BACK TO THE FUTURE: SCENARIO GENERATOR FOR ECOSYSTEM SERVICES ANALYSIS

WWF and Natural Capital Project, ACES Workshop

December 8, 2014

Amy Rosenthal

Adam Dixon

Nasser Olwero

Emily McKenzie

Nirmal Bhagabati

Gregory Verutes

SCENARIO GENERATOR

A new tool in the InVEST 3.1 software suite

SCENARIO MODELING TOOLS

MANY OPTIONS, DIFFERENT STRENGTHS

- IDRISI Land Change Modeler
- Metronamica
- PoleStar
- IMAGE
- WaterGAP
- AIM
- GLOBIOM
- CLUE-S
- GTAP/MAGNET
- LandSHIFT
- International Futures Model
- Marxan
- Dinamica
- GeoMod
- Vensim
- MAGICC/SCENGEN
- IPAT Scenario Navigator

SCENARIO MODELING TOOLS

SPATIAL MODELS

- IDRISI Land Change Modeler
- Metronamica
- PoleStar
- IMAGE
- WaterGAP
- AIM
- GLOBIOM
- CLUE-S
- GTAP/MAGNET
- LandSHIFT
- International Futures Model
- Marxan
- Dinamica
- GeoMod
- Vensim
- MAGICC/SCENGEN
- IPAT Scenario Navigator

SCENARIO MODELING TOOLS
SPECIFIC THEMES

WATER
- WaterGAP

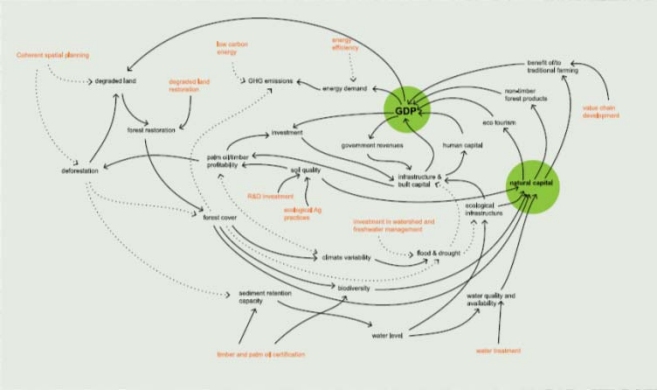
CLIMATE
- MAGICC/SCENGEN
- AIM
- GTAP/MAGNET
- IMAGE

LAND USE PLANNING
- Metronamica

SYSTEM DYNAMICS
- Vensim

OPTIMIZATION
- Marxan

GLOBAL
- GLOBIOM
- IMAGE
- International Futures



WHY ANOTHER TOOL?
CURRENT CHALLENGES IN PRACTICE

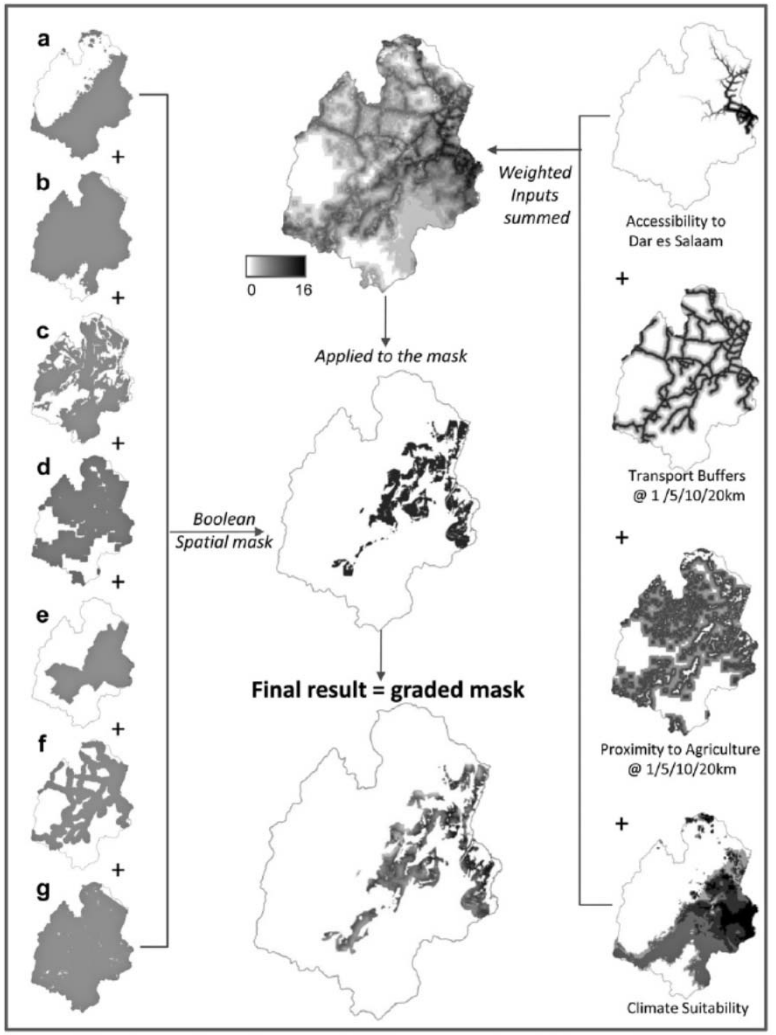
- Complexity of modelling
- Lack of scenario development expertise
- Data scarcity
- Time required
- Translating qualitative to quantitative
- Engaging and using stakeholder input


@ Taylor Ricketts

WHY ANOTHER TOOL?
SCENARIO GENERATOR

Experience in Tanzania

- Sparse data
- Stakeholder engagement
- Few easy tools
- Many steps in GIS
- Difficult to estimate relative strength of drivers



Swetnam et al. 2011

INVEST SCENARIO GENERATOR

Converting storylines into maps

INVEST SCENARIO GENERATOR

- Primarily designed to incorporate
  - Storylines based on stakeholder input, often gathered in a workshop setting
  - Inputs gleaned from scientific literature surveys, policy documents, etc.

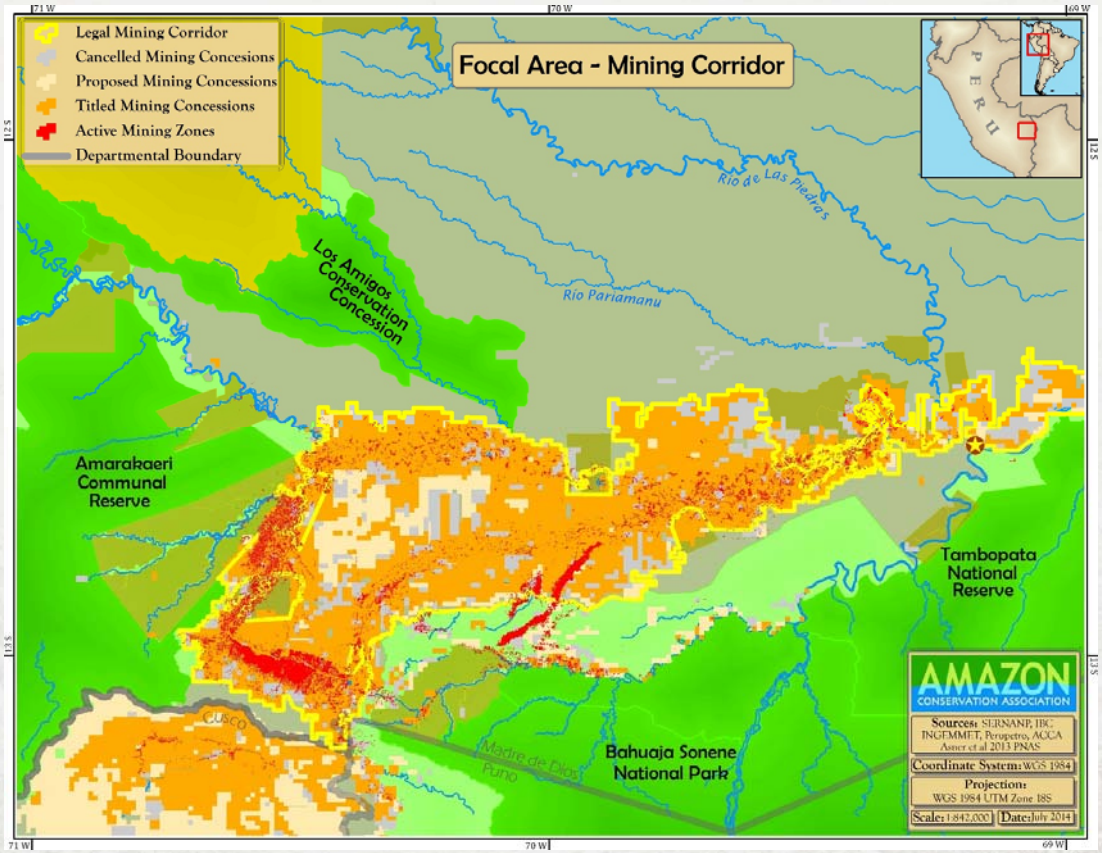
- Converts these inputs into a transition likelihood that a given pixel will change to a different land cover in the future

INVEST SCENARIO GENERATOR

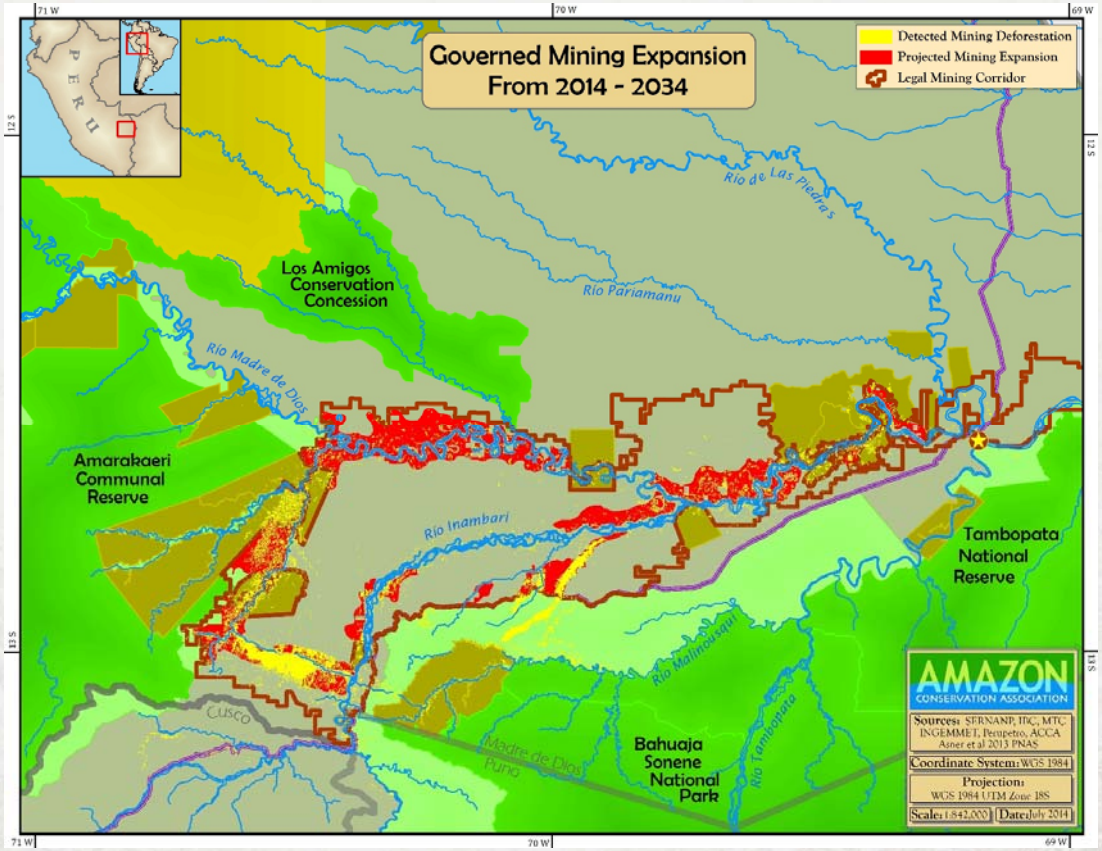
WHAT IT'S NOT

- Econometric modeling tool
- Forecasting model
- Optimization tool
- Regression-based
- Highly complex

