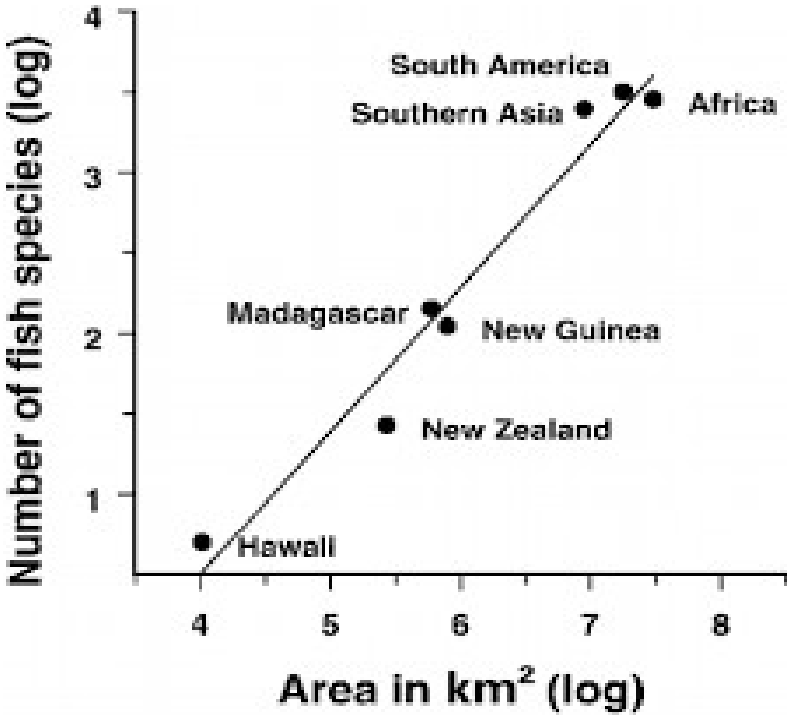
Applied Biogeography



Applied Biogeography

Introduction to the course

1. Aims and objectives of the course
2. Example of applied biogeography
3. Details of the assignment and the exam
4. Lecture program
5. Teaching methods
6. Reading

Applied Biogeography

Focus of the unit

The analysis and description of geographical patterns and their effects on biological processes.

Changes in such patterns over time in response to natural and anthropogenic factors,

Relationships between spatial pattern and biological processes that operate at landscape and regional scales.

Focus of the unit

The unit uses powerful spatial tools developed by **geographers** for analysing and quantifying **patterns**.

The tools are applied within the context of ecological **processes** that are occurring on managed landscapes

Geographical patterns affect **processes**, **processes** affect geographical **patterns**.

These interactions need to be understood in order to conserve **biodiversity** and wildlife in the context of **human driven processes** such as urbanisation, road construction, agriculture, habitat fragmentation and destruction.

Landscape ecology evolved from **biogeography** and is closely related.

Landscape studies are an essential element of modern planning.

They combine elements from classical **geography** and **ecology**.

Intended Learning Outcomes

An ability to assess land cover change using appropriate methods such as **remote sensing** and **GIS.**

A critical understanding of the **relationship between biogeographical patterns and the key ecological processes**

A critical understanding of how **human activities** influence biogeographical patterns, land cover change and ecological processes operating at a regional and landscape scale.

An understanding of the **spatial dynamics** of landscape patterns and processes and how these relate to human society.

A critical awareness of relevant **research methods** and sources.

Biogeographical questions

- Why are certain species and certain groups of organisms found in certain localities and nowhere else?
- What has caused these patterns on a world scale?
- Why is it that for many groups of organisms there are fewer and fewer species in the north and in the south compared to the tropical regions?
- Why is it that in some regions there are few species but the abundance of some individual species is very high?
- How does the fragmentation of landscapes affect biodiversity and what can we learn from naturally fragmented systems such as islands?

Applying biogeography

Conservation of wildlife and habitats is achieved partly through protected areas.

Where should protected areas be located, and why?

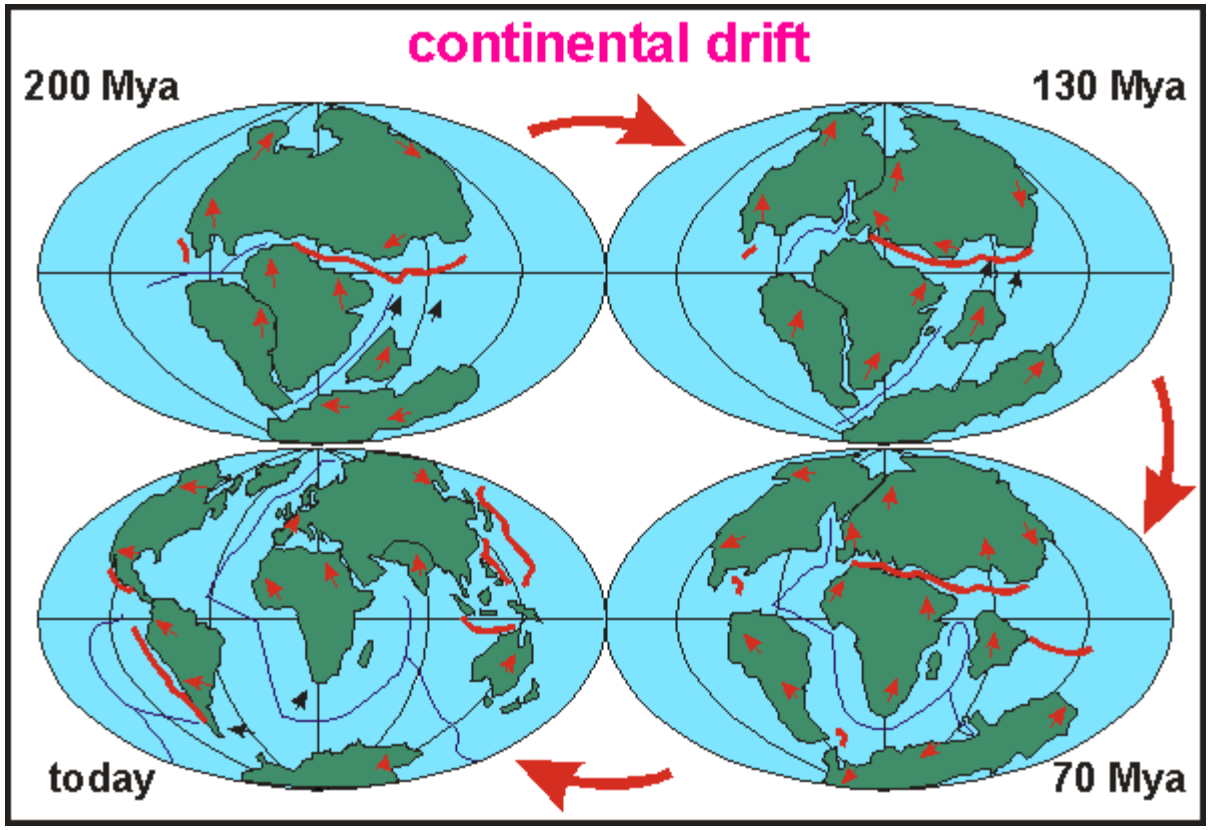
How large should they be?

How well connected should they be?

