





Integrating social and land-use/land-cover data to assess the success of community-based conservation goals for riparian forest conservation

A study of the Community Baboon Sanctuary, Belize

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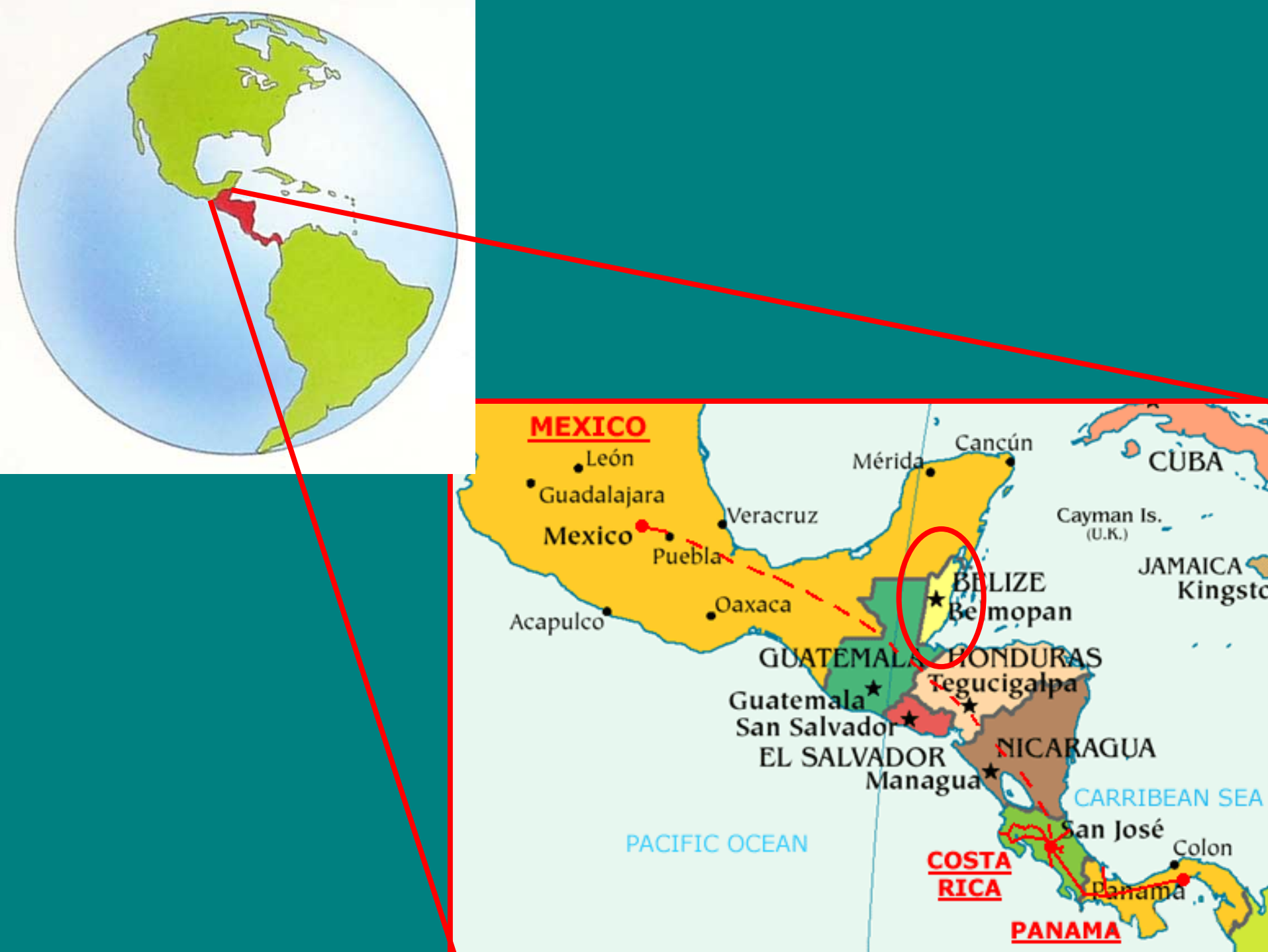
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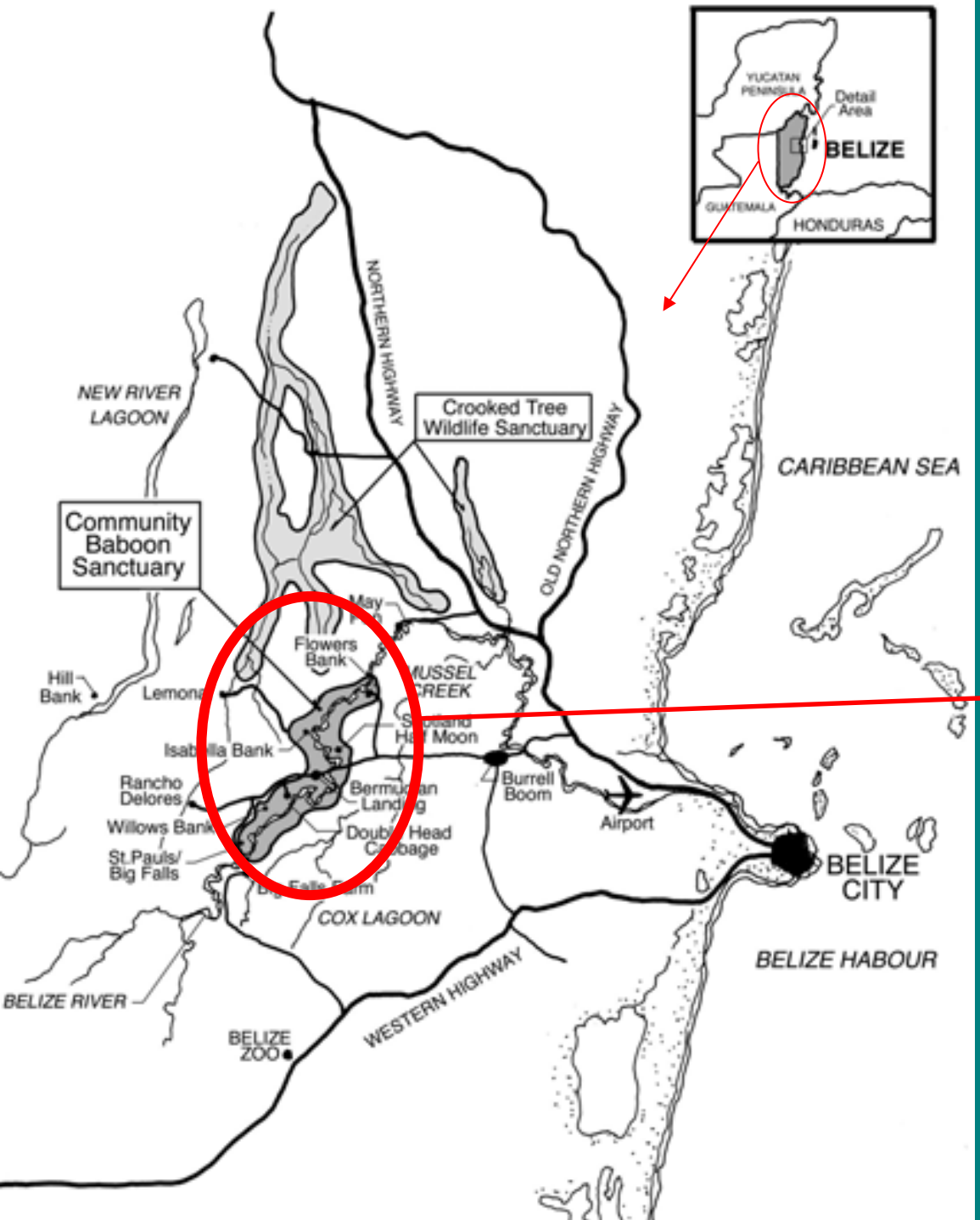
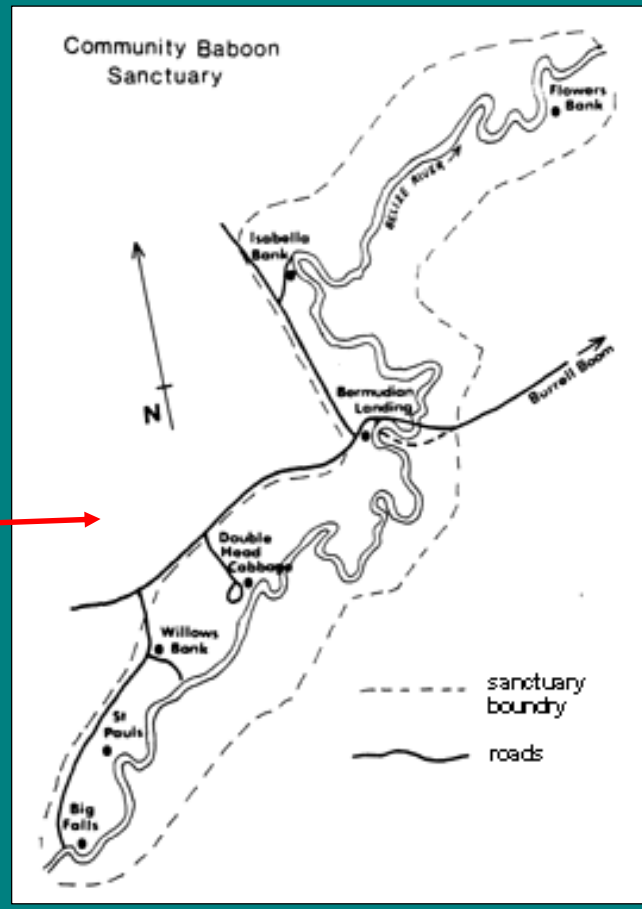