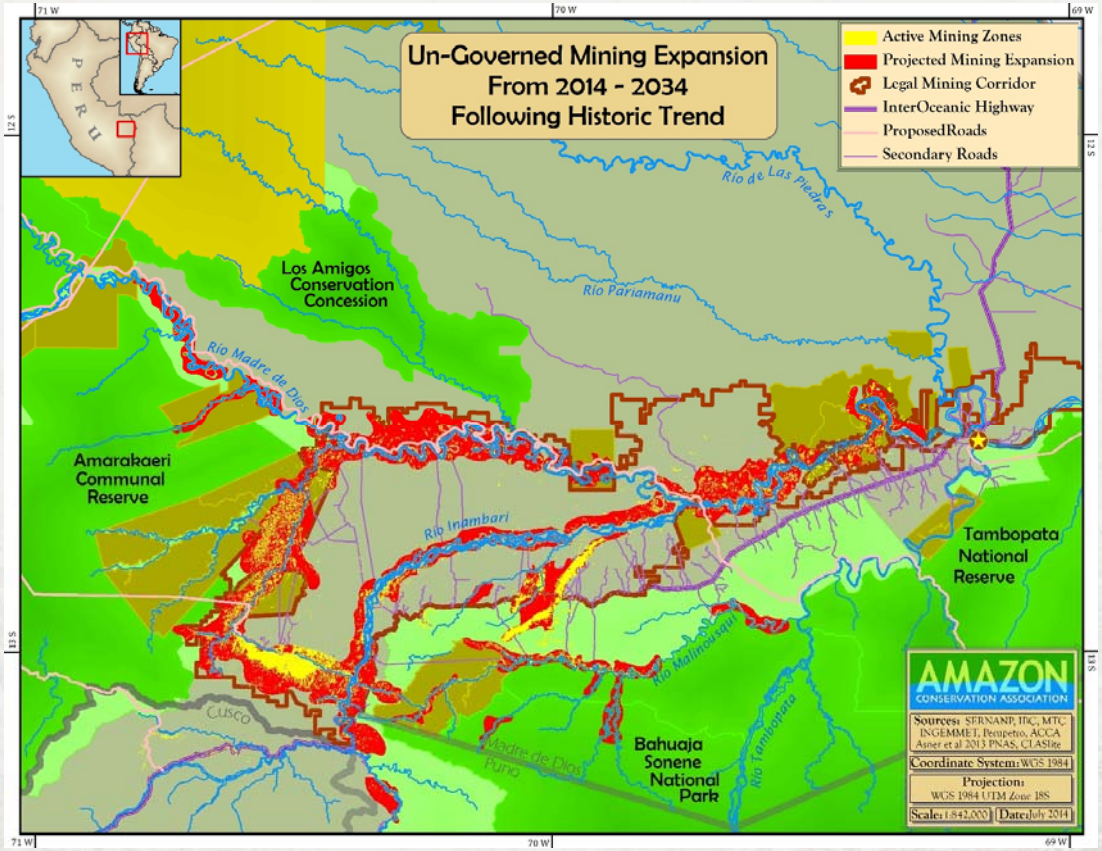
ILLEGAL GOLD MINING, PERU
A CASE FROM SCENARIO GENERATOR



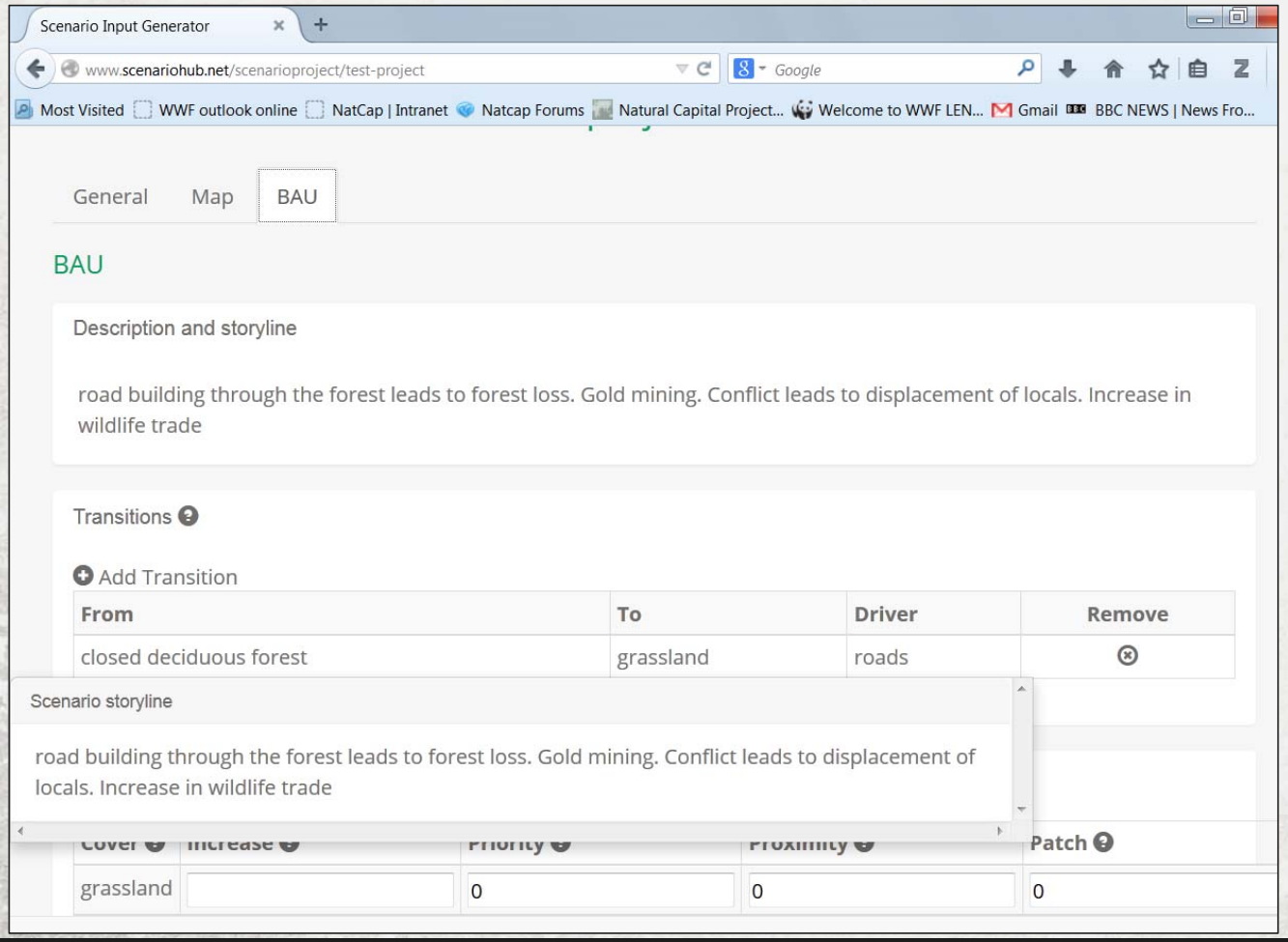
ILLEGAL GOLD MINING, PERU
AN EXAMPLE



ILLEGAL GOLD MINING, PERU
AN EXAMPLE



SCENARIOHUB.NET



Web-based forms to gather info from stakeholders & experts

Info converted to inputs in correct format for Scenario Generator

Under construction…

GLOSSARY

TERMS IN SCENARIO GENERATOR

- Drivers
- Storylines
- Transition likelihood
- Factors
- Patch size
- Constraints
- Overrides

DRIVERS

Category	Drivers	
Social and demographic	•Population growth or decline •Migration •Cultural values •Awareness	•Poverty •Diet patterns •Education •Religious values
Technological	•Technological innovation	•Technology choice
Economic	•Economic growth •Trade patterns and barriers •Commodity prices	•Income and income distribution •Market development •Demand and consumption patterns
Environmental	•Climate change •Air and water pollution	•Introduction of invasive alien species
Political	•Macroeconomic policy •Other policy, e.g. subsidies, incentives, taxes	•Governance and corruption •Property rights and land tenure •Land-use plans, zoning and management

STORYLINES

Narrative scenarios: Matazamio in Tanzania

Annual GDP growth in Tanzania is 6 percent. Per capita GDP in the country is now over USD 1500 (PPP), with agriculture being the largest employer, and the tourism and mining sectors continuing to grow fast. Population growth has slowed to 2 percent per year due to child mortality and falling fertility rates. The population in 2025 will be about 55 million. Growth occurs mainly in regional and coastal cities due to migration.

Government and private investment greatly increase the marketing, processing and transportation of agricultural goods, including livestock products (milk and meat). There is a large increase in irrigated agriculture and water storage schemes. On-farm technology improves. The percentage of area under medium- and large-scale farming doubles. Global commodity prices rise, increasing total exports and export crops.

The population with access to electricity increases from 12 percent to 40 percent. The additional generation comes from increased gas and coal plants and increasing hydroelectric capacity. Catchment management is deemed important for this sector and resources for this have been available. Biomass-derived energy is used mainly for cooking, but more efficient stoves and waste residue fuels reduce the demand.

A growing global market for biofuels encourages plantations of sugarcane, oil palm and jatropha. International payments for carbon credits (REDD) and national investments in payments for watershed services schemes are growing and facilitating improved catchment management. There is more capacity to monitor forest reserves for encroachment and timber extraction.

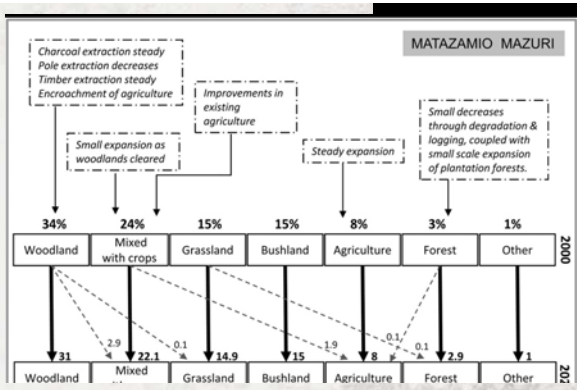
From: McKenzie, E., A. Rosenthal et al. 2012. Developing scenarios to assess ecosystem service tradeoffs: Guidance and case studies for InVEST users. World Wildlife Fund, Washington, D.C

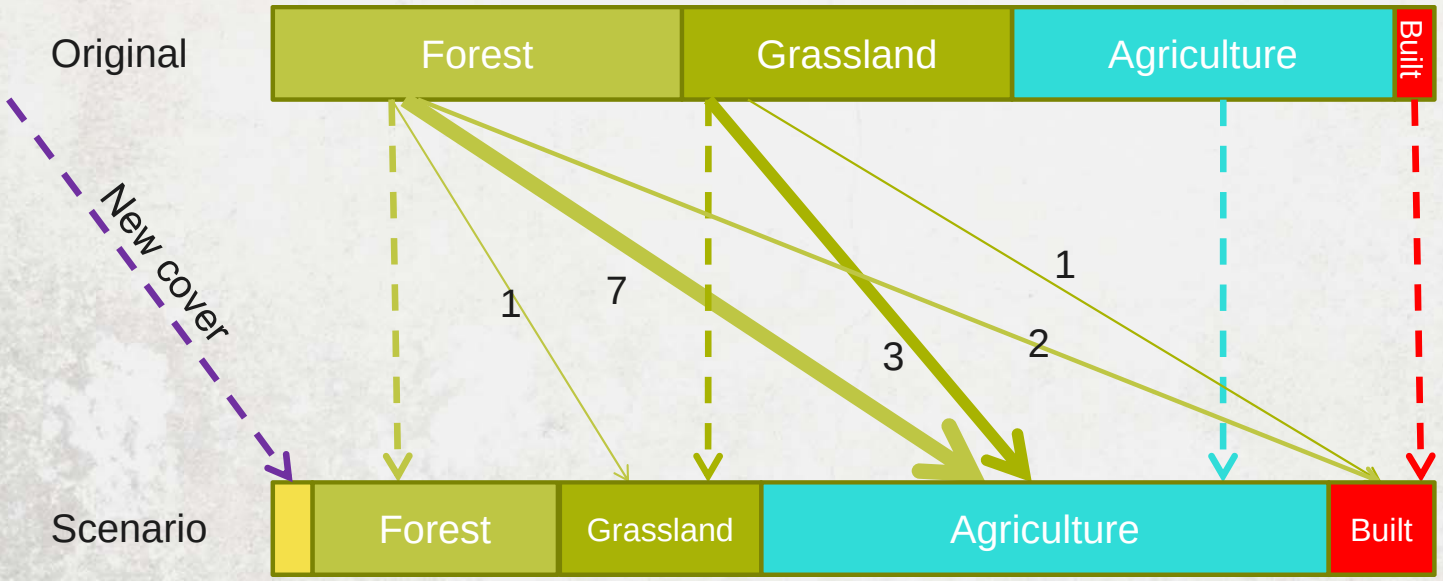
SPATIAL RULES
IN SCENARIO GENERATOR

Landcover Types	Change	Rules
Broadleaved tree plantation	increase	along roads, in poor soils, on hilltops, difficult to cultivate areas, in and around community forests
Coniferous plantation	increase	along roads, in poor soils, on hilltops, difficult to cultivate areas, in and around coniferous plantatios,
Tropical high forest	increase	in and around community forests, not in nps
Degraded forest	decrease	not in national parks
Woodland	increase	outside Protected areas

TRANSITION LIKELIHOOD

GOING FROM STORYLINES TO MAPS





TRANSITION MATRIX

		Forest	Grassland	Agriculture	Urban	Change	Proximity	Proximity distance	Priority
LOSS	/Forest	0	1	7	2	-30%	0	0	0
	Grassland	0	0	3	1	-40%	0	0	0
	Agriculture	0	0	0	0	50	1	10	2
	Urban	0	0	0	0	10	1	5	1

GAIN

Loc n

TRANSITION MATRIX

	Forest	Grassland	Agriculture	Urban	Change	Proximity	Proximity distance	Priority
/Forest	0	1	7	2	-30%	0	0	0
Grassland	0	0	3	1	-40%	0	0	0
Agriculture	0	0	0	0	50	1	10	2
Urban	0	0	0	0	10	1	5	1

Quantity

TRANSITION MATRIX

	Forest	Grassland	Agriculture	Urban	Change	Proximity	Proximity distance	Priority
/Forest	0	1	7	2	-30%	0	0	0
Grassland	0	0	3	1	-40%	0	0	0
Agriculture	0	0	0	0	50	1	10	2
Urban	0	0	0	0	10	1	5	1

Quantity

Note: in the current version of the tool, you can only specify increases.