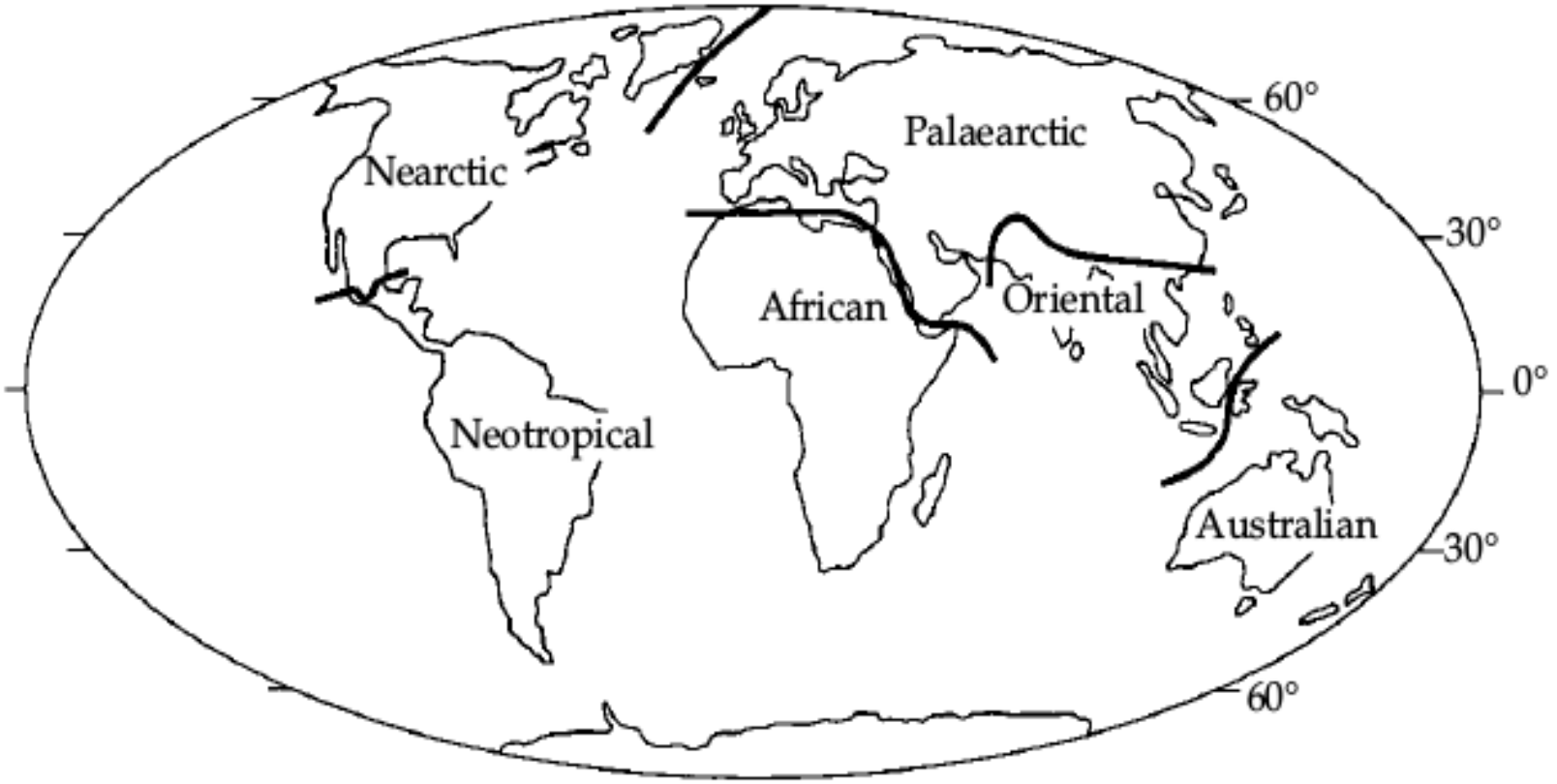
How should they be managed?

How should the landscape outside protected ?

The big picture



The big picture

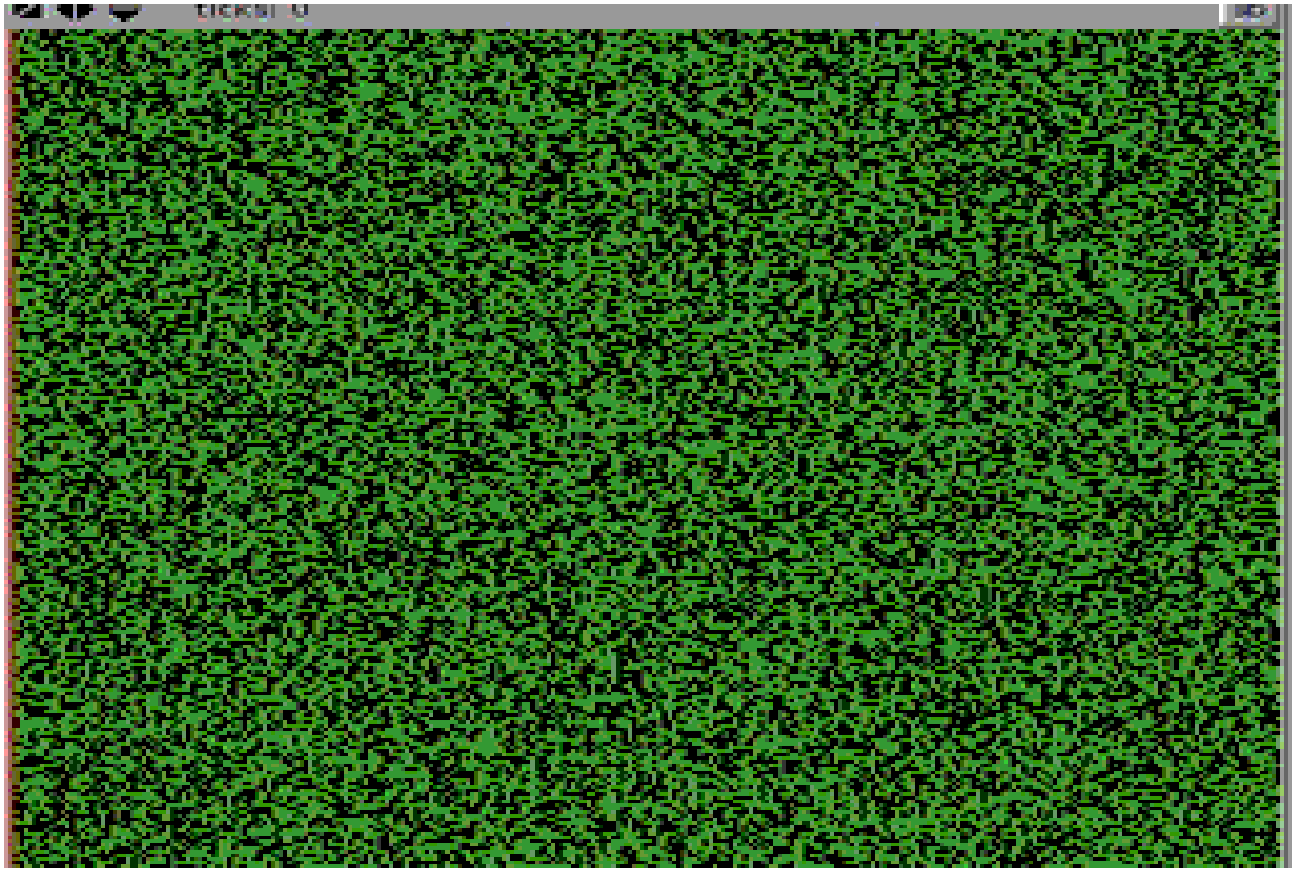


Landscape scale patterns and process

Can you tell what this **process** is?

Simple rules are applied to patches that produce emergent properties at the **landscape** scale.

The result is a distinct **pattern**.



The process forming the pattern

The model represents fire spread across a landscape of vegetation patches.

Each patch contains fuel that may ignite.

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The public perception of landscape patterns and processes may be based on a limited temporal and spatial scale.

This unit will help you to see the “big picture” and place landscape change in context.

How can we manage more effectively at regional scale?

