

Lecture given at the

WCS Workshop on Land Change Modeling for REDD

October 25– 29, 2010

Wildlife Conservation Society - Bronx Zoo
Bronx, New York, USA

Hosted by

Clark Labs and the Wildlife Conservation Society



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Introduction to Land Change Modeling for REDD



General Steps

- Develop Project Idea Note
- Discuss with host government
- Seek project development funding
- Project Design
- **Creation of PDD**
- Host Country Approval
- Project Validation
- Project Registration
- Project Implementation
- Verification
- Credit Issuance



Creation of PDD

- Standard set of VCS methodologies
- A number of organizations
- Modular
 - Carbon Pool Modules
 - **Baseline Modules**
 - Leakage Modules
 - Emission Modules
 - Net emission Modules
 - Monitoring Modules
 - Miscellaneous Modules
- Eventually Pre-Approved by VCS
- Fairly general – open to interpretation

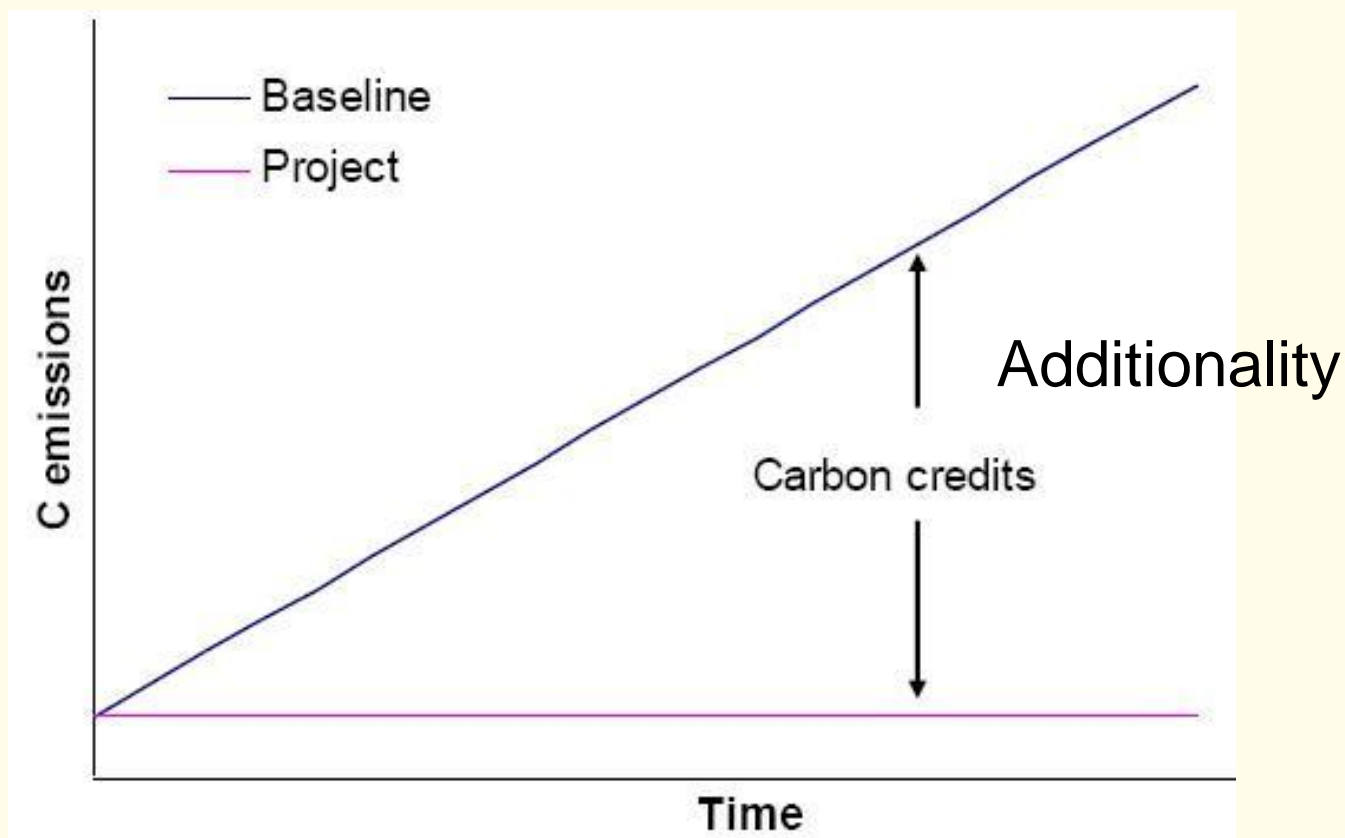
Baseline Development

- Carbon Pools
 - Usually around 3-5 carbon strata in a landscape
- **Project Geography**
 - Project area
 - Reference area
 - Leakage belt
- **Monitoring deforestation**
- **Baseline Prediction**
- Some straight forward/some not



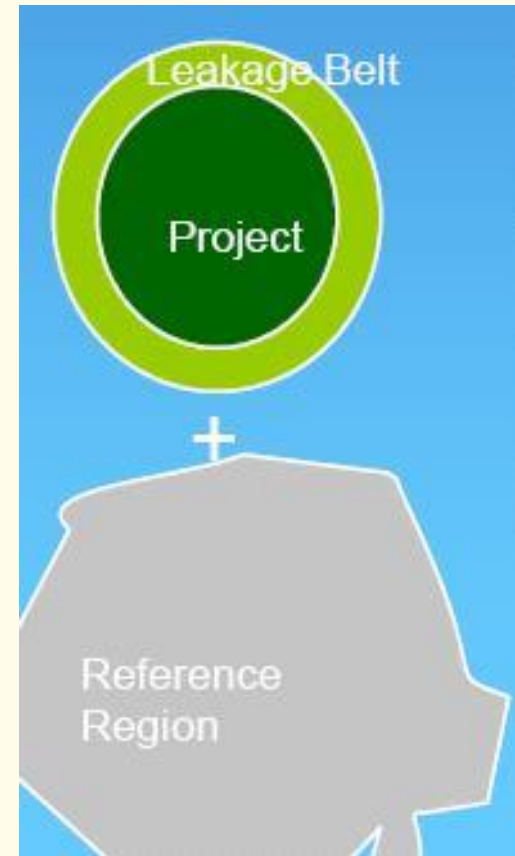
Baseline Prediction

- Expected deforestation in the absence of the project
 - additionality
- Integral in identifying the number of carbon credits the project can sell
 - Difference between expected baseline emissions and actual emissions at the end of crediting period
- Possibly the most difficult aspect to get right



Based on **very** conservative estimates

Project Geography





Baseline Development

- Past land cover analysis
 - Leads to land cover change maps
- Assessment of drivers
 - Drivers as spatial layers
- Develop model of change
- Predict future location of change
 - By carbon strata