Decreases will be addressed in a future version

TRANSITION MATRIX

	Forest	Grassland	Agriculture	Urban	Change	Proximity	Proximity distance	Priority
/Forest	0	1	7	2	-30%	0	0	0
Grassland	0	0	3	1	-40%	0	0	0
Agriculture	0	0	0	0	50	1	10	2
Urban	0	0	0	0	10	1	5	1

TRANSITION MATRIX

	Forest	Grassland	Agriculture	Urban	Change	Proximity	Proximity distance	Priority
/Forest	0	1	7	2	-30%	0	0	0
Grassland	0	0	3	1	-40%	0	0	0
Agriculture	0	0	0	0	50	1	10	2
Urban	0	0	0	0	10	1	5	1

TRANSITION MATRIX

	Forest	Grassland	Agriculture	Urban	Change	Proximity	Proximity distance	Priority
/Forest	0	1	7	2	-30%	0	0	0
Grassland	0	0	3	1	-40%	0	0	0
Agriculture	0	0	0	0	50	1	10	2
Urban	0	0	0	0	10	1	5	1

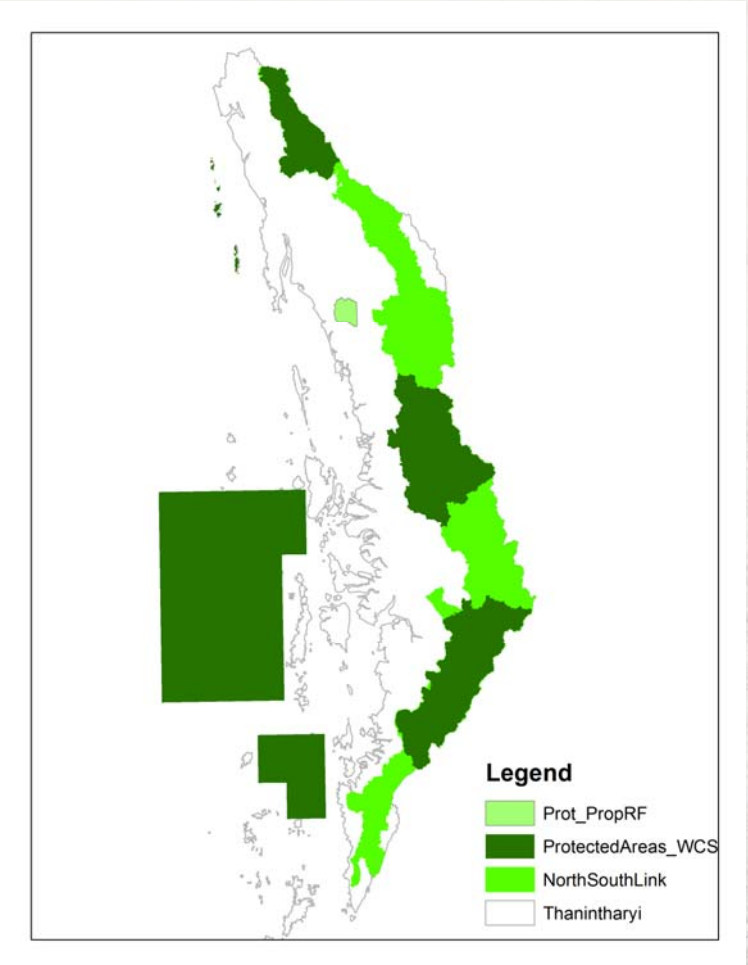
FACTORS

- In the scenario tool, “factors" are rules that increase or reduce likelihood of a change in land cover
- E.g.,
  - Deforestation may be higher close to roads and cities
  - Agriculture may occur only within certain ranges of elevation or slope

CONSTRAINTS

- Areas where a change cannot take place, or has a lower propensity to take place

- E.g., no-go or limited conversion zones, enforced protected areas



PATCH SIZE

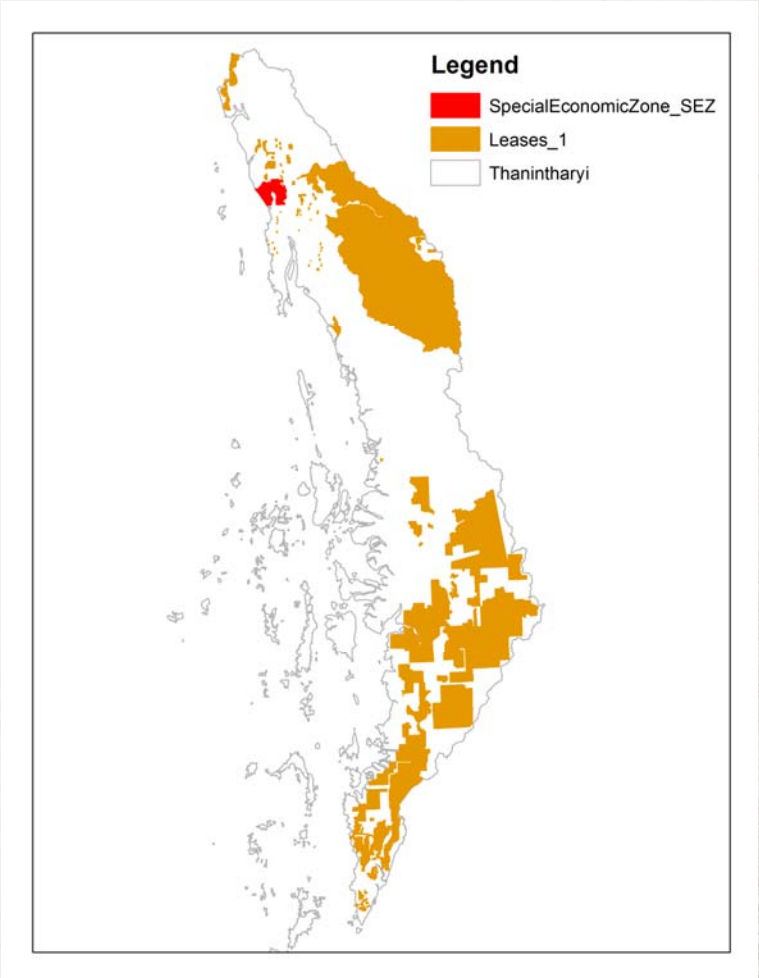
- Minimum area threshold for a land cover or use

- E.g., new large-scale agricultural areas have to be at least 10 hectares

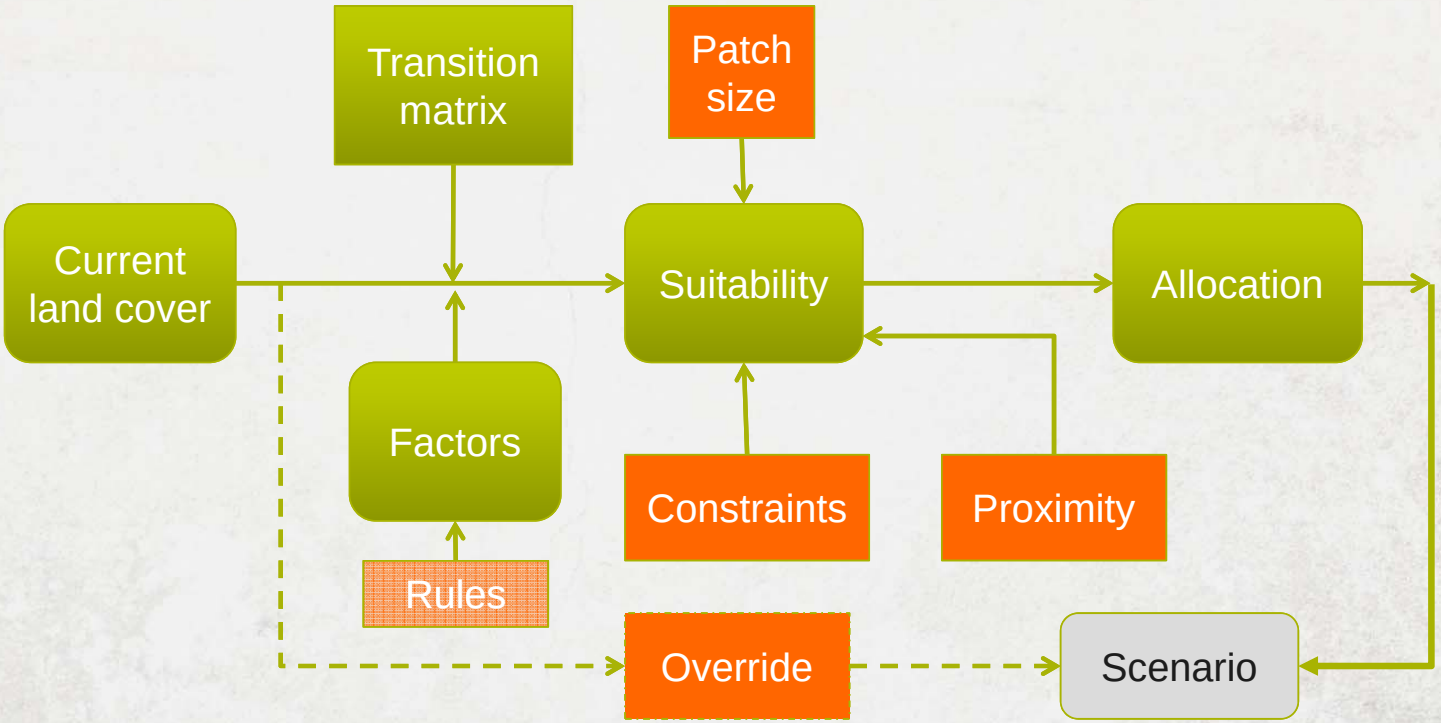
OVERRIDES

- Areas where a land cover change will definitely take place

- E.g., a forest concession destined to convert to an oil palm plantation under BAU



MODEL FLOW


Transition matrix
Patch size
Current land cover
Suitability
Allocation
Factors
Constraints
Proximity
Rules
Override
Scenario

SCENARIOS QUIZ

What have you learned?

CONSIDERATIONS
CURRENT LIMITATIONS

- Accuracy depends on stakeholders
- Stakeholder-given values are best for near future

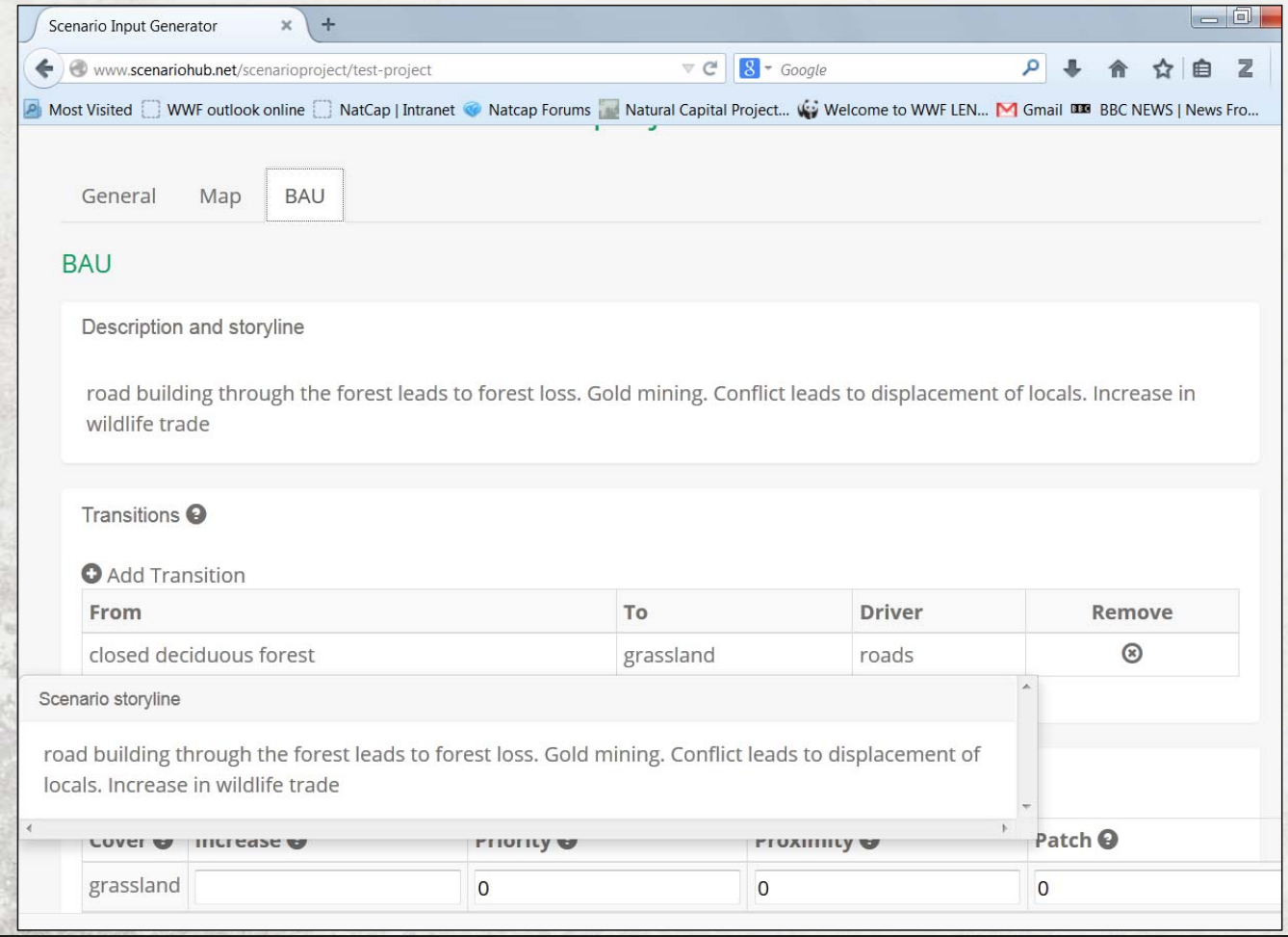
- Currently, users can input desired increase in a specific land cover, but not loss
  - This feature will be added in future releases

- Model assumes a cover type either increases or decreases but not both
- Assumes a single-step transition

USER NOTES

- Minimize number of transitions, select most important ones
- Iterative process

SCENARIOHUB.NET



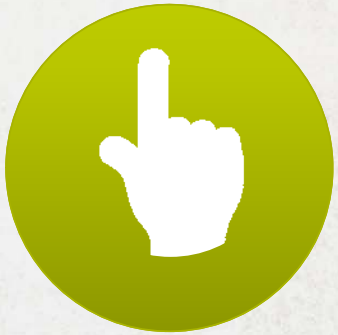
Web-based forms to gather info from stakeholders & experts

