# Dynamic Modeling for land use and land cover changes in sub-basin of Arroio Grande, Rio Grande do Sul – Brazil

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## INTRODUCTION



- Located between the physiographic areas of the Central Depression and Southern Tableland of Rio Grande do Sul, Brazil;
- Area: more than 35.000 hectares
- Integrate the hydrographic hydrological basin of the Vacacaí-mirim River
- The occupation of the area date from the second half of the XIX century, with the arrival of the Italian immigrants, being intensified in the end of the same century with the increase of the agricultural activities, wooden extraction, and the commerce driven by these sectors.

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- Previous works in the area:
  - Ruhoff (2004) which was dedicated to referring questions to the modeling of the superficial drainage and the loss of grounds;
  - Kleinpaul (2005) and Torres (2011) that had the objective to analyze the forest evolution, they identified increase in the areas of forest and reduction of the areas of fields and pastures.



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Analyses about changes of use and cover are essential to the development of sceneries who aim the local and regional sustainability.
- Pedrosa (2004) proposes the use of dynamic space models for such, and those will have to describe the evolution of space standards of a system along the time.

- Burrough and McDonnel (1998), a dynamic space model, understands a mathematical representation of a process of the real world, in which a location in the silent land surface in reply to variations in the coercive ones of such a process.

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## Objective

- Use of tools of modeling to analyze dynamic space-time in the micro-basin of the Arroio Grande, Rio Grande do Sul, between the years of 1991 to 2011 and on basis of this model, project future sceneries of use and covering of the land.



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## BACKGROUND

The dynamic models of space simulation appear with the intention of introducing a new way of understanding the geographical space (ROCHA; SOUZA; TENEDÓRIO; 2001);

Dynamic models of space simulation has by objective support the analyses for the understanding of the environmental systems, taking into account all the processes involved, to be able to determine them how they envolve before different sceneries (socioeconomic, political and environmental. (RODRIGUES, SOARES-FILHO and COSTA, 2007)

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## (… background)

- Dynamic models of use and cover of the land, it has been having great distinction in the last years, many works are dedicated to these models, looking to overcome of the statistic analyses, insufficient for the analyses of dynamic processes like the evolution of the scenery (SOARES-FILHO; PENNACHIN; CERQUEIRA, 2002);

- Urbane evolution (ALMEIDA; et al. 2003);



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## ( … background)

- Advance of the forest deforestation (GARCIA; SOARES-FILHO; MORO, 2004);

- Changes the forest covering (HENDGES, 2007; PEREIRA; BENEDETTI; ALMEIDA, 2011);

- Land use and changes of land cover (SERRATO; et al, 2011).

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## ( … background)

Acoording Briassoulis (2000), the models can be classified, in view of his methodological and functional aspects, in:
- statistical or econometric;
- models of space interaction;
- models of optimization (including linear, dynamic, hierarchical and non-linear planning;
- integrated models (models of gravity, of simulation and of entry-exit);
- models based on natural sciences; models based on SIG;
- models based on Chains of Markov.



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## METHODOLOGY

According MAS et al., (2011) the procedures involved in the modeling can to be describe in five steps:

(1) calculate the area of each transition;

(2) determination of the probability of change;

(3) component indicating the location of changes;

(4) eventually a space module that simulates the spatial patterns of changes and

(5) a procedure for comparing the reference map with the map simulated.

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## Dinamica EGO software

The design of the spatial model in *Dinamica EGO* requires the definition of two different types of thematic maps:

1. The first, due to its time-space variation in the period of analysis, called "dynamic variables" in the modeling process.

2. The second type includes maps "statistic variables", so called because they disregard the occurrence of processes of transition in their classes during the analyzed period.



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## Dynamic Modeling

The model was implemented in the Dinamica EGO application, developed by the Department of Remote Sensing, Federal University of Minas Gerais – UFMG, Brazil, in order to enable the construction and implementation of models for dynamic studies of landscape and environmental modeling (SOARES-FILHO; RODRIGUES; COSTA, 2009).

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## Calibration Model

The calibration model involves calculating taxes of transition from the classes of land use and land cover (Table 1) were generated for which two matrixes, multiple and simple, the first comprises transitions occur annually and second transitions observed throughout the period of analysis.

The calibration step is also composed by the calculation of transition probabilities between classes of maps of static and dynamic variables, for which we use the method of Weights of Evidence. This method is based on Bayesian probability theorem, based on Bayes' theorem that determines the possibility of occurrence of an event, given the prior occurrence of an evidence (BONHAM-CARTER, 1994).