Past Land Cover Analysis

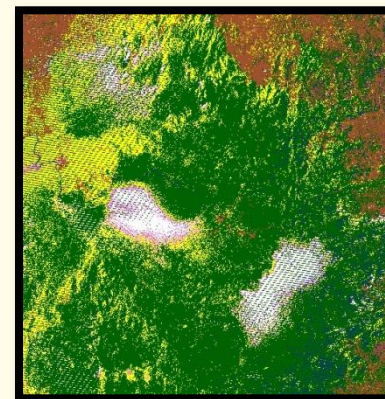
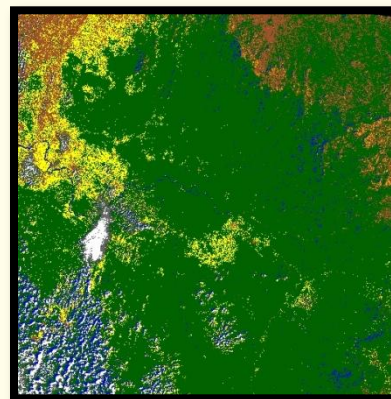
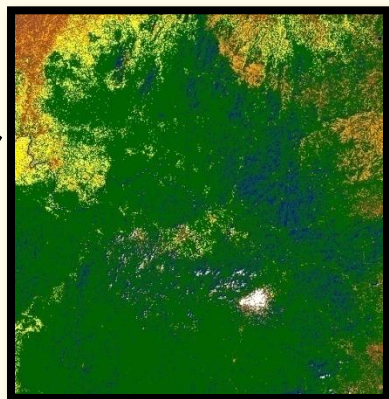
Past Land Cover Analysis

LULC T1

LULC T2

LULC T3

Land Cover

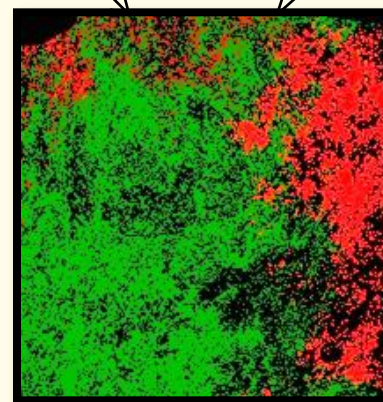
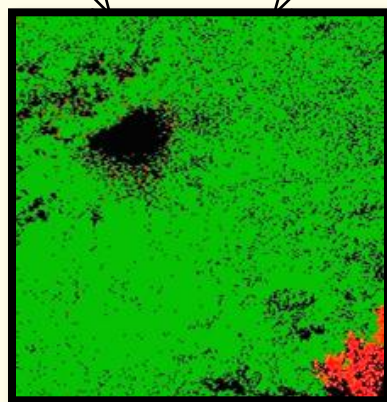


(1990)

(2000)

(2008)

Land Cover
Change



LULCC T1-T2

LULCC T2-T3



Past Land Cover Analysis

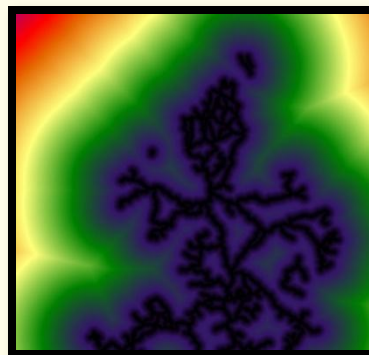
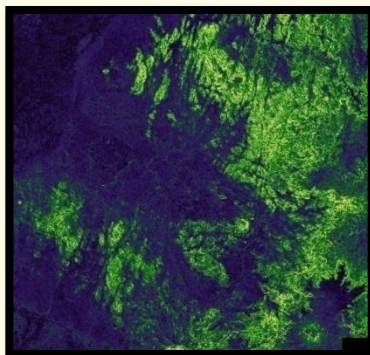
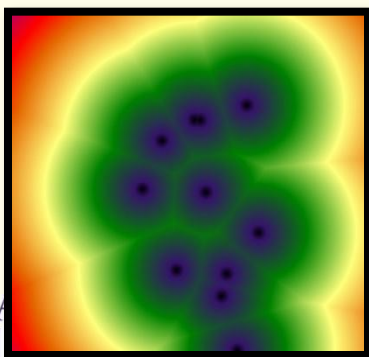
- Need a minimum of 2 dates
 - 3 realistically (2 periods of LC change)
- Dependent on good satellite images
 - Or existing data
- Ground truth data
- Remote sensing analyst familiar with landscape
- Standard RS techniques for land cover analysis
 - Potentially use updated methods

■ Fairly simple classes

Drivers of Change

Drivers of Deforestation

- Landscape factors
- Human infrastructure
- Land tenure and management



Drivers

- Intimate knowledge of landscape and local actors
- Threats assessments
- Convert drivers to spatial representations
 - Proximate causes
 - Growth in agriculture = distance to market