Info converted to inputs in correct format for Scenario Generator

Under construction…

natural capital PROJECT

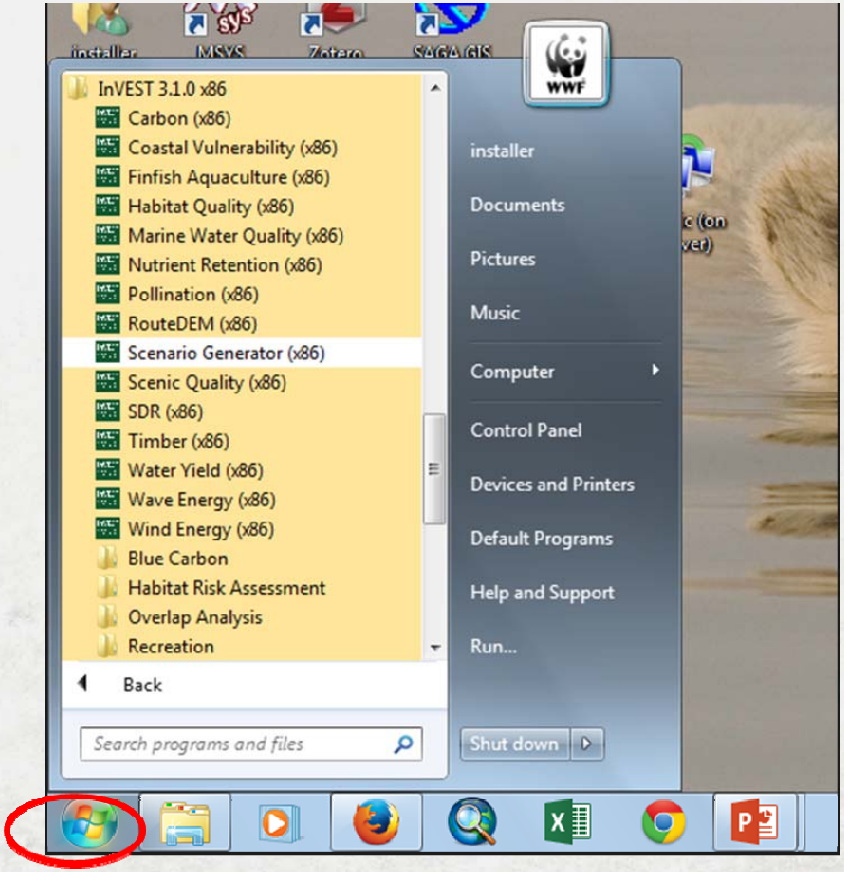
DEMO



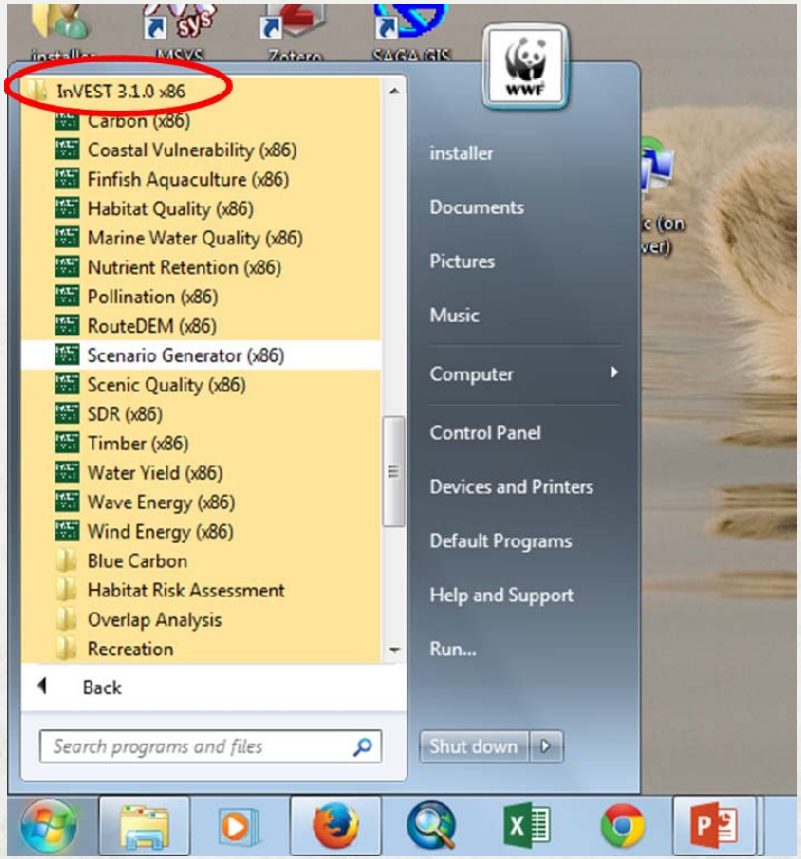
LET'S RUN IT!

