

Tools for Landscape Assessment: Quantitative Analysis

Joaquin Solana Gutiérrez

School of Forestry Engineering

Department of Forestry Management of the Universidad Politecnica of
Madrid

-
Environmental Information System: Environmental Sciences
Applied Statistic: Forestry Engineering

2005 12 27

Tools for Landscape Assessment:

Quantitative Indexes

- **Object**
 - Ecosystem, feno-system and landscape
- **Elements of the landscape analysis**
 - Elements and influencing factors
 - Sample points, surrounding areas and panoramic views
- **Methodology for evaluating a landscape**
 - Territorial assessment of the quality landscape
- **Fittings and validations**
 - Range and weights
- **GIS applications**

Object of study



Ecosystem

Fenosystem

Landscape

Ecosystem

An ecosystem is compounded by biological, chemical and geological elements and their interactions

ELEMENTS

Biological elements:

Living organisms

Death organic substances or detritus

Chemical stocks:

Water

Energy and CO2 abstraction

Nutrients

Geological elements:

Topography

Soil

Rocks

INTERACTIONS

-Predations and competitions

-Births and deaths

-Land uses

-Shelters and breeding places

-Feeding zones

- Flows of energy

- Flows of feeds

- Flows of water

- Fire hazard, erosion and slicing risk

Geosystem

The term ecosystem is used in a general context.

When we need to describe a particular ecosystem we should talk about "GEOSYSTEM"

A geosystem is a delimited and particular ecosystem located in a specified place.

Therefore we can specify its components: its topography, geomorphology, rivers, soils, vegetation, fauna, paths, roads, buildings, etc...

Geosystem components

GEOSYSTEM:

It's what I **CAN PERCEIVE** from a territory

FENOSYSTEM

+

CRIPTOSYSTEM

It's what I **CAN'T PERCEIVE** from a territory

Fenosystem

It is the set of territory elements that can be capture by our senses because are visible, audible or touchable.

We focus us about our perceptions of territory.

We don't consider the hidden flows as energy and water neither interactions between alive populations.

The fenosystem is the simple picture of an ecosystem.

Criptosystem

On the other hand, there are hidden internal complexities called criptosystem: flows of energy, nutrients and water, relationships between populations and distributions of lands occupied by species .

Landscape analysis

Stand
landscape

Surrounding
landscape

Panoramic
view



Elements of
landscape

The media
amplifiers

Elements of the stand landscape analysis

The object is the **FENOSYSTEM**

Visual approach

Colour
Texture
Line
Shape
Scale

Territorial approach

Topography
Rivers and waters surfaces
Lithology
Geomorphology
Vegetation
Fauna
Human elements

Visual assessment method

Colour

Texture

Line

Shape

Scale

Smardon: United States Depart. Agriculture, 1979

Visual elements have to be described on the photogram and analysed in terms of homogeneity versus variety, abundance versus scarcity, equilibrium versus visual unbalance.

On first sight this analysis seems ease to do however it is quite difficult to break down the different elements of the landscape and to make a separated assessment.

Visual elements

*Visual assessment
method*

Color
Texture
Line
Shape
Scale



Different textures

Different colors

Visual elements: Color

*Visual assessment
method*

Color:

Property of reflecting the light with a certain intensity and wavelength.

It is defined by the hue (tone), the bright (light) and the saturation (density).

It is the most important property of a surface.

The criteria in the landscape assessment is the luminous and bright places prevail over the dark and dull ones.

Color

Texture

Line

Shape

Scale

Visual elements: Texture

*Visual assessment
method*

Texture:

It is the aggregations of small combinations of shapes and colors forming a continuous superficial configuration.

It is studied in terms of relative dimensions of the superficial variations, object's density, regularity and degree of scattering elements in the countryside.



Color

Texture

Line

Shape

Scale

Visual elements: Line

Line:

The image edges perceived when there are different colors or textures.

The special configuration or unidimensional arrangement of the objects.

It is distinguished by its complexity (broken or smooth), orientation (vertical or horizontal) and strength (intense or weak).

The strong and vertical lines tend to prevail over the weak and horizontal.

Color

Texture

Line

Shape

Scale

Visual elements: Shape

*Visual assessment
method*

Shape:

It is the contour of the surfaces and volumes of territorial elements, as a consequence it can be bi-dimensional or tri-dimensional.

It is explained in terms of geometrical shapes, complexity of contours and main direction of forms.

It depends on the observation's visual angle and is modified by the illumination.



Color

Texture

Line

Shape

Scale

Visual elements: Shape Pattern

*Visual assessment
method*

Shapes Pattern:

Determined by the tridimensional arrangement of solid bodies and empty spaces.

Distinguished by the spatial composition which gives place to panoramic, closed or focal landscape, dominated by one particular component.

Its perception is closely connected with the observer's position in relation to the landscape, vertically as well as horizontally.

Color

Texture

Line

Shape

Scale



Visual elements: Scale

*Visual assessment
method*

Scale:

Relationship between an object and its environ.

Intimately related to the notions of dominancy and contrast.

It is altered by the distance, the configuration of external space and the relative position of the observer.

They can be panoramic, opened, closed, focused, filtered or dominated scenes.

Color

Texture

Line

Shape

Scale



Objects to Assessment

*Visual assessment
method*

	VISION ZONES	Meters	
We can distinguish lines, textures and colors	Foreground (Stand)	0	800
We can distinguish textures and colors	Middle-ground (Surrounding)	800	5000
We can only distinguish the color	Background (Viewshed)	>5000	

Source: Smardon, 1982

Vision zones when applying the methodology

Visual assessment method

Due to the **three zones of visions** we have to consider three landscape components:

1. Stand landscape (0-800 meter)
2. Landscape of the surroundings (800-5000 m)
3. Panoramic views (>5000 m)

Territorial assessment method

Topography

Rivers and waters surfaces

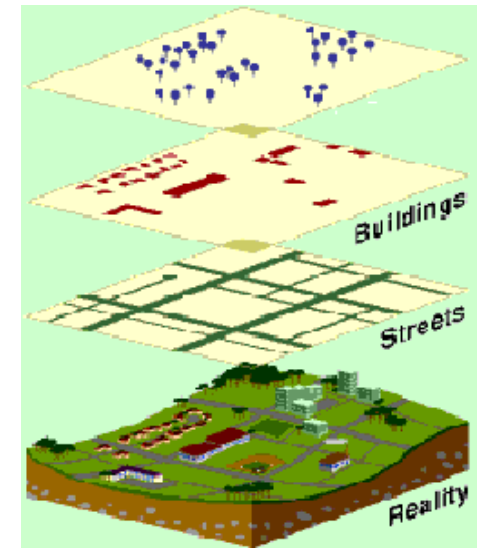
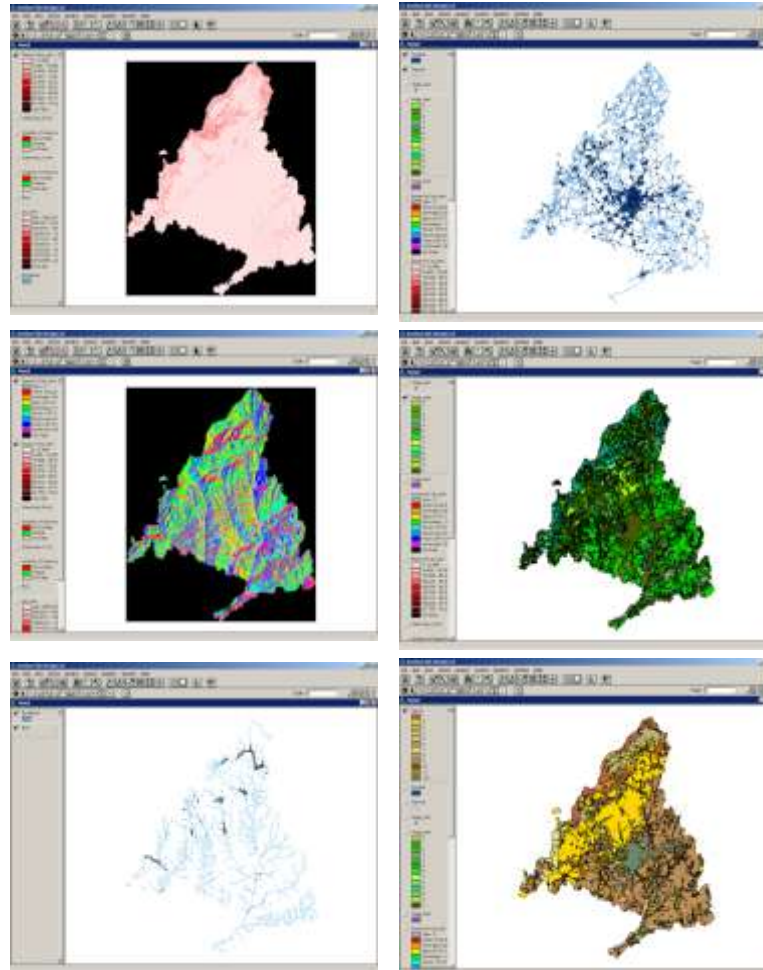
Lithology

Geomorphology

Vegetation

Fauna

Human elements



Territorial assessment method

Altitude (DEM)
Slope
Aspect

Sandy places
Gypsum grounds
Slate grounds
Granite stony places
Dolomitic stony places
Limestone places

Crops
Meadows and pastures
Scrubs and bushes
Little woods
Forests
Mature forests

Topography

Rivers and waters
surfaces

Lythology

Geomorphology

Vegetation

Fauna

Human elements

Brooks and Rivers
Lakes and Seas

Lowlands
Valleys
Hills
Highlands
Peaks and summits
Cliffs
Plateaus
Plains and flat grounds

Flocks and breeding ranges
Birds and nests
Sounds of the birds and mamals

Towns and cities
Roads and paths
Castles and churches
Bridges and dams
Chimneys and electric towers

Slope

Territorial
assessment method

The bigger the slope the more valuable



BEFORE MAP	AFTER MAP
Plain-5%	1
5%-30%	2
30%-40%	3
40%-50%	4
>50%	5

Aspect

The more sunny the more valuable

BEFORE MAP	AFTER MAP
Flat	3
North	1
North-east	1
East	2
South-east	5
South	5
Souht-west	5
West	2
North-west	1

Territorial
assessment method



Rivers and water surfaces

Territorial
assessment method

The bigger the area the more worthy

Permanent streams of water are worth more than dry
summer streams



Lithology

Territorial
assessment method

The bigger the rocks the higher the score



Geomorphology

Territorial
assessment method

The sharper the hill the more worthy



Vegetation

Territorial
assessment method

The more complex the more
valuable

The more abundant canopy
the bigger value

The taller the tree the more
worthy.

BEFORE MAP	AFTER MAP
0. Meadows	5
1. Wet crops	5
2. Dry crops	3
3. Mixed crops	3
4. Scrubs and bushes	2
5. Evergreen oaks	3
6. Deciduous oaks	3
7. Other deciduous trees	4
8. Other coniferous	4
9. Pine trees	4
E. Carrys	1
H. Dams	1
U. Citys and towns	1

Fauna

Territorial
assessment method

The mere existence of cattle or flecks increases the value of a landscape.



Human elements

Territorial
assessment method

The current human elements as tracks, roads, wind turbines, warehouses and buildings decrease the natural landscape appraisal, however the ancient and historic elements increase the value .



Human elements

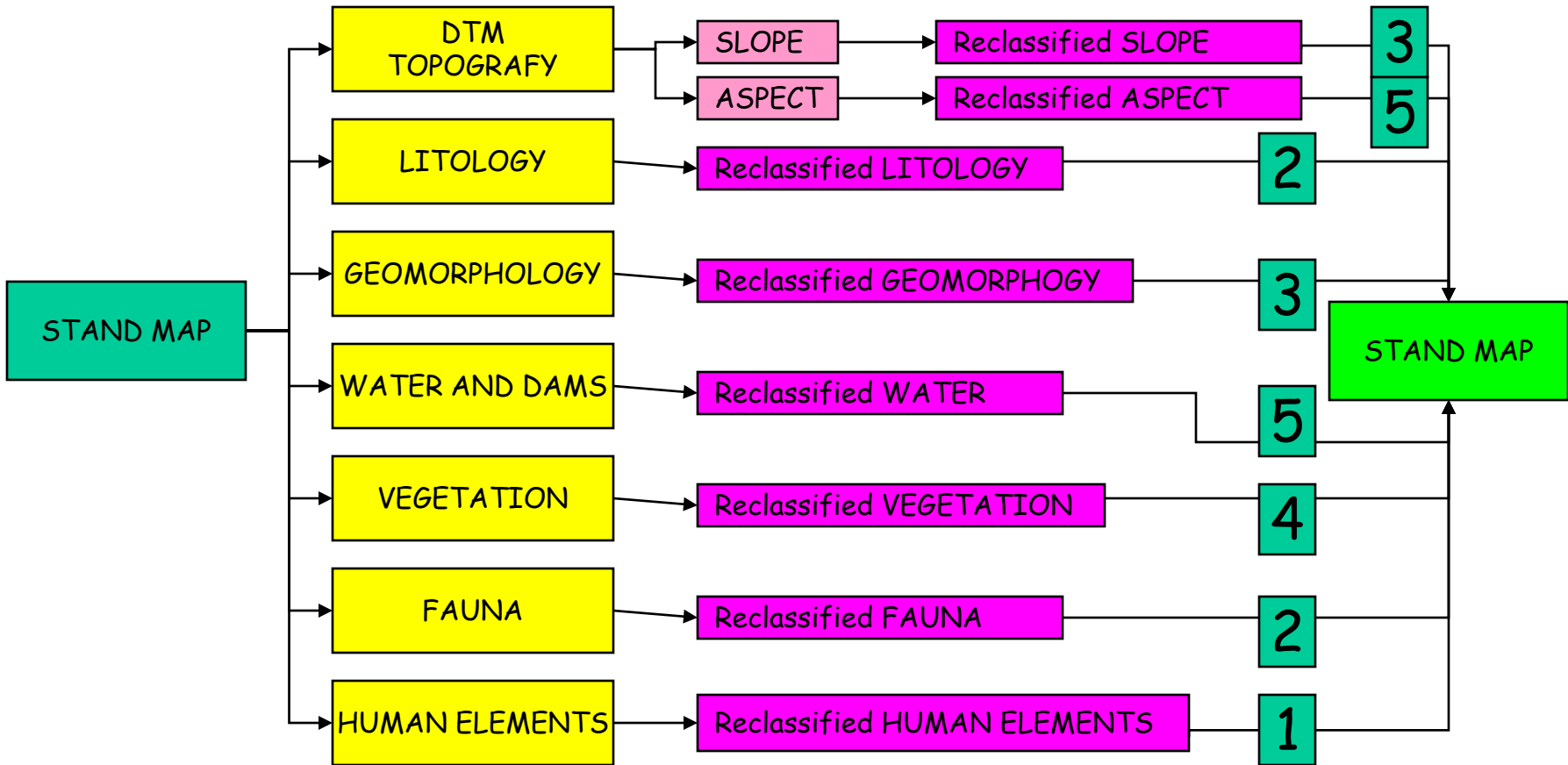
Territorial
assessment method

In addition, the human elements provoke an increase in the frequency of observation. Therefore, roads and emblematic buildings magnify their own value, increasing its value when it is beautiful or decreasing when ugly.