Map Credit: Horwich and Lyon, 1998

Impetus for the CBS = protect black howler monkey (*Alouatta pigra*)

LOCATION:

Black howler monkeys are found only in low altitude areas under 1,000 ft. (300m) above sea level, and primarily in riparian / riverine forests.

- CBS established in 1985
- Area identified as one of few healthy populations left in Meso-America
- Importance of riparian forests for “baboons”

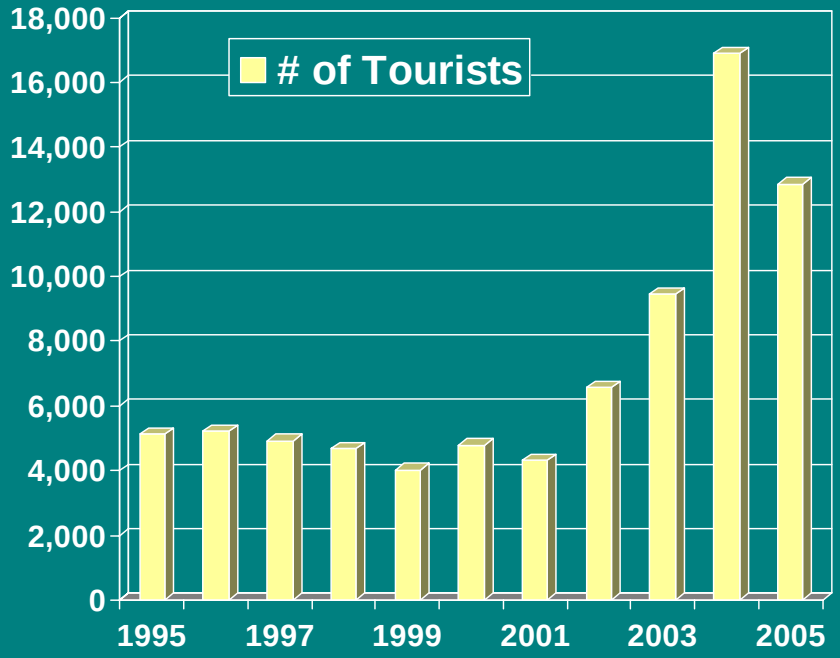






Conservation Initiatives:

1. Nature Based Tourism (howler monkey)



Conservation Initiatives:

2. Pledge (voluntary, written)

Residents agree to:

- not clear forest along the river (if applicable)
- leave strip of trees along property boundaries

Pledge and money

- Pledge not initially linked with any financial compensation (e.g. tourism, or grant $)
- CBS records indicate that pledged landowners have been paid twice (1998 and 2000, ~$125) but currently no landowners paid to pledge
- Interviews show that from earlier payment and recognition of tourism $ coming into the CBS, pledged landowners expect to be paid

Reality now associates the pledge with financial compensation







Sample

- 131 residents interviewed within 7 villages (approx. 20 households per village / 60% of pop.)
- Stratified Sample (Tourism & Pledged Residents)
  - 26 Tourism (~ 50 total)
  - 51 Pledged (~ 75 total)
- Other residents (non-tourism / pledged) randomly selected (N= 54)


Unique Attributes

CBS population

- 220 households (approx. 1150 people)
- 7 Creole villages
- Private landholdings / Govt. lease (50%)
- 4800 ha **(my study = 8703.54 HA)**

Main economic activities

(131 household interviews = 60% of CBS)

- 85 households (65%) = outside employment (Belize City)
- Small-scale agriculture (slash and burn milpa for home consumption)
- Small-scale cattle raising
- Nature-based tourism (primarily in Bermudian Landing)
- 45 households receive remittances (34%)

Remittances:

Out of 131 households interviewed
- 45 families (34%) received remittances

- 7 households depended on remittances as their only form of monetary income

- 4 households who also received remittances, also sold some livestock as their only other form of monetary income,

Total Income from HH who get remittances	BZE	USD	% of total
Total wage income	163,073	81,536.5	
remittances	95,850	47,925	28.5%
total other income (non-remittances)	76,939	38,469.5	
TOTAL	**335,862**	**167,931**	







Research Questions and Objectives I:

1. How has the CBS landscape changed?

- Forest cover change of the CBS and 500 meter river buffer
- 1989 – 2004 (15 year time period)

2. Is there a difference in riparian forest cover between residents?

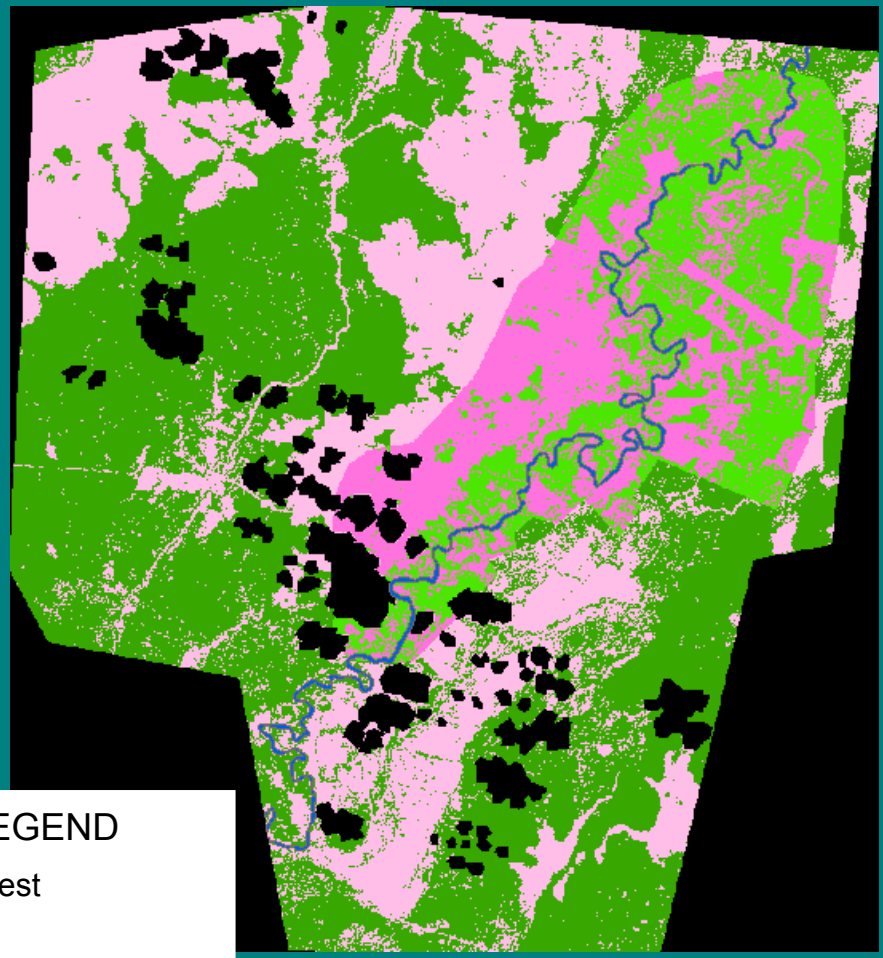
- LULCC change detection 90 m river buffer
- Pledged vs. Non-pledged residents
- 1989, 1994, 2000, 2004

