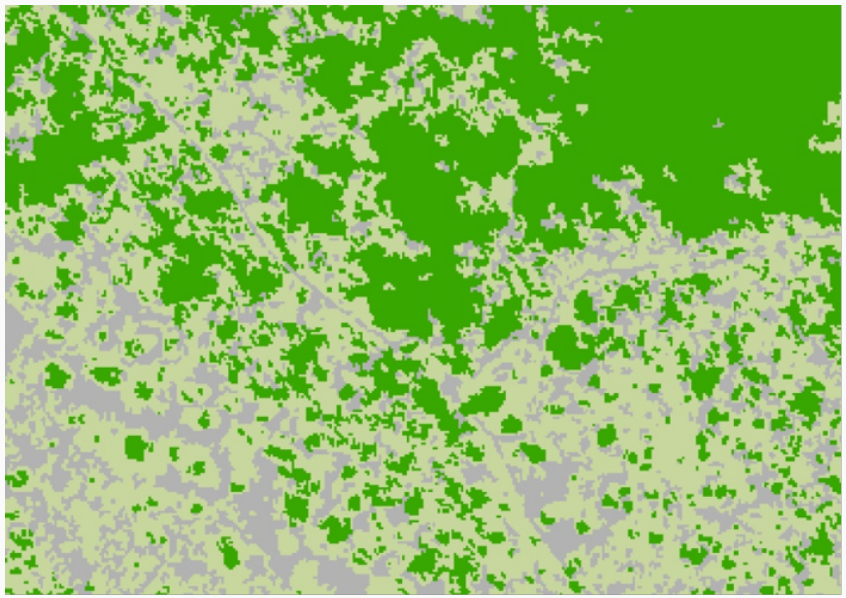

Tree Cover Classification

- Remote sensing analysis led by Stanford Spatial Analysis Center
- Object-Based Image Analysis: Segment image into and classify polygons ("objects") rather than pixels

Overlaying land boundaries

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- Village: Administrative boundaries from Ugandan govt

Household survey

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  - Higher attrition among non-enrollee treated PFOs
  - Likely biases effects away from 0; calculate Lee bounds

Descriptive statistics and baseline balance

	Treatment	Control	Std. diff.
Household head's age	47.499	47.589	0.003
	[13.605]	[14.659]	
Household head's years of education	7.715	7.931	-0.056
	[4.003]	[4.187]	
IHS of self-reported land area (ha)	4.062	4.004	0.053
	[1.021]	[0.968]	
Self-reported forest area (ha)	1.727	2.068	-0.042
	[3.318]	[12.413]	
Cut any trees in the last 3 years	0.845	0.858	-0.031
	[0.362]	[0.350]	
Cut trees to clear land for cultivation	0.236	0.241	-0.016
	[0.425]	[0.428]	
Cut trees for timber products	0.704	0.721	-0.037
	[0.457]	[0.449]	
Cut trees for emergency/lumpy expenses	0.250	0.292	-0.088
	[0.433]	[0.455]	
IHS of total revenue from cut trees	1.238	1.397	-0.085
	[2.118]	[2.248]	
Observations (forest owners)	564	535	
Number of villages	60	61	

Descriptive statistics and baseline balance (continued)

	Treatment	Control	Std. diff.
Rented any part of land	0.163 [0.370]	0.198 [0.399]	-0.091
Dispute with neighbor about land	0.218 [0.413]	0.206 [0.405]	0.035
Involved in any environmental program	0.100 [0.301]	0.111 [0.315]	-0.035
Agree: Deforestation affects the community	0.539 [0.499]	0.548 [0.498]	-0.014
Agree: Need to damage envi. to improve life	0.064 [0.245]	0.043 [0.204]	0.089
Tree cover in land circle (ha)	4.355 [12.466]	3.845 [9.178]	0.050
Weighted tree cover in land circle (ha)	4.403 [11.643]	3.999 [8.252]	0.057
% of land circle with tree cover	0.199 [0.161]	0.209 [0.157]	-0.044
% change in vegetation, 1990--2010	0.035 [0.066]	0.037 [0.058]	-0.016
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Empirical specification

Intent-to-treat analysis

- PFO-level analysis of tree cover

$$TreeCover_{ij} = \alpha + \beta Treat_j + \delta BaselineTreeCover_{ij} + \gamma X_{ij} + \varepsilon_{ijk}$$

- PFO i in village j

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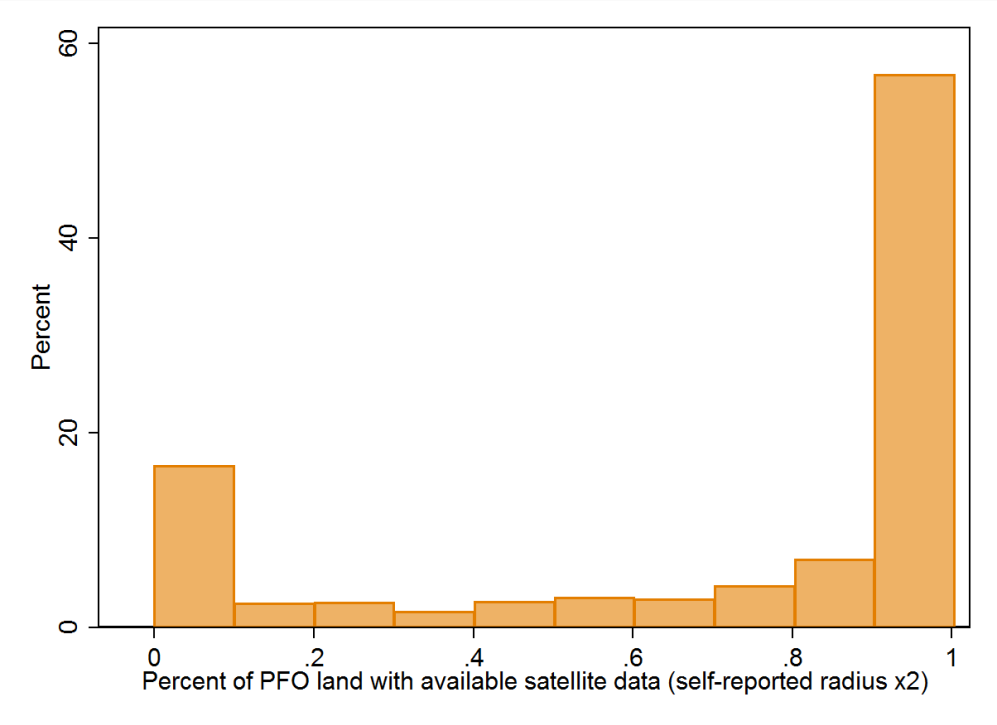
- Cluster standard errors at village level
- Weighted by % of data available for PFO (e.g., cloud-free)