Weight of each map

Territorial assessment method



Population amplifiers

Exposure to the observation:

Accessibility

Frequency of visits

Observation time

Magnifies the properties, whether they are positive or negative



Media amplifiers



Light

Blur

Clouds

Pollution

Climate



Clouds



Pollution



Climate

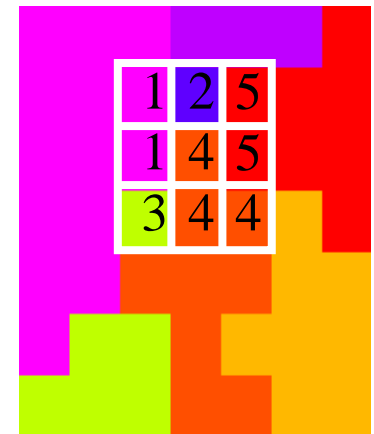
The surrounding landscape

Territorial
assessment method

Once we have obtained the visual value of each point of the territory we check the surroundings.

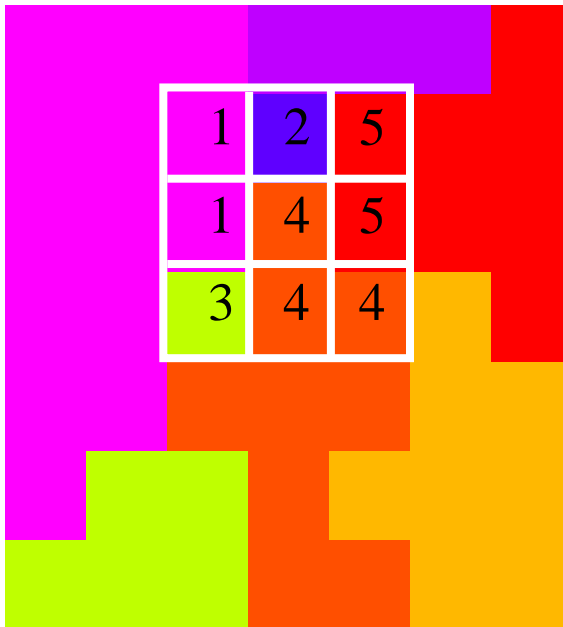
If the neighbourhood is more visual worth the value of landscape will improve, conversely if the surrounding view is bad will decrease the value.

The way of checking the surroundings is by means of an statistical filter that calculates the median of the neighbour values.



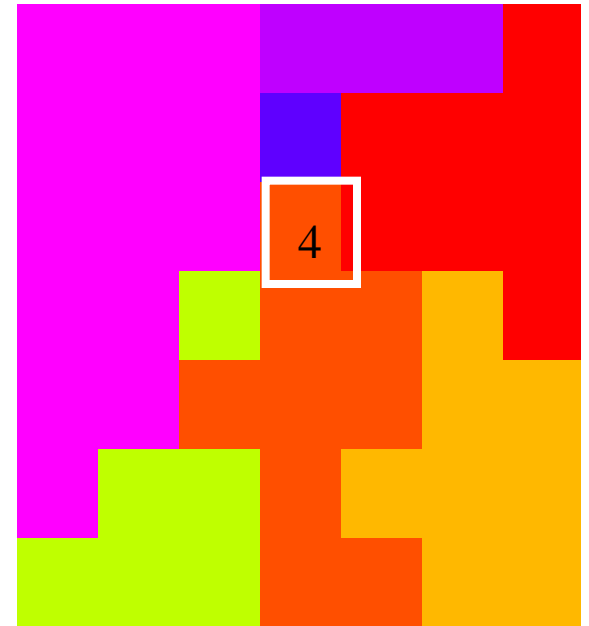
Filter median

(Median of the neighbours)



Median

1,1,2,3,**4**,4,4,5,5



Panoramic views: Viewshed

Territorial
assessment method

From some points we can observe large views, if the observed points are valuable the landscape will improve.

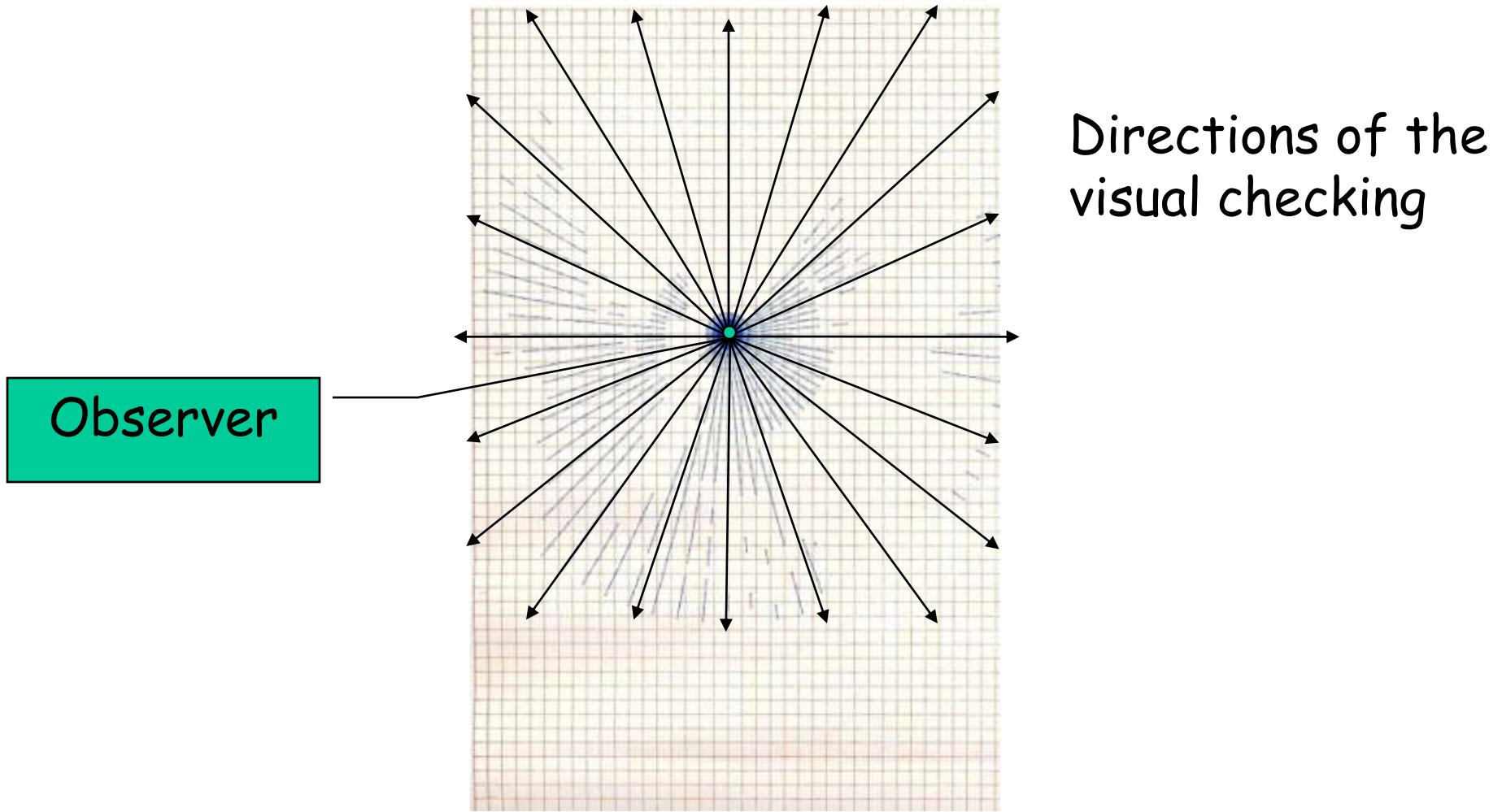
The extension, the shape and the compactness of the viewshed are very important parameters in the assessment of landscape.

The larger the area of view the more valuable.

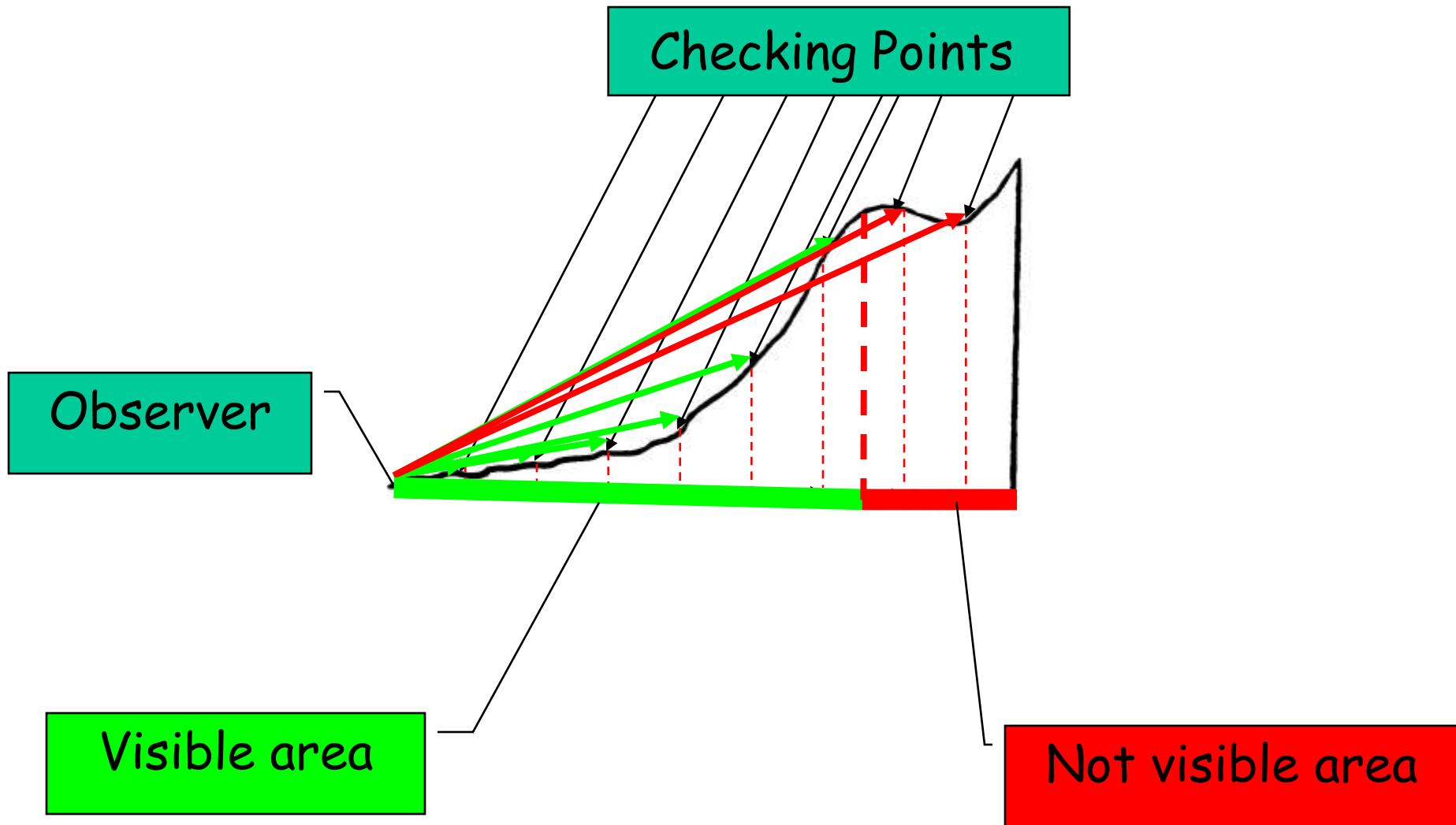
The roundy shapes are better than the narrow views.

The more compact the view the fewer visual planes.