Spatial Methods

- Satellite images:
  - Landsat MS: 1989, 1994, 2000
  - Landsat ETM+ 2004

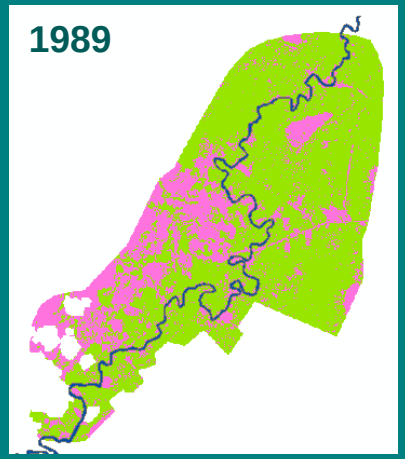
Change Detection Analysis

- Classified images (Forest and Non-forest)
  - Training samples from the field (for 2004 image)
  - Signatures, NDVI, thermal band (for other images)

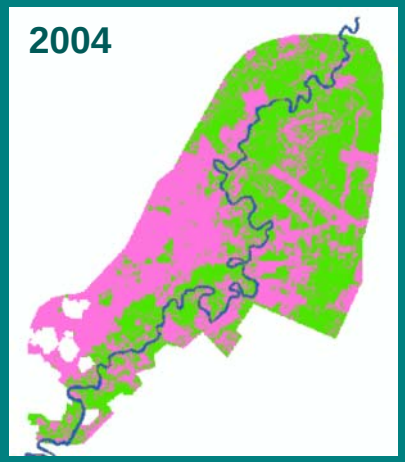


RESULTS

Analysis I: CBS Landscape



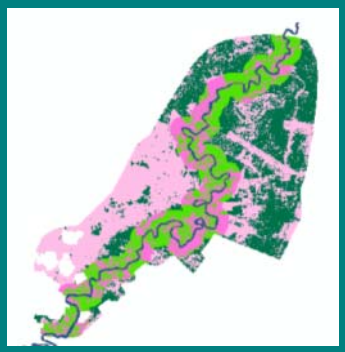
1989	Total Area	% Land
Forest	6167.79 Ha	70.87%
Non-Forest	2535.75 Ha	29.13%
Total	**8703.54 Ha** **21758.85 Acre**	

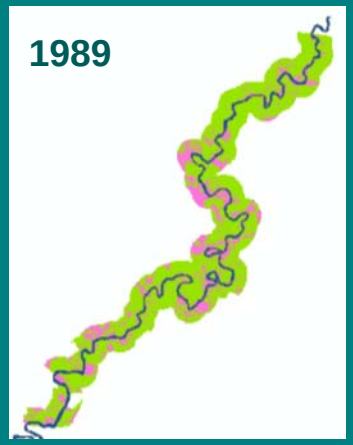


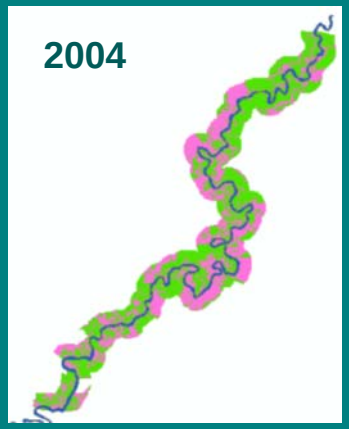
2004	Total Area	% Land
Forest	4144.05 Ha	47.61%
Non-Forest	4559.49 Ha	52.39%
Total	**8703.54 Ha** **21758.85 Acre**	

RESULTS

Analysis II: 500 meter river buffer







1989	Total Area (Ha)	% Land
Forest	2231.37 Ha	74.34%
Non-Forest	770.4 Ha	25.66%
Total	**3001.77 Ha** **7504.43 Acres**	

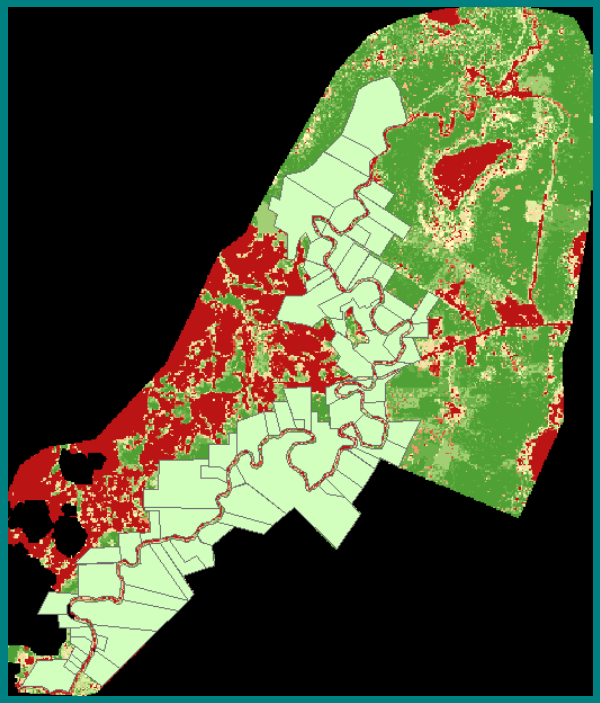
2004	Total Area (Ha)	% Land
Forest	1520.01 Ha	50.64%
Non-Forest	1481.76 Ha	49.36%
Total	**3001.77 HA** **7504.43 Acres**	

Part 2:
Pledged Residents and River Forest Conservation

Question:

Is there a difference in river forest cover between residents?