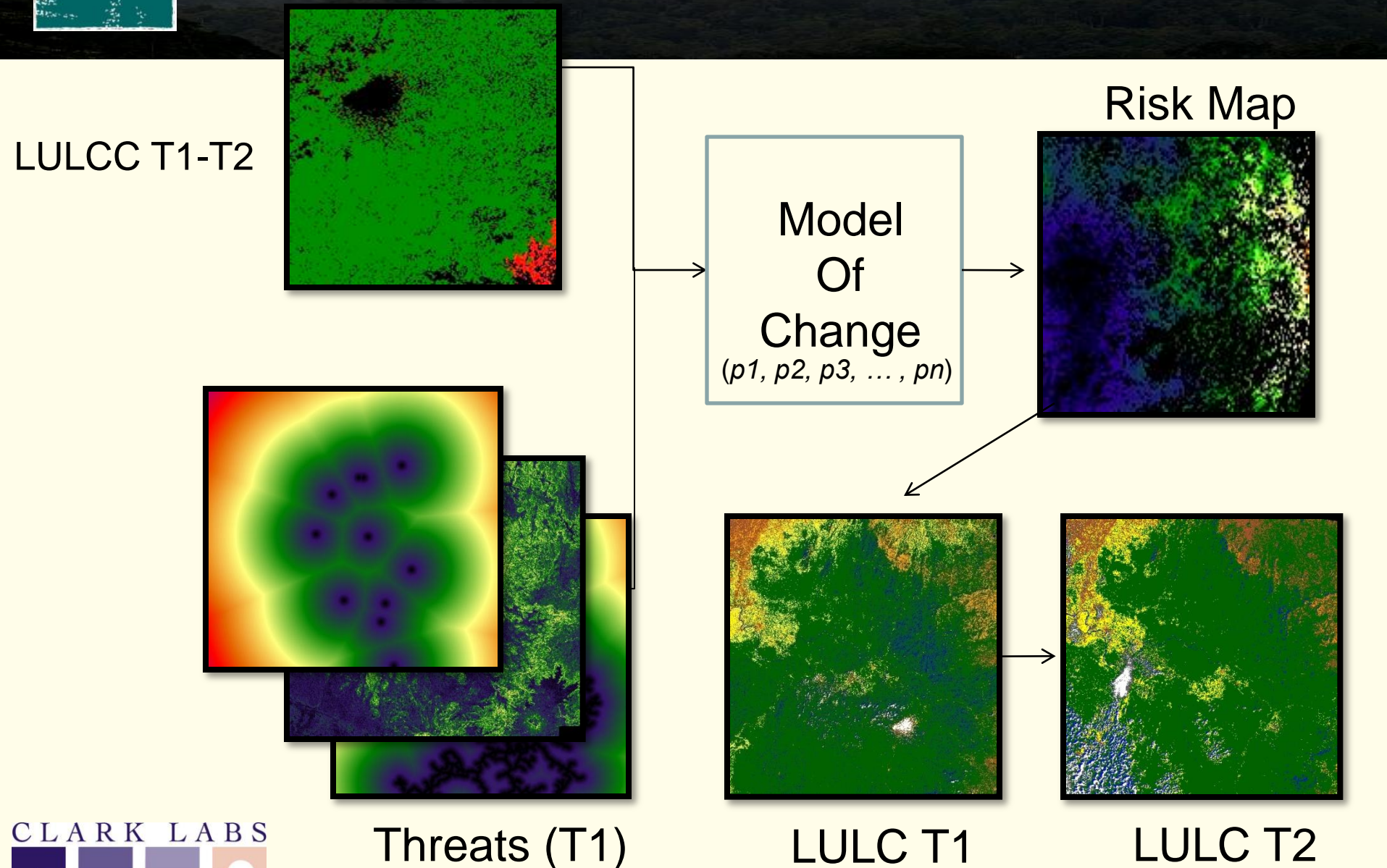
Models of Future Deforestation



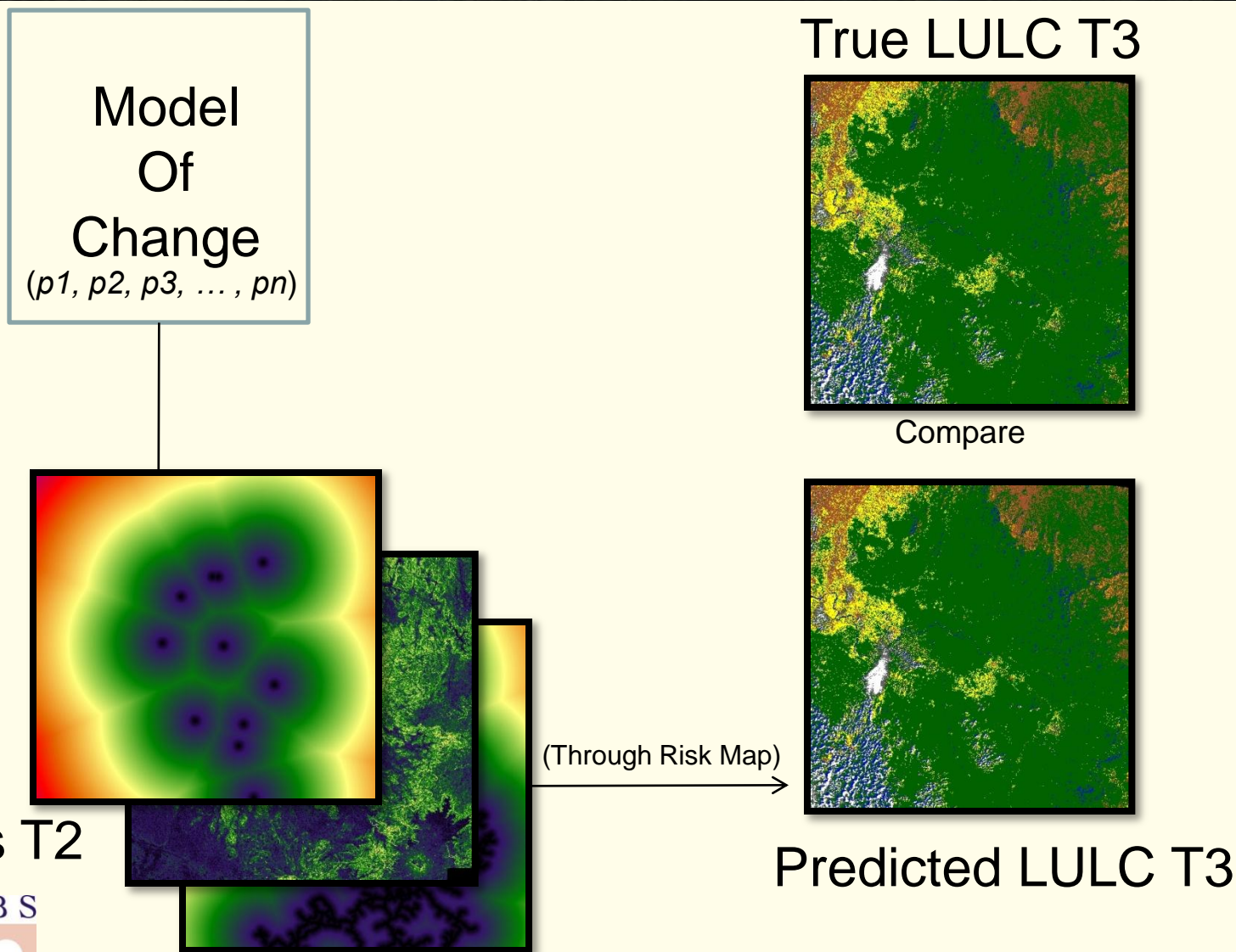
Model of Future Deforestation

- Three step procedure
 - 1 Calibrate model
 - 2 Validate model
 - 3 Predict future land deforestation