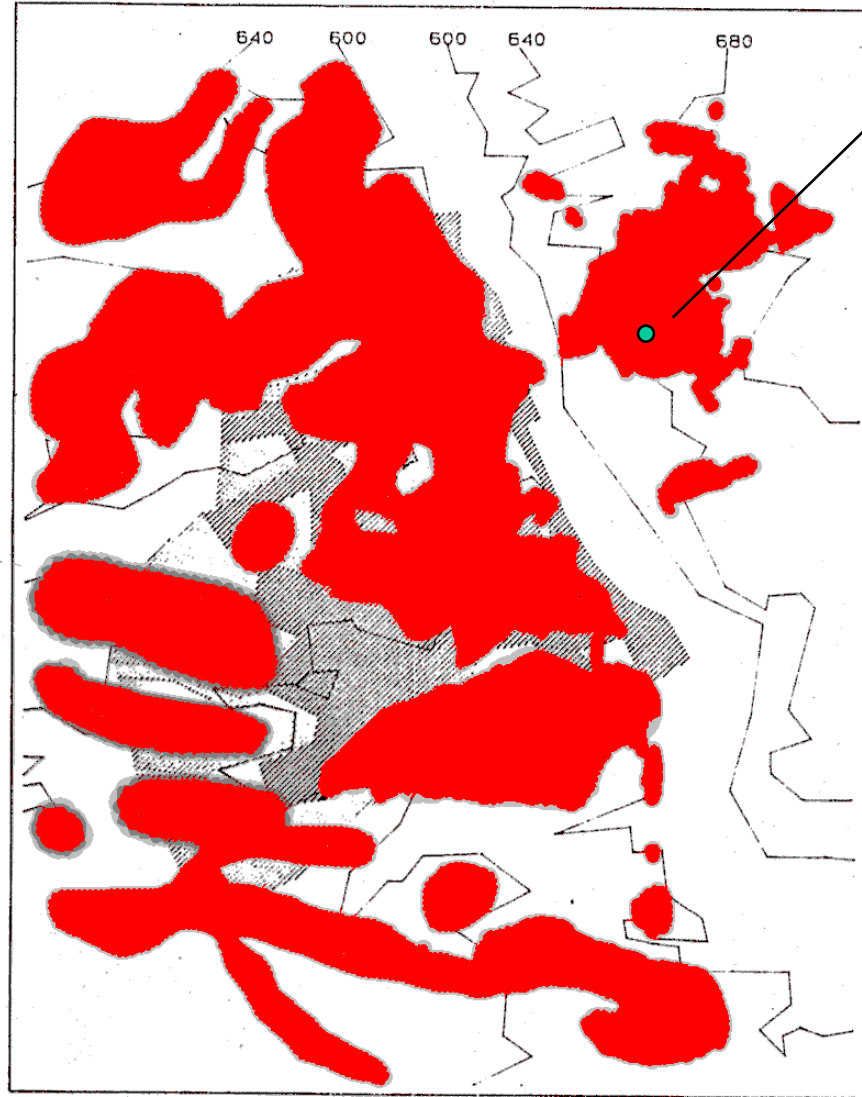
The panoramic views Viewsheds



Directional checking



Viewshed from the Faculty of Information Sciences to "Casa de Campo(Madrid)"



Observer

Quantitative indexes of the viewshed

Relative viewshed: RV

Equivalent Rectangle: ER

Morphometric Indexes of Davis

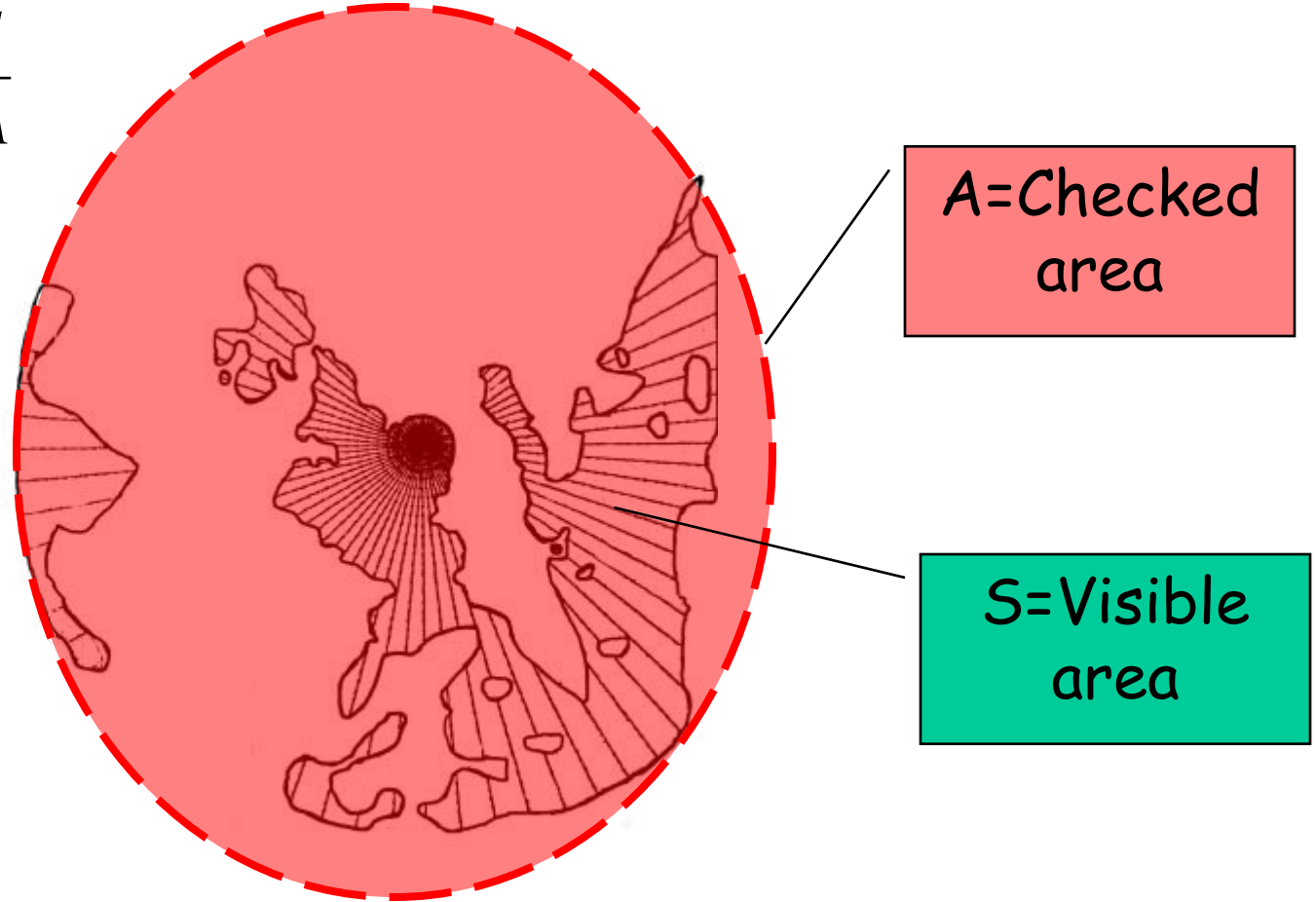
Compactness of viewshed: CV

Relative height: RH

Visual ellipse: VE

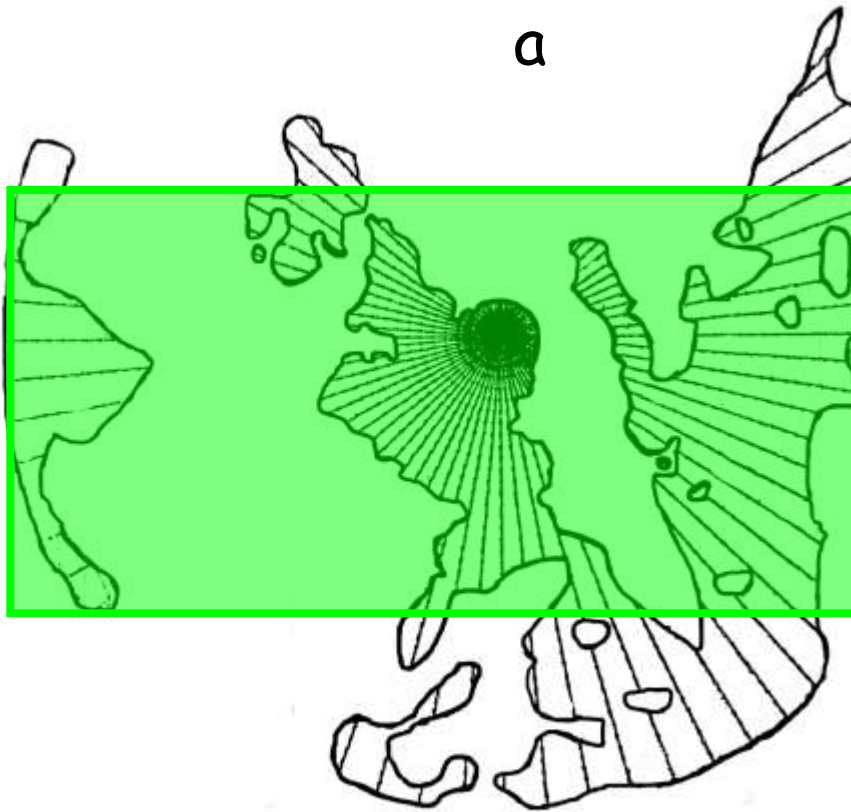
Relative Viewshed: RV

$$RV = \frac{P_{observed}}{P_{checked}} = \frac{S}{A}$$



Equivalent Rectangle: ER

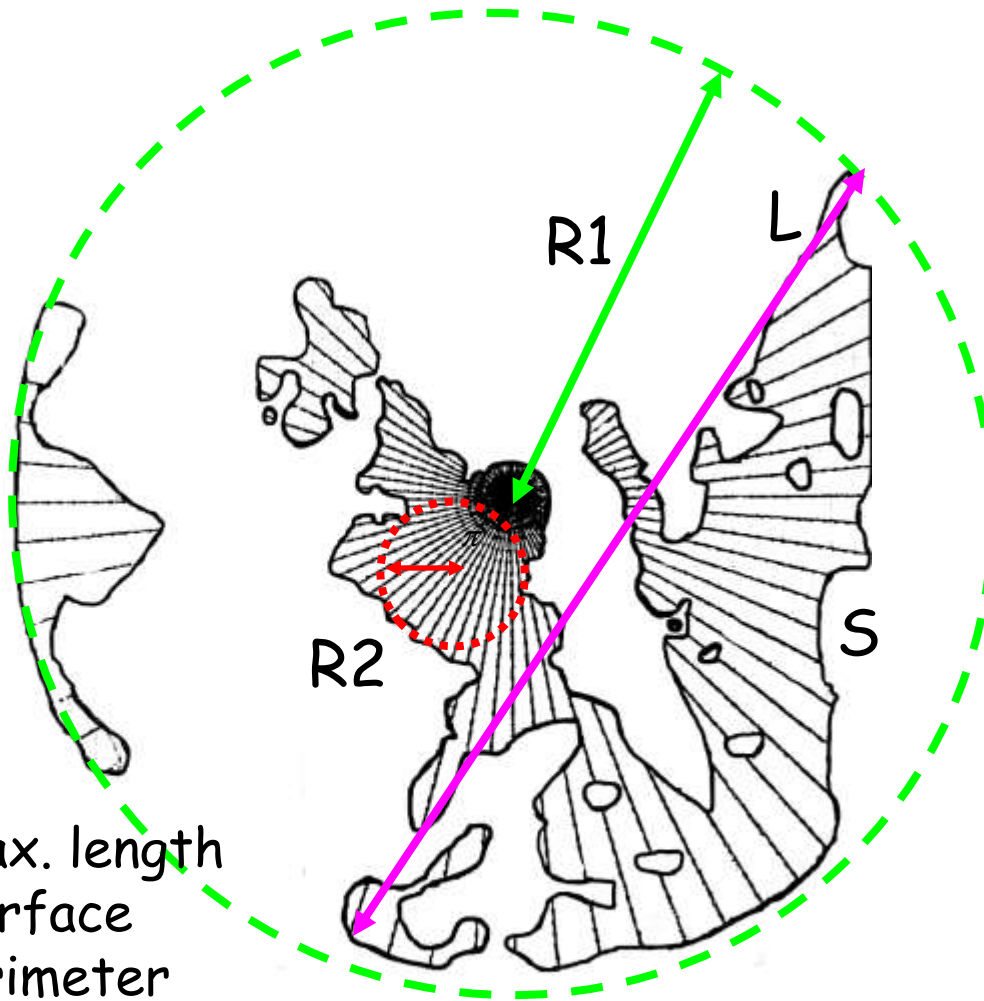
$$ER = a \cdot b = S$$



Properties:

- Main side in the direction of the bigger momentum of inertia
- Same centre of gravity
- Same surface