- Use the best evidence from remote sensing
- Place change in a historical perspective
- Use GIS to quantify pattern
- Obtain insights from dynamic systems models
- Use ecological theory critically
- Be fully aware of scaling issue

All these elements are integrated in the course

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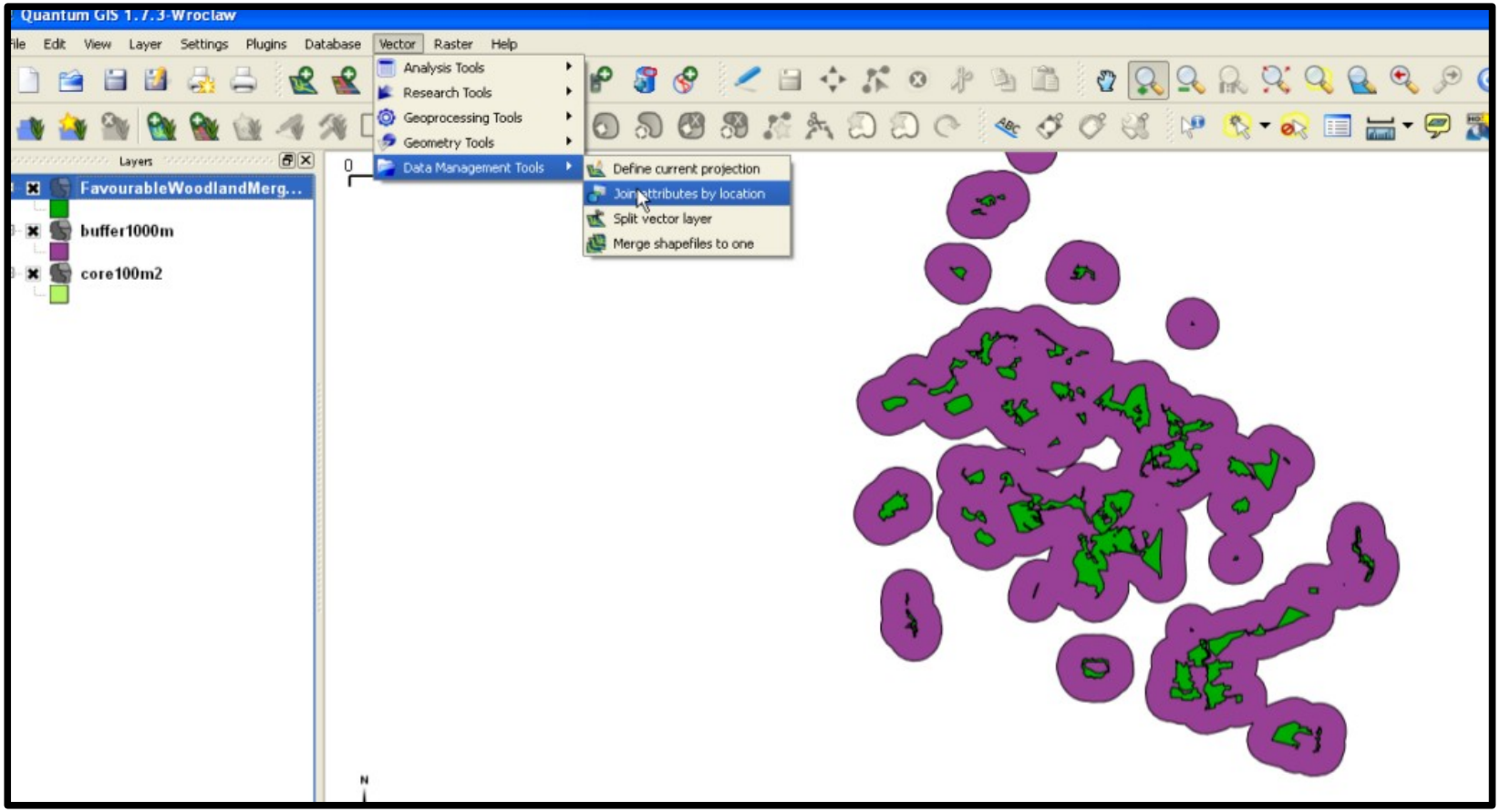
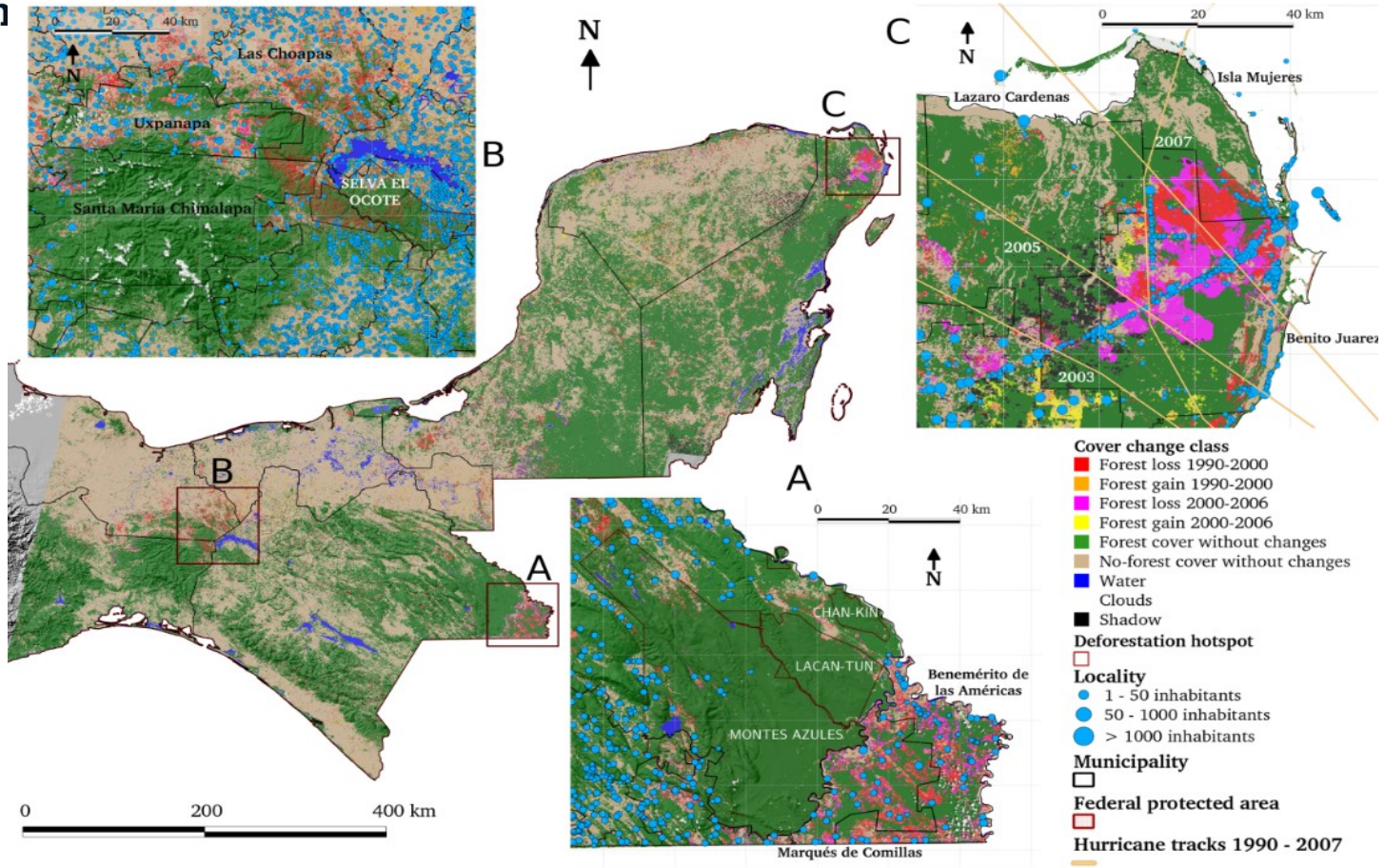
Analysing satellite imagery