Weight by % of PFO's land with valid forest classification

- We have valid forest data a subset of a PFO's land



98 of 1099 observations are 100% cloud-covered ▸ Sample

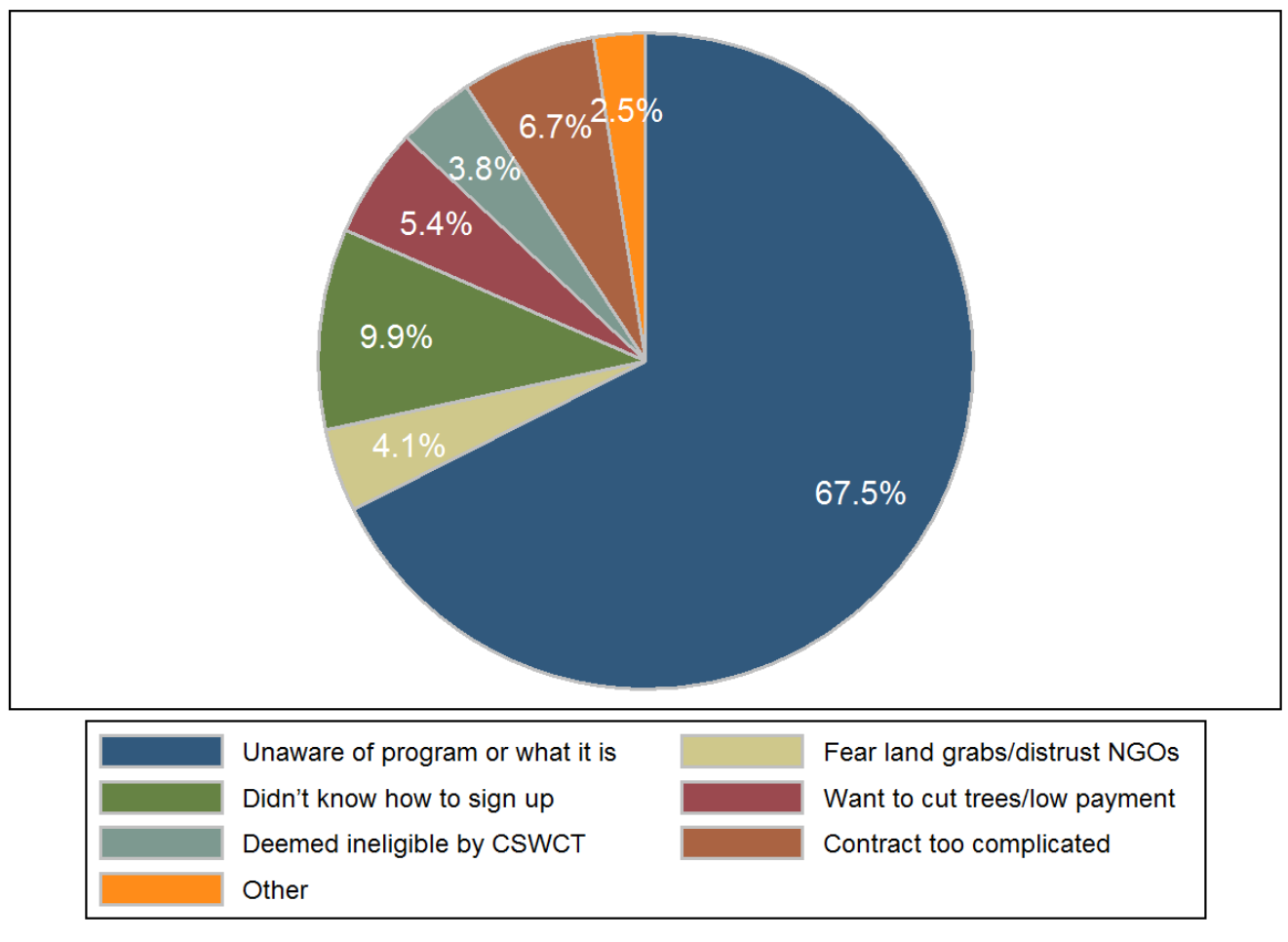
Results

Program take-up

	Take-up	Amount paid	Amount paid for conserva-tion	Proportion of eligible amount paid
	(1)	(2)	(3)	(4)
Treated	0.319***	8.991***	7.962***	0.254***
	[0.030]	[1.862]	[1.799]	[0.026]
Control group mean	0.011	0.416	0.403	0.007
Observations	1,099	1,099	1,099	1,099