Morphometric indexes of Davis



$$I_1 = \frac{S \cdot P}{0.282}$$

$$I_2 = \frac{S \cdot L}{0.866}$$

$$I_3 = \frac{R_1}{R_2}$$

$$I_4 = \frac{4 \cdot S}{\pi \cdot L^2}$$

$$I_5 = \frac{1.27 \cdot S}{L}$$

L= max. length
S=Surface
P=Perimeter

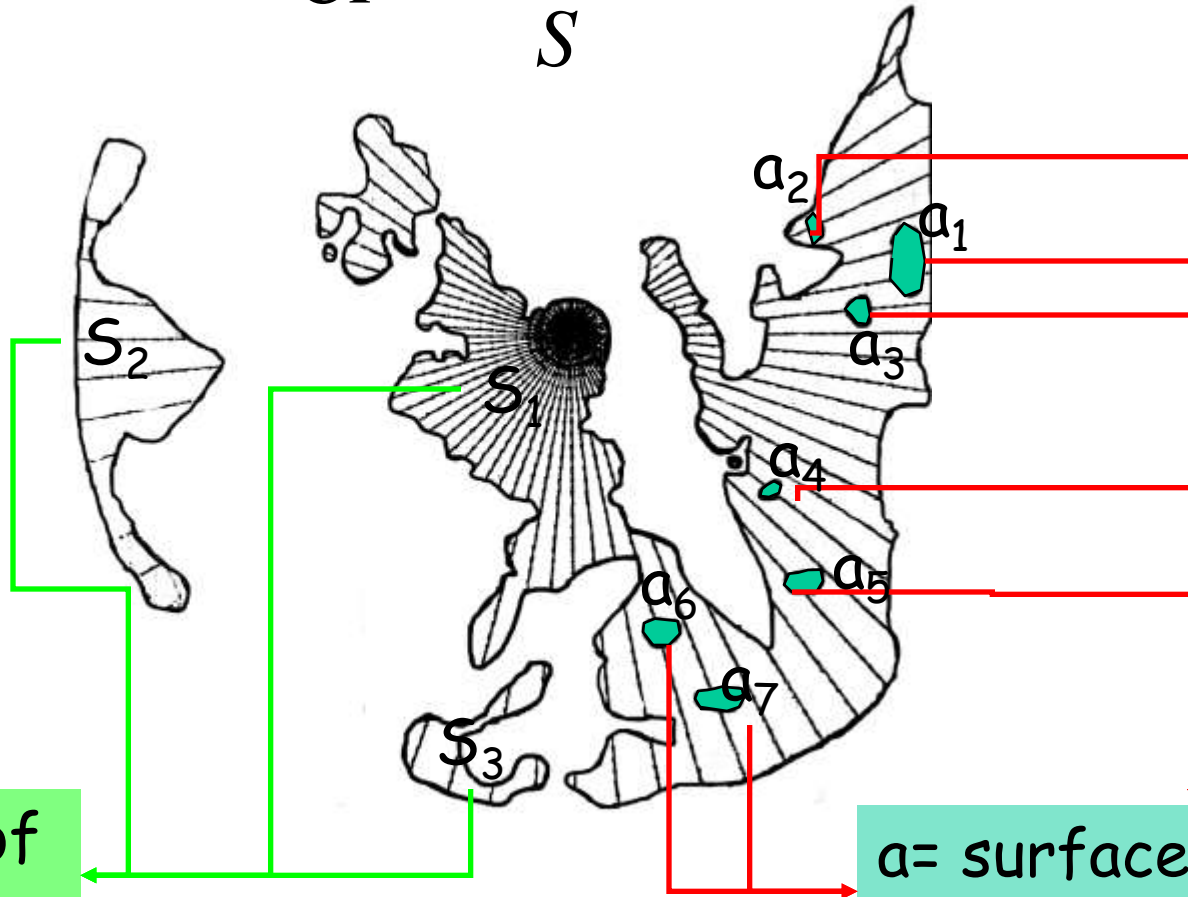
R1=Radius of the circle that contains all of points of the view
R2=Radius of the maximum circle contained into the view

Compactness index: CI

$$CI = \frac{S - a}{S}$$

$$S = \sum_{i=1}^n S_i$$

$$a = \sum_{i=1}^k a_i$$

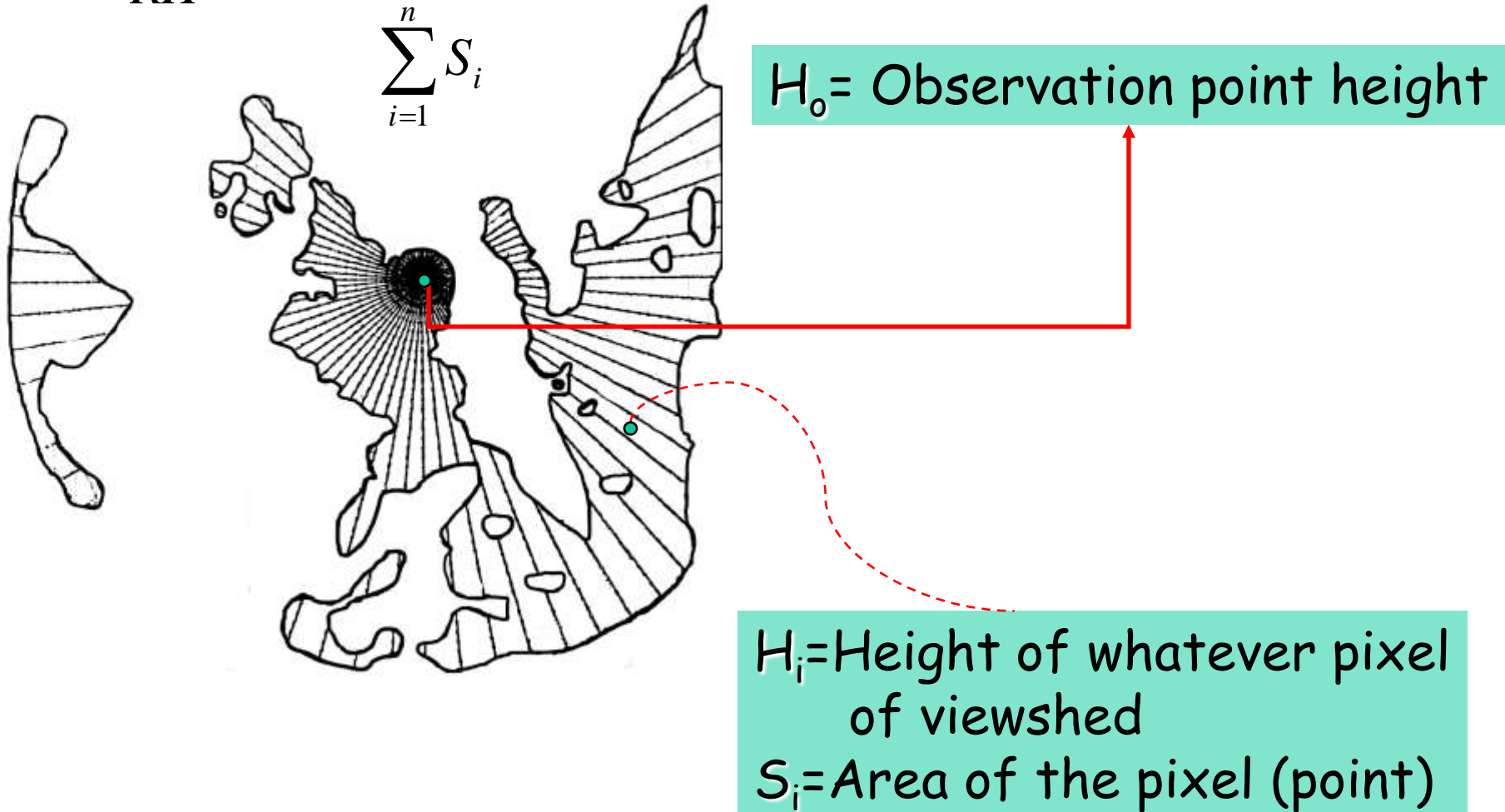


S = surface of the view

a = surface not visible into view

Relative height: RH

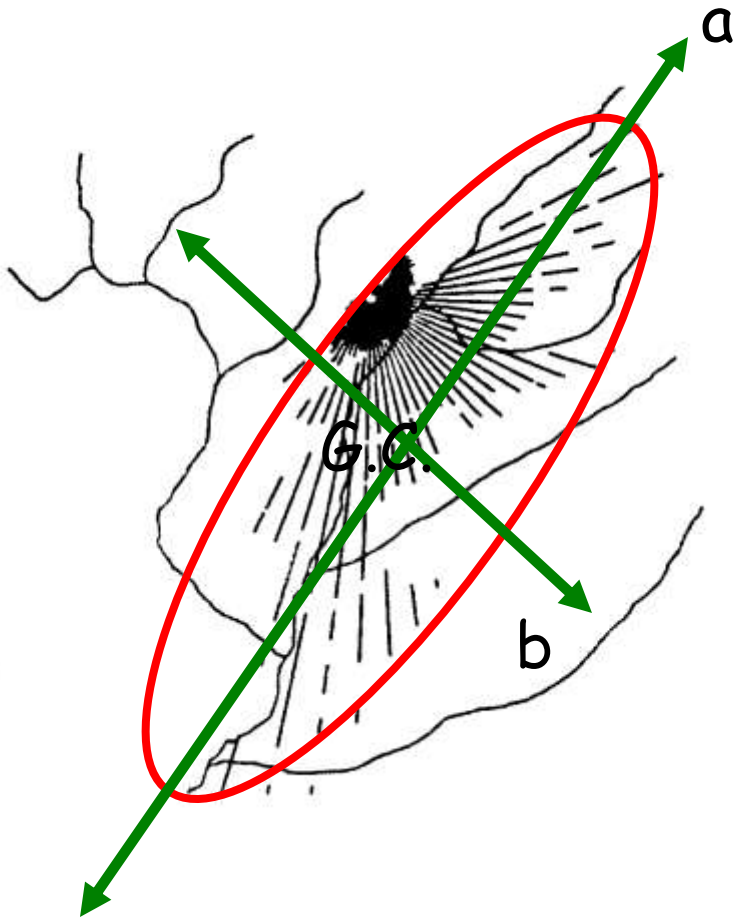
$$RH = \frac{\sum_{i=1}^n (H_i - H_0) \cdot S_i}{\sum_{i=1}^n S_i}$$



Visual Ellipse:

Inertia Tensor

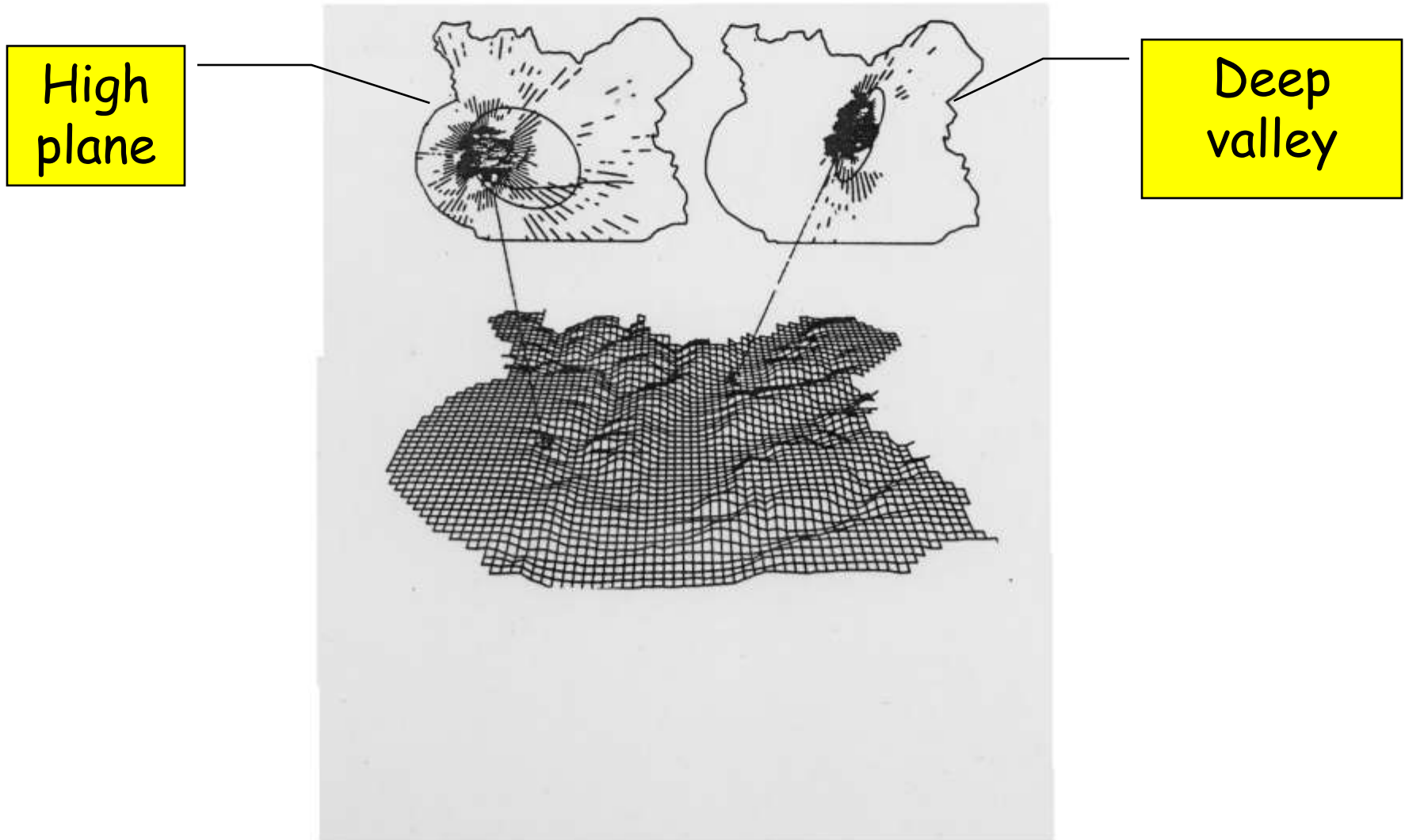
- 1st Maximum axe of the momentum of inertia
- 2nd Maximum axe of the momentum of inertia