Scenario Generator

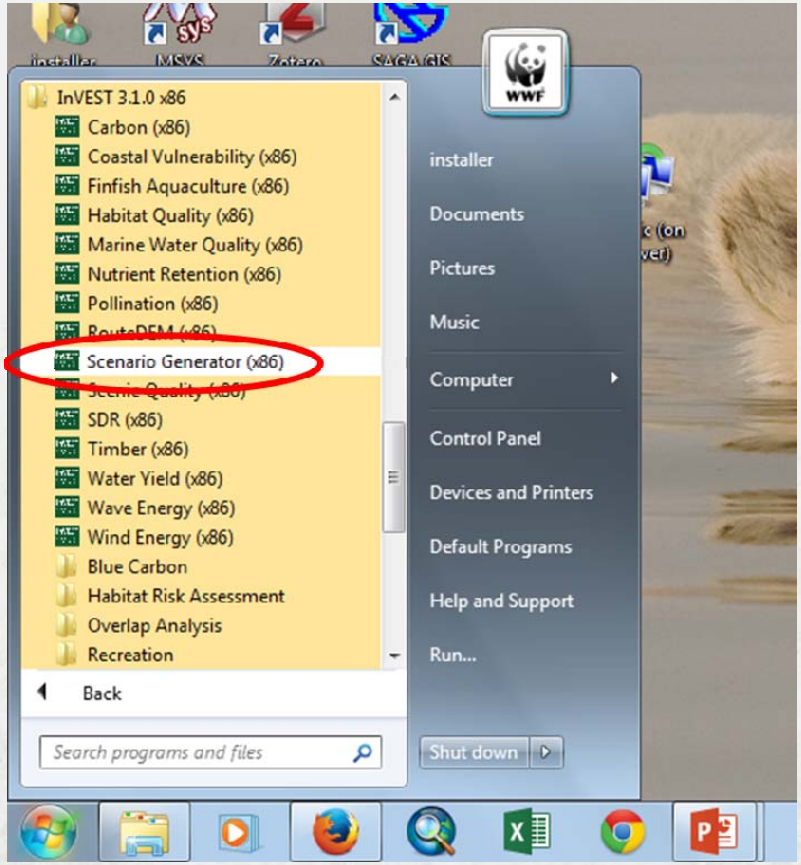
SCENARIO GENERATOR
INVEST 3.1.0

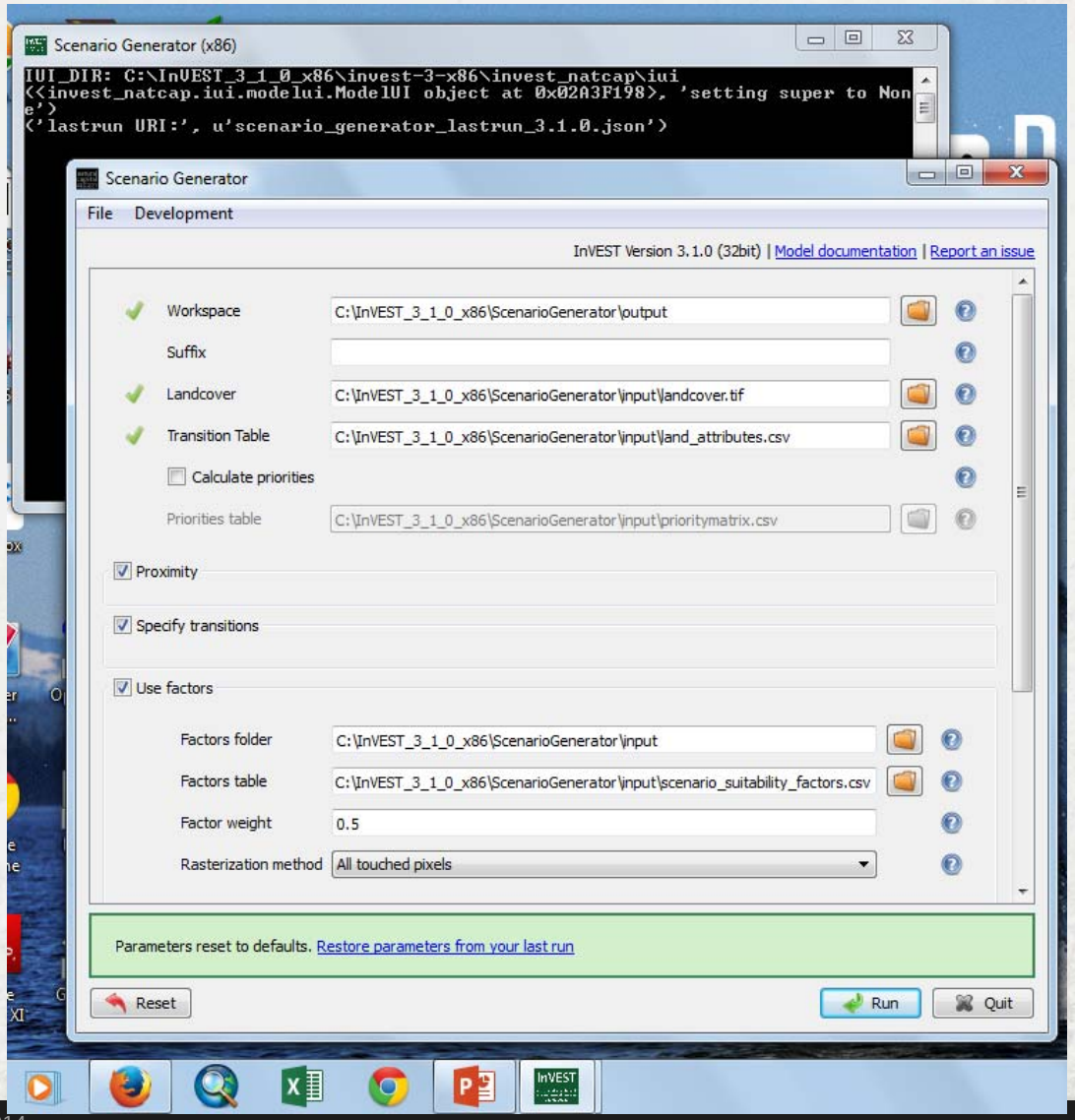


SCENARIO GENERATOR
INVEST 3.1.0

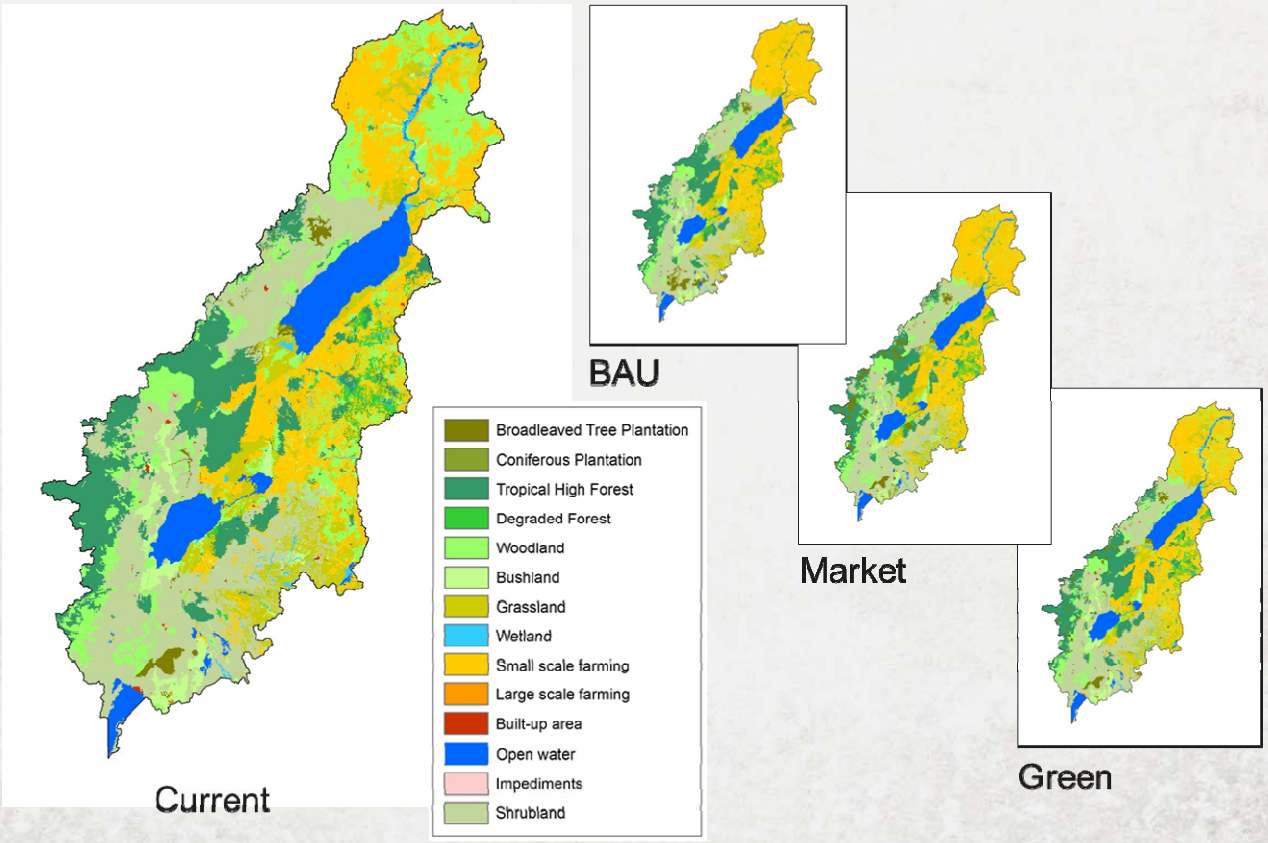


SCENARIO GENERATOR
INVEST 3.1.0

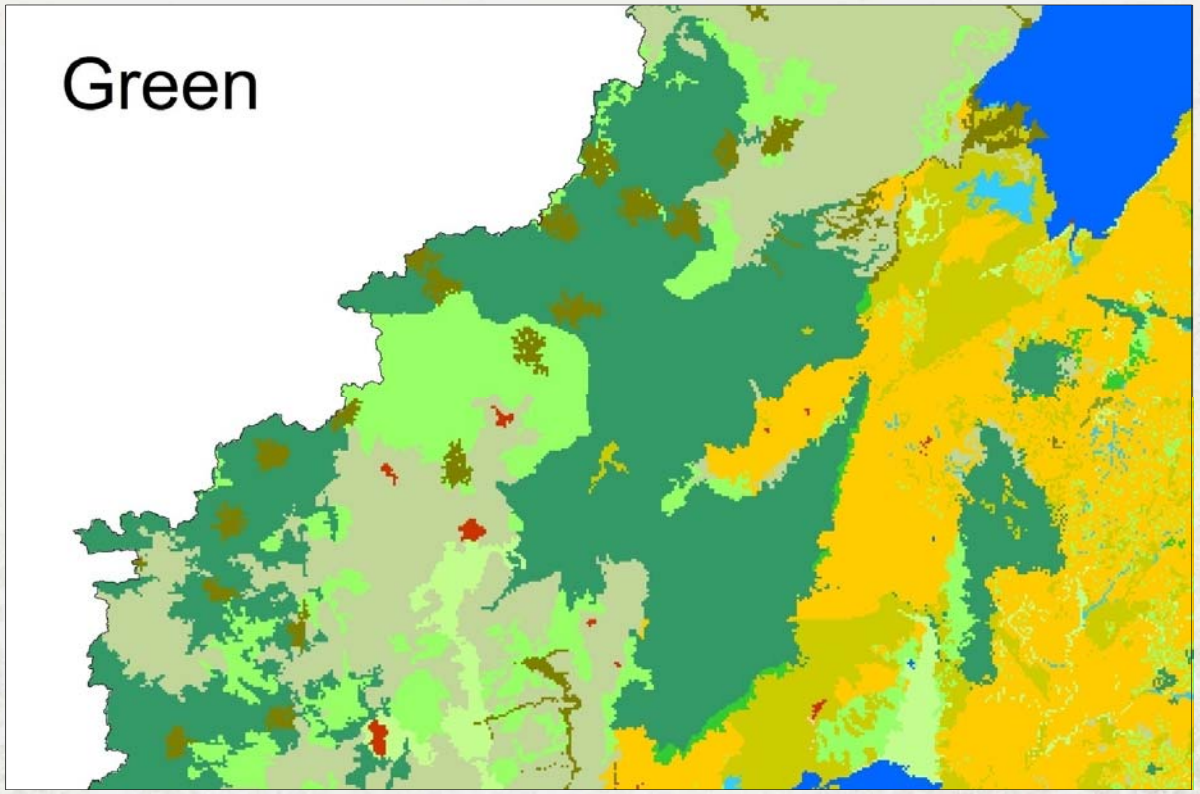



Scenario Generator (x86)
IUI_DIR: C:\InVEST_3_1_0_x86\invest-3-x86\invest_natcap\iui
(<invest_natcap.iui.modelui.ModelUI object at 0x02A3F198>, 'setting super to None')
('lastrun URI:', u'scenario_generator_lastrun_3.1.0.json')
Scenario Generator
File
Development
InVEST Version 3.1.0 (32bit) | Model documentation | Report an issue
Workspace
C:\InVEST_3_1_0_x86\ScenarioGenerator\output
Suffix
Landcover
C:\InVEST_3_1_0_x86\ScenarioGenerator\input\landcover.tif
Transition Table
C:\InVEST_3_1_0_x86\ScenarioGenerator\input\land_attributes.csv
Calculate priorities
Priorities table
C:\InVEST_3_1_0_x86\ScenarioGenerator\input\prioritymatrix.csv
Proximity
Specify transitions
Use factors
Factors folder
C:\InVEST_3_1_0_x86\ScenarioGenerator\input
Factors table
C:\InVEST_3_1_0_x86\ScenarioGenerator\input\scenario_suitability_factors.csv
Factor weight
0.5
Rasterization method
All touched pixels
Parameters reset to defaults. Restore parameters from your last run
Reset
Run
Quit

SAMPLE DATA
GREATER VIRUNGA REGION, EAST AFRICA

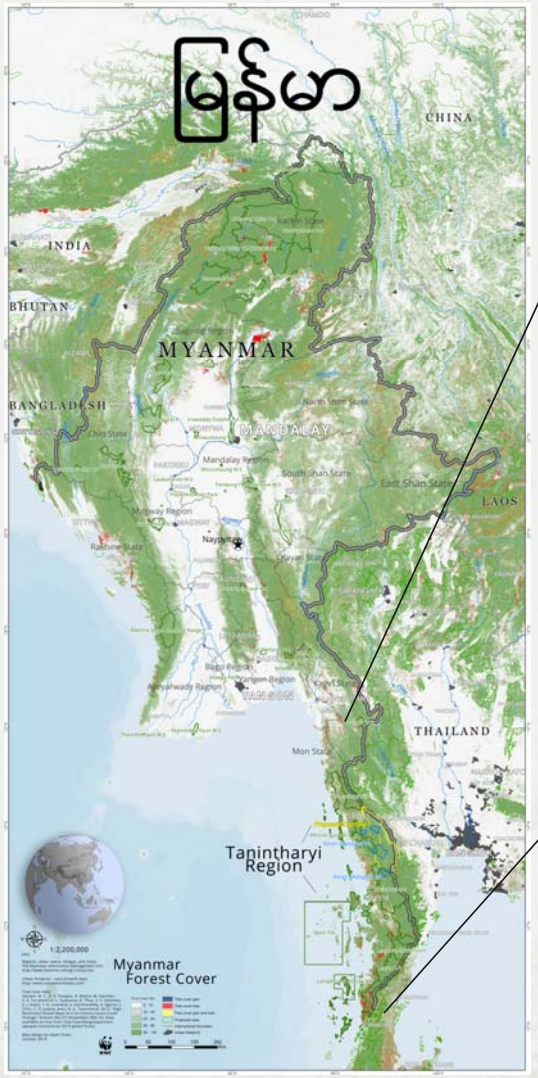


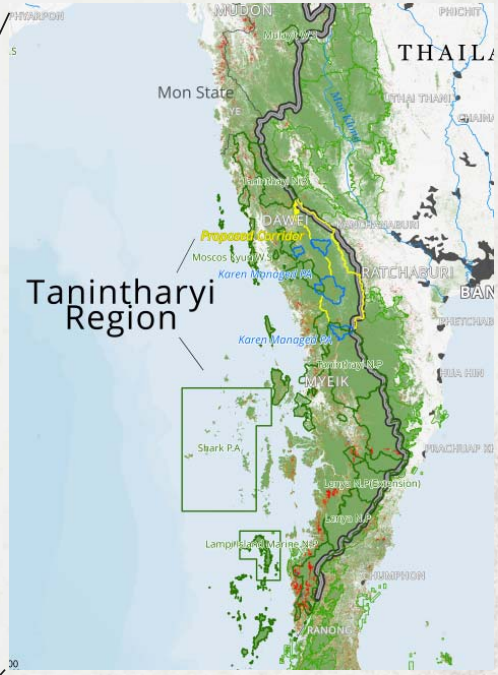
VIRUNGAS EXAMPLE



TANINTHARYI, MYANMAR

Scenario Generator case





- Biodiverse forests
- Infrastructure development
- Complex politics around land use, reform, resettlement
- Lessons for national-level planning

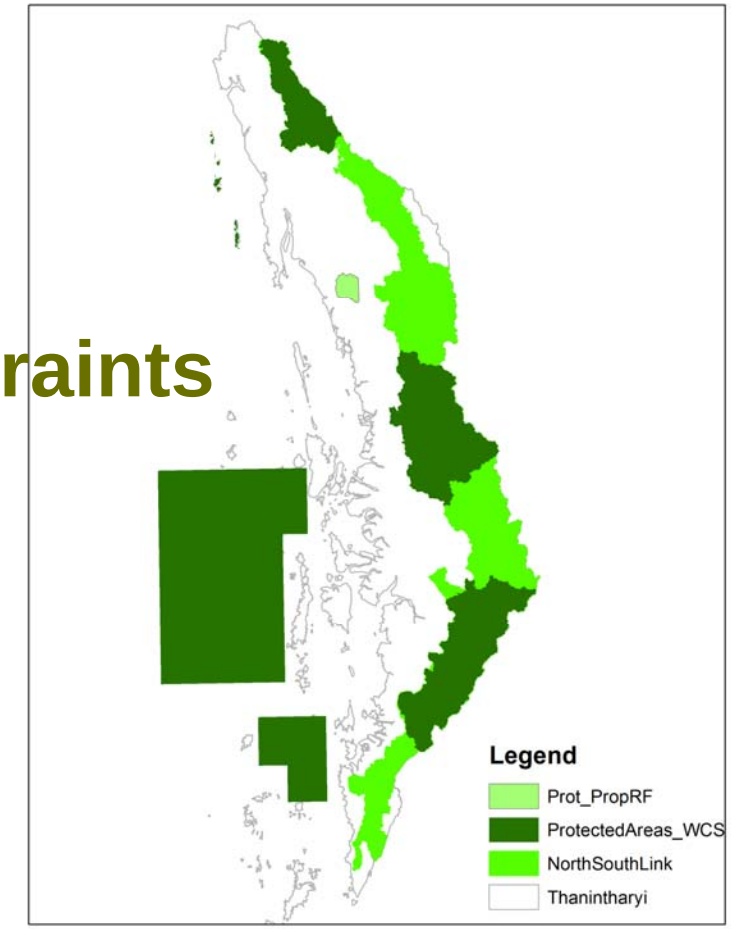
SCENARIO ASSUMPTIONS

natural capital PROJECT

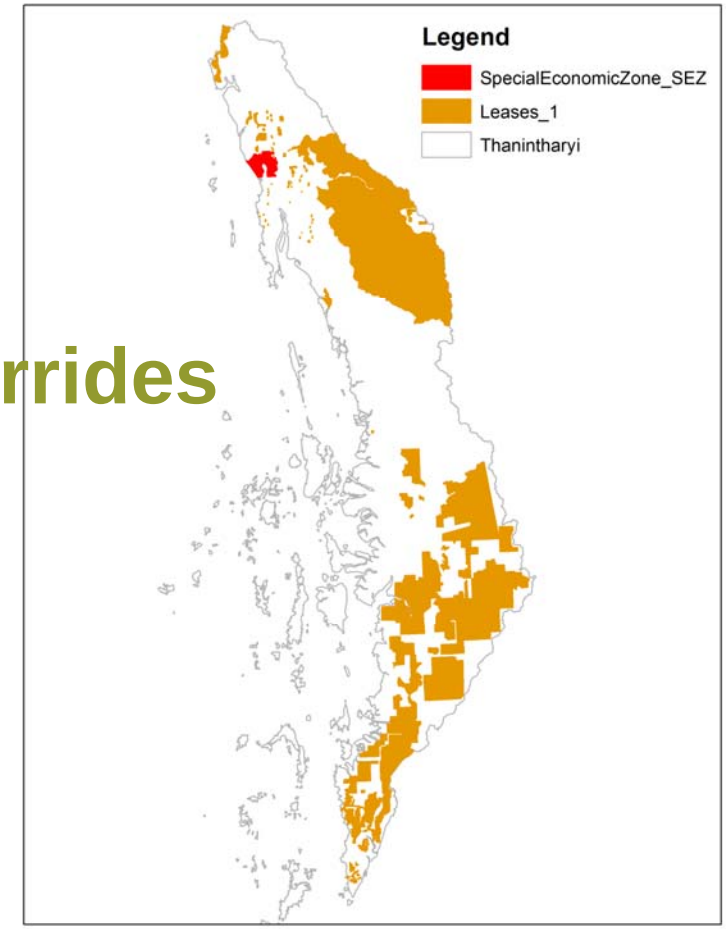
Some assumptions	Limited deforestation	More deforestation
Settlements / agriculture/ bare lands	5% increase, close to existing roads and settlements	30% increase, all over the landscape
Mangroves	No change	Allowed to degrade
Protected areas & wildlife corridors	No change	Allowed to degrade
Elevation constraint	Most deforestation at < 200m Some deforestation between 200-500m Least conversion >500m	No elevation constraints
Around population centers	Most impact within 5 km	Up to 20 km from population centers
Around major roads	Most impact within 4 km	Up to 10 km