Using GIS effectively



Research on regional patterns

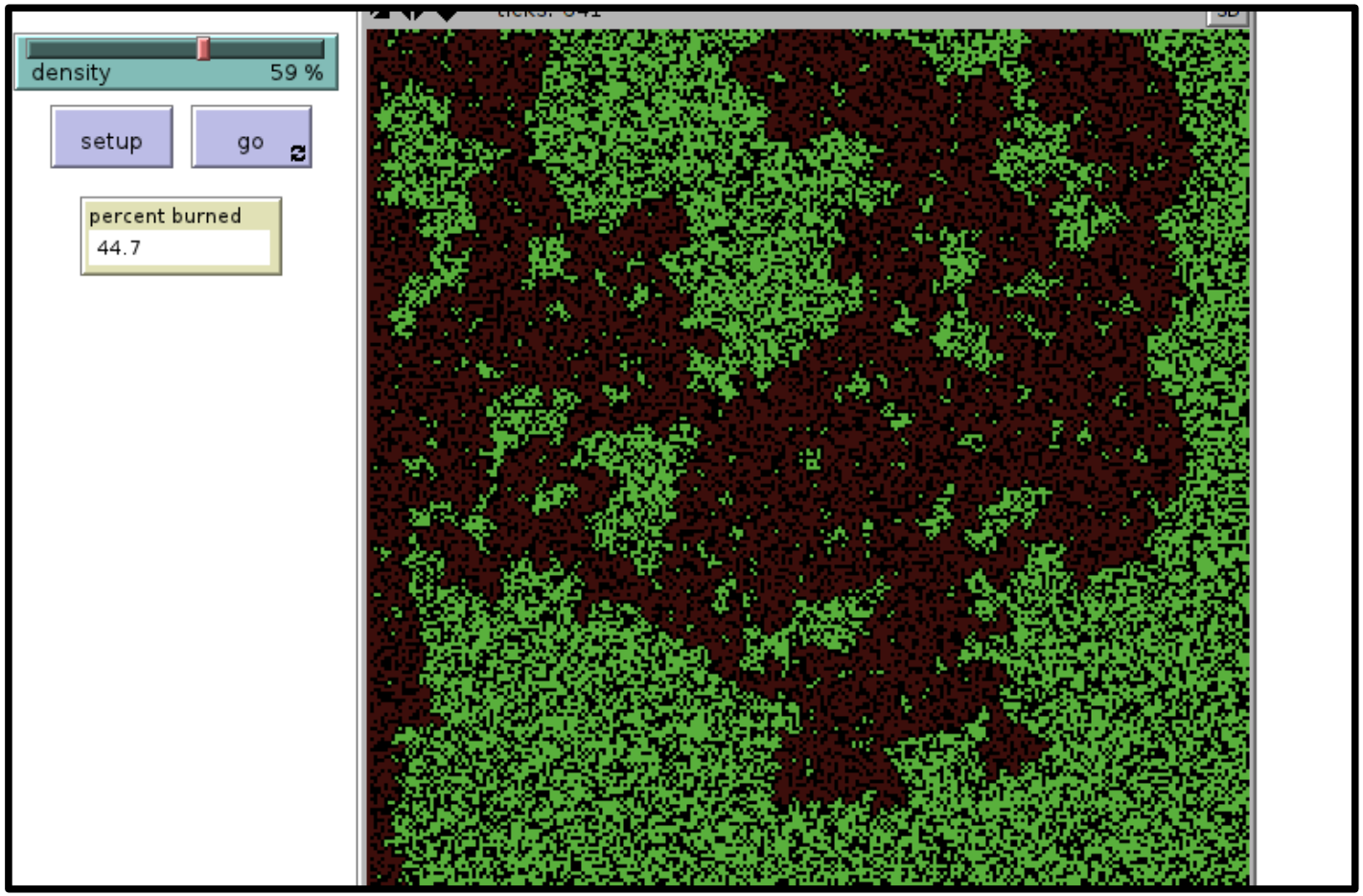


Vaca RA, Golicher DJ, Cayuela L, Hewson J, Steininger M (2012)
Evidence of Incipient Forest Transition in Southern Mexico. PLoS ONE 7(8): e42309. doi:10.1371/journal.pone.0042309

Insightful simulation modelling

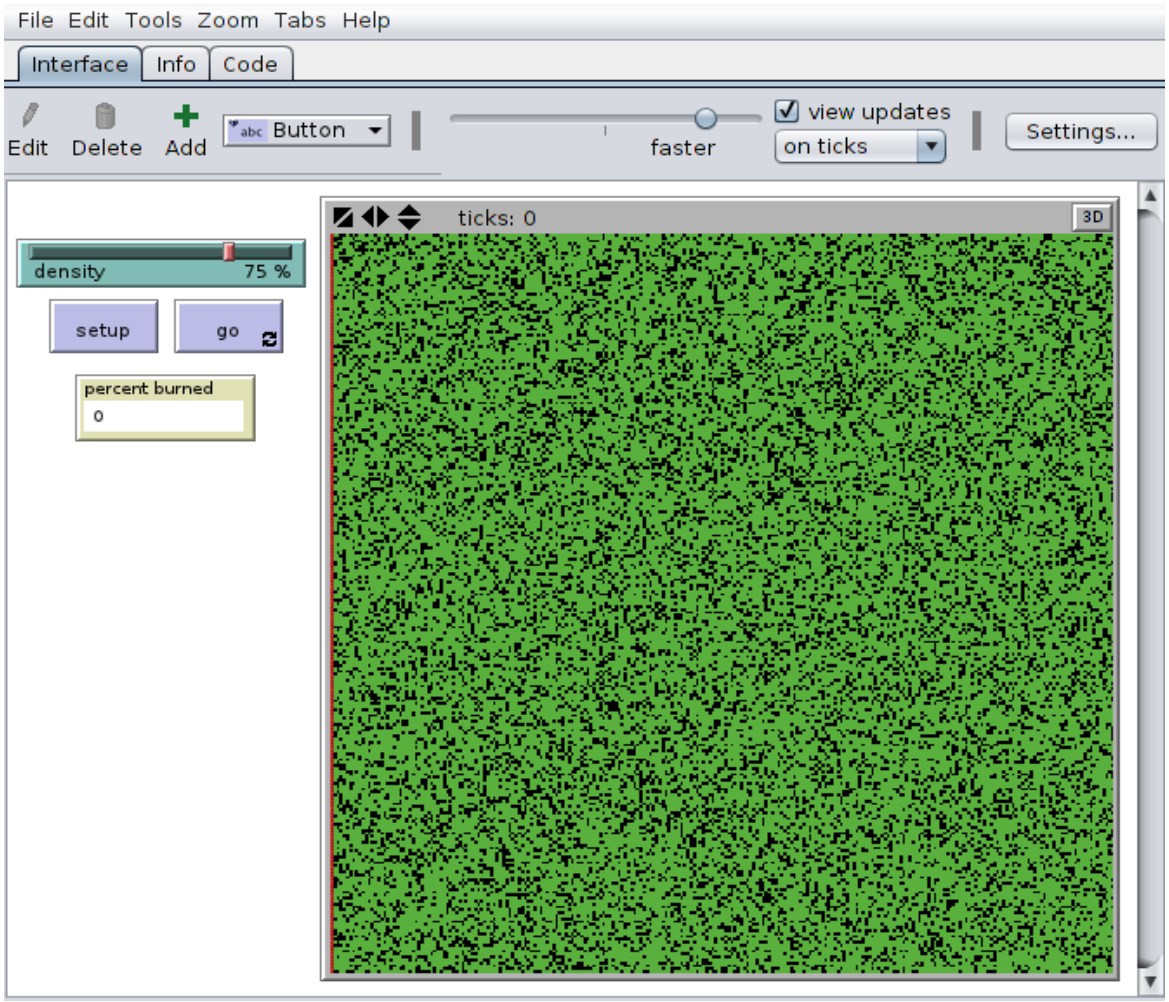
Models do not need to be highly complex in order to reproduce realistic patterns.

Analysing comparatively simple models can help us understand how landscapes form and function.