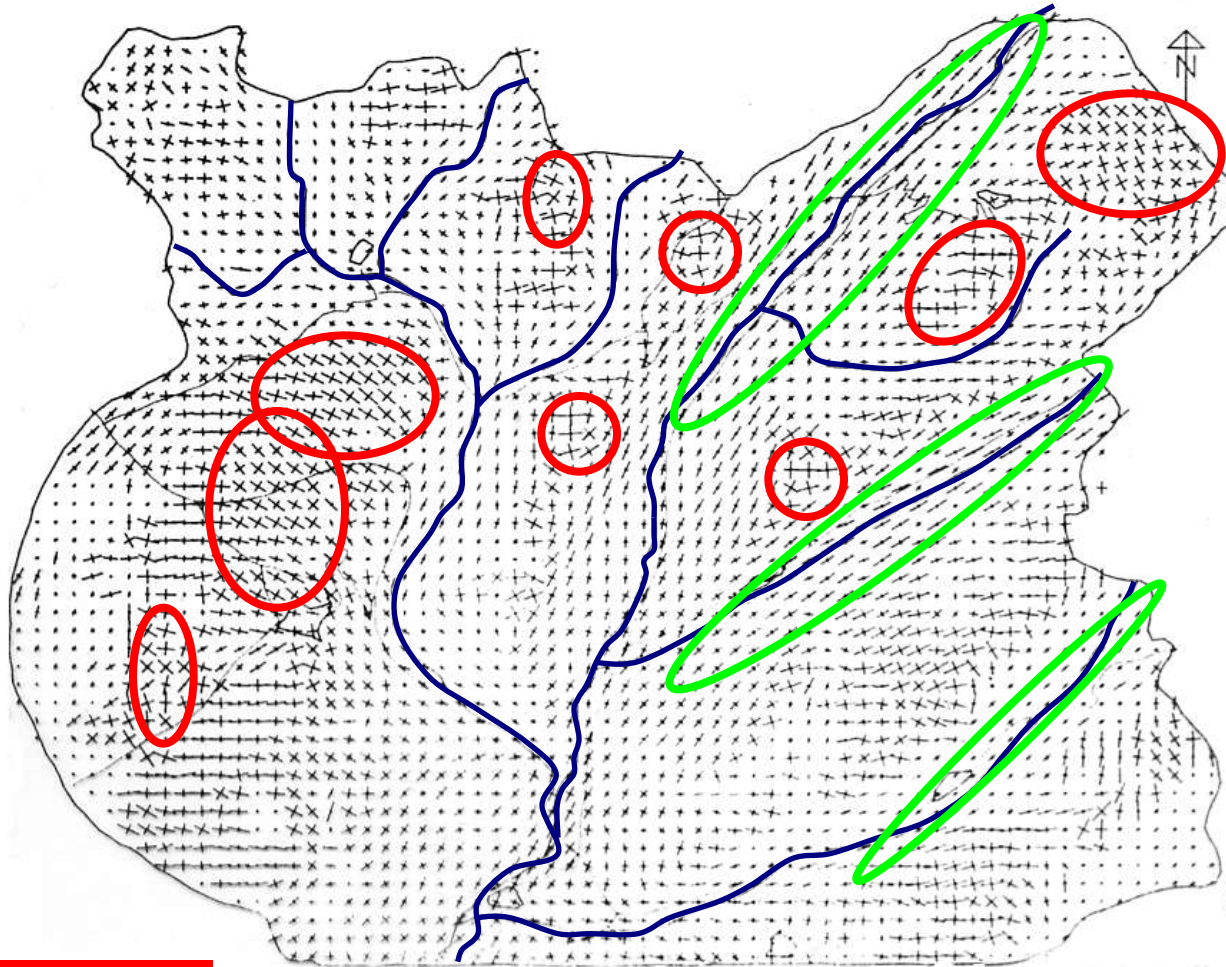
Properties:

- Same centre of gravity of the viewshed
- Same surface
- Same main direction

Two examples of visual ellipses



Elipses map



Rounded and large

Thin and tall

Intervisibility map

A point can belong to many viewsheds that can not be easy to use. For this reason we generally use the concept of intervisibility .

The intervisibility is the capacity of a point to be seen from many other points.

A map of intervisibility can be done by adding a representative set of the viewsheds of the countryside.

If a point belongs to many viewsheds it will be seen from a lot of places. The more number of views the more visible the point will be.

Assessment methodology

There are two criterium to assess a landscape: the assessment of **quality** and the assessment of **fragility**.

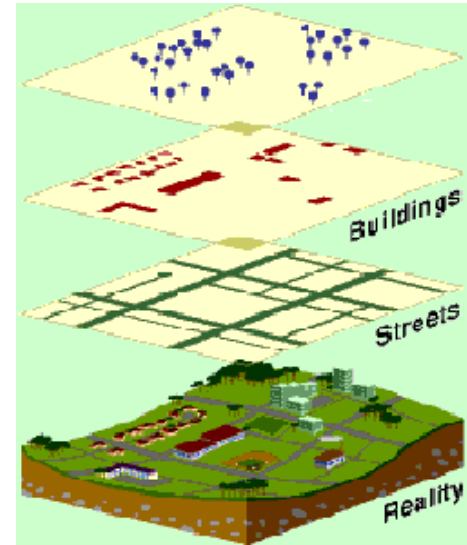
QUALITY: It is the inner quality of a landscape

FRAGILITY: It is the capacity of a landscape to absorb a human activity without losing quality.

The fragility can be evaluated by the difference between the quality before and after an action.

Methodology by GIS

QUALITY OF LANDSCAPE



STAND LANDSCAPE ANALYSIS

SURROUNDING LANDSCAPE ANALYSIS

VIEWSHED LANDSCAPE ANALYSIS

How can I make a stand quality map ?

1. CHOOSE THE ELEMENTS AND PARAMETERS WHICH HAVE INFLUENCE
2. BREAK DOWN EACH PARAMETER IN CLASSES (Not more than 7 classes)
3. ARRANGE THE CLASSES WITH A CRITERIA
4. SET A VALUE FOR EACH CLASS. (From 1 to 10)
5. MAKE ALL FACTOR MAPS
6. DETERMINE THE RELATIVE LOAD OF EACH FACTOR
7. ADD ALL OF THEM

How can I make a quality surrounding map?

- FIRST OF ALL, YOU HAVE TO OBTAIN THE STAND QUALITY MAP
- DEPENDING ON THE PIXEL SIZE YOU HAVE TO CHOOSE THE SIZE OF THE FILTER IN ORDER TO CONSIDER A SCOPE BETWEEN 3 AND 5 KMS.
- CHOOSE THE KIND OF FILTER: MEDIAN OR AVERAGE (Better the former)

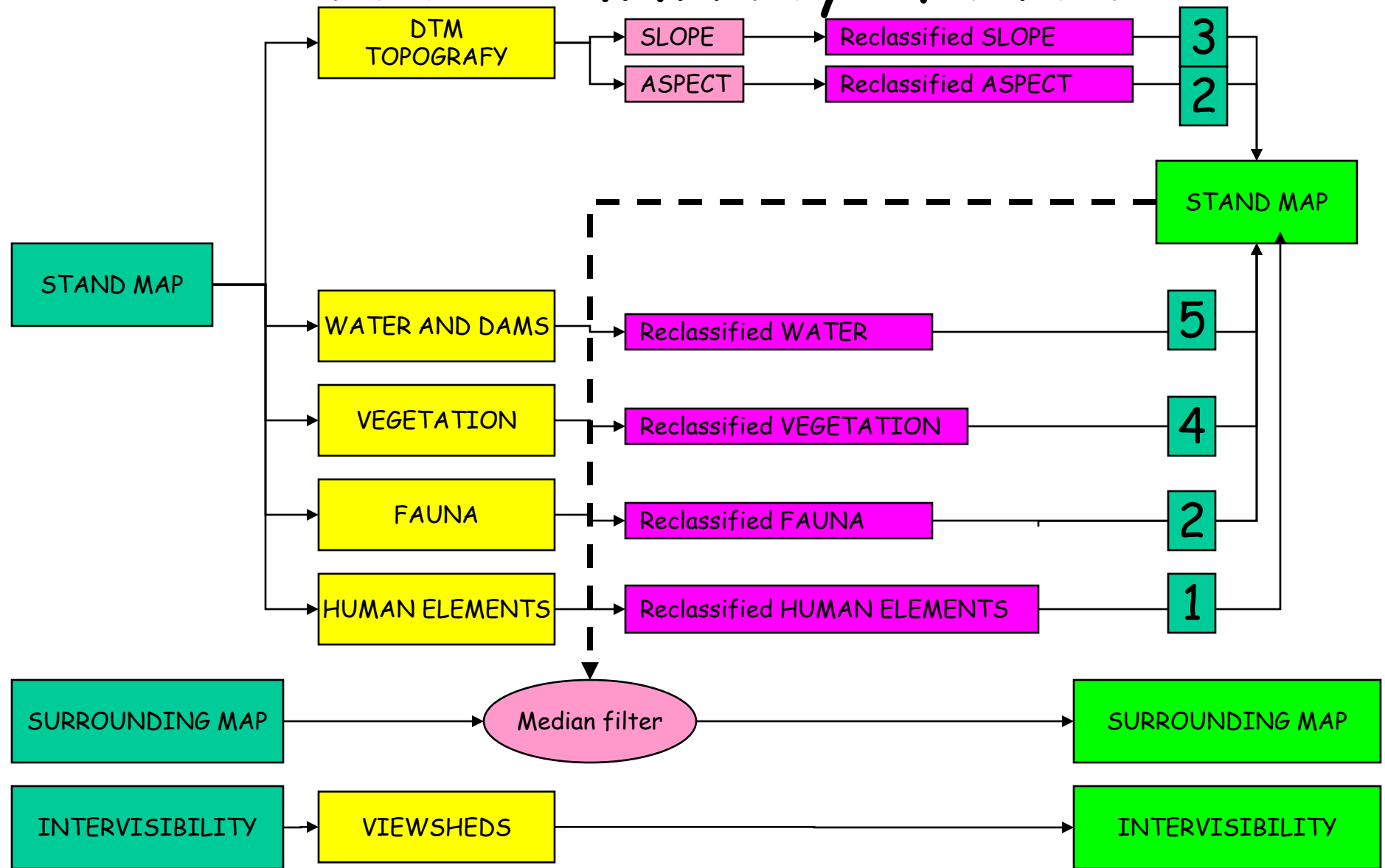
How do you consider the frequency of vision?

- MAKE A MAP OF ROADS AND SIGHTS
- STUDY HOW LIKELY IS TO FIND PEOPLE STANDING , WALKING OR DRIVING ON THE WAYS AND PLACES (Surely you have to make some buffers of these places and roads).
- MULTIPLY THIS MAP BY THE ADDITION OF THE "STAND QUALITY MAP" AND THE "SURROUNDINGS QUALITY MAP".

How can I make an intervisibility map?

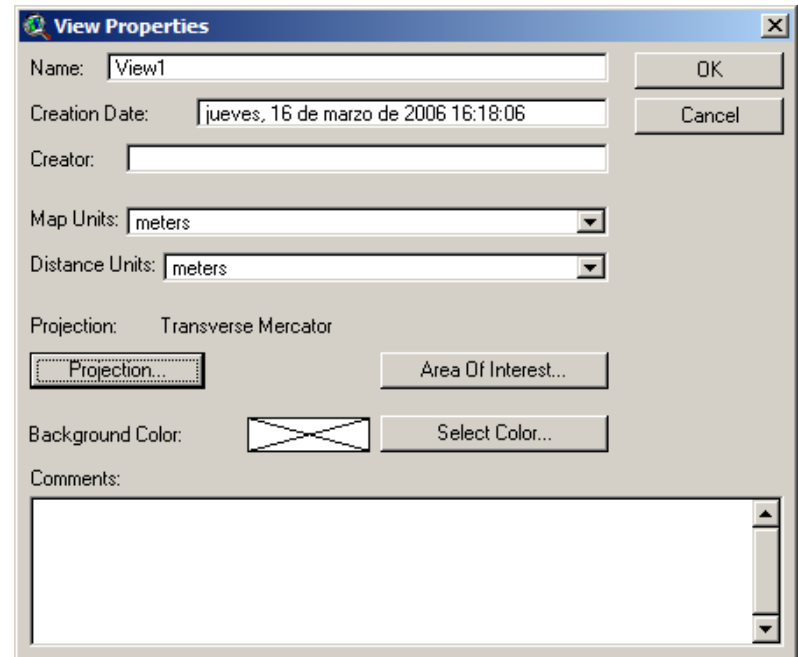
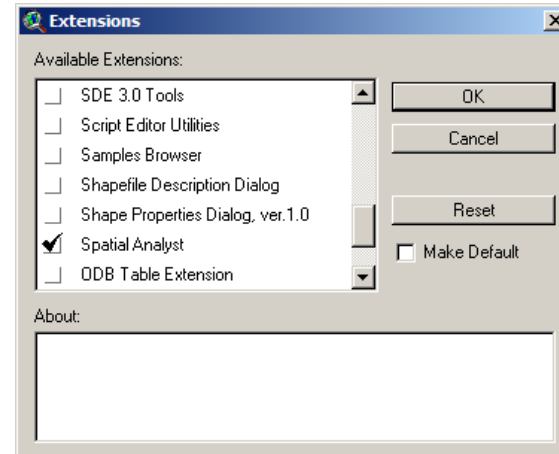
- DRAW A SISTEMATIC SAMPLE ONTO THE TERRITORY (A SAMPLE POINT EACH 10 KMS APROXIMATELY.)
- MAKE A VIEWSHED AT EACH SAMPLE POINT
- ADD ALL VIEWSHEDS

Application: Quality of the landscape in the Community of Madrid

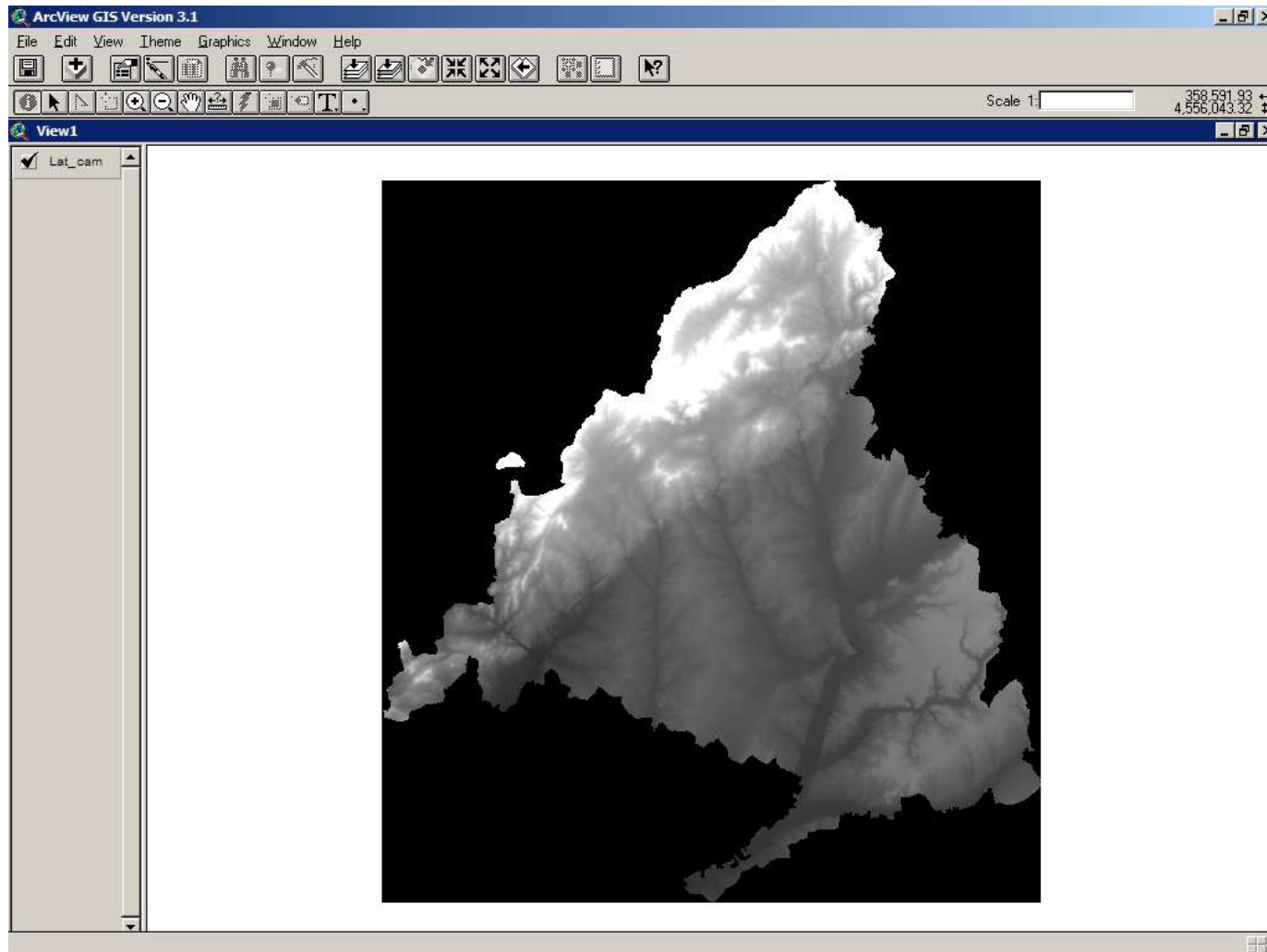


How can we do it with GIS ArcView?