- Average payment over 2 years for those who take up: $108
- Compliance rate $>$ 80%

Low take-up mostly for mundane reasons



Take-up uncorrelated with counterfactual deforestation Go

Impacts of PES on tree cover

	PFO-level land circles		
	Tree cover (ha) (1)	Tree cover (ha) (2)	Change in tree cover (3)
Treated	0.246**	0.273**	0.273**
	[0.109]	[0.107]	[0.107]
Baseline outcome	0.998***	1.005***	
	[0.034]	[0.072]	
Control group mean	3.650	3.650	-0.349
Control variables	No	Yes	Yes
Observations	995	995	995

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- Some non-enrollees reported in endline survey that they were enrolled; self-reported take-up exceeds official take-up by 5 ppt
    - Confusion about needing to sign contract to enroll, or mistake by CSWCT (but they were not monitored or paid)

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- Possible effect on village norms, e.g., don't cut trees, allowed to bar others from land

Robustness checks

- No weighting
- Proportional effects (IHS of tree cover)
- Drop outliers
- Land circles that are 1x or 3x land area
- Drop cases where baseline image was after lottery

Shifting of deforestation and spillovers

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  - PFO shifts deforestation from enrolled forest to his other land
  - Two PFOs in village collude and one enrolls
- Use village boundaries to net out spillovers to PFOs not in sample or non-PFOs in village

Village-level effects on tree cover

	Village boundaries	
	Tree cover	Change in tree cover
	(1)	(2)
Treated	4.929*	5.344**
	[2.607]	[2.508]
Baseline outcome	0.960***	
	[0.025]	
Control group mean	155.530	-13.371
Control variables	Yes	Yes
Observations	121	121

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Baseline outcome	0.960***	
	[0.025]	
Control group mean	155.530	-13.371
Control variables	Yes	Yes
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- Can convert PFO-level estimate to village level:
  0.273 ha per PFO $\times$ 12 PFOs in the census per village = 3.27 ha
- Comparable to village-level estimate

Shifting of deforestation and spillovers (continued)

- No evidence of spillovers outside the village, e.g., to govt forest reserves ▸ Table

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- No evidence of spillovers to control group or price effects
- GE effects would be pertinent in scale-up

Heterogeneity in the treatment effects

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- Consistent with
  - Take-up not correlated with (predicted) counterfactual deforestation
  - Enrollees comply with contract

Heterogeneous effects on tree cover

	Heterogeneous treatment effects on tree cover by:	
	Above-median tree cover in land circle (1)	% of land circle with tree cover (2)
Treat × Characteristic	0.469**	1.964**
	[0.200]	[0.927]
Treated	0.021	-0.157
	[0.070]	[0.150]
Characteristic	-0.578***	-3.001**
	[0.199]	[1.176]
Observations	995	995

Heterogeneous effects on tree cover (continued)

	Heterogeneous treatment effects on tree cover by:					
	Cut any trees in the last 3 years	Cut trees to clear land for cultivation	Cut trees for timber products	Cut trees for emergency/lumpy expenses	IHS of total revenue from cut trees	Predicted change in tree cover
	(1)	(2)	(3)	(4)	(5)	(6)
Treat × Characteristic	0.429**	0.032	0.344**	0.408*	0.122***	-0.694**
	[0.171]	[0.133]	[0.167]	[0.220]	[0.043]	[0.295]
Treated	-0.092	0.269**	0.021	0.147	-0.015	-0.006
	[0.138]	[0.119]	[0.126]	[0.091]	[0.081]	[0.086]
Characteristic	-0.329**	0.071	-0.334**	-0.411**	-0.105***	0.523
	[0.131]	[0.116]	[0.139]	[0.196]	[0.038]	[0.352]
Observations	993	995	995	995	993	994

Results using endline survey

- Examine outcomes from endline survey
  - Self-reported tree-cutting
  - Forest access given to others & perceived strength of property rights
  - Economic well-being

Self-reported tree-cutting

	Cut any trees in the last year	Cut trees to clear land for cultivation	Cut trees for timber products	Cut trees for emergency/lumpy expenses	Total revenue from cut trees	IHS of total revenue from cut trees	Any revenue from cut trees in the last year
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Treated	-0.140***	-0.034*	-0.090***	-0.027**	-28.929	-0.232*	-0.041*
	[0.034]	[0.018]	[0.030]	[0.013]	[21.639]	[0.118]	[0.021]
Lee bound (lower)	-0.161***	-0.041**	-0.107***	-0.031**	-31.575	-0.312**	-0.049**
	[0.034]	[0.018]	[0.030]	[0.013]	[22.719]	[0.120]	[0.022]
Lee bound (upper)	-0.104***	0.011	-0.048*	0.021**	5.905**	0.065	0.001
	[0.033]	[0.016]	[0.028]	[0.011]	[2.339]	[0.105]	[0.020]
Control group mean	0.453	0.085	0.339	0.069	32.900	0.823	0.152
Observations	1,018	1,018	1,018	1,018	1,018	1,018	1,018
Observations (Lee bounds)	994	994	994	994	994	994	994

Restricting others' access to land

	Allow others to gather firewood from own forest	Decreased access to others who take trees from forest in last 2 years	Increased level of patrolling the forest in last 2 years	Has any fence around land with natural forest	Claim to ownership of forest became stronger in last 2 years
	(1)	(2)	(3)	(4)	(5)
Treated	-0.170***	0.039	0.109***	0.036	0.071**
	[0.033]	[0.024]	[0.039]	[0.033]	[0.033]
Lee bound (lower)	-0.185***	0.033	0.094**	0.007	0.048
	[0.033]	[0.025]	[0.039]	[0.033]	[0.033]
Lee bound (upper)	-0.148***	0.062**	0.132***	0.055	0.081**
	[0.032]	[0.024]	[0.039]	[0.034]	[0.033]
Control group mean	0.427	0.202	0.378	0.667	0.663
Observations	976	980	984	1,020	999
Observations (Lee bounds)	957	965	965	998	982