CONSTRAINTS & OVERRIDES

Constraints

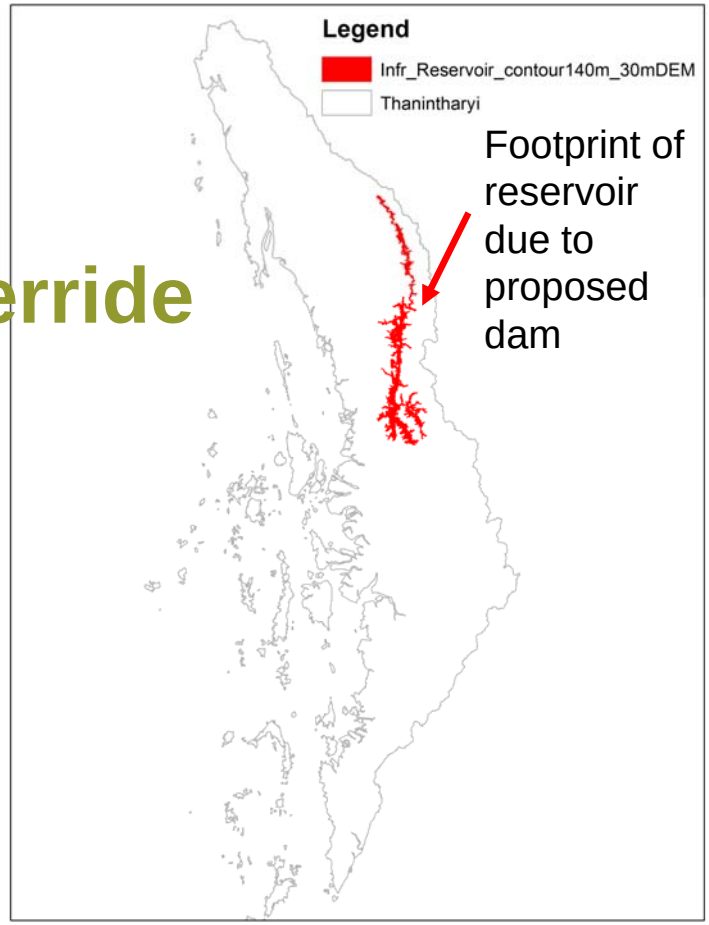


Overrides

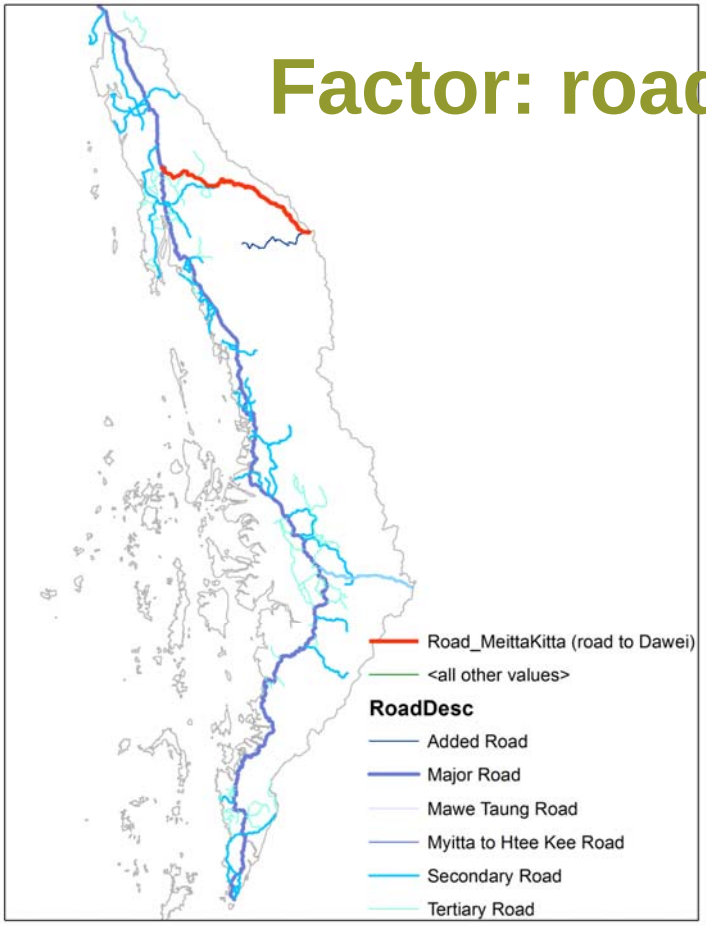


ADDITIONAL INPUTS

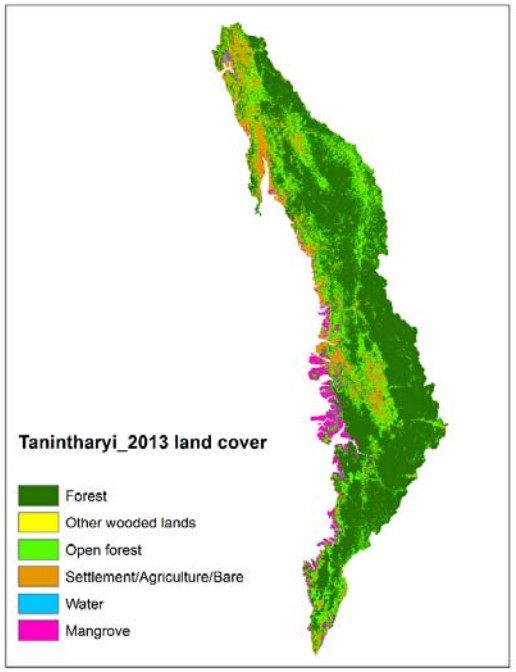
Override

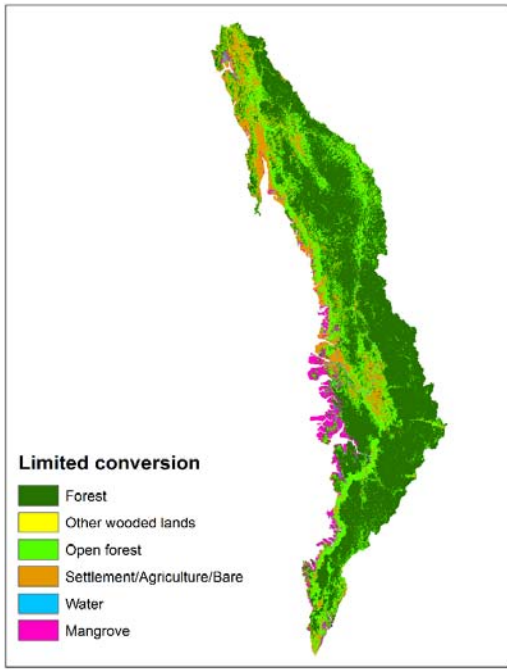


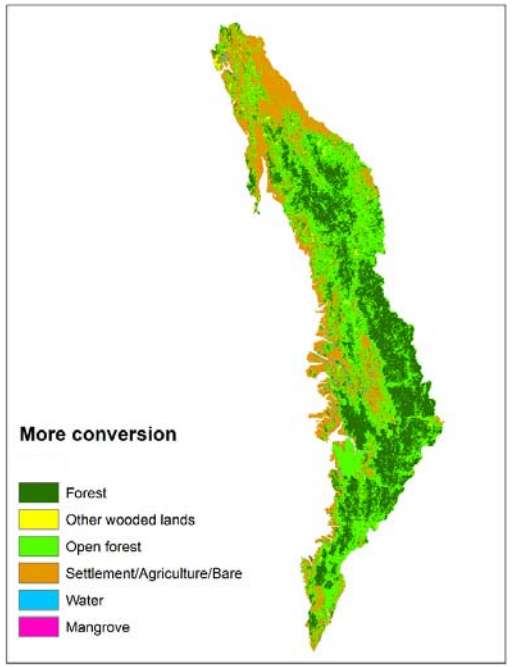
Factor: roads



BASELINE & SCENARIOS

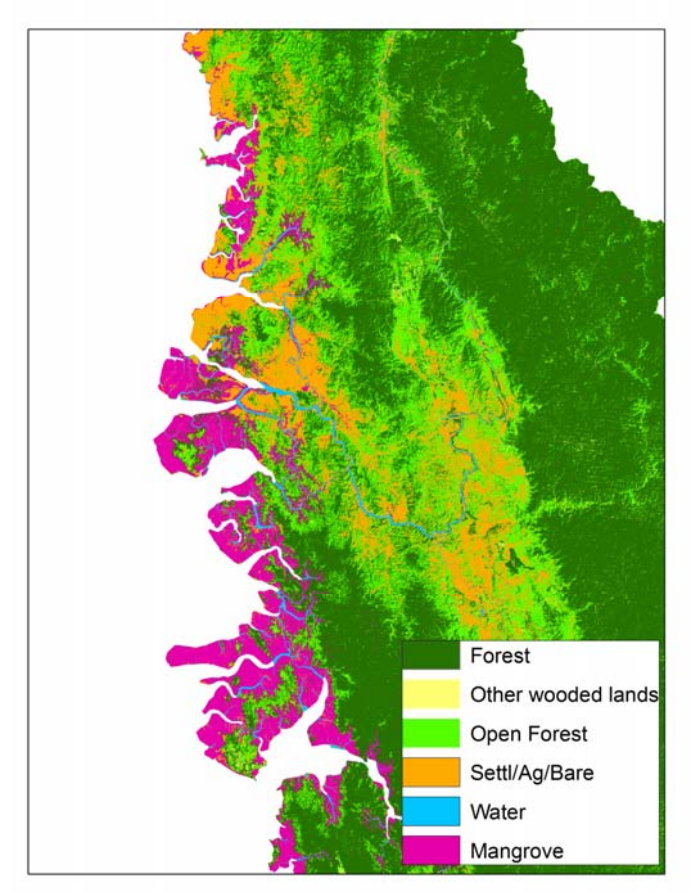


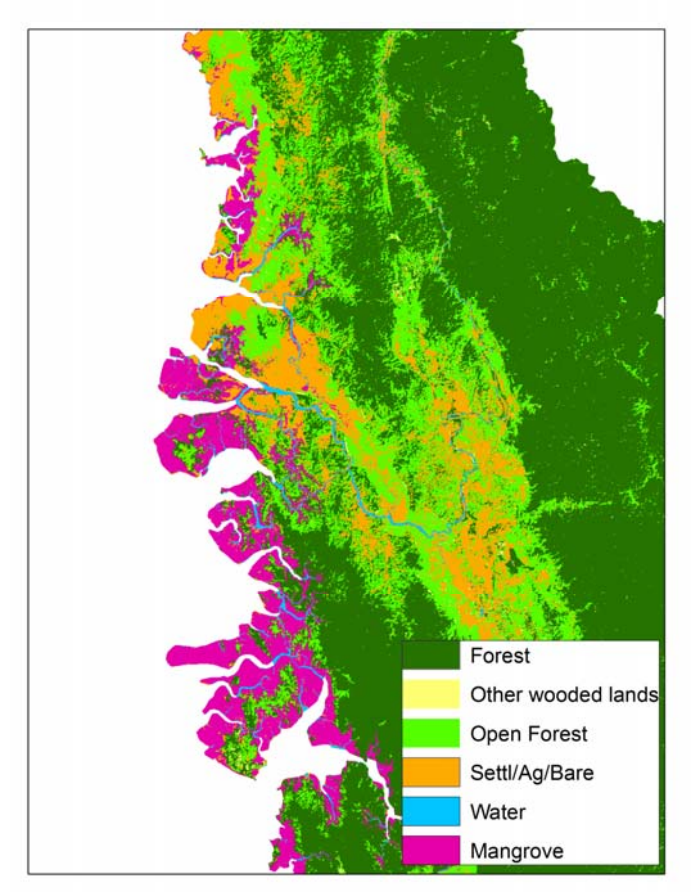




Some assumptions		
Settlements / ag/ bare lands →	5% increase, close to existing roads and settlements	30% increase, all over the landscape
Mangroves →	No change	Allowed to degrade
Protected areas & corridors →	No change	Allowed to degrade

Baseline land cover (2013)