Insight from simple simulation

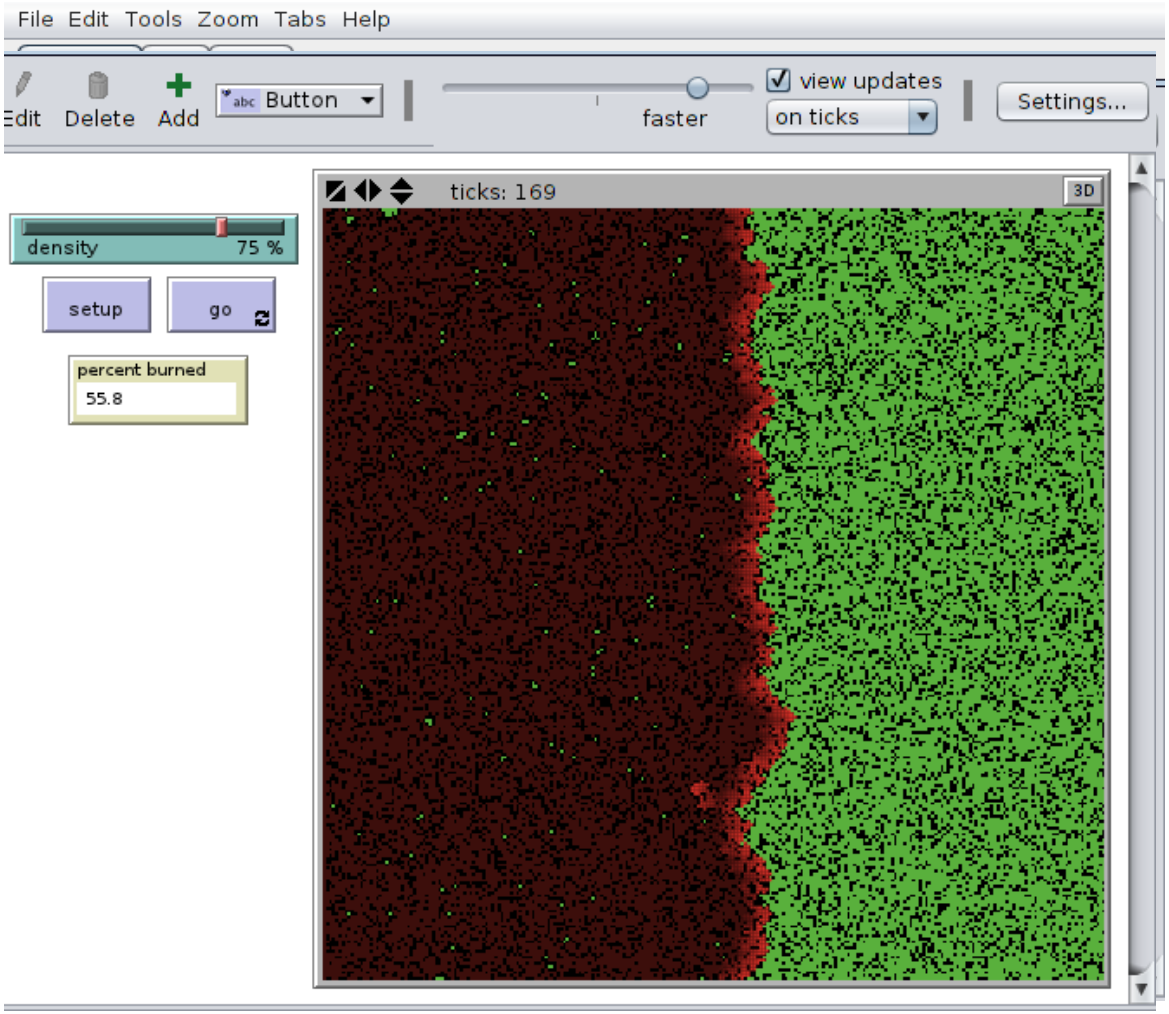
In the simple example increasing fuel density will change the pattern dramatically



Insight from simple simulation

An increase in fuel density increases rate and homogeneity of fire spread.

More patches are burnt more quickly.

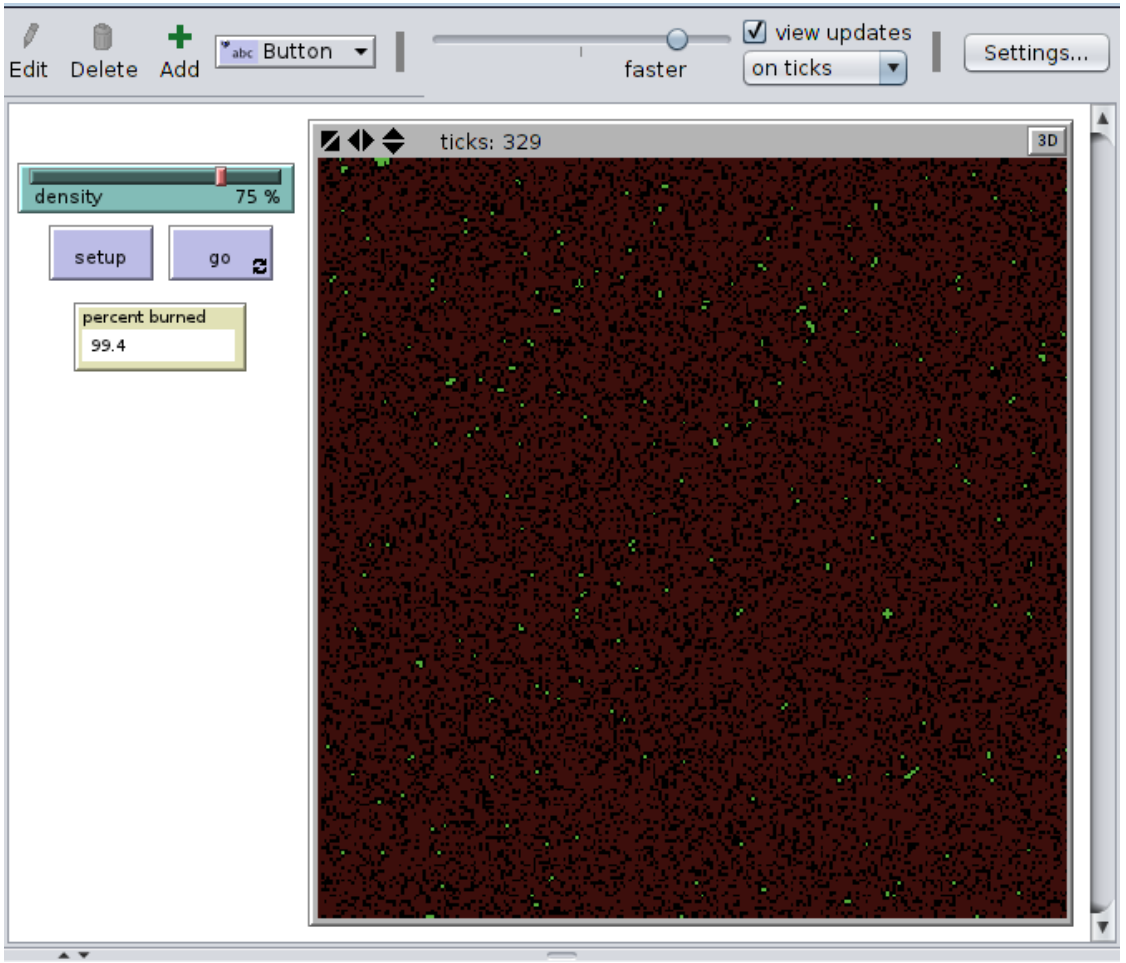


Insight from simple simulation

The result

A small change
in the parameters
of a model
of underlying process
can have a
large effect on the
landscape
pattern.

This feeds into
other processes.



Assessment

Exam. Answer 3 questions from 6 (50%). Questions drawn from the material delivered in the lectures, seminars and workshops

Coursework (50%) consisting of a **report** of around 3000 (50%)

- Training and hands on **support for GIS** analysis will be provided in the practical sessions and lectures up to the hand in date.

Assignment overview

The assignment involves the original evaluation and interpretation of spatially explicit data within a real world conservation context. The analysis should be fully supported by citations of both theoretical and empirical research into applied biogeography.

Assignment detail

Ecoregions are spatially defined biogeographical units containing a distinct assemblage of natural communities and species, within boundaries that approximate to the original extent of the natural communities prior to major land-use change. Terrestrial ecoregions within the moist tropics were originally covered by forests. These forests have been fragmented through ongoing human activity, resulting in threats to global biodiversity.

Assignment detail

In 2013 the results of a long term collaborative research between the University of Maryland, Google and NASA were published in the form of a global map tracking forest gains and losses over the last decade, as detected by Landsat imagery. The classified imagery reveals recent changes in both the extent and pattern of tropical forest cover.

Assignment instructions

Your task is to investigate a tropical ecoregion undergoing ongoing landuse change that is causing loss and fragmentation of forest cover. You will use this state of the art imagery and GIS software to quantify the patterns of change. The report of your findings will discuss the implications of forest cover change from an applied biogeography perspective.

Assignment instructions

You will be provided with GIS layers representing the geographical boundaries of terrestrial ecoregions, the extent of all protected areas within these ecoregions, recent forest cover change and Modis derived fire events registered throughout the last decade. You will also be provided with detailed historical climatic data for the ecoregion.