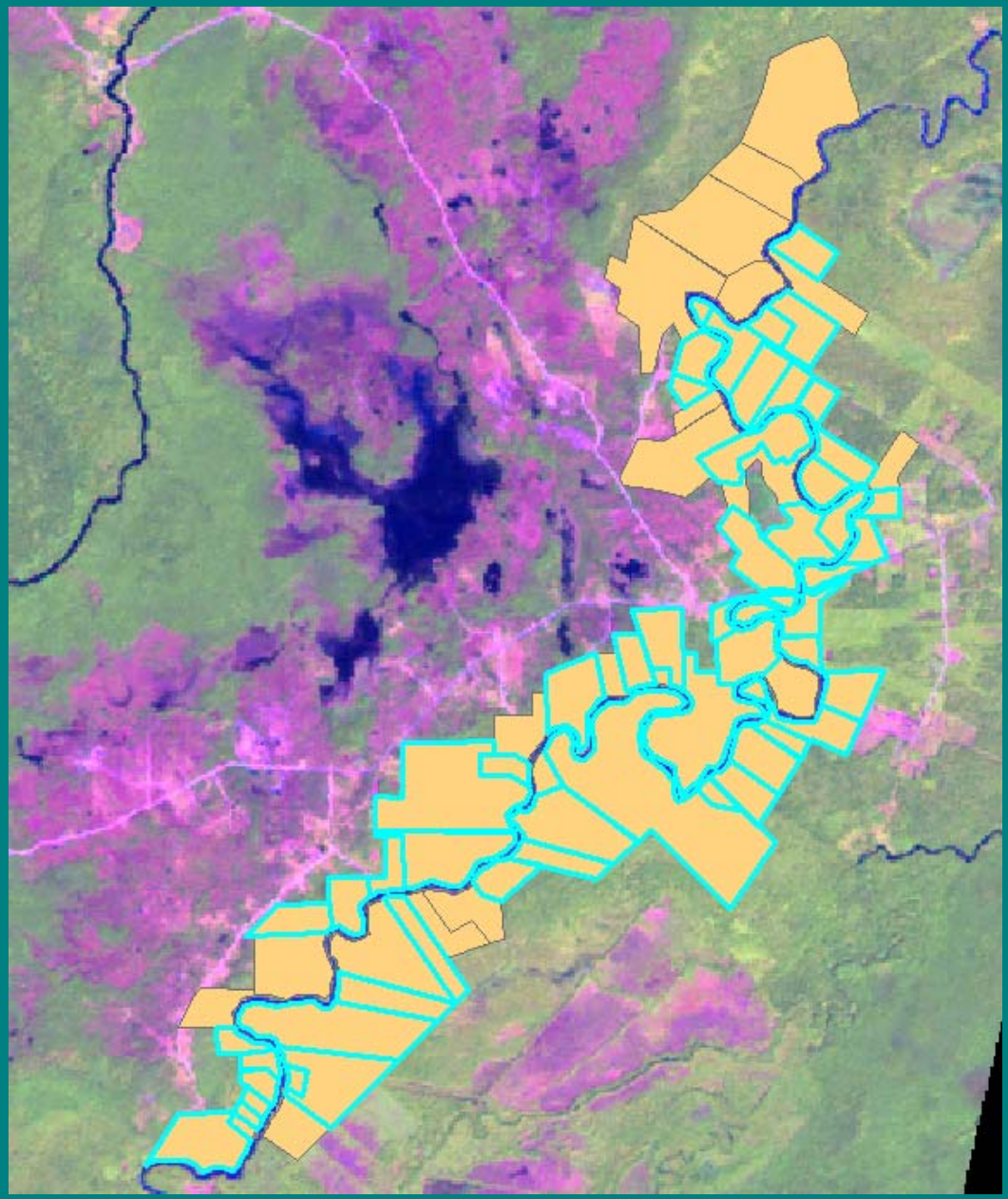
- Examine pledged and non-pledged residents with river property
- 90 m (295 feet) river buffer
- Satellite images for the years: 1989, 1994, 2000, 2004