1. WE HAVE TO LOAD THE MODULE "SPATIAL ANALYST"
2. THE BASIC CARTOGRAFY MUST BE GEOREFERENCED
3. ALL MAPS MUST BE RASTER FORMATED



Digital Terrain Model (DTM) of Madrid

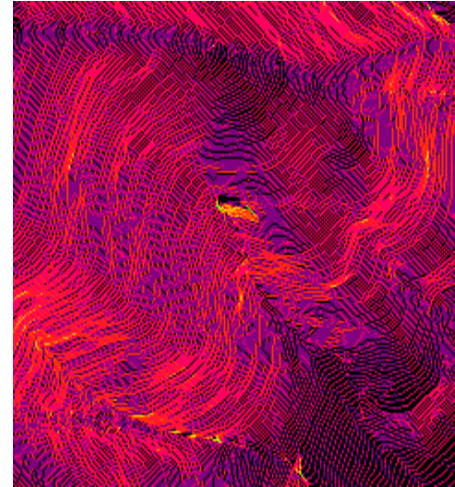


Derive Slope

Altitude



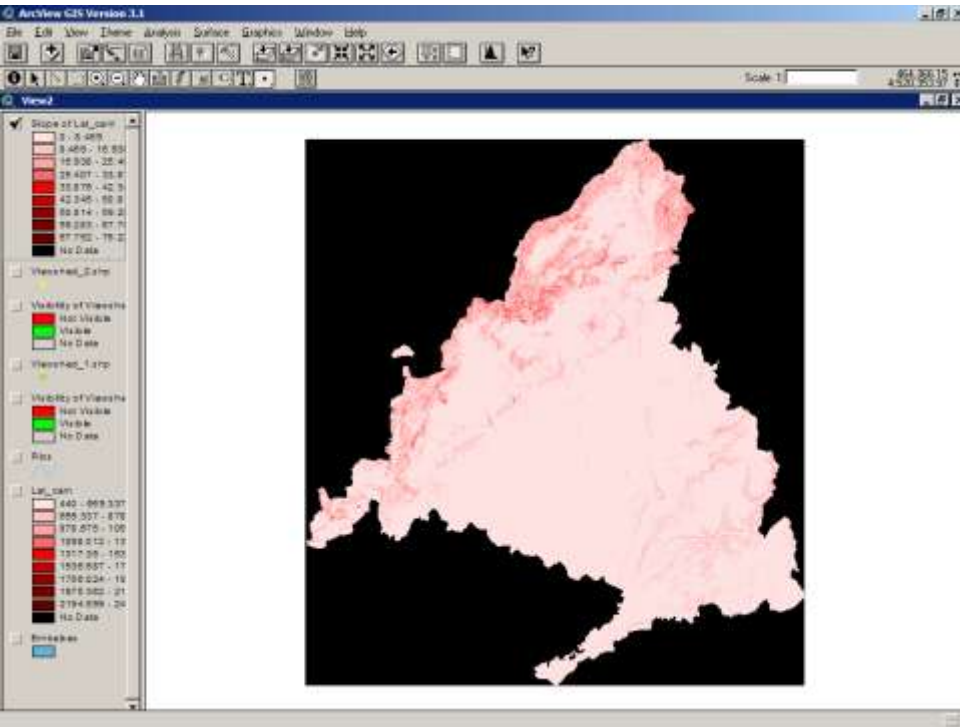
Slope



Slope

Reclassify in 5 classes

Criteria: The bigger the slope the higher the value



BEFORE MAP	AFTER MAP
Plain-5%	1
5%-30%	2
30%-40%	3
40%-50%	4
>50%	5

Reclassify

Reclassify Values

Classification Field: Value

Classify... Unique Lookup...

Old Values	New Value
-1 - 39.111	1
39.111 - 79.222	2
79.222 - 119.333	3
119.333 - 159.444	4
159.444 - 199.555	5
199.555 - 239.666	6
239.666 - 279.778	7

+ X

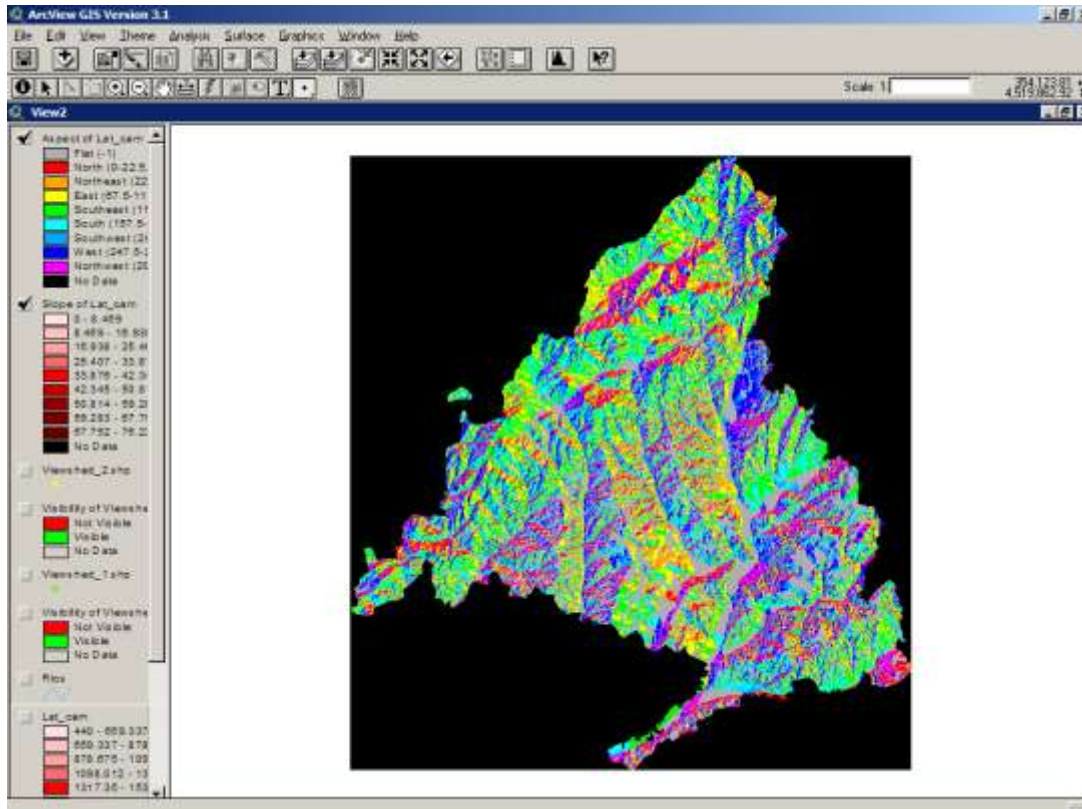
Load

Save OK Cancel

Aspect

Reclassify in 5 classes

Criteria: The more sunny the more value

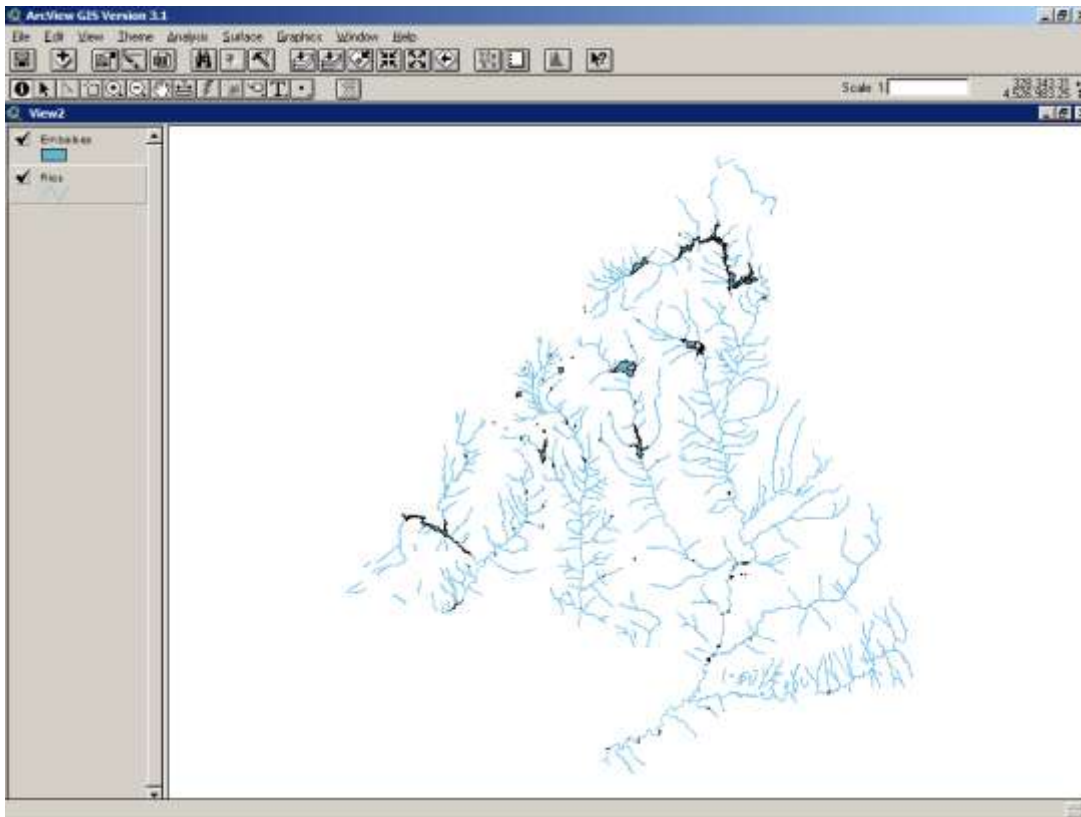


BEFORE MAP	AFTER MAP
Flat	3
North	1
North-east	1
East	2
South-east	5
South	5
Souht-west	5
West	2
North-west	1

Rivers and dams

Reclassify in 3 classes

Criteria: The bigger the river the higher the value

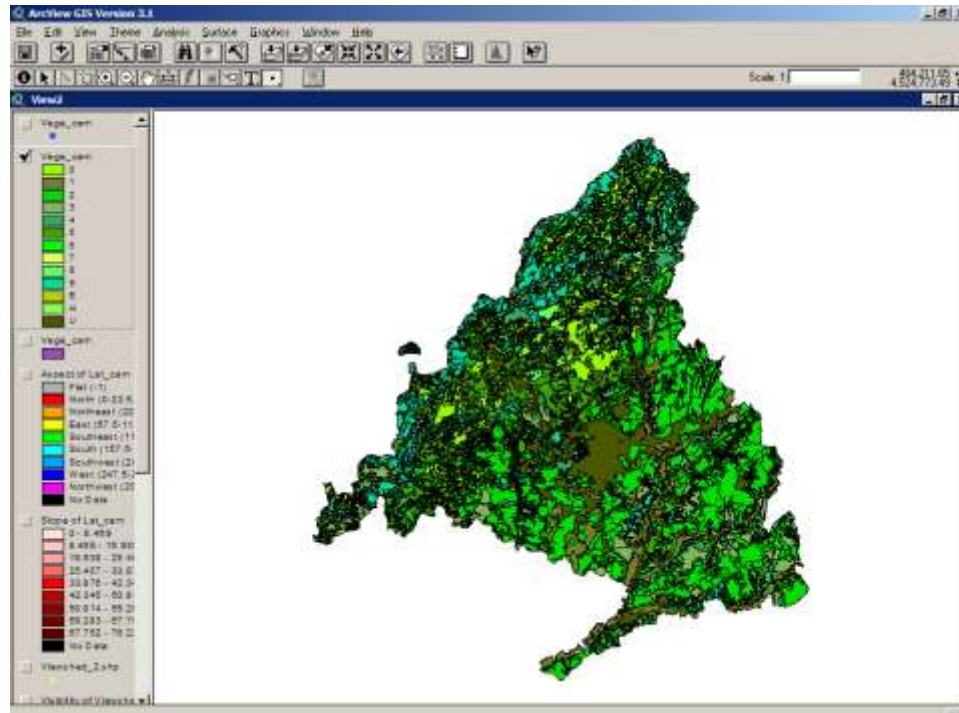


BEFORE MAP	AFTER MAP
Dams	5
Rivers	3
Little Streams	1

Vegetation

Reclassify in 5 classes

Criteria: According with a preference survey: meadows, forests, crops and bushes.