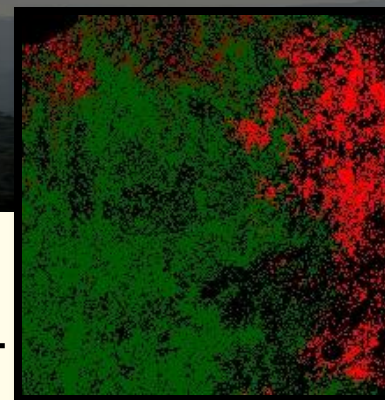
Model Calibration



2 Model Validation



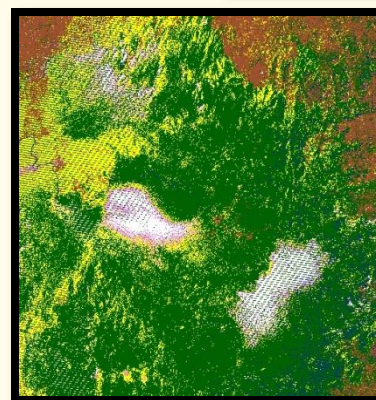
3 Baseline Prediction



LULCC T3-T4

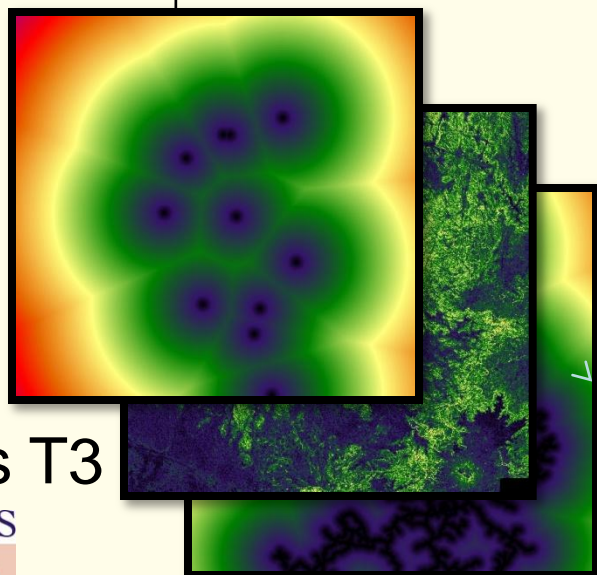
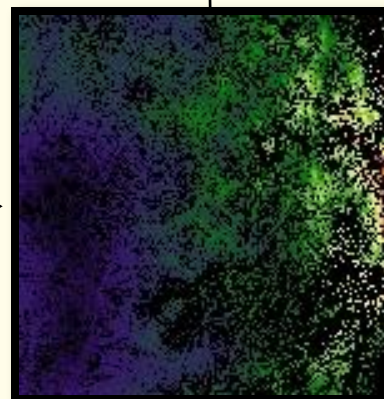
Model
Of
Change
 $(p1, p2, p3, \dots, pn)$

Predicted
LULC T4



LULC T3

Risk Map



Threats T3



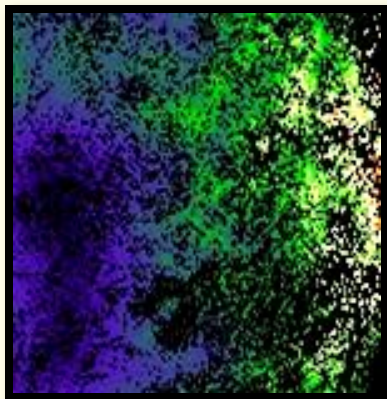
Models

- Many models
- Range from simple to extremely complex
- No specific model specified
 - GEOMOD – expert opinion based
 - LCM – Logistic regression
- Good at predicting location of deforestation but not amount
- Testing other models – more analytical
 - CART
 - Neural network

Model
Of
Change
 $(p_1, p_2, p_3, \dots, p_n)$

Predicting Location

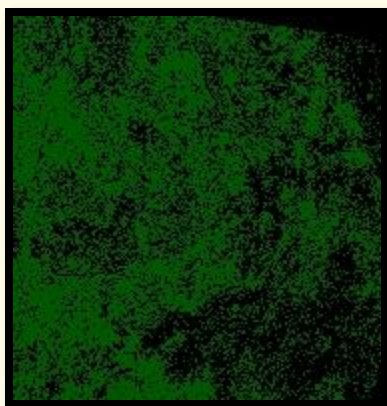
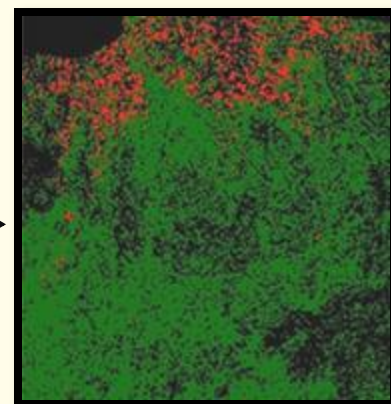
Risk Map



Deforestation



Predicted
Landcover



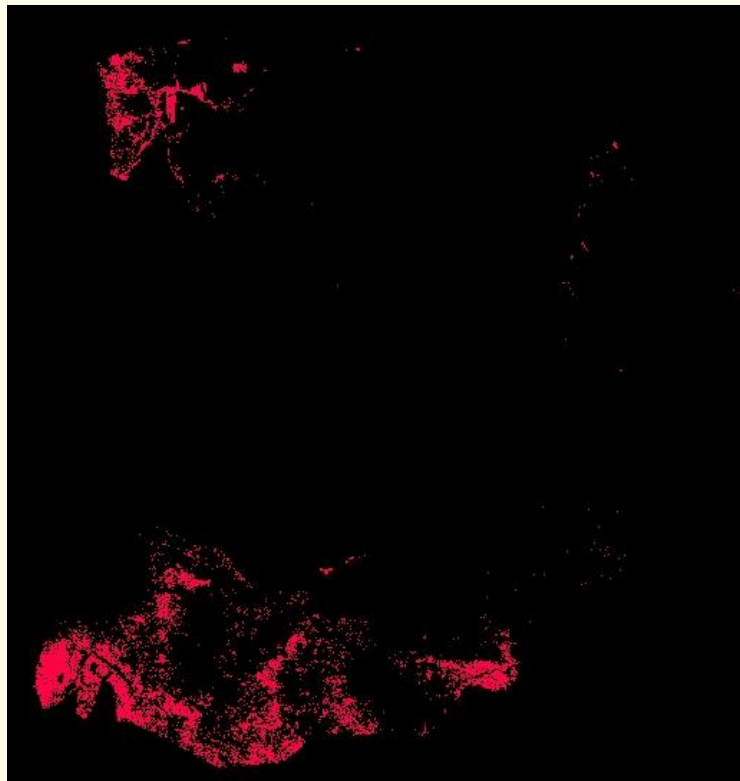
Forest Tn

Location of deforestation
based on expected amount

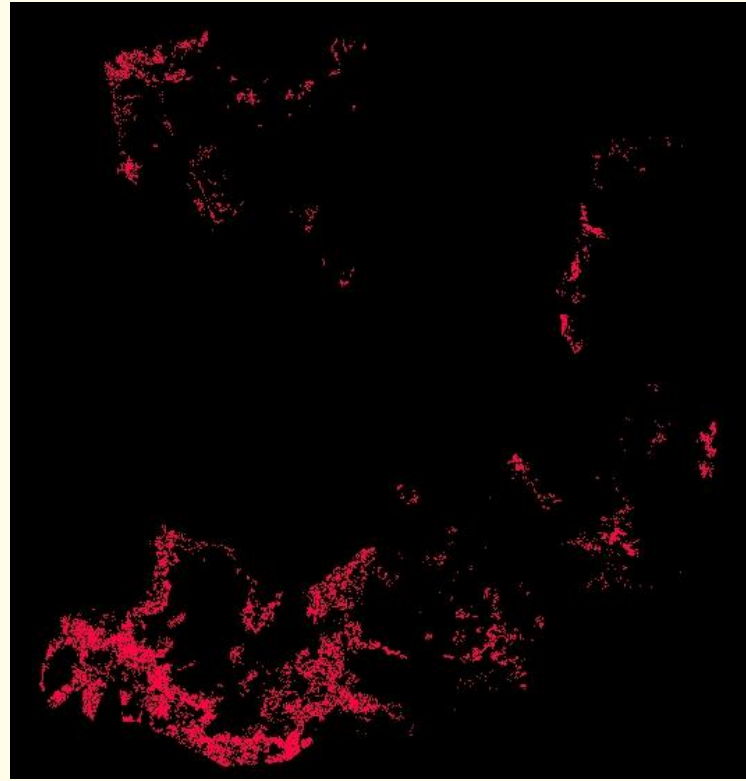


Predicted Location of Change

- Simply selects pixels with highest risk until “correct” number of pixels deforested
- Cannot account for stochastic occurrences
 - The deforestation patch far from a road or village