Assignment instructions

Choose a tropical forest Ecoregion situated within Central America, South America, Indonesia or Madagascar as the focus for your analysis. The ecoregion must include at least one protected area. There should be clearly noticeable recent deforestation within the ecoregion boundary.

Assignment content

Write an introduction which describes the main biogeographical characteristics of the ecoregion including climate, topography, soils and vegetation type. Discuss key conservation issues resulting from anthropogenic forest loss. Explain the reasons underlying the study area's anthropogenic transformation. Explain why forest fragmentation may be of both local and global conservation concern.

Assignment content

Analyse the contrasting patterns of forest cover within the ecoregion for the years 2000 and 2017. You may use qualitative pattern interpretation and/or quantitative GIS based analysis, as appropriate.

Example questions

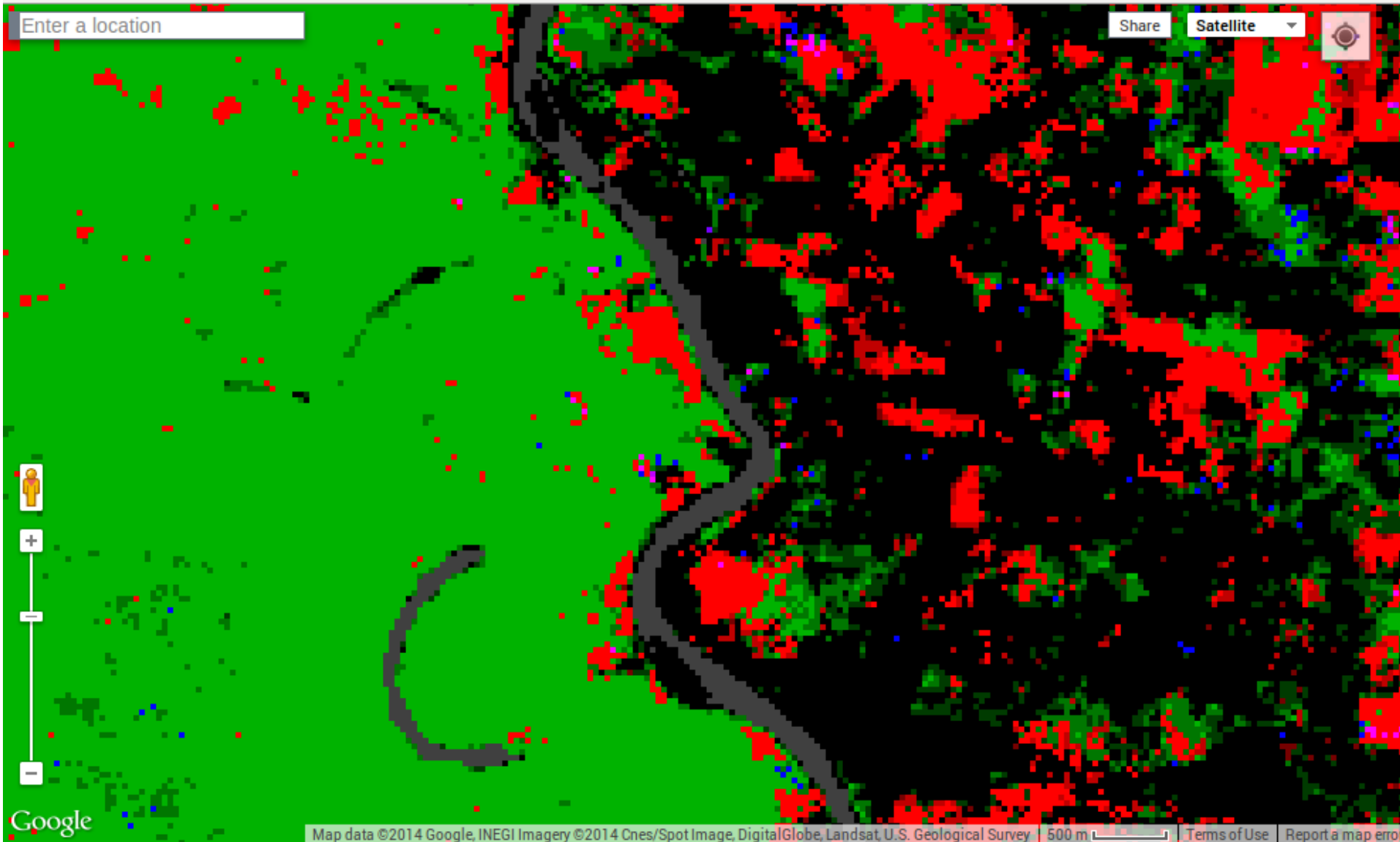
1. How much has overall forest cover changed?
2. Has recent deforestation led to increased forest fragmentation?
3. What proportion of the remaining forest is subjected to edge effects?
4. What proportion of the remaining forest cover lies within officially protected areas?

Example questions

5. How effective have protected areas been in preventing deforestation?
6. How well connected are the protected areas?
7. Does the landscape outside protected areas provide suitable habitat for forest dependent species?
8. To what extent is forest fragmentation impeding the movement of forest dependent species?

Assignment discussion

Critically discuss the strengths and weaknesses of the analytical methods you chose to use. Discuss the implications of your finding within the context of the conservation issues identified in your introduction. Place the results of your study within the broader context of global tropical forest change and species loss. Discuss management options that may be available in order to enhance the value of both protected and unprotected areas for biodiversity conservation. Summarise your key findings as a concise conclusion.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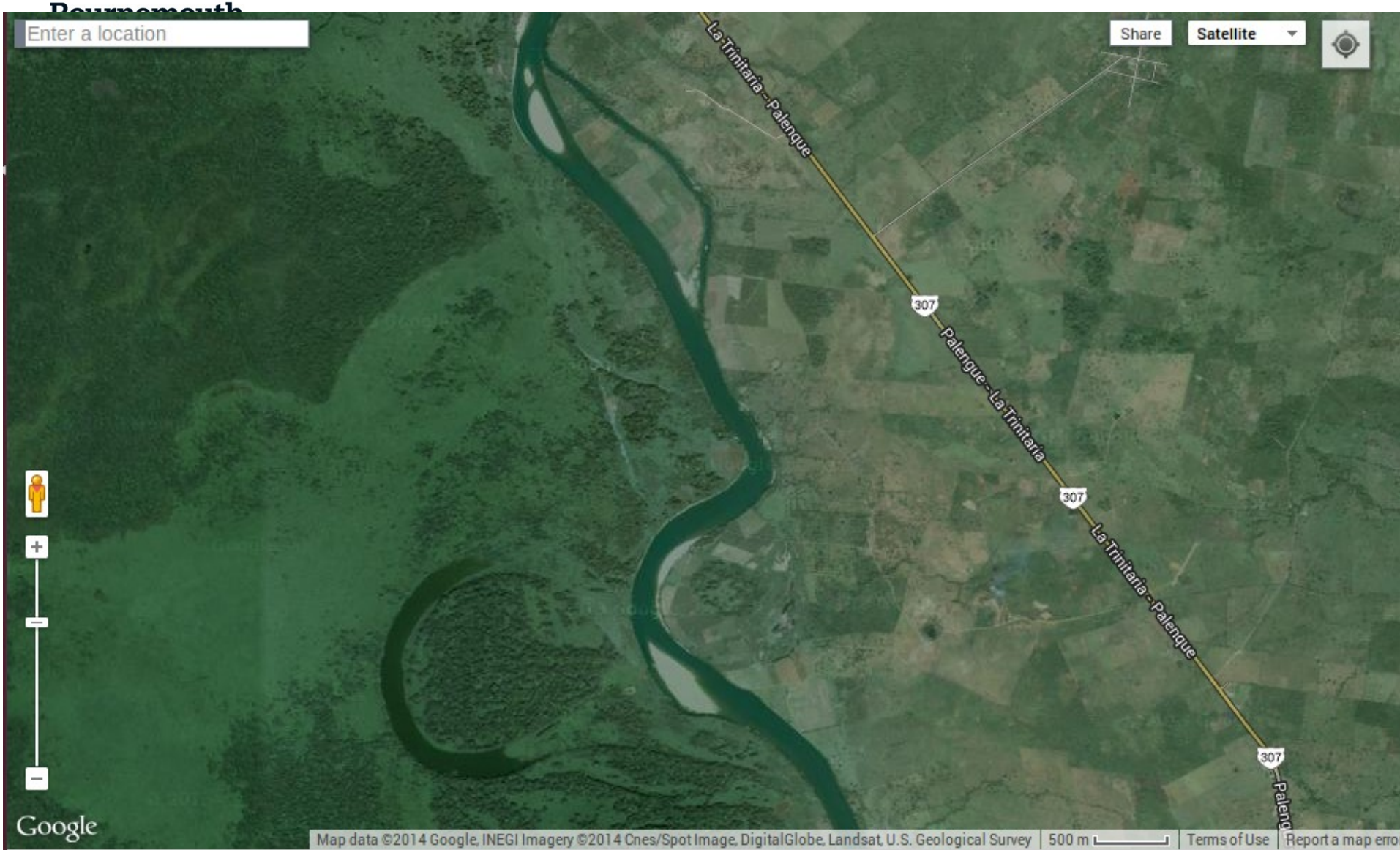
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GIS support