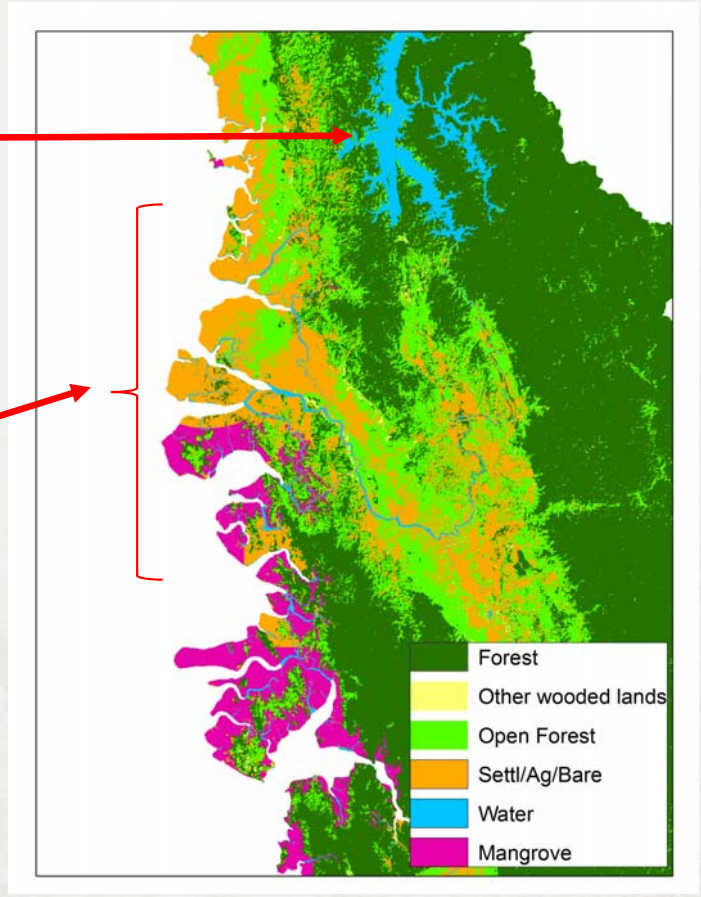




"Limited conversion" scenario

Dam reservoir

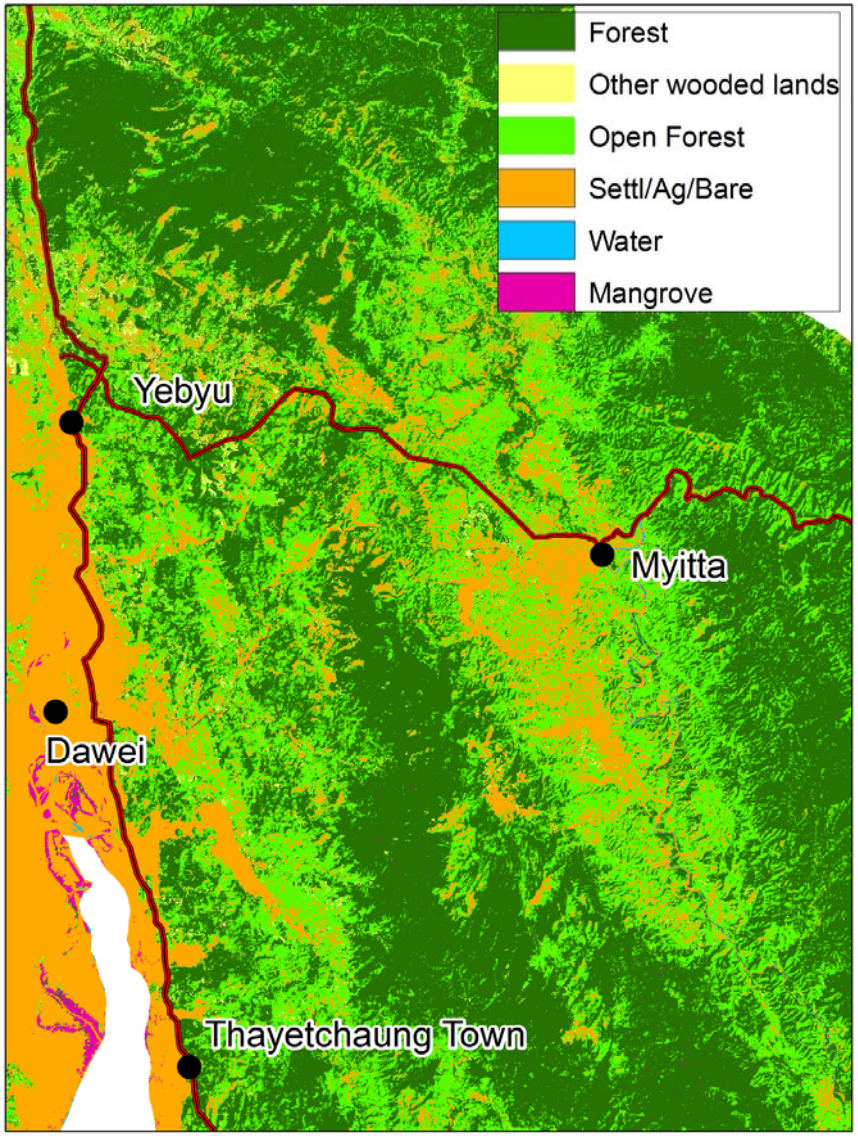
Mangrove loss



"More conversion" scenario

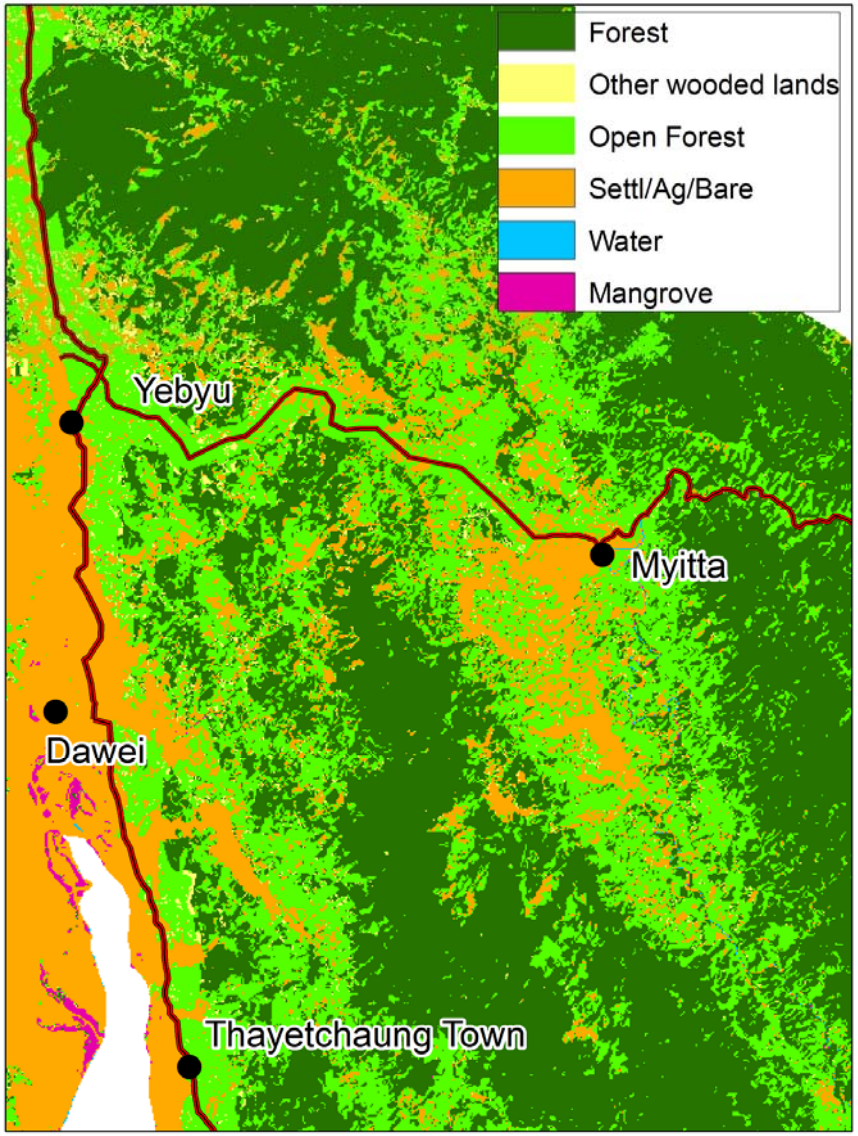
Baseline

2013 land cover



“Limited conversion”

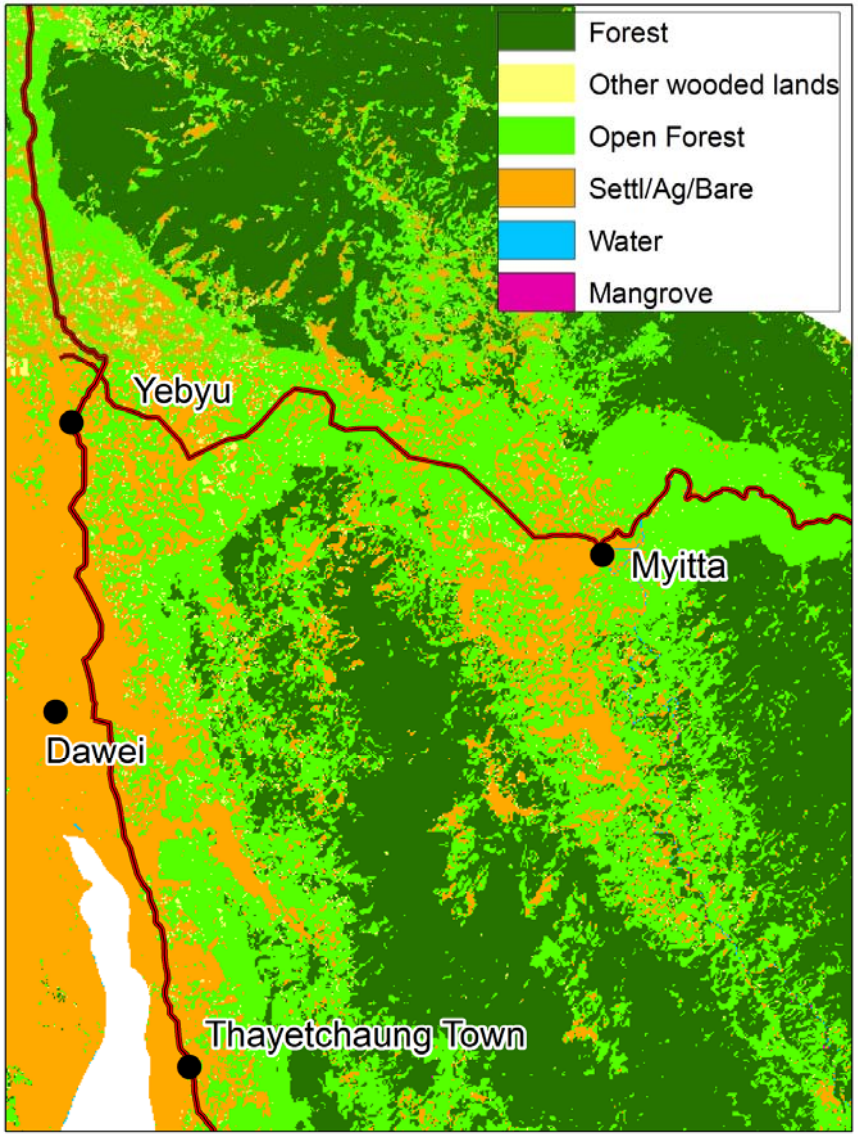
Some deforestation around roads and population centers



natural capital PROJECT

“More conversion”

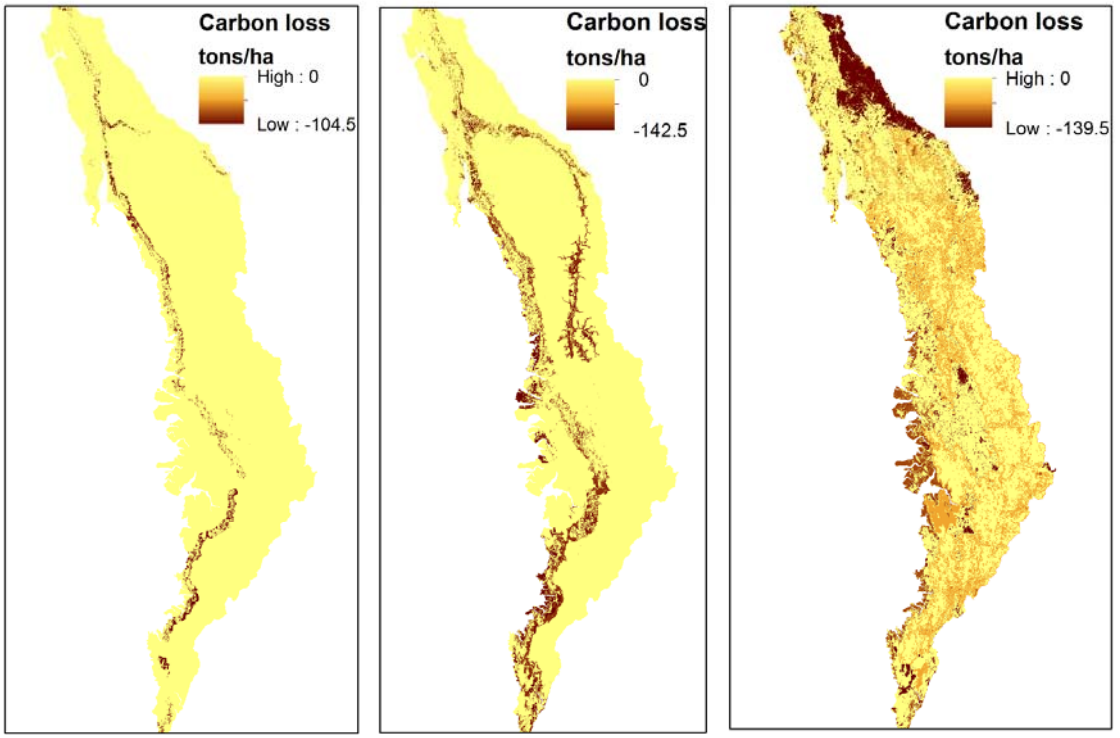
More deforestation around roads and population centers



natural capital PROJECT

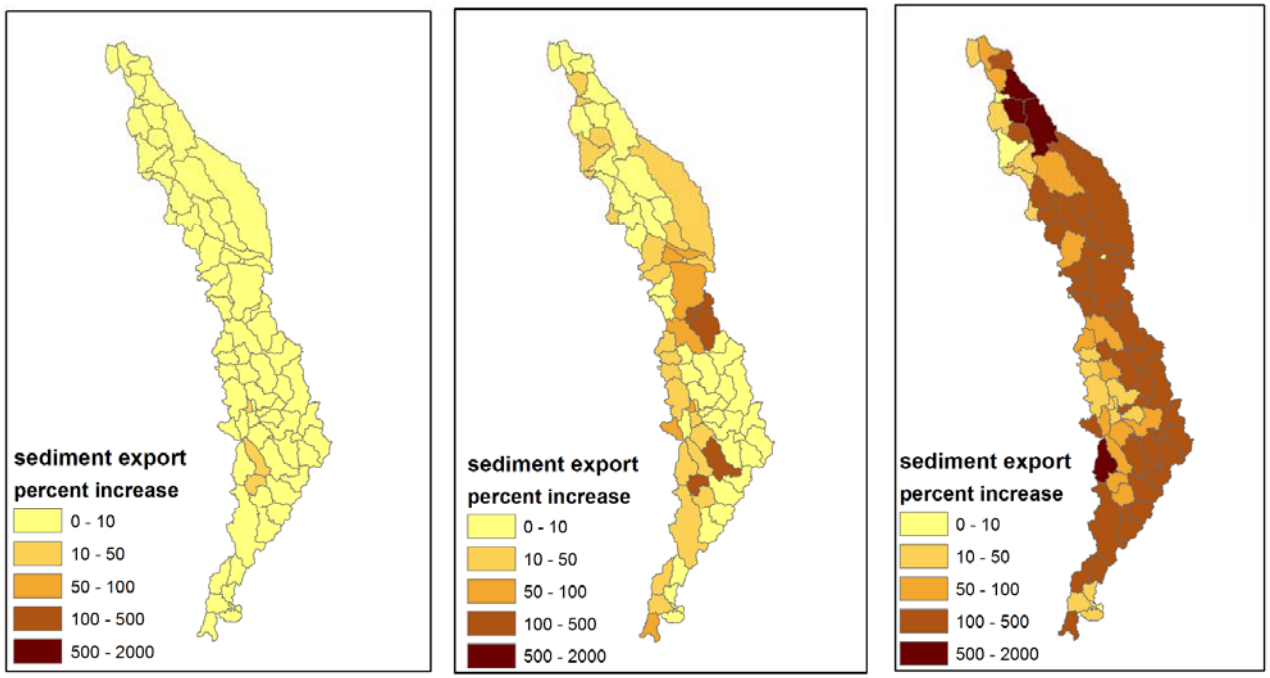
ECOSYSTEM SERVICE OUTCOMES UNDER TANINTHARYI SCENARIOS

CARBON EMISSIONS



Limited deforestation | Some deforestation | More deforestation

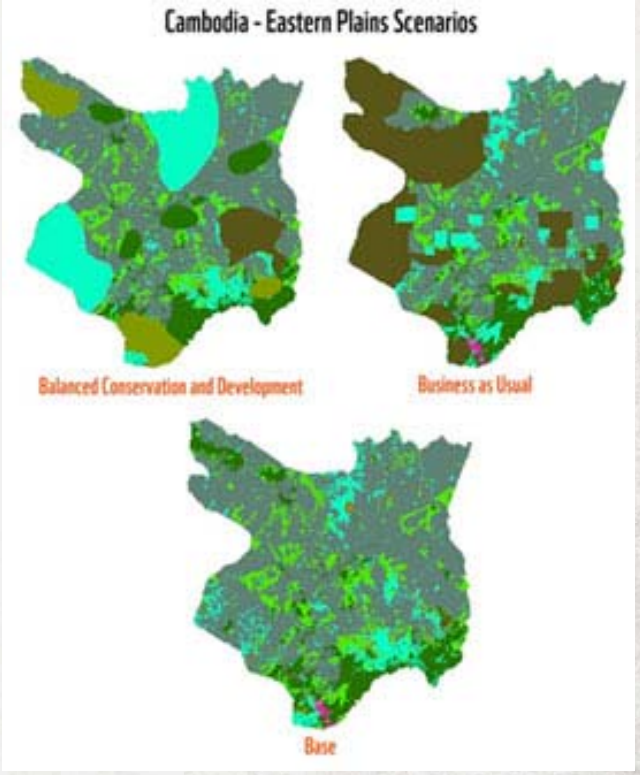
EROSION



Limited deforestation | Some deforestation | More deforestation

SCENARIO GENERATOR
WHAT IT DOES

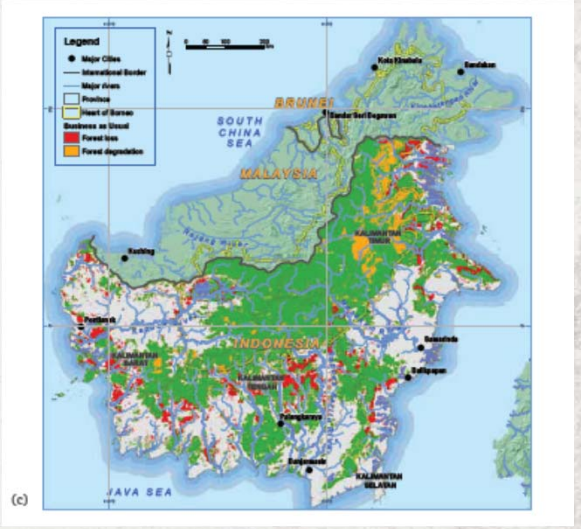
- Turn storylines into maps
- Useful for projects with short timeline or in data-sparse environment
- Translation of qualitative & stakeholder inputs into scenario maps
- Replicable
- Good ‘what-if’ tool
- Particularly good for visions, explorations & interventions (in data-poor areas)



SCENARIO MODELING TOOLS

SPATIAL MODELS

- Land Change Modeler
- CLUE
- LandSHIFT
- Marxan
- Dinamica
- GeoMod
- MAGICC/SCENGEN
- Metronamica