Actual Deforestation (1084 Km²)
2002 - 2008

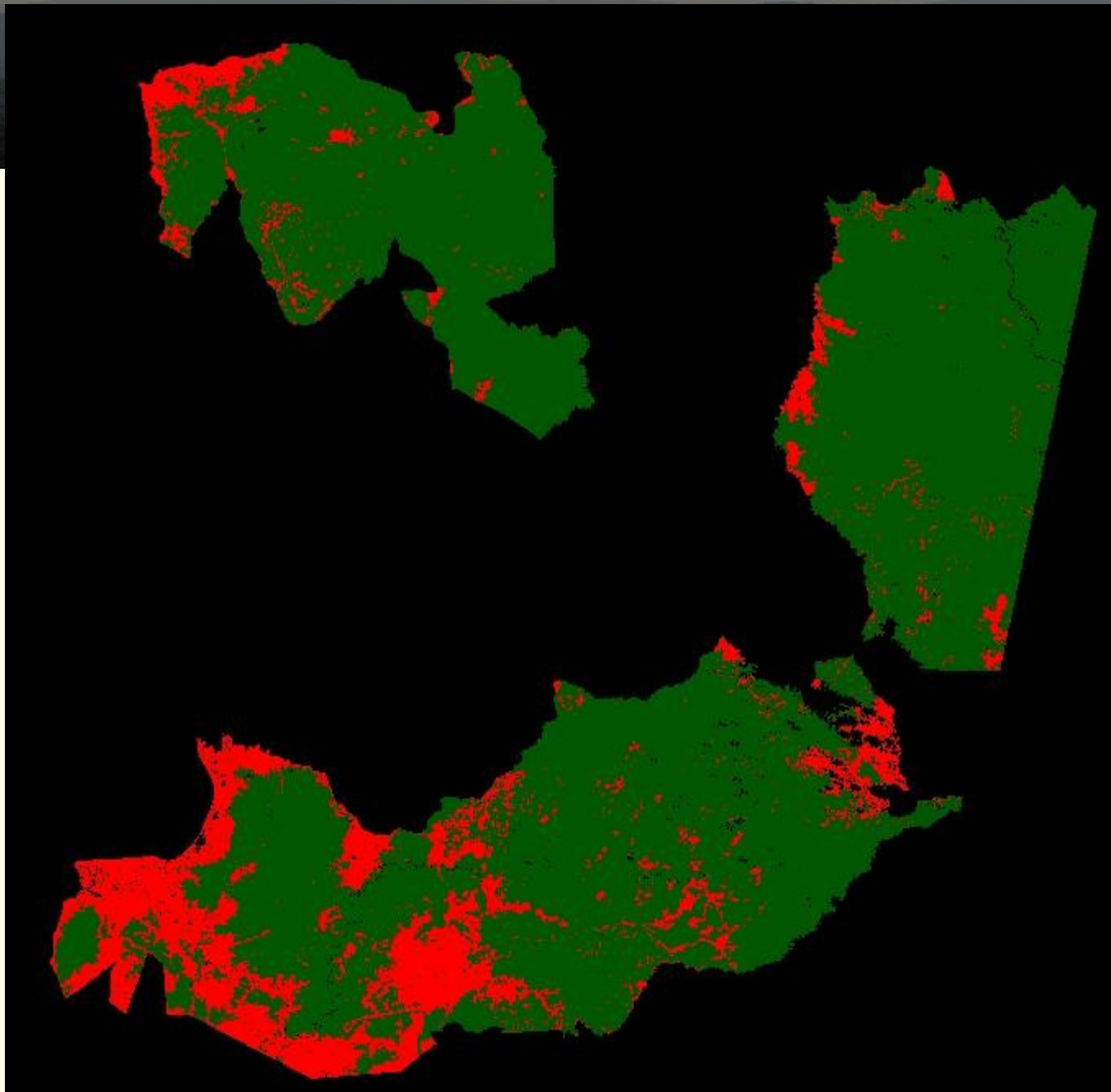


Predicted Deforestation (1187 Km²)
2002 - 2008



Rates of Change

- Based on previous rates from Reference Region
- Extrapolated into future
- Regression analysis
 - Based on threats and historic change
- Modeling?
- Different VCS methodologies have suggest different algorithms