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## Simulation of future scenario

The scenarios simulation until the year 2020 was performed using the parameters of "Expander" and "Patcher" validated in simulation the year 2011.

How to map into the model was used to map land use and land cover the year 2011, the process resulted in nine annual statements for the period 2012 to 2020.

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## Validation of simulation model

The method used in the application Dinamica EGO consists of an adaptation of the method Hagen (2003) apud Soares-Filho et al. (2005), its uses similarity measures for fuzzy logic applied in the context of the local neighborhood on the actual maps and simulated maps.



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## Running the model using Cellular Automata (CA)

The Dinamica EGO uses the Cellular Automata (CA) method as a model of spatial simulation, the input parameters are thematic maps of the landscape (usually derived from remote sensing data), represented by a matrix.

In the modeling process implemented in this application are considered spatial variables classified into dynamic and static (SOARES-FILHO, 2001). The structure of the Dinamica EGO is based on "functors", the procedure for allocation changes.

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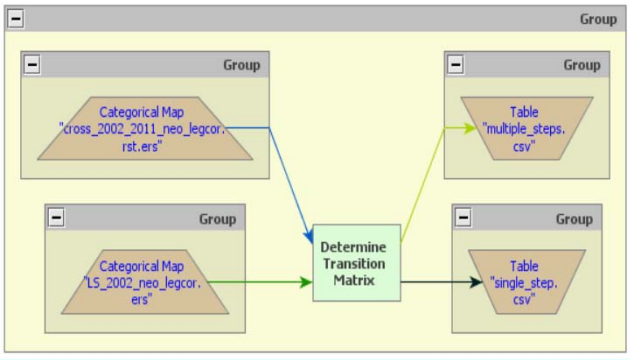
## Step 1 – Determine transition matrix



## RESULTS AND DISCUSSION

Table 1. Transition matrices for simple step and multistep for the time series from 1991 to 2002 and from 2002 to 2011.

| Transition Of | To | 1991-2002 *Single Step* | *Multi Step* |
|---|---|---|---|
| Forest | Field | 0.1070403199 | 0.01318074854 |
| Forest | Agricultural use | 0.03706688155 | 0.002119729206 |
| Field | Forest | 0.1573897986 | 0.01873791136 |
| Field | Agricultural use | 0.2615001367 | 0.04398651453 |
| Agricultural use | Forest | 0.09646479863 | 0.007372688804 |
| Agricultural use | Field | 0.355796592 | 0.05958485846 |
| **Transition Of** | **To** | **2002-2011 *Single Step*** | ***Multi Step*** |
| Forest | Field | 0.09736738344 | 0.01470341556 |
| Forest | Agricultural use | 0.03326342737 | 0.002229871116 |
| Field | Forest | 0.1758382562 | 0.02529109198 |
| Field | Agricultural use | 0.2572167137 | 0.04527245417 |
| Agricultural use | Forest | 0.09746629275 | 0.01022843404 |
| Agricultural use | Field | 0.2182368141 | 0.03793385165 |



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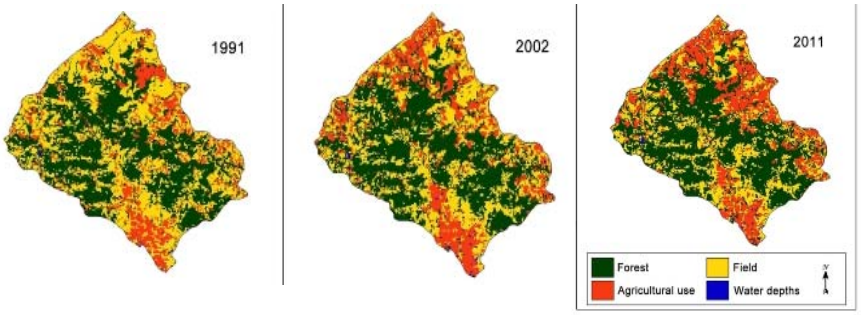
## Land Use and Land Cover Classification