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- Program could decrease income if PFOs forgo current income to build up an asset (intact forest)
- Program could increase income if some payment is inframarginal (at least on intensive margin)
- Findings: No appreciable increase or decrease in current economic well-being ▸ Tables

Cost effectiveness

Valuing the CO_2 benefits of the program

Hectares of trees $\rightarrow$ Tons of delayed CO_2

- 0.268 ha per PFO $\rightarrow$ 151 metric tons of delayed CO_2 per PFO

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  - CO_2 molecule weighs 3.67 times as much as C atom

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  - Average time from cutting to emissions is 10 years

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  - Assume treatment PFOs catch up to control group in 4 years (implies tree-cutting delayed by average of 3 years)
  - Average time from cutting to emissions is 10 years
  - 3% discount rate

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- Total program costs: \$0.57 per delayed ton of CO_2
- **CO_2 benefit of \$1.11 $>$ Program cost of \$0.57 per ton**

Cost-benefit ratio under different assumptions

Scenario	Benefit per ton of CO2	Cost per ton of CO2	Cost-benefit ratio
1. Base case: Program effects undone over 4 years	$1.11	$0.57	0.51
2. Program effects accumulate for final 6 months	$1.11	$0.43	0.38
3. Program effects undone immediately	$0.37	$0.57	1.52
4. Deforestation resumes at normal rate (permanent delay)	$0.74	$0.06	0.08
5. Program effects undone over 2 years	$0.74	$0.57	0.76
6. Avg time until emissions is halved to 5 years	$1.17	$0.57	0.48
7. Avg time until emissions doubled to 20 years	$1.00	$0.57	0.57
8. Monitoring rate remains at 1 spot check per day	$1.11	$0.66	0.59

- NB: Not modeling behavioral responses, e.g., price elasticity of demand for charcoal, what fuels consumers substitute toward

Most programs: Cost per ton of averted CO_2 $\gg$ Benefit

Program	*Cost-benefit ratio*
Cash for Clunkers (US)	4 to 13
Cash for Coolers (Mexico)	10
Weatherization Assistance Program	9
Hybrid vehicle tax credits	4.7
Electric vehicle tax subsidy	8 to 24
CAFE fuel standards	5 to 6
Conservation Reserve Program	2 to 6

Sources: Feather et al. (1999); Classen et al. (2008); Knittel (2012); CBO (2012); Gayer and Parker (2013); Jacobsen (2013); Li et al. (2013); Davis et al. (2014); Fowlie, Greenstone, and Wolfram (2015)

Other program costs and benefits

- Benefits
  - Biodiversity (e.g., chimpanzees, butterflies)
  - Water table, siltation
  - Redistribution from rich international donors to Uganda
- Costs
  - Reduced forest access for non-PFOs
  - Increased wealth inequality within villages

Conclusions

- Reducing carbon emissions is a major global priority, but few effective ways have been identified
- Reducing deforestation in developing countries is considered the low-hanging fruit
- PES is a popular approach, but many concerns about whether it actually leads to much gain in forest cover
- Proof of concept: This paper provides evidence of a PES program that seems to have reduced CO_2 emissions cost-effectively

Extra slides

Deforestation included in Paris Agreement in 2015

Article 5

Parties are encouraged to take action to implement and support, including through results-based payments, the existing framework as set out in related guidance and decisions already agreed under the Convention for: policy approaches and positive incentives for activities relating to reducing emissions from deforestation and forest degradation, and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries.

Randomization

- Public lotteries held in each of 7 subcounties
- Generated permutations for each subcounty that divided villages into 2 groups
- Kept permutations that were balanced on covariates
  - # of PFOs; distance to road; income per capita; area of land owned
- Randomly chose 1 permutation for lottery
- Govt official drew one of two "tickets" $\rightarrow$ treatment villages