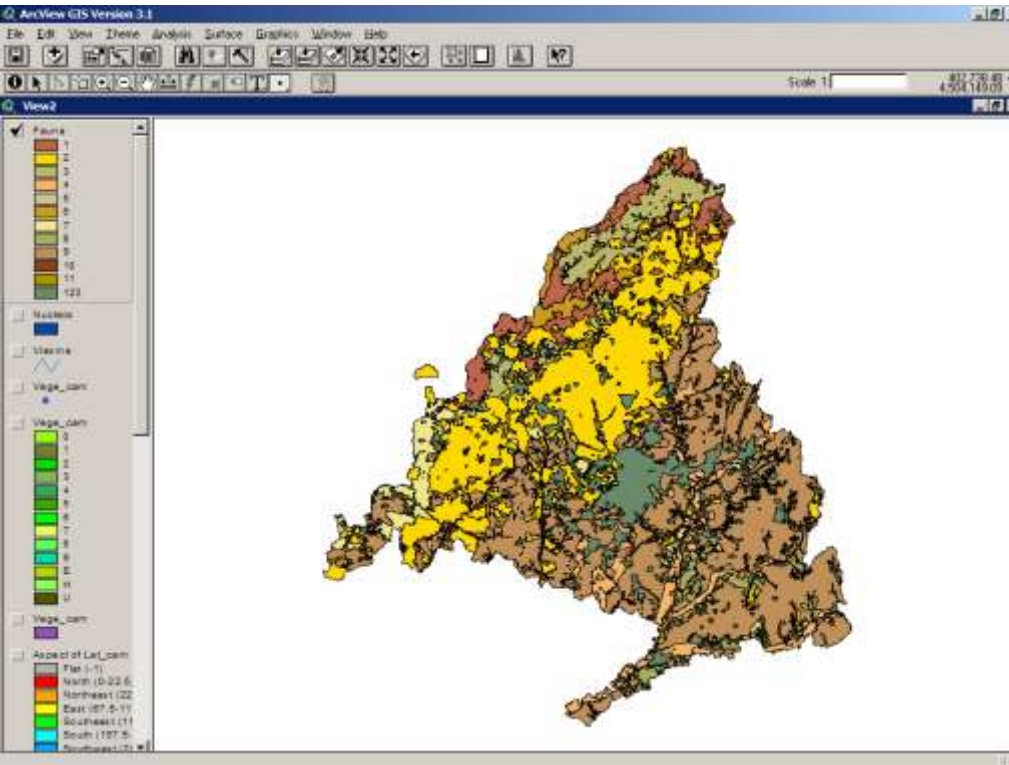


BEFORE MAP	AFTER MAP
0. Meadows	5
1. Wet crops	5
2. Dry crops	3
3. Mixed crops	3
4. Scrubs and bushes	2
5. Evergreen oaks	3
6. Deciduous oaks	3
7. Other deciduous trees	4
8. Other coniferous	4
9. Pine trees	4
E. Carrys	1
H. Dams	1
U. Citys and towns	1

Fauna

Reclassify in 5 classes

Criteria: According to the abundance of animals

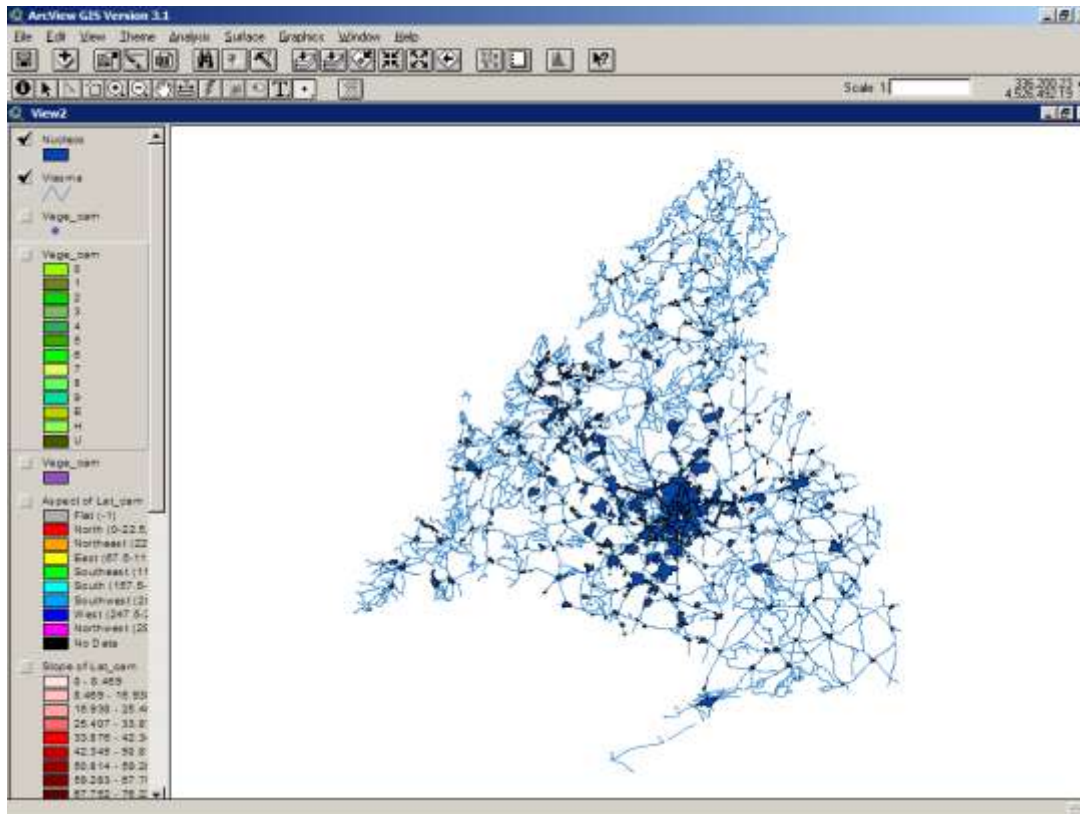


BEFORE MAP	AFTER MAP
1. Forest of pine in mountain	2
2. Evergreen oaks	4
3. Oaks of plateaus	4
4. Galery forest	5
5. Beechwood	3
6. Bushes	1
7. Forest of Pinus pinea	3
8. Slopes and cliff of gypsum	1
9. Improductives and crops	2
10. Marshlands	5
11. Dams	5
123. Mixtures of ecosystem	5