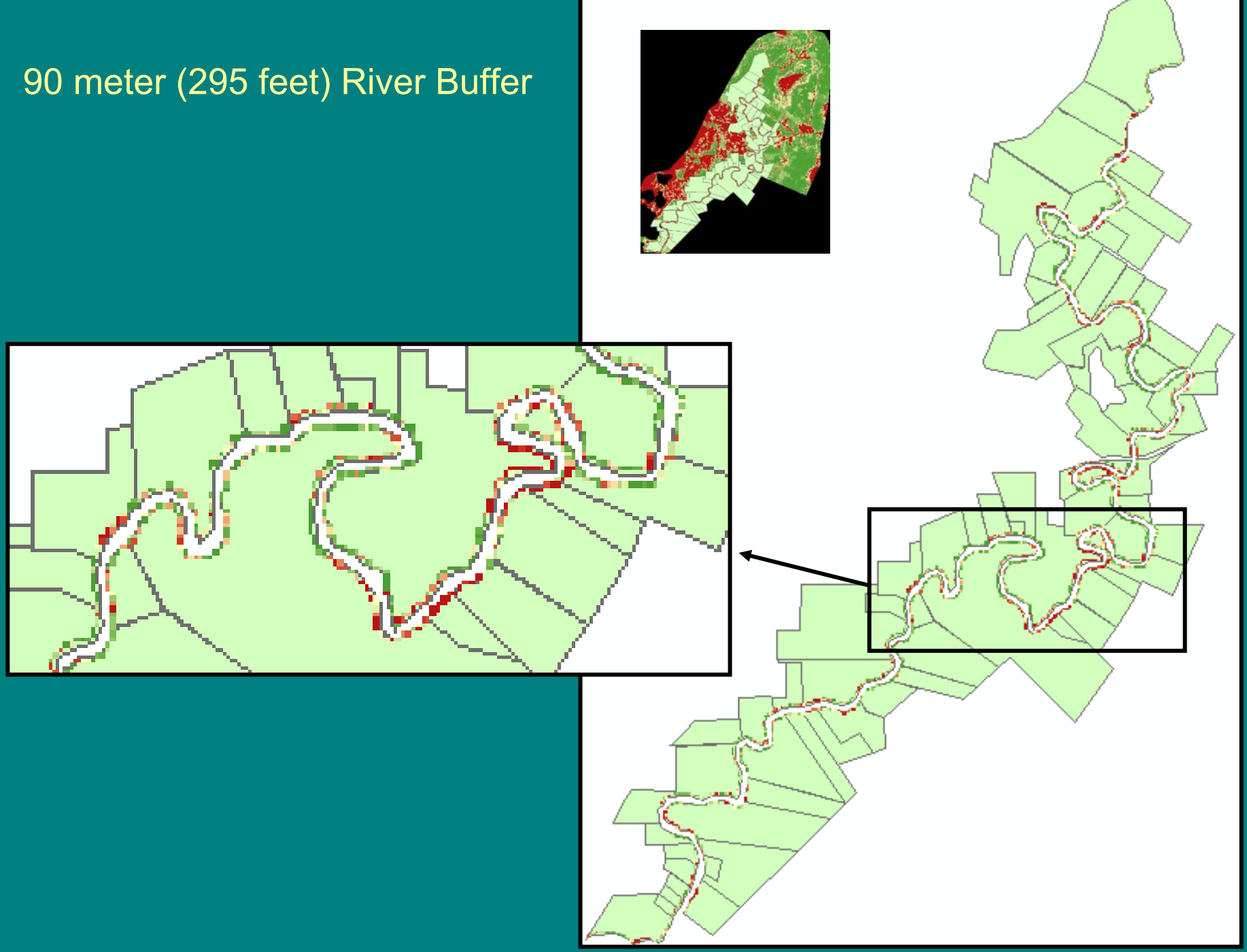
River owners = 77

Residents

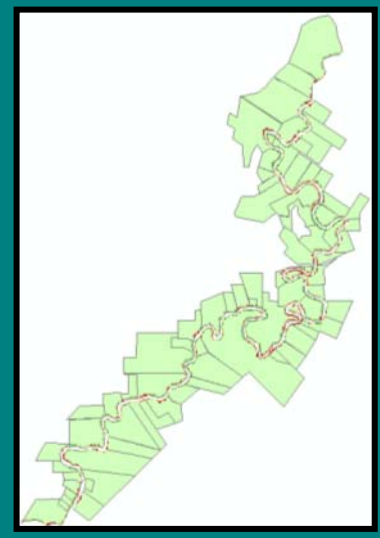
- Pledged = 53
- Non-Pledged = 24



90 meter (295 feet) River Buffer



Methods:



Forest cover change over 2 different years:
1989 – 1994
1994 – 2000
2000 – 2004
1989 – 2004

Four Change Possibilities:
Forest – Forest (F-F): it was forested and remained forested
Forest – Non-Forest (F-NF): it was forested but later deforested
Non-Forest – Forest (NF-F): it was non-forested and then grew back
Non-Forest – Non-Forest (NF-NF): it was non-forested and stayed non-forested

What we might expect…
1. We would expect to find P > NP property in the F-F trajectory.

2. We would expect to find NP > P property in the NF-NF trajectory

Methods:

Analysis

compared how the average proportion of land (90 m river buffer) within four change trajectories (F-F, F-NF, NF-F, NF-NF) differed between pledged and non-pledged landowners

Result:

No statistically significant difference between pledged and non-pledged landowners for any of the 4 change trajectories

Conclusion

The pledge has not been an effective conservation tool

Main threats to Howler habitat (within the CBS):

1. CATTLE

Main threats to Howler habitat:

2. AGRICULTURE

Main threats to Howler habitat:

3. URBAN GROWTH / DEVELOPMENT

Why is the Pledge not successful at promoting conservation and protecting riverside forest cover for the howler monkey?

Pledging:

- Other research I am analyzing shows that people involved in the pledge place higher values towards river forests and conservation but these *intangible* benefits may not be enough

Use of riverside economically important:

- Cattle, Farming, Development, etc.
- Unless people have tangible benefits of pledging, they probably cannot afford to do so.
- Considering CBS tourism figures, a percentage of this income could be allocated for pledged residents







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CIFOR (PEN)
Poverty Environmental Network Project







Special Thanks to: Mandy Bailey Comstock (research assistant)

Questions?



COHUNE

(Orbignya cohune)





CASHEW

The Faces of the Community Baboon Sanctuary

Why 90 m river buffer and not 30 m?