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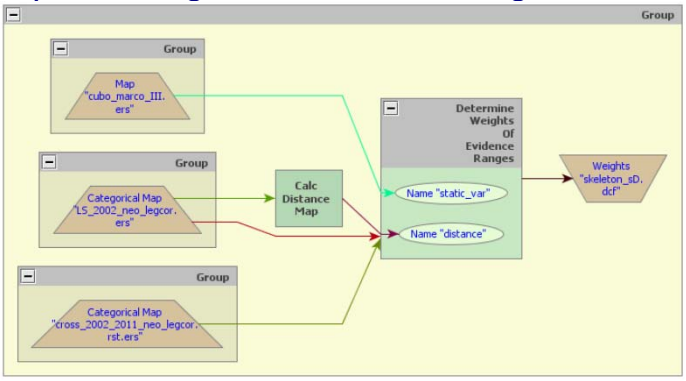
## Step 2 – Weights of evidence ranges calculation



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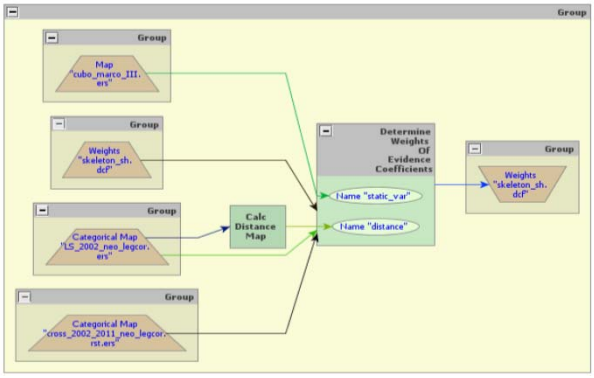
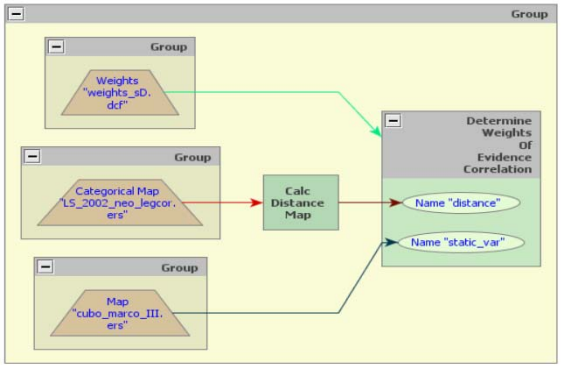
## Step 3 – Weights of evidence coefficient calculation



## Step 5 – Weights of evidence correlation



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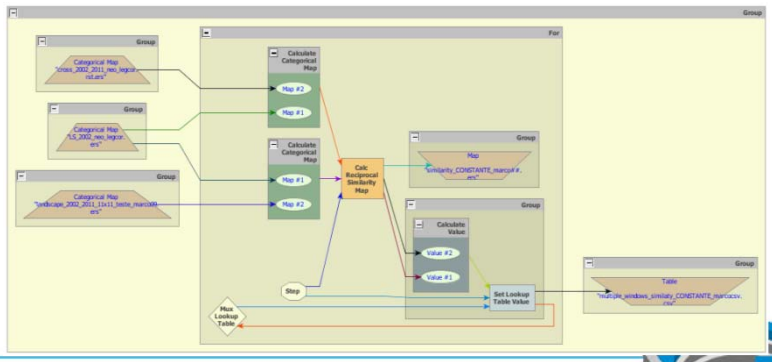
## Step 8 – Validate using multiple windows constant decay function



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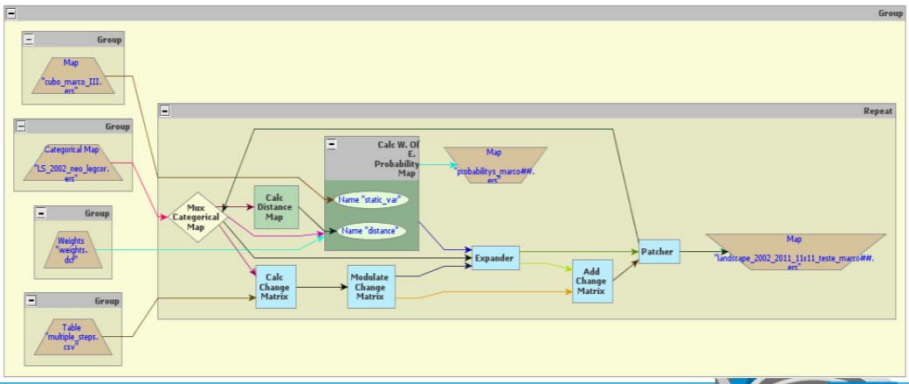
## Step 10 – Run LUCC



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## Simulation Map in 2020 – Micro basin Arroio Grande, RS-