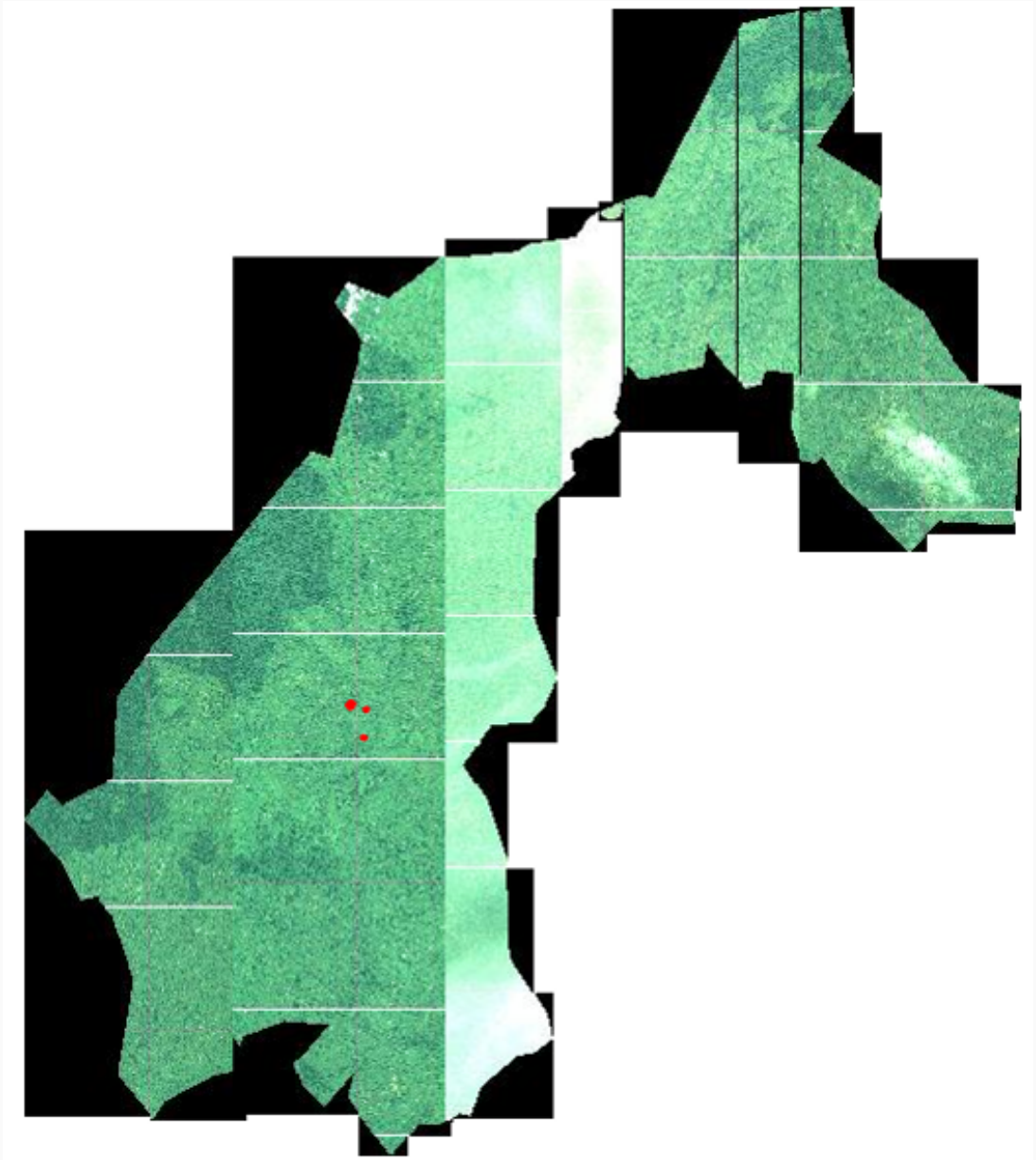
▸ Back to study design ▸ Back to estimating equation

Temporary versus permanent PES programs

- PES payments are a flow payment to refrain from behavior temporarily
- Cost-effective if flow payments are less than flow benefits of delaying CO_2 emissions
- Such a program would likely be run indefinitely
- Two-year program results extrapolate to longer program if opportunity costs and social cost of carbon increase over same time at same rate
- Trickiest conceptual issue with permanent program: Exiting the program should be an absorbing state, but then eligible pool shrinks over time
    - Program could avoid this problem if it valued the carbon stock and conditioned payments on state of the forest