- Addressing the possibility for measurement error

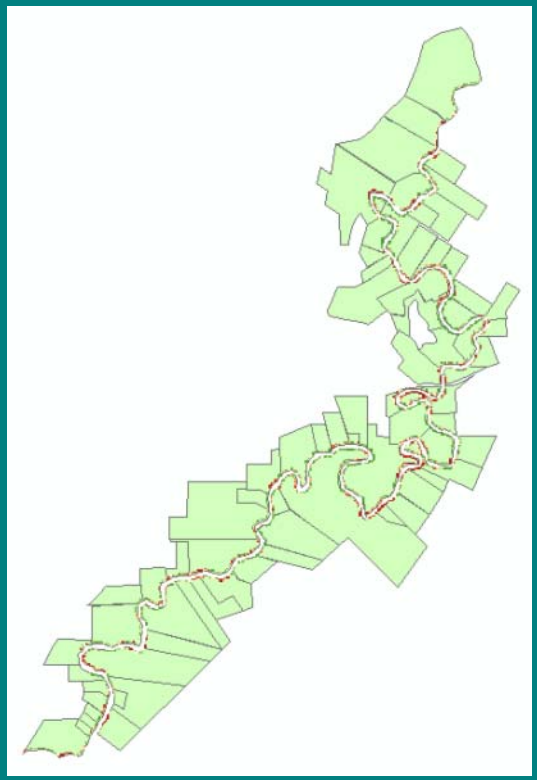
- Law in Belize to not clear 66 feet from river's edge (~20 meters)
- Each pixel is 30 m x 30 m (30 m seems an appropriate distance)
- However, there is the possibility of measurement error and so I was encouraged (both from remote sensing professor and from a review of the literature) to do this assessment at 90 m to account for imagery accuracy issues
- Similar results for 30 m, 60m, and 90m

Interview Set-up

- I asked all households involved in nature-based tourism and the pledge to be involved in the interviews (a stratified sample).

- I then assigned numbers to all other village households (those not involved in tourism or the pledge) and entered these numbers into an Excel spreadsheet (computer program) and ran a random ordering of the numbers.

- My goal was to get at least 30 households per village. I went through this list of house numbers until I had 30 agreed participating households in every village. In villages where total household numbers were less than 30, I asked every household to participate.



90 meter (295 feet) River Buffer Forest Cover Change

Forest (HA)	1989	1994	2000	2004
	453.42	333.63	385.02	329.94
Forest Cover Change	**HA**		**% landscape**	**% change**
1989 – 1994	- 119.79	Decrease	70% → 51%	- 18%
1994 – 2000	+ 51.39	Increase	51% → 59%	+ 8%
2000 – 2004	-55.08	Decrease	59% → 51%	- 8%
1989 - 2004	- 123.48	Decrease	70% → 51%	- 19%

NDVI

In addition to a change detection analysis, a NDVI (normalized difference vegetative index) was conducted on landowner properties within the 90 meter buffer.

- NDVI = a ratio between the red and near-infrared bands
- an estimate of vegetation greenness and is commonly used for assessing overall green biomass for tropical dry forests
- accounts for more subtle changes in vegetation growth that a change detection analysis would miss (seasonal and inter-annual changes in vegetation growth and activity)

For Landsat images, NDVI uses the following equation: NDVI = Band 4 − Band 3 / Band 4 + Band 3 and produces values ranging from –1.0 to +1.0.

- Negative NDVI values indicate non-vegetated surfaces (e.g., water, sand).
- Positive NDVI values indicate green, vegetated surfaces with higher values signifying increases in green vegetation.

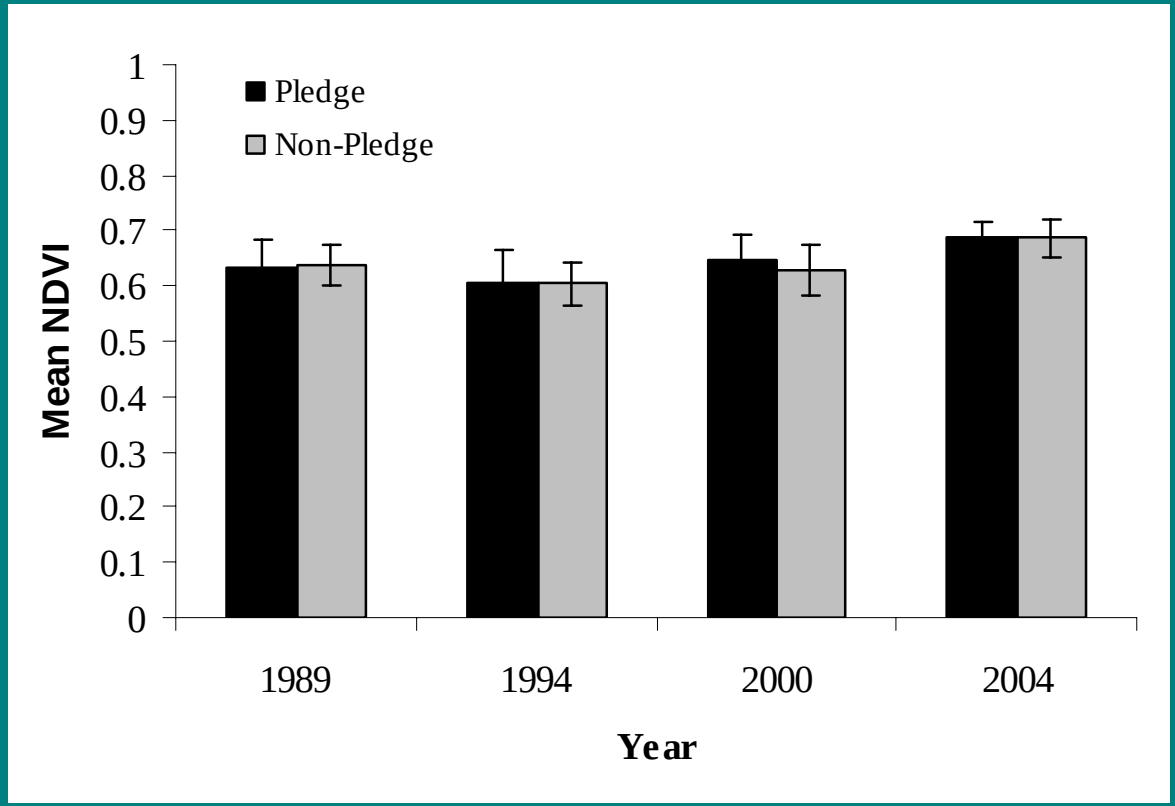
NDVI was conducted on the 90 m river buffer between P and NP landowners