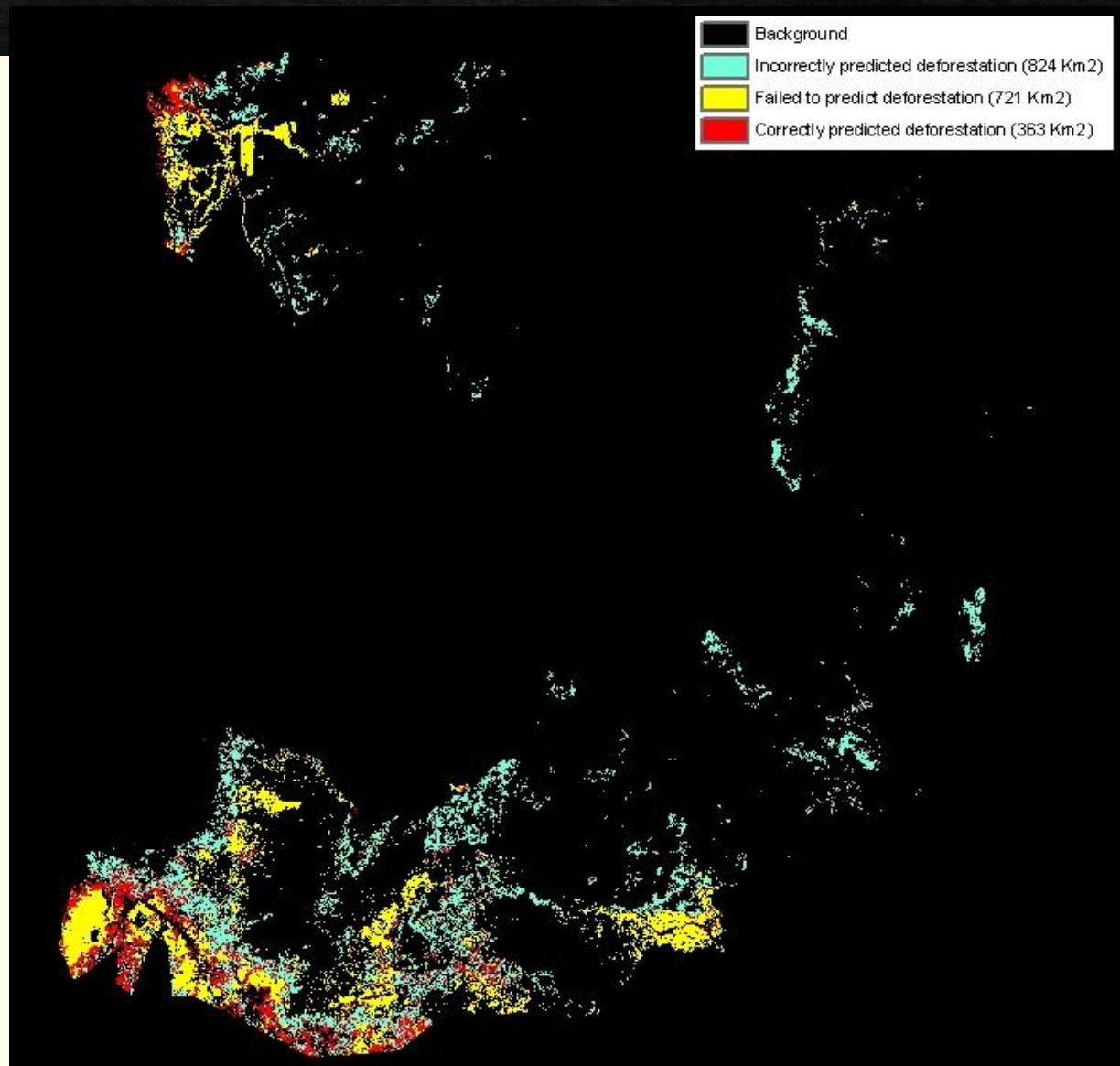


Accuracy Assessment

- How do we assess the accuracy of models
 - Calibration validation stage
 - Predicted baselines
- Standard methods (RS methods)
 - Kappa stats
 - ROC curves
- Assess accuracy on a pixel by pixel basis

Accuracy

Pixel by pixel
Results



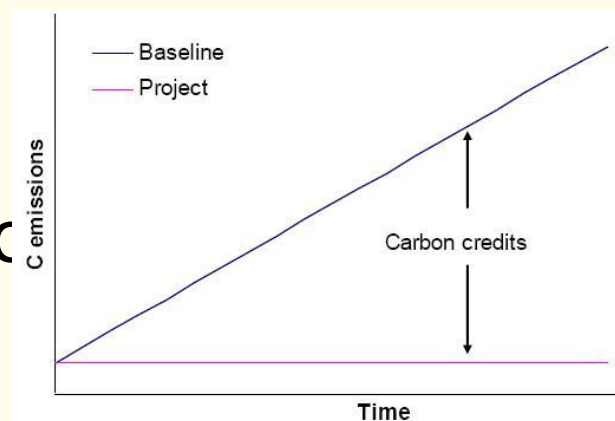


Accuracy Assessment

- Might be better to look at accuracy across an area
 - Carbon strata
 - Grid
- How well do we predict change within that area
- Kappa by location

Scenario Development

- Predict LC change
 - Deforestation by carbon strata
- Different scenarios
 - Business as usual
 - Increasing deforestation
 - New protected areas
 - Others
- Include final Baseline Prediction in PDD to represent carbon credits



Carbon Mis-Credits



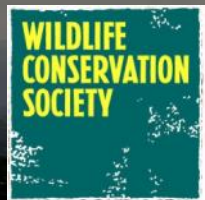
Potential Problems

- Goals of any REDD project
 - Accuracy
 - Transparency
 - Repeatable
 - Cost effective
 - Conservative estimate
- If anybody ran the analysis, would the baseline model come out the same?
- More questions than answers



Potential Problems

- Logistical issues
 - Especially in past land cover and land cover change analysis
- Methodological issues
 - Mapping drivers
 - Predicting rates of change
 - Changes over time
 - Other methodological gaps
- The spatial domain