SCENARIO GENERATOR KIT
WHAT IT DOES

SCENARIO GENERATOR KIT
WHAT IT DOES

Scenario Documenter

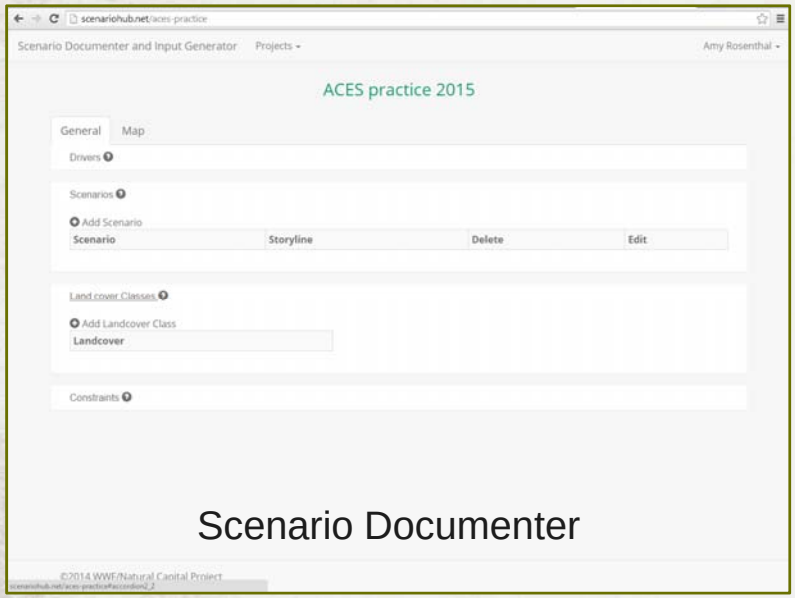
- Can be used in workshop setting with stakeholders
- Inputs from scientific literature, surveys & policy documents

Scenario Generator

- Converts inputs into *transition likelihood* that a given pixel will change to a different land cover in the future
- Based on total area allocated, user-defined constraints, proximity and access rules

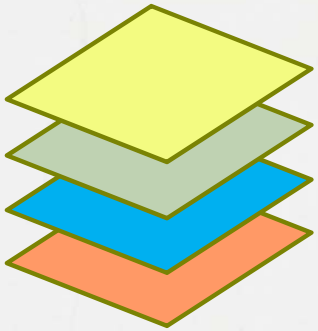
Survey for Scenarios

- Gathers info from stakeholders & experts
- Info converted to kit-ready inputs for Scenario Hub and Generator
- *(Under construction!)*



Scenario Documenter

Scenario Generator



Rules

Likelihood(+)

Factors(+)

Proximity (+)

Constraints (x)

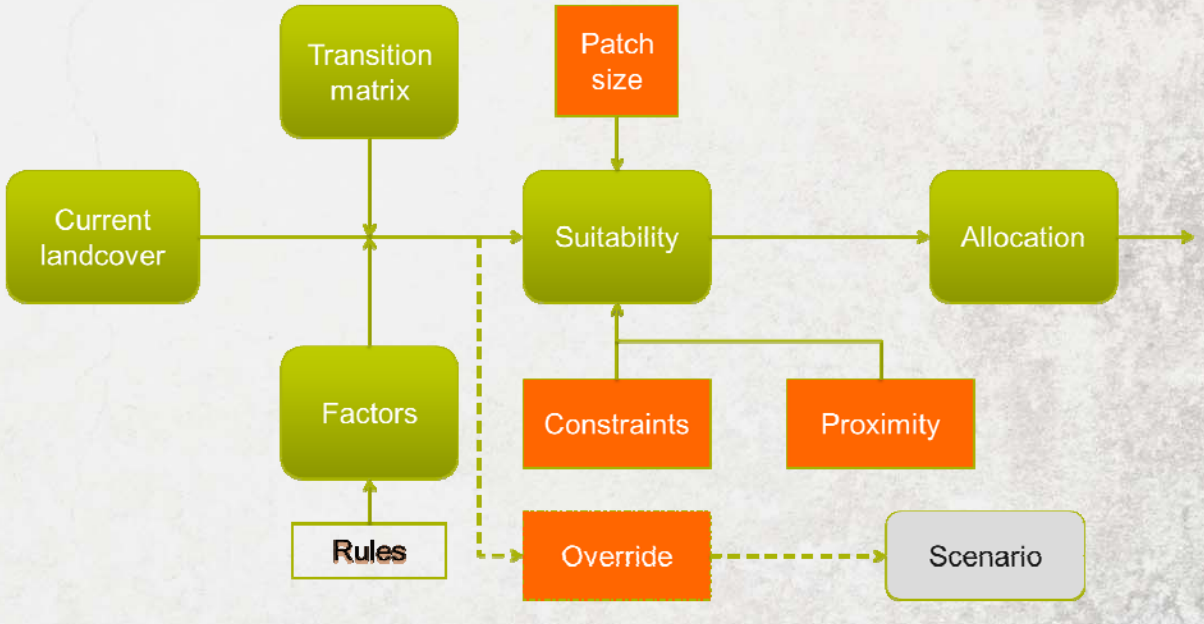
weighted

Survey for Scenarios

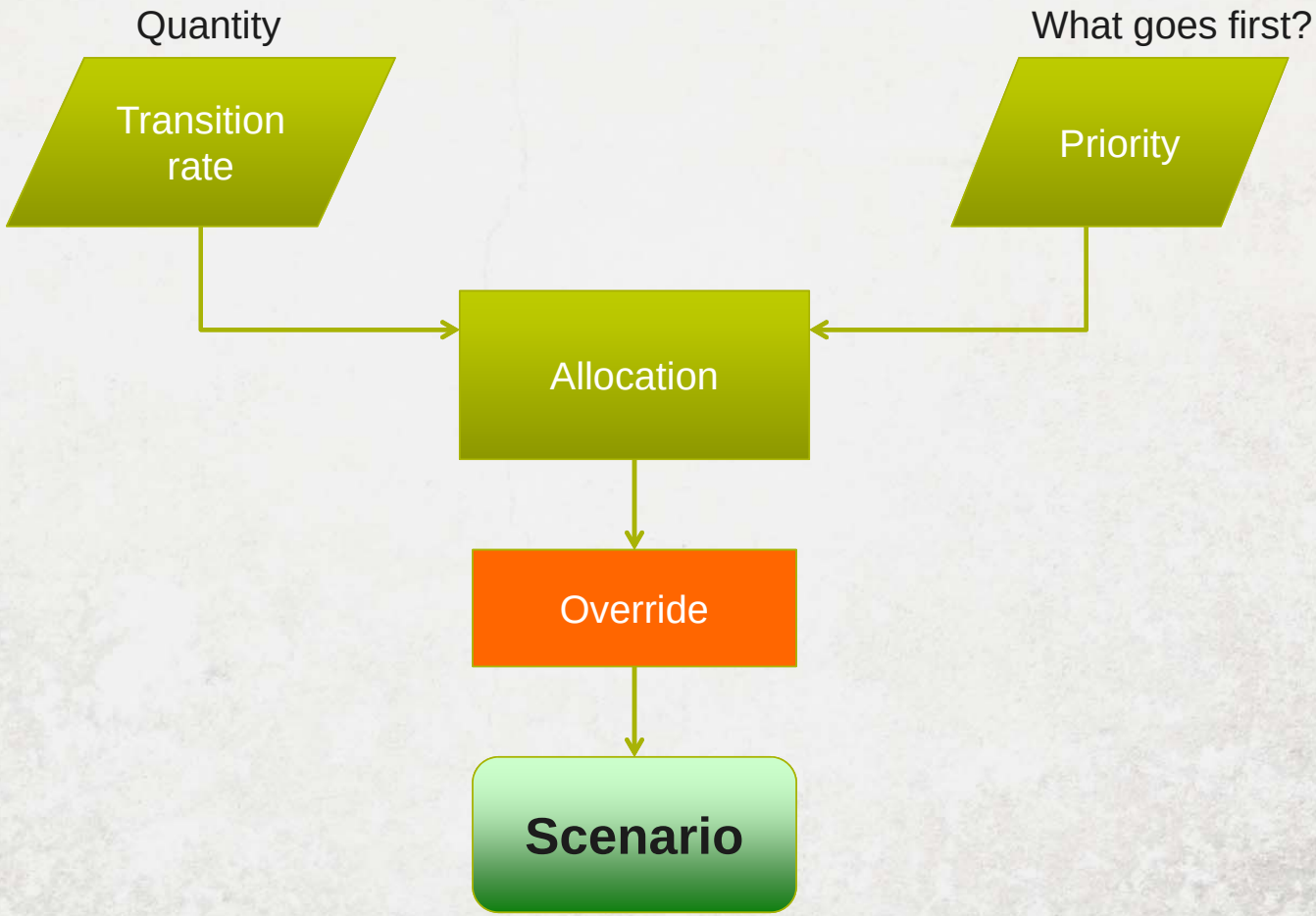
Aggregate transition probability

SCENARIO GENERATOR
WHAT IT'S NOT

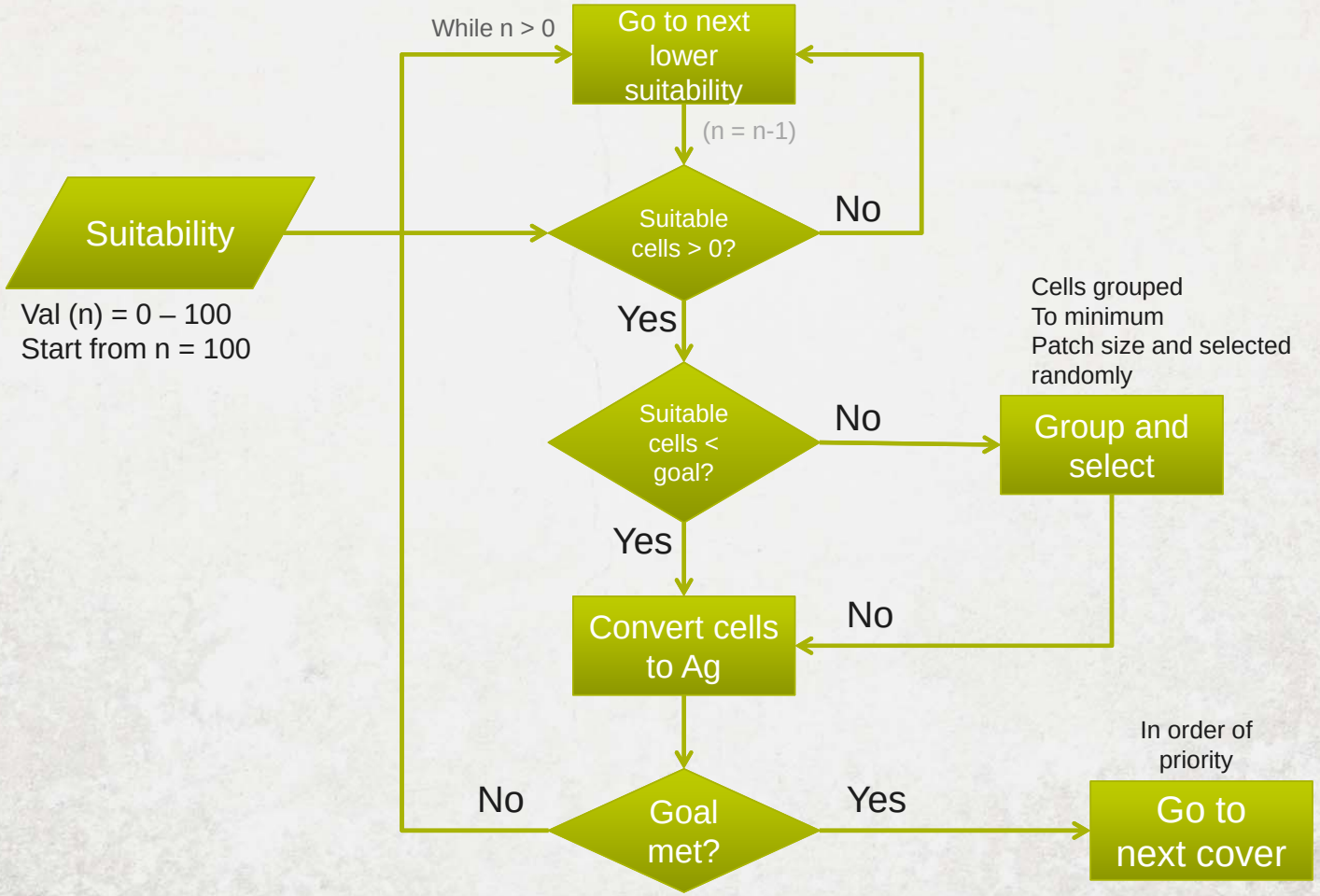
- Econometric modeling tool
- Projection or prediction model
- Optimization tool
- Regression-based
- Highly complex



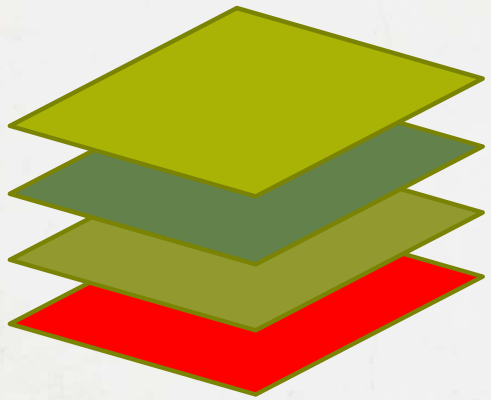
SCHEMATIC


Quantity
What goes first?
Transition rate
Priority
Allocation
Override
Scenario

ALLOCATION


While n > 0
Go to next lower suitability
(n = n-1)
Suitability
Suitable cells > 0?
No
Yes
Val (n) = 0 – 100
Start from n = 100
Cells grouped
To minimum
Patch size and selected randomly
Suitable cells < goal?
No
Group and select
Yes
Convert cells to Ag
No
In order of priority
No
Goal met?
Yes
Go to next cover

PREPARING SUITABILITY LAYERS



Rules

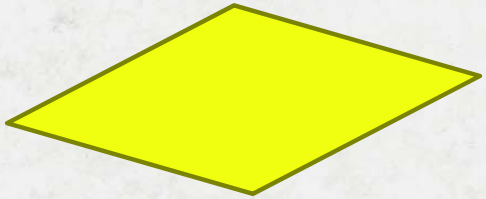
Likelihood(+)

Factors(+)

Proximity (+)

Constraints (x)

weighted



Aggregate transition probability/suitability