If you already have learned GIS skills they will be extended in this course.

You will learn how to quantify landscape structure and measure connectivity.

If you have not used GIS before, **don't worry**. Screenshot based tutorials will guide you through all the steps needed.

GIS support

- The computer rooms have been booked for a practical session each week.
- During the sessions you will be shown any steps needed to complete your GIS analyses for the assignment.
- The assignment does not require the application of advanced GIS skills
- Visual pattern analysis can answer many of the key questions

GIS software

The work for the assignment can be carried out using Arc GIS.

It can also be achieved easily and efficiently using Quantum GIS (QGIS).

This program is very similar to Arc, with the advantage of being Open Source (i.e free).

You can therefore install it, use it, and update the version on your own laptop whenever you need to

Quantum GIS was developed for academic use. It is easy to learn and can be extended through plugins and add ons.

The QGIS interface and menu is very similar to Arc.

Arc users will have nothing additional to learn if they do use QGIS. All files can be opened in either, so you can use the best of both.

Lecture topics

Drivers of tropical deforestation

The impact of tropical deforestation on biodiversity

Consequences of habitat fragmentation

Macroecology: Global and regional patterns of species richness.

Ecoregions and climatically constrained species distributions

The biodiversity of islands and continents

Lecture topics

Island Biogeography: Theory and application

The SLOSS debate

Quantifying pattern: The patch-matrix model

Edge effects on fragmented landscapes.

Measures of connectivity

Metapopulations and metacommunities

Applied biogeography in practice: Ecological networks.

Applied biogeography in practice: Policy implications.

Tools for understanding theoretical concepts

Some agent based modelling will also be used to illustrate processes taking place on landscapes

There are some simple models programmed specifically for the course

Each model is based on a key theoretical concept. They have the same structure as the more detailed models that are used in research and management.

You will run your own simulation experiments to improve understanding of theoretical concepts

You are not expected to learn to program the models yourself.

Example. Island Biogeography

The figure shown on the left is the classic graph of MacArthur and Wilson.

It is the basis of a large amount of theory and practice in conservation.

But, does it make sense at first sight?

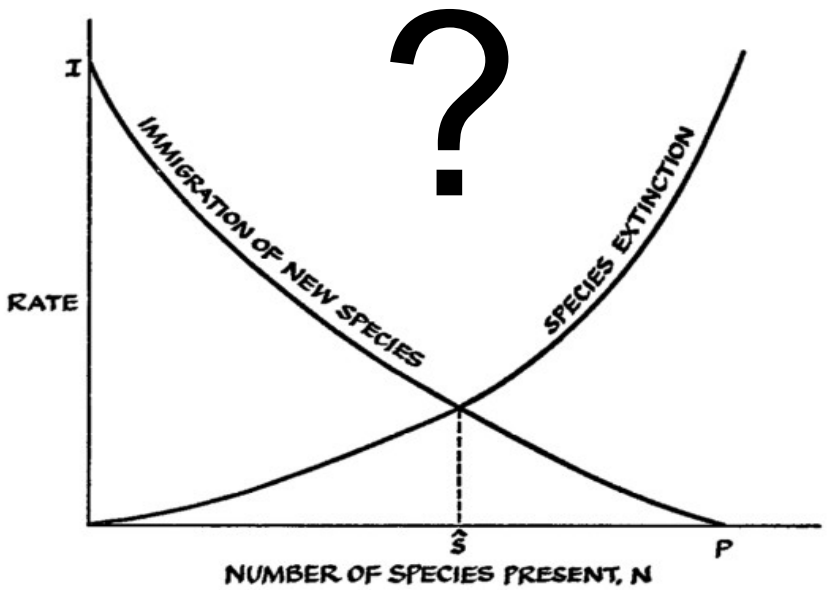
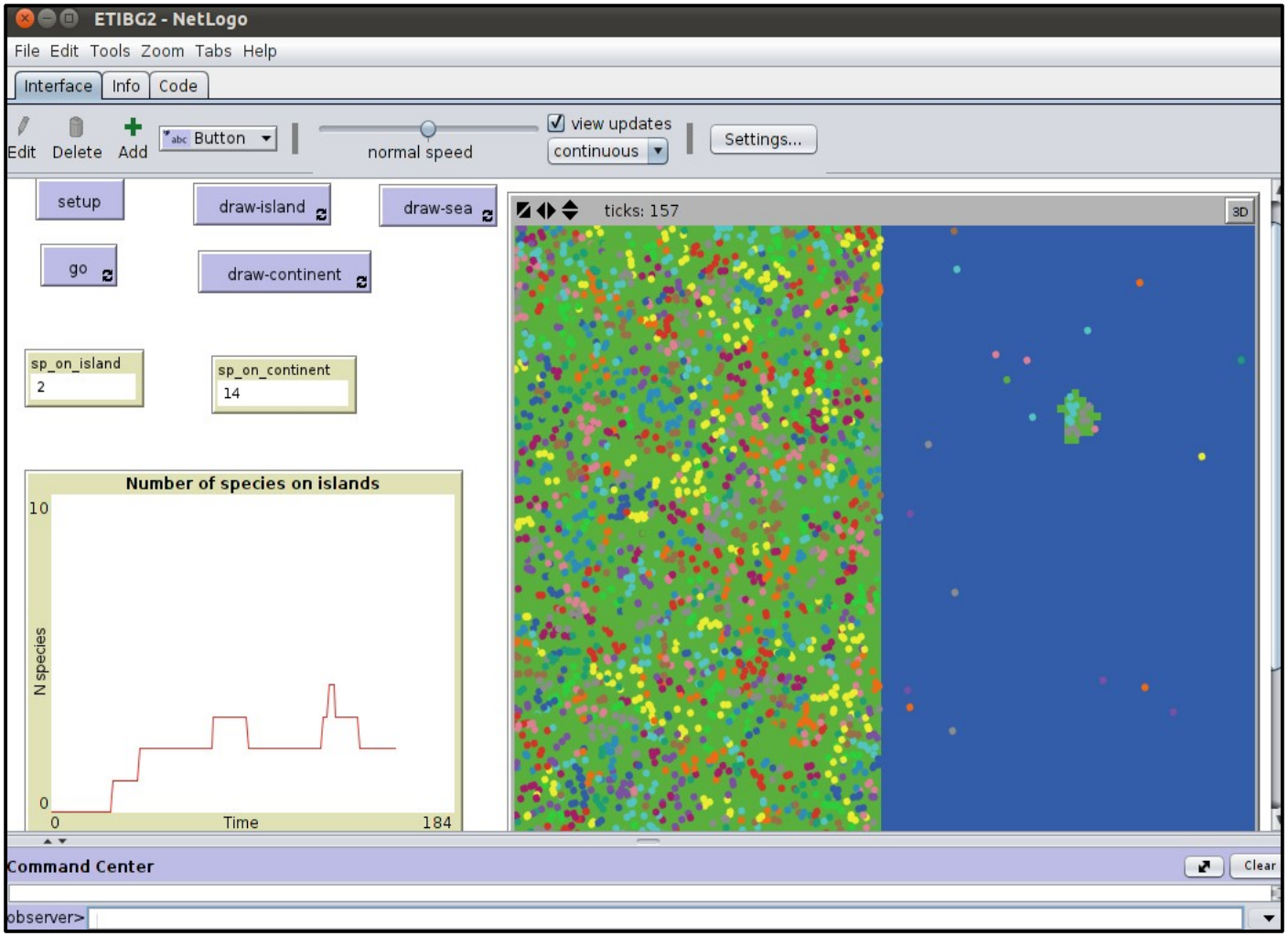


FIGURE 7. Equilibrium model of a biota of a single island. The equilibrial species number is reached at the intersection point between the curve of rate of immigration of new species, not already on the island, and the curve of extinction of species from the island. (After MacArthur and Wilson, 1963.)