- tested whether mean NDVI values differed between P and NP over time using a two factor (pledge, year, pledge*year) repeated measures ANOVA on ranked NDVI values ($\alpha = 0.05$) with individual landowners as the subjects in the analysis.
- The analysis was conducted on ranked data because the data were skewed and no transformation achieved normality.

NDVI Results

Pledged landowners had slightly higher mean NDVI values than non-pledge landowners in 1994, 2000, and 2004 (Figure 3-5). However, two factor repeated measures ANOVA indicated that NDVI values did not differ significantly between pledged and non-pledged landowners ($p = 0.405$), among years ($p = 0.904$), nor was there a pledge*year interaction ($p = 0.362$).

NDVI values (means) within the 90 m buffer between pledged and non-pledged residents.



Change Detection Analysis results (P vs. NP)

Mean proportion of property within 90 meter river buffer between pledged and non-pledged landowners.

1989 – 2004 2-yr trajectories

1989 – 1994	F, F	F, NF	NF, F	NF, NF
Trajectory	**1**	**2**	**3**	**4**
p-value	0.73	0.98	0.64	0.25
Pledge	0.38	0.32	0.06	0.24
Non-Pledge	0.35	0.30	0.06	0.29

1994 – 2000	F, F	F, NF	NF, F	NF, NF
Trajectory	**1**	**2**	**3**	**4**
p-value	0.47	0.77	0.41	0.30
Pledge	0.32	0.12	0.26	0.30
Non-Pledge	0.28	0.13	0.24	0.35

2000 – 2004	F, F	F, NF	NF, F	NF, NF
Trajectory	**1**	**2**	**3**	**4**
p-value	0.20	0.87	0.78	0.24
Pledge	0.38	0.21	0.14	0.28
Non-Pledge	0.31	0.21	0.15	0.33

1989 - 2004	F, F	F, NF	NF, F	NF, NF
Trajectory	**1**	**2**	**3**	**4**
p-value	0.18	0.40	0.52	0.40
Pledge	0.43	0.28	0.09	0.21
Non-Pledge	0.33	0.32	0.12	0.22

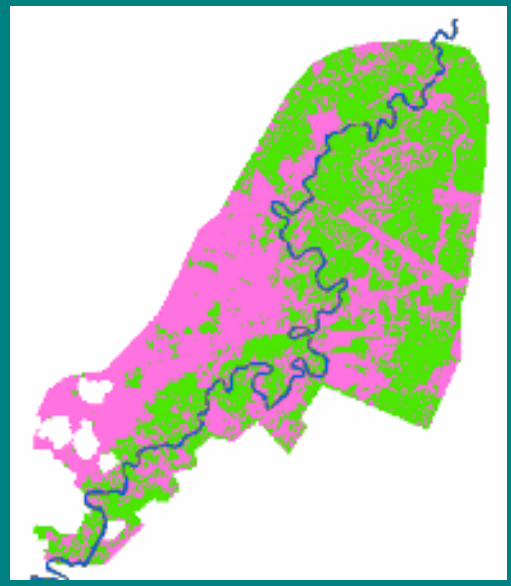
Result Summary

Part 1: CBS Forest Cover Change

CBS Landscape

Deforestation within 15 year time period (1989 – 2004)

- 23.36% decrease in CBS forest cover
- 23.70% decrease in 500 meter river buffer



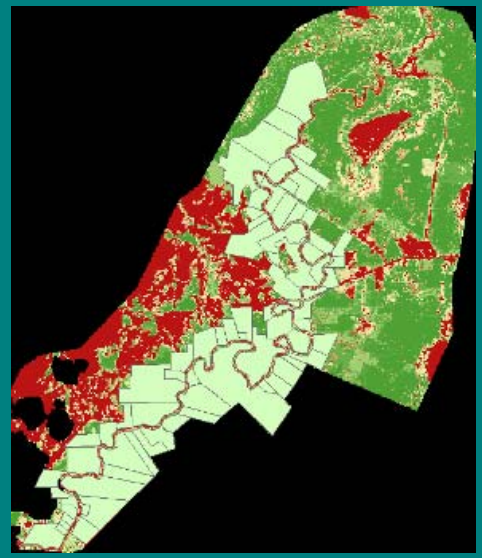
Result Summary

Part 2: Pledged Residents and River Forest Conservation

90 meter (295 feet) river buffer

- No statistically significant difference between pledged and non-pledged residents with protection of riverside forest

The Pledge is not effective in protecting river forest



CBS Forests

The CBS villages are located in the climatic region of north-central Belize classified as lowland, semi-deciduous rainforest

As is the case of the majority of forests in Belize, the forests of the CBS have been periodically logged for some 300 years.

Most of the area is now a patchwork of secondary forests (10-75 years old), interspersed with cleared areas and secondary growth

CBS Property Map developed by former researcher in 1992