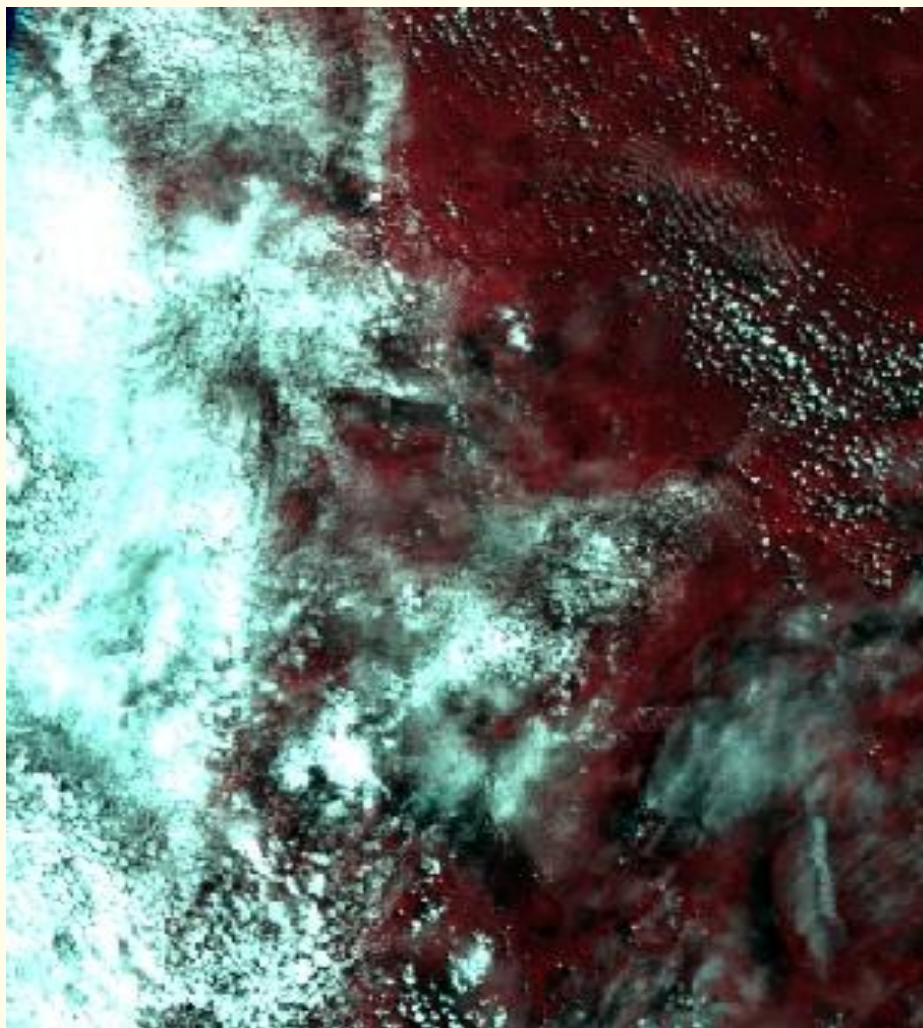


Remote Sensing

- Getting good images
 - Especially current
- Processing difficulties



Clouds

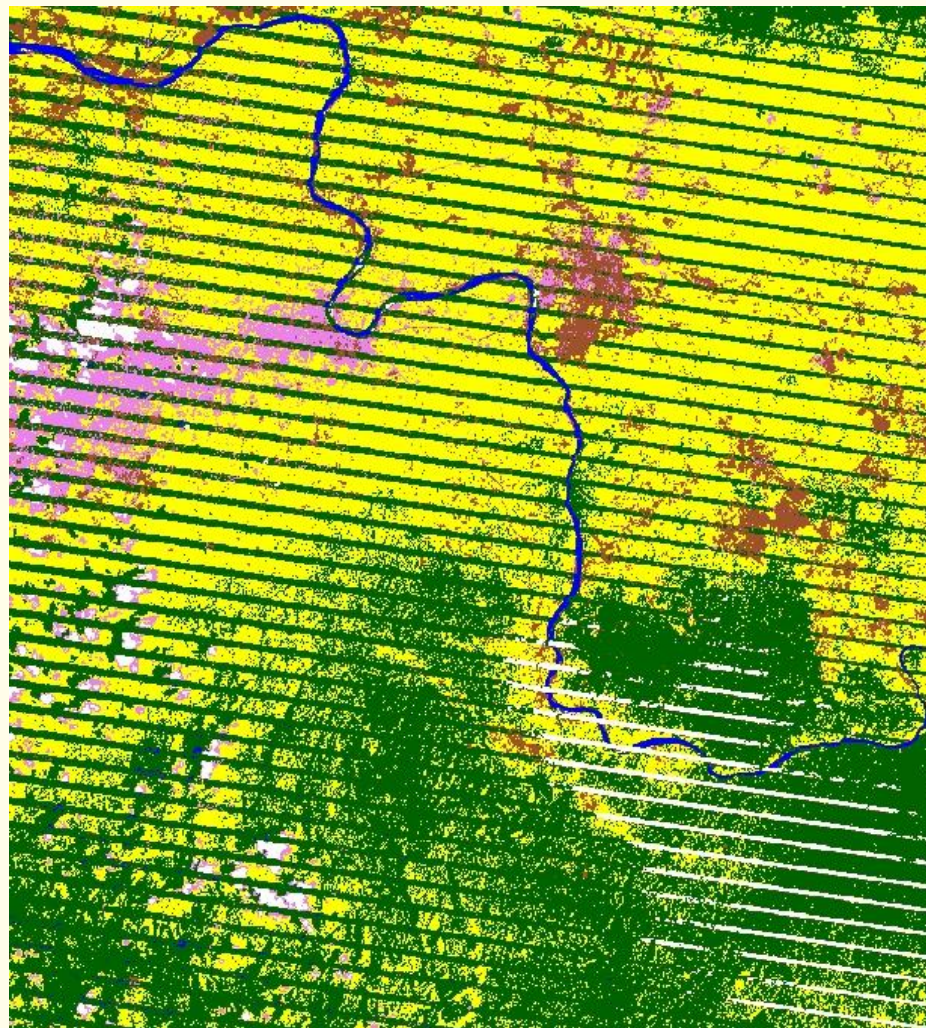




Scan Line Correction Error



Scan Line Correction





RS Potential Error Sources

- Mis-registration of images
- Pre/post processing
- Interpretation of land use/cover types
 - What is a forest?
 - Natural an anthropogenic non-forest
 - Grasslands



Other RS issues

- Accuracy assessment on historic images
- Remote sensing capacity in the field



Significant Gaps in Methodology

- Changing drivers
- Two Models or One?
 - Predict the rate of change
 - Predict the location of change
 - Can one model predict location and rate accurately?
- Location of predicted deforestation
- Time/Space
- Accuracy assessment
- What about degradation

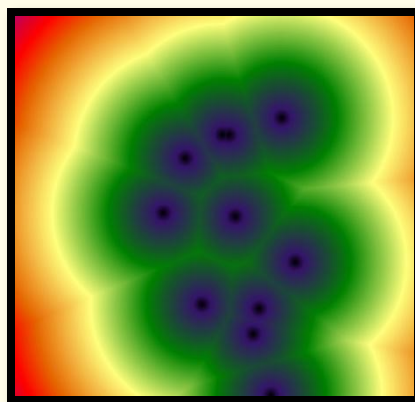


Drivers

- What methods do we use to identify most important drivers?
 - Threats assessment
- Change over time?
- Project drivers into future?
 - Create new risk map