▸ Back

Raw satellite images



Segmentation scale for object-based image analysis

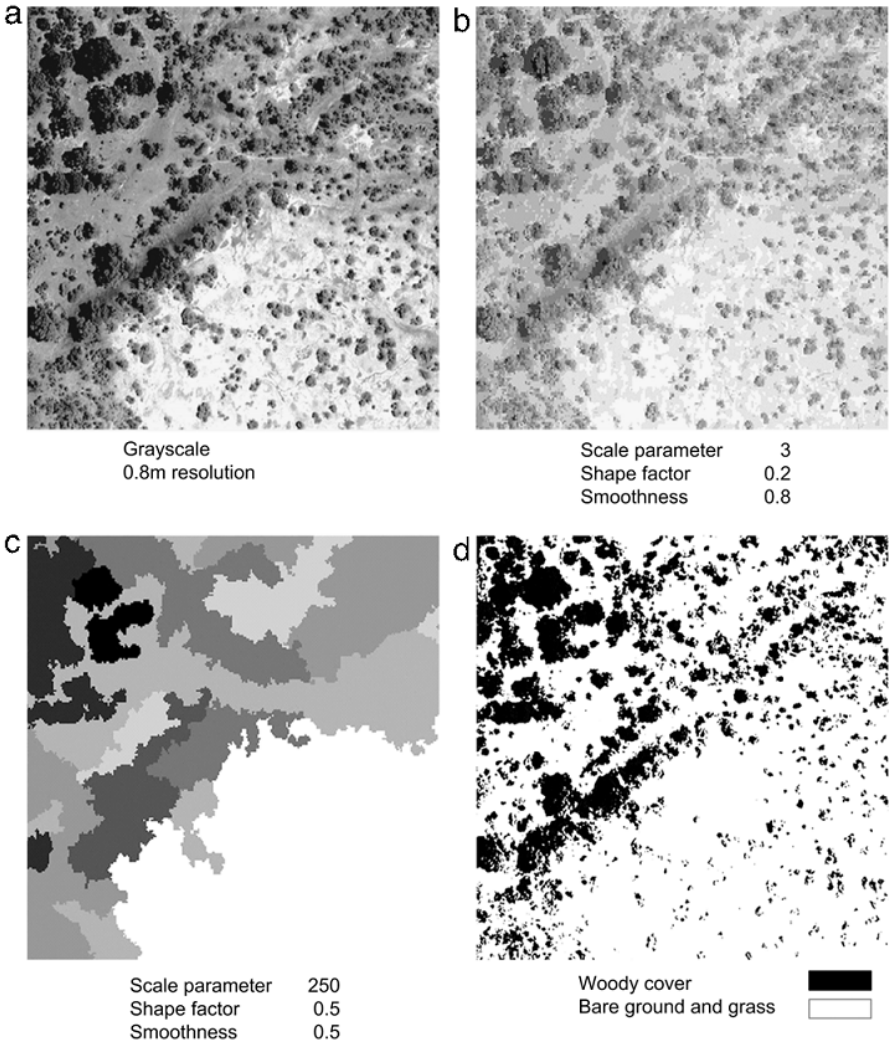
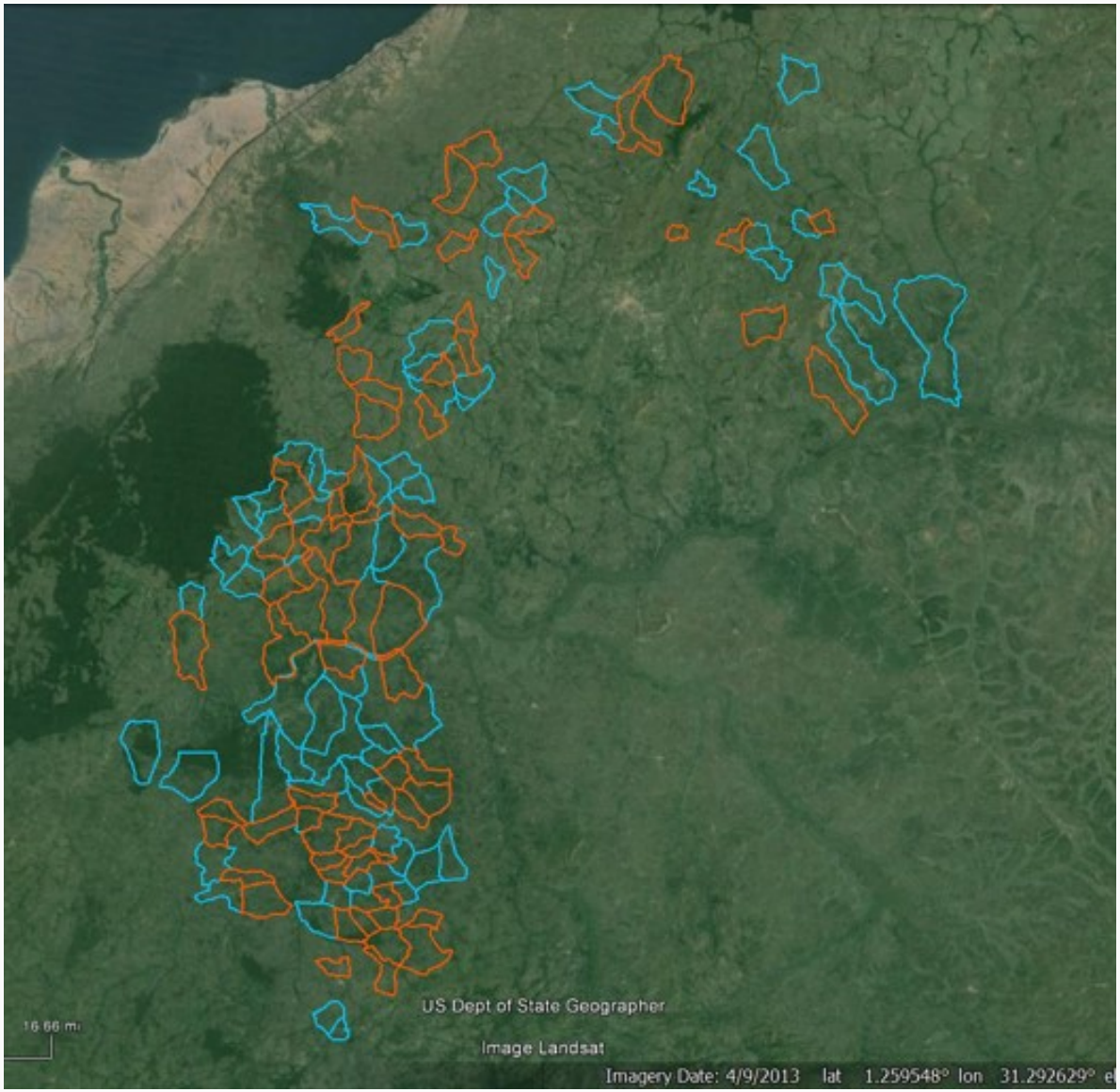


Fig. 2. (a) Aerial photograph of heterogeneous landscape (b) fine scale segmentation (c) coarse scale segmentation (d) object based classification of woody cover, resulting in 97% accuracy (from: Levick and Rogers, 2008, with permission).

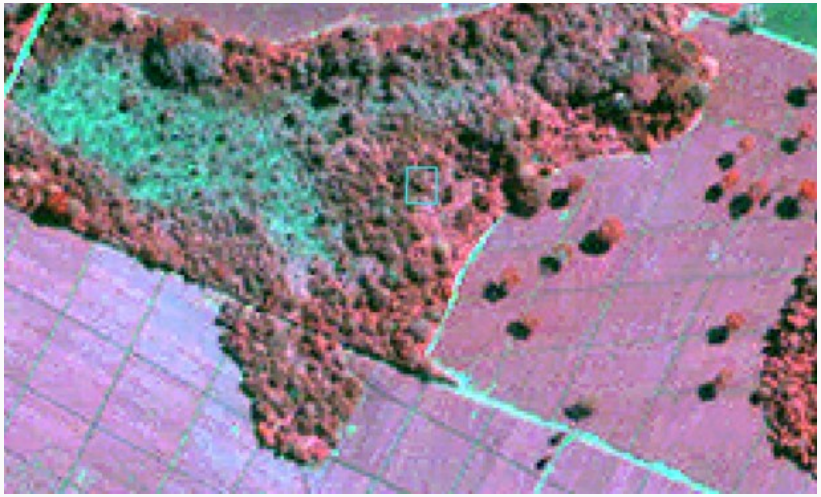
Back

Village boundaries



Ground-based measurements

- Forestry NGO, NAHI, "ground-truthed" the forest classification
- Gave them about 440 GPS points, randomly chosen, stratified by initial land classification
- Use their data to validate image classification