Island Biogeography simulation

The process of dispersal to islands or habitat fragments and extinction can be simulated.

Run your own experiments and record the results.



Island Biogeography

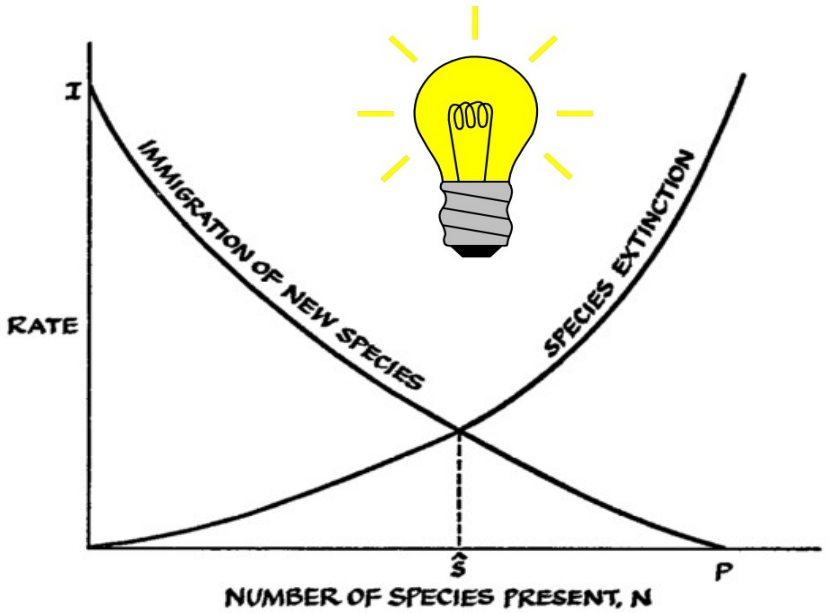


FIGURE 7. Equilibrium model of a biota of a single island. The equilibrial species number is reached at the intersection point between the curve of rate of immigration of new species, not already on the island, and the curve of extinction of species from the island. (After MacArthur and Wilson, 1963.)

The processes that lead to these curves are explicit in the model. More complex landscapes can easily be explored.

Metapopulations

Levin's metapopulation model is simplicity itself to any mathematician.

?

It is the basis of many more complex models

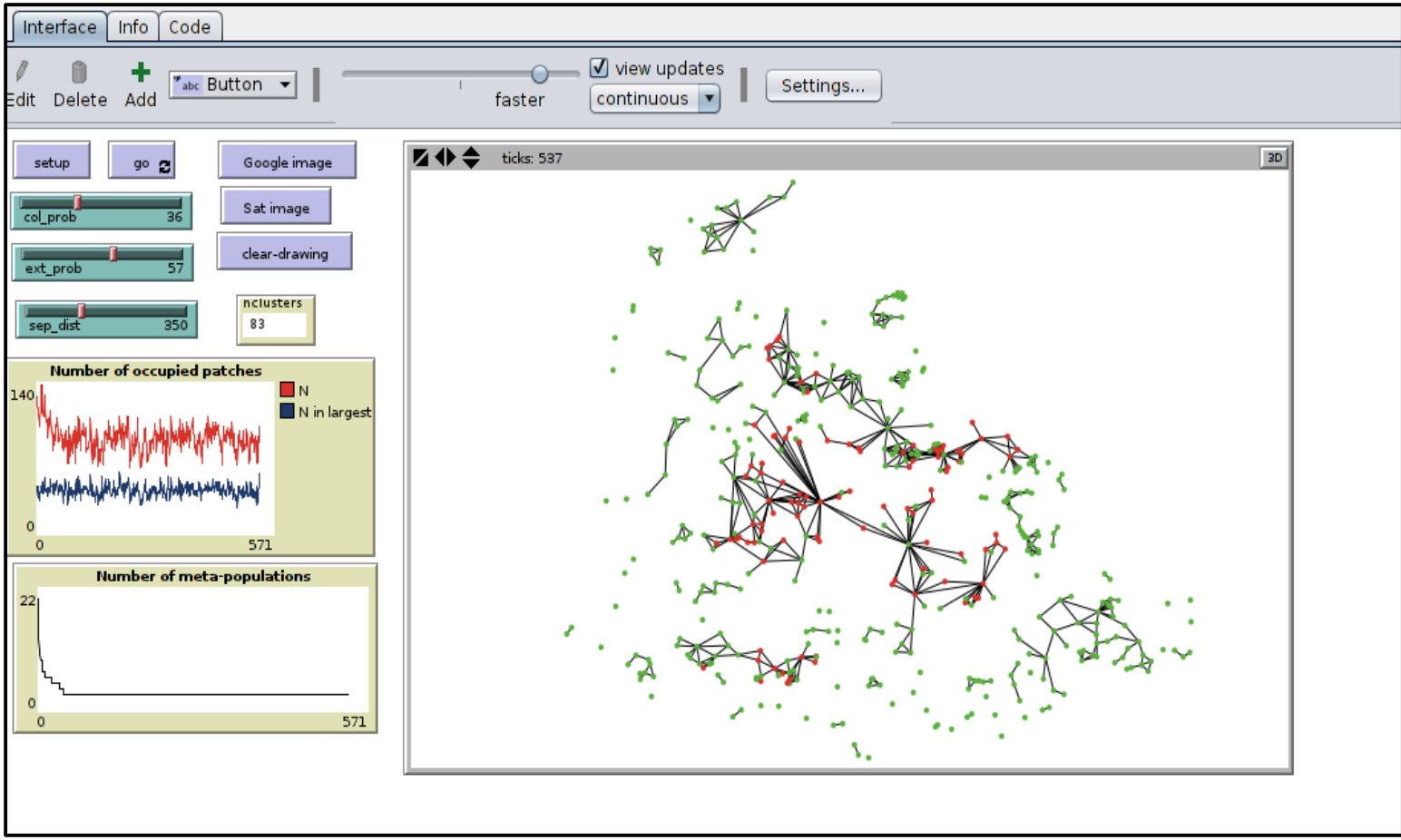
$$\frac{dN}{dt} = cN(1-N) - eN.$$

However if you do not know any calculus even this little equation will tell you nothing.

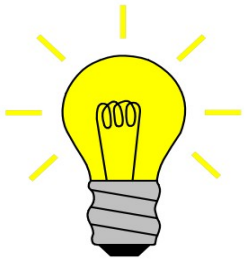
Metapopulation simulation

Simulating a network of connected patches is more subtle than the equation.

This will make the maths obvious.



Metapopulations



$$\frac{dN}{dt} = cN(1-N) - eN.$$

Once you have run the models, the formula will seem simple. Even the simplest spatially explicit models contain a lot more detail than this.

Link to Hansen's data

http://earthenginepartners.appspot.com/science-2013-global-forest

Key reading

Conservation Biogeography edited by Ladle and Whittaker

An important formal text book for the course.

Available in the library and through the reading list

Useful reading

The Song of the Dodo by David Quammen

An accessible and enjoyable popular science book that covers many of the themes in the unit

Journal articles

Journal articles will be cited in lectures and should be read in full

All journals available in the library or through the Web of Science

Web pages

http://www.globalspecies.org/ecoregions

Very useful link for the assignment.

Always use and cite web pages critically, with due attention to quality as explained in the assignment brief