Towns and roads

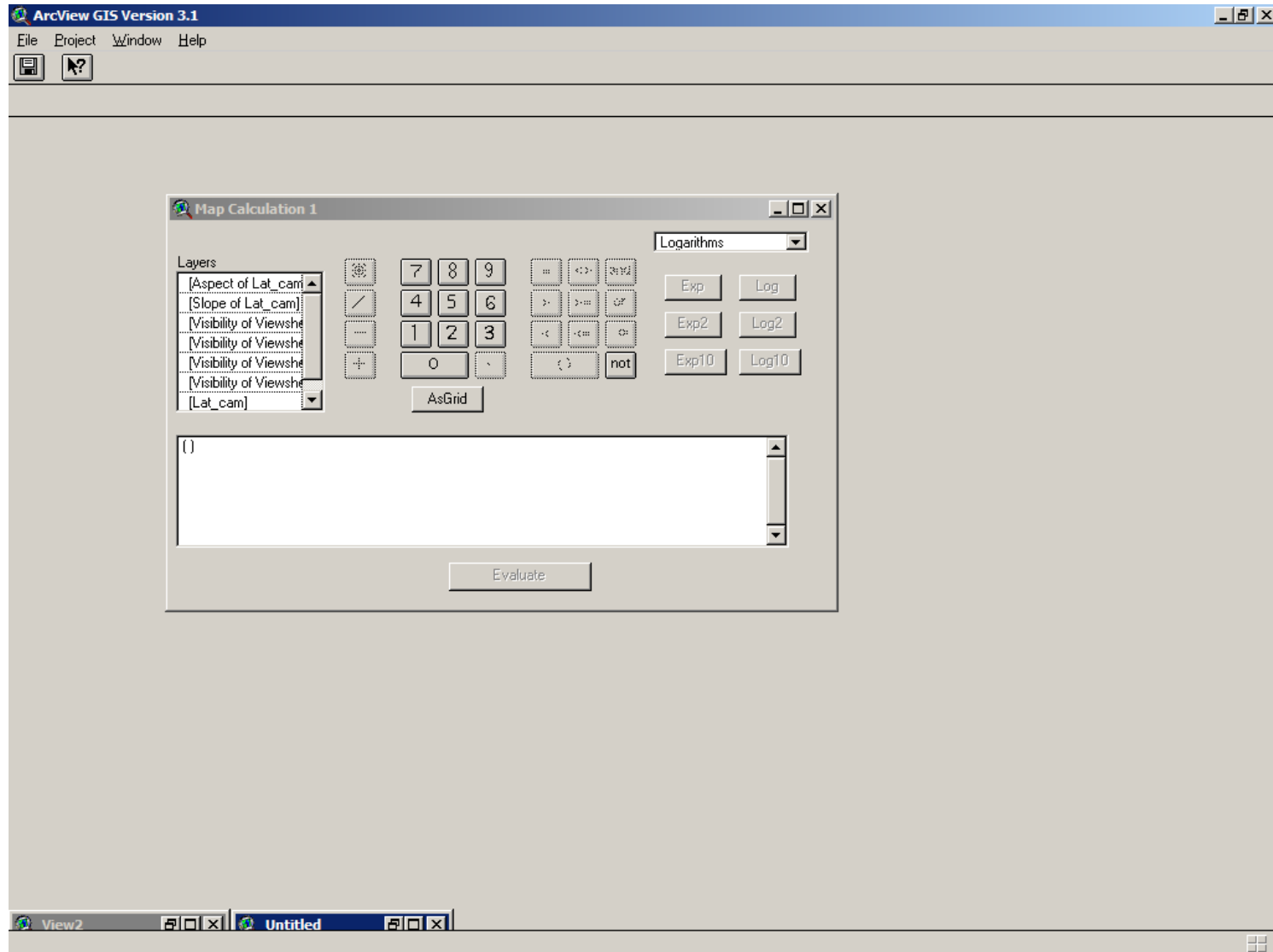
Reclassify in 5 classes

Criteria: The more frequented the less valuable

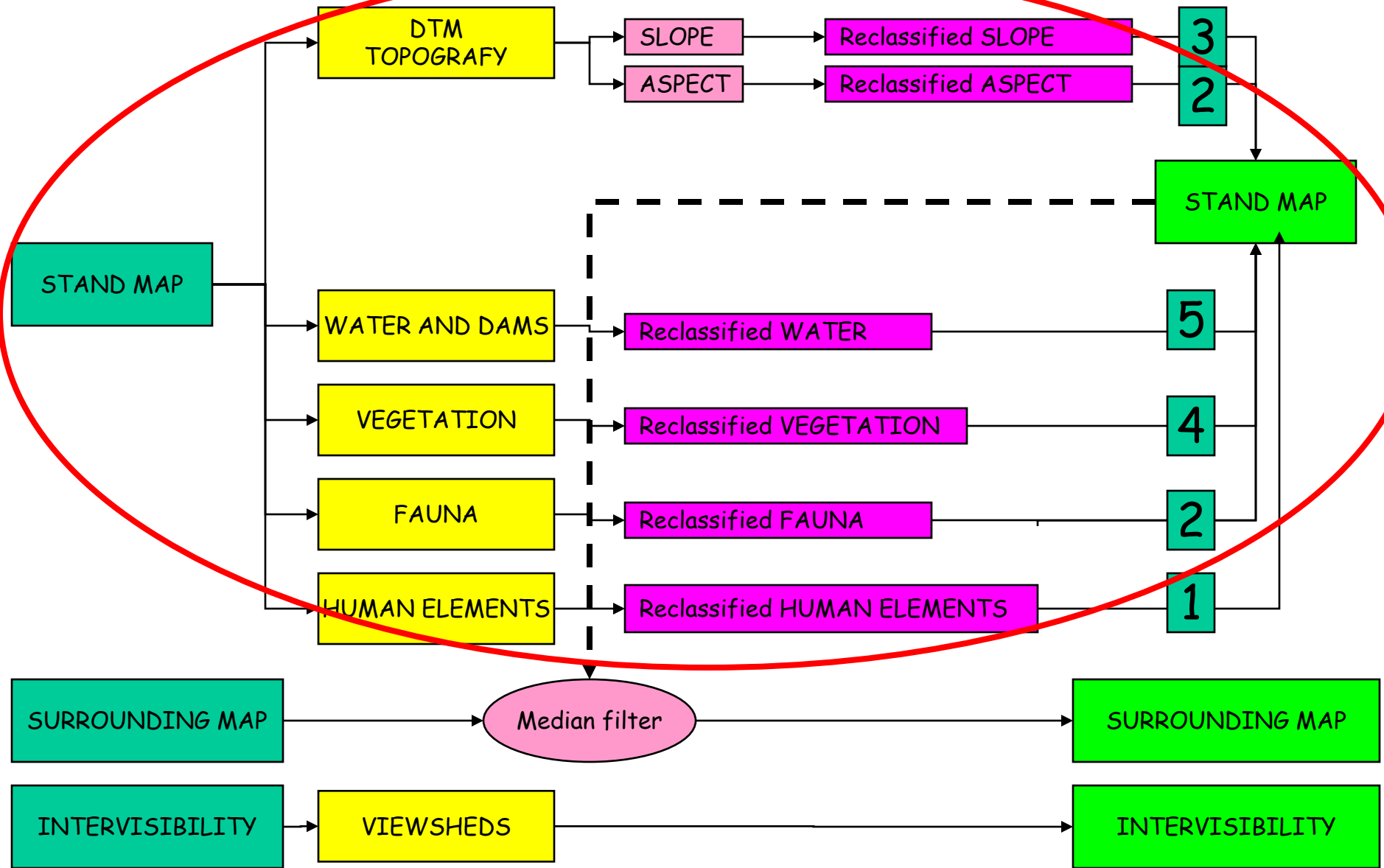


BEFORE MAP	AFTER MAP
Citys	1
Towns	2
Highways	3
Roads	4
Tracks	5

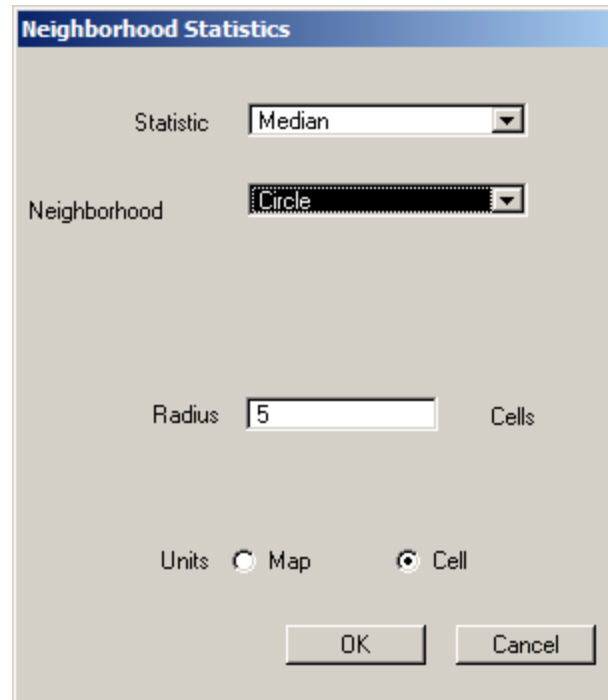
Map calculator



Quality of Stand



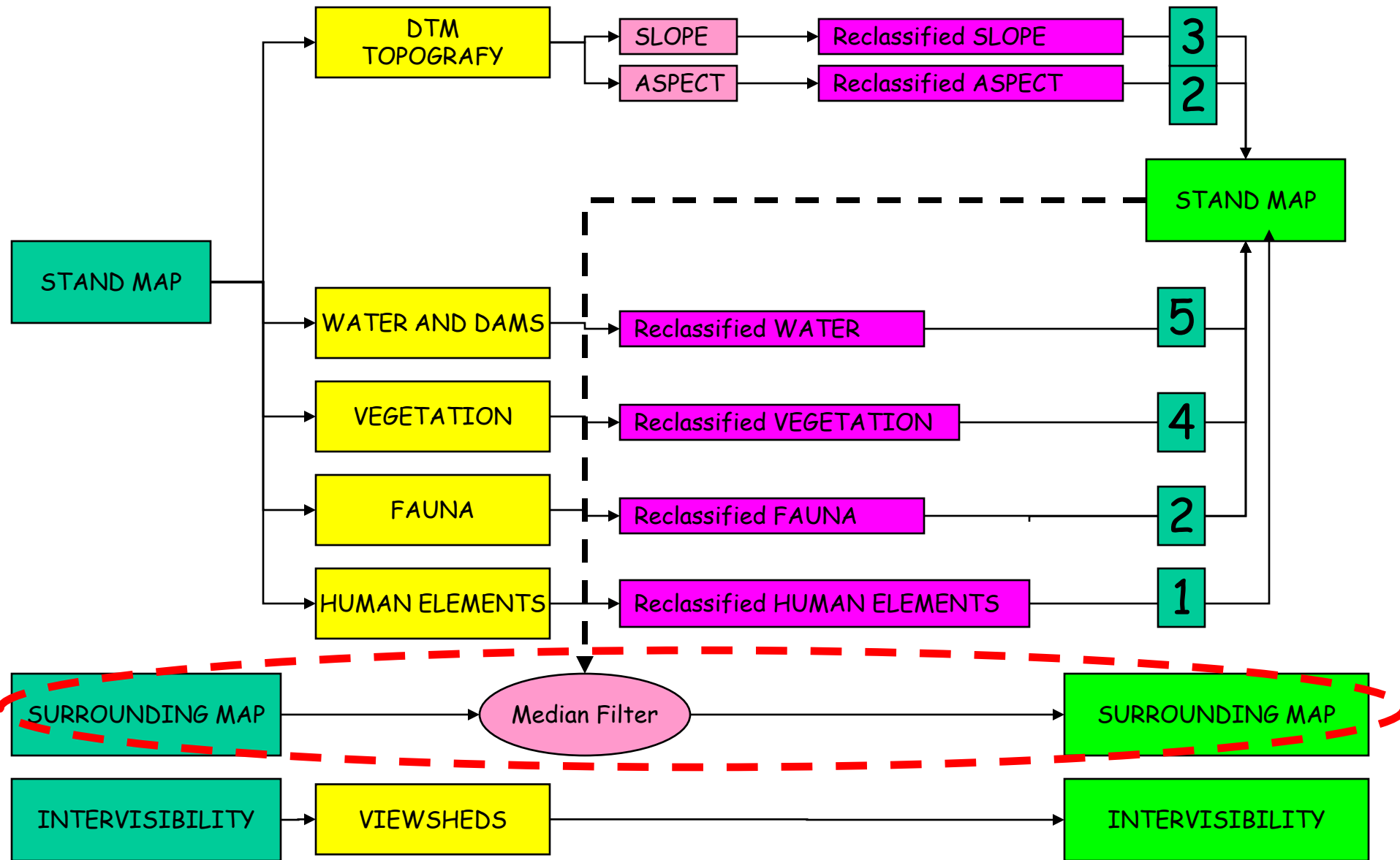
Neighbourhood Statistics



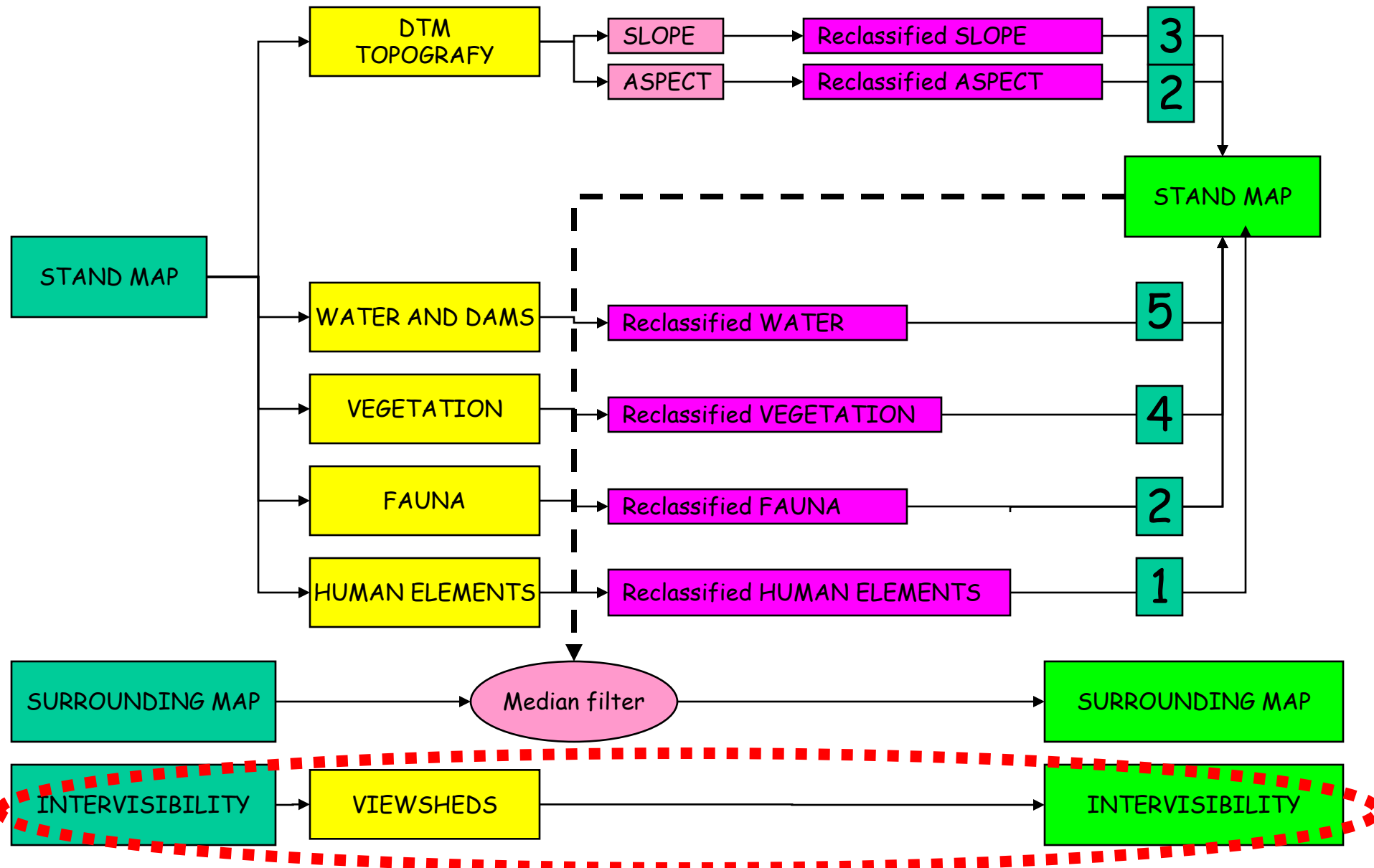
The image shows a dialog box titled "Neighborhood Statistics". It contains the following controls:

- A "Statistic" dropdown menu with "Median" selected.
- A "Neighborhood" dropdown menu with "Circle" selected.
- A "Radius" text input field containing the number "5", followed by the label "Cells".
- Radio buttons for "Units", with "Map" unselected and "Cell" selected.
- "OK" and "Cancel" buttons at the bottom.

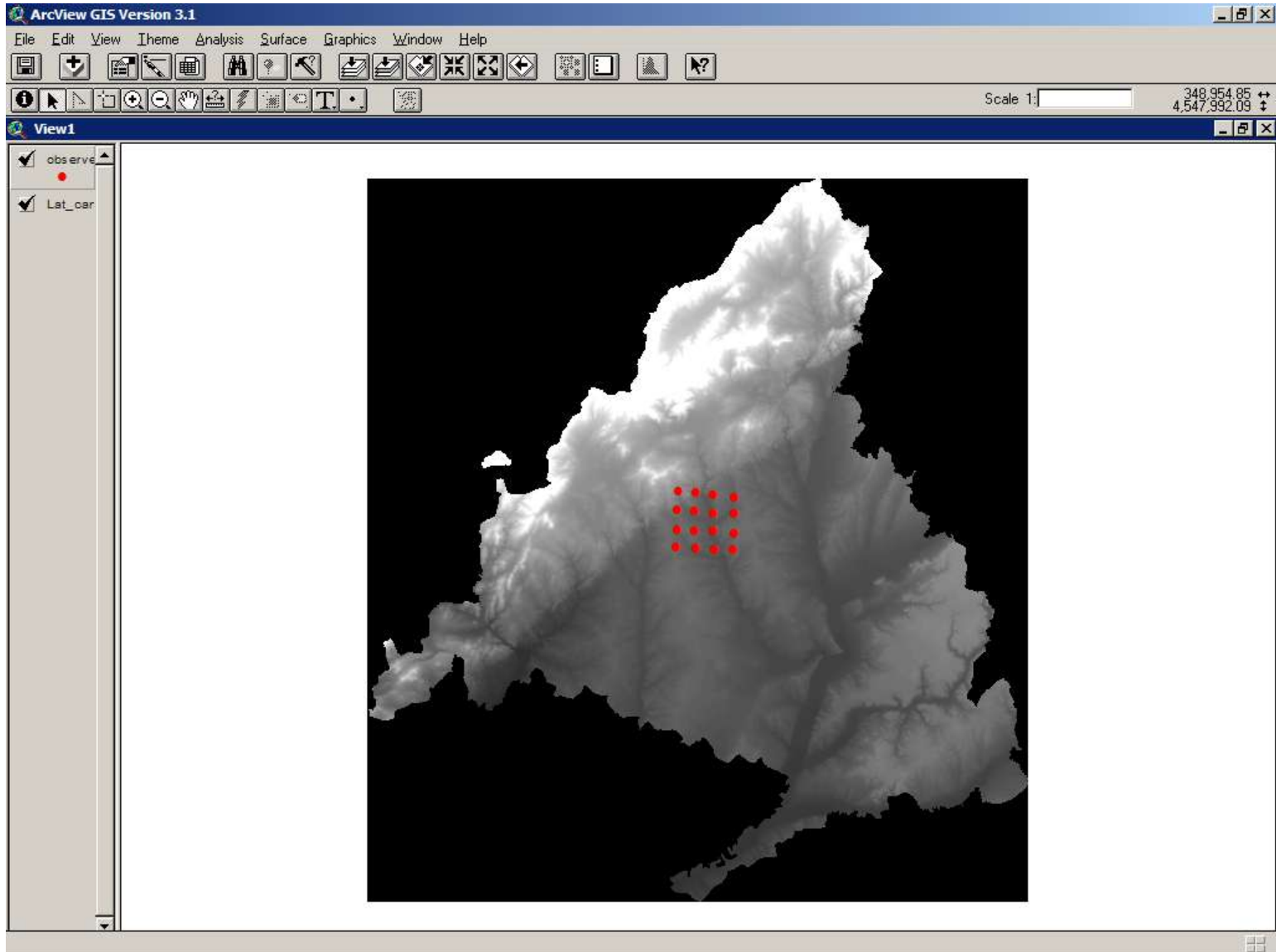
Quality of Stand



Quality of Stand



Sample points to make the intervisibility map.



Viewshed from the city of Madrid