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Ground-based measurements

- Plot level measurements (20m by 25m)
- Count all trees
- Measure diameter at breast height (DBH) of the largest trees
- Estimate tree height and crown diameter
- Identify tree species

Back

PFO land boundaries (available for selected sample)

- Conducted land mapping *after* randomization
- Initially local partner NAHI was going to do this
- Using handheld GPS units did not work as a technique
  - Not accurate enough
  - Cloud cover worsened accuracy
- Instead: Loaded baseline images onto netbooks and traced boundaries manually in the field
- Problem: In treatment villages, those who did not sign up for the program differentially select out of land mapping
- Overestimate program impacts because tree-cutting PFOs are missing from treatment group

Conducting the land mapping

Back

Boundaries marked by walking the land

Back

Sample size and attrition

	Number of PFOs		
	Treatment group	Control group	Total
Baseline survey (with GPS location of PFO home)	564	535	1,099
Baseline survey and satellite land circle	508	487	995
HH reports owning no land	2	3	5
Didn't report land area	0	1	1
Entire land circle has cloud cover	54	44	98
Baseline survey and endline survey	512	508	1,020
Baseline survey, satellite land circle, and endline survey	463	464	927

▶ Back to survey sample ▶ Back to remote sensing sample

Correlates of attrition

	All PFOs	PFOs with missing satellite data	PFOs with missing endline data	Std. diff. (1-2)	Adj. std. diff. (1-2)	Std. diff. (1-3)
	(1)	(2)	(3)	(4)	(5)	(6)
Household head's age	47.543	47.500	44.671	0.035	-0.070	0.207*
	[14.122]	[13.555]	[14.772]			
IHS of self-reported land area (ha)	4.034	3.543	3.804	0.540***		0.253*
	[0.996]	[1.348]	[1.165]			
Self-reported forest area (ha)	1.893	1.213	1.197	0.072*	-0.088	0.078**
	[8.978]	[2.500]	[1.450]			
Cut any trees in the last 3 years	0.851	0.760	0.772	0.273**	0.165	0.271**
	[0.356]	[0.429]	[0.422]			
IHS of total revenue from cut trees	1.315	1.030	1.086	0.094	-0.010	0.135
	[2.183]	[2.176]	[1.992]			
Involved in any environmental program	0.106	0.071	0.013	0.148*	0.103	0.335***
	[0.307]	[0.259]	[0.114]			
Treated	0.513	0.538	0.658	-0.072	-0.098	-0.324***
	[0.500]	[0.501]	[0.477]			
Take-up	0.319	0.250	0.154	0.171	0.124	0.306*
	[0.467]	[0.437]	[0.364]			
Observations	1,099	104	79			

▶ Back to survey sample ▶ Back to remote sensing sample

Baseline correlates of program take-up

	Take-up (1)	Take-up (2)
IHS of self-reported land area (ha)	0.059**	
	[0.024]	
Cut trees for emergency/lumpy expenses	-0.099**	
	[0.040]	
Agree: Need to damage envi. to improve life	-0.200***	
	[0.068]	
Tree cover in land circle (ha)	-0.003**	
	[0.001]	
Predicted change in tree cover		-0.024
		[0.034]
Observations	564	564

Back

Forest cover results: Proportional impacts

	PFO-level land circles		
	IHS of tree cover	IHS of tree cover	Change in IHS of tree cover
	(1)	(2)	(3)
Treated	0.038	0.044*	0.044*
	[0.024]	[0.023]	[0.023]
Baseline outcome	0.982***	0.940***	
	[0.006]	[0.015]	
Control group mean	2.866	2.866	-0.073
Control variables	No	Yes	Yes
Observations	995	995	995

IHS = Inverse hyperbolic sine function, $f(x) = \ln(x + \sqrt{x^2 + 1}) \approx \ln(x) + \ln(2)$

▶ Back

Forest cover results: Dropping outliers & using equally-sized land circles

	PFO-level land circles (dropping top 1%)			PFO-level land circles (median-sized)		
	Tree cover	Tree cover	Change in tree cover	Tree cover	Tree cover	Change in tree cover
	(1)	(2)	(3)	(4)	(5)	(6)
Treated	0.196**	0.206**	0.240**	0.115**	0.138***	0.147**
	[0.088]	[0.081]	[0.097]	[0.052]	[0.051]	[0.056]
Baseline outcome	0.898***	0.833***		0.898***	0.877***	
	[0.026]	[0.042]		[0.027]	[0.028]	
Control group mean	3.239	3.239	-0.336	2.112	2.112	-0.209
Control variables	No	Yes	Yes	No	Yes	Yes
Observations	986	986	986	1,002	1,002	1,002

▶ Back

Forest cover results: Unweighted results

	PFO-level land circles		
	Tree cover	Tree cover	Change in tree cover
	(1)	(2)	(3)
Treated	0.183*	0.213**	0.215**
	[0.099]	[0.095]	[0.098]
Baseline outcome	1.004***	1.007***	
	[0.034]	[0.067]	
Control group mean	3.526	3.526	-0.319
Control variables	No	Yes	Yes
Observations	995	995	995