Mapping drivers

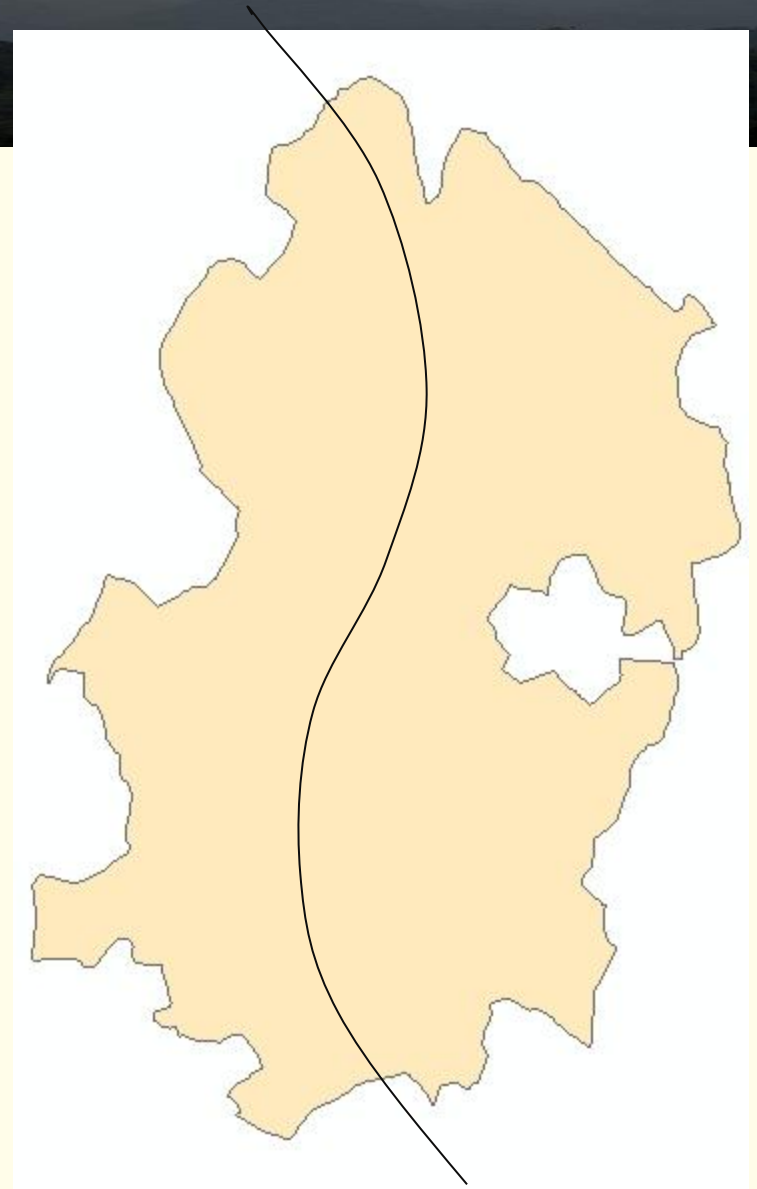
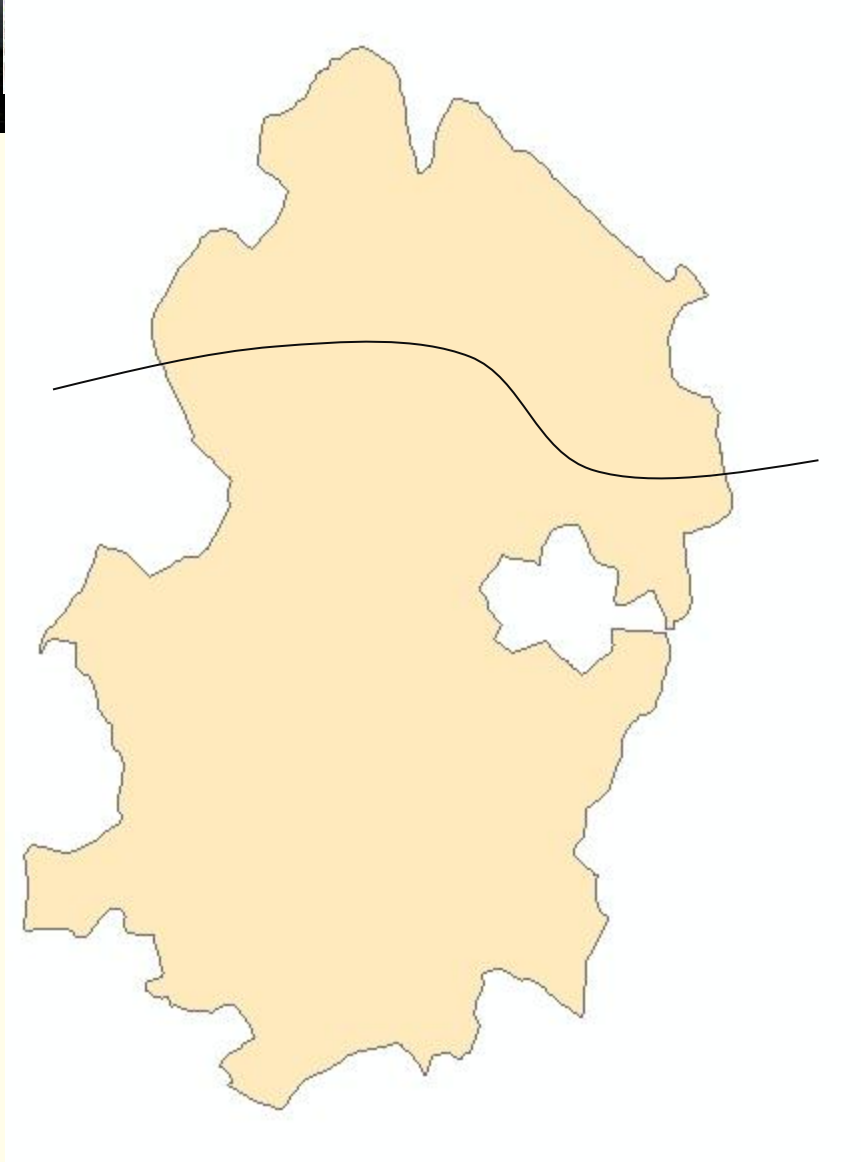
- Do the threats we map actually represent drivers of deforestation?
- Rising agricultural prices



- Scale of threats

Rates of Change

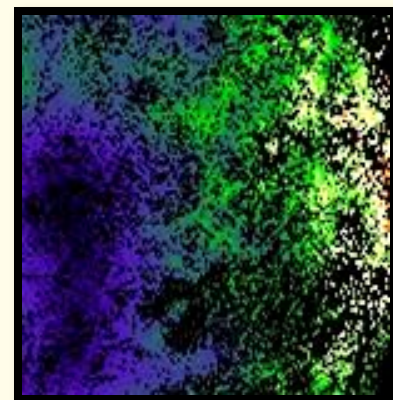
- We assume that past history informs future trends
- Based on previous rates from Reference Region
 - Are historic rates a good predictor of future rates?
 - Do 3 points in time provide a trend?
- Studies certainly show that rates are not linear through time
- What if a driver changes



Would rate of deforestation be the same?

Location of change

- Right now, based on that risk map
- But what about the farmer who finds a nice forested area away from villages or roads
- May not be significant but we should account for randomness in humans
- Use risk map as probability surface



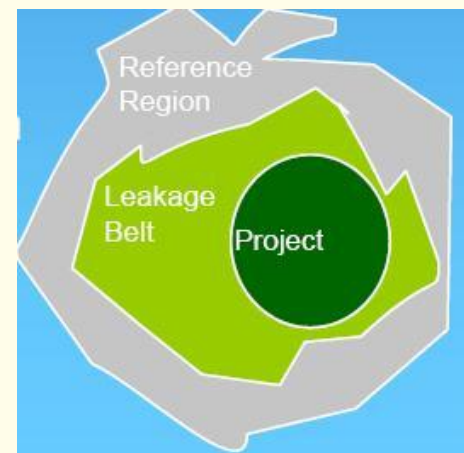


The Time Factor

- Land cover change is non-stationary over time
 - Drivers will change
 - Rates will change
- But we base models of deforestation in the future on drivers and models from the past.
- Can cause significant differences in projected carbon credits available

Spatial Domain

- How do we know if we are picking the right Reference Region
- Does it represent the future Project Region in the absence of the project
 - Increasing road density
 - Increasing population density
- Or do they need similar attributes now
- Different methods have different recommendations
- Should Reference Area include Project Region
- In either case, can it be used to develop a deforestation scenario for the project area?





Not As Bad as it Seems

- Better understanding of models of change
 - Better baseline projections
 - Other conservation outcomes
- Approved methodology will help clarify issues
- Approved project to see how its done
- Working with partners and other organizations to develop standards
- Ensure quality and reliability of models

Next Steps

- RS and modeling capacity in field
 - On-line training course
- Access to satellite images
 - ASTER SPOT or other sources beyond Landsat
- Final methodology to work with
- Continue to develop tools with partners
 - Other NGOs
 - Clark Labs
- Conference focused on models of change

Questions?