Back

Forest cover results: Alternative land circle sizes

	PFO-level land circles (x1)			PFO-level land circles (x3)		
	Tree cover	Tree cover	Change in tree cover	Tree cover	Tree cover	Change in tree cover
	(1)	(2)	(3)	(4)	(5)	(6)
Treated	0.140**	0.155**	0.155**	0.330**	0.363***	0.357***
	[0.067]	[0.066]	[0.065]	[0.139]	[0.134]	[0.136]
Baseline outcome	1.021***	1.013***		0.962***	0.971***	
	[0.062]	[0.094]		[0.017]	[0.042]	
Control group mean	1.758	1.758	-0.173	5.618	5.618	-0.539
Control variables	No	Yes	Yes	No	Yes	Yes
Observations	973	973	973	1,008	1,008	1,008

Back

Forest cover results: Drop cases with baseline after lottery

	PFO-level land circles			Village boundaries	
	Tree cover	Tree cover	Change in tree cover	Tree cover	Change in tree cover
	(1)	(2)	(3)	(4)	(5)
Treated	0.300**	0.407***	0.406**	8.050***	8.148***
	[0.144]	[0.143]	[0.154]	[2.808]	[2.678]
Baseline outcome	0.944***	0.833***		0.990***	
	[0.032]	[0.061]		[0.024]	
Control group mean	4.095	4.095	-0.459	172.841	-16.576
Control variables	No	Yes	Yes	Yes	Yes
Observations	580	580	580	78	78

Back

Program effects on reforestation

	Took up reforestation option	Reforestation area	Total trees planted	Total trees survived
	(1)	(2)	(3)	(4)
Treated	0.149***	0.101***	31.007***	9.813***
	[0.018]	[0.016]	[3.556]	[1.555]
Control group mean	0.002	0.001	1.710	0.933
Observations	1,099	1,099	1,099	1,099

▶ Back

CO_2 impacts of reforestation

- Mature tree absorbs about 20 kilograms (0.02 ton) CO_2 per year
- Newly planted trees absorb considering less, e.g., 4 kilograms, so \$0.156 of benefit per year
- Treated PFOs planted 10 surviving trees each, so \$1.56 of CO_2 benefit per year
- Paid about 5000 UGX = \$2 per year
- Per PFO, CO_2 benefit of the program was 10 trees * 0.004 kg * 2 years = 0.08 tons of CO_2
- As comparison, averted deforestation from program was 150.7 tons per PFO

Seedlings provided by CSWCT

Back

Leakage to govt forest reserves & effect of being nearer to treatment villages

	Tree cover (1)	Tree cover (2)	Tree cover (3)
Treated	0.202	0.313***	
	[0.241]	[0.112]	
Treat × Distance to forest reserve	0.009		
	[0.035]		
Treat × Contiguous to forest reserve		-0.338	
		[0.339]	
# of treatment villages within 5km			0.019
			[0.039]
Sample	All	All	Control group
Observations	995	995	487

▸ Back

Visits from timber dealers

	Get visits from timber dealers	Increase in timber dealer visits last 2 years
	(1)	(2)
Treated	0.020	-0.016
	[0.034]	[0.025]
Observations	1,020	1,020

Back

Role of expectations

- Expectations about the future of the PES program might affect PFOs' behavior
- We told the truth: No plans/funds for expansion but the study results could bring in funds, but not in near future
- Control PFOs: Might change their behavior in either direction
  - Deforest more now before it entails a financial penalty
  - Deforest less so forest is intact and eligible for PES
- Treated PFOs: If thought program was permanent (high continuation value), this could increase enrollment/compliance
- Endline survey asked questions about expectations
  - Control group: Is program coming to your village?
  - Treatment group: How long does program last?
- Expectations do not seem to affect deforestation ▸ Table

How deforestation is correlated with expectations

	Tree cover (1)	Tree cover (2)
Believes program likely to come to village	0.076	
	[0.075]	
Believes program ends in 2015 or later		-0.118
		[0.112]
Sample	Control group	Treatment group
Observations	487	508

Back

Economic outcomes

	IHS of food expend. in last 30 days	IHS of non-food expend. in last 30 days	IHS of alcohol/tobacco expend. in last 30 days	9-step income ladder
	(1)	(2)	(3)	(4)
Treated	0.065	0.156**	-0.010	0.214*
	[0.074]	[0.066]	[0.062]	[0.114]
Lee bound (lower)	-0.029	0.053	-0.072	0.070
	[0.070]	[0.064]	[0.060]	[0.113]
Lee bound (upper)	0.144*	0.215***	0.090	0.432***
	[0.075]	[0.064]	[0.059]	[0.110]
Control group mean	2.524	4.363	0.613	4.034
Sample	Households	Households	Households	Households
Observations	1,020	1,020	1,020	1,016
Observations (Lee bounds)	998	998	998	994

Economic outcomes

	Has outstanding loan or repaid a loan in past year (1)	Child was sick with malaria in last 30 days (age 0-15) (2)	Child was sick with diarrhea in last 30 days (age 0-5) (3)
Treated	-0.009	-0.031	-0.064**
	[0.024]	[0.029]	[0.032]
Lee bound (lower)	-0.049**	-0.105***	-0.118***
	[0.023]	[0.029]	[0.033]
Lee bound (upper)	0.010	0.042	0.034
	[0.024]	[0.030]	[0.030]
Control group mean	0.770	0.401	0.202
Sample	Households	Children	Children
Observations	1,019	2,266	498
Observations (Lee bounds)	996	2,145	470

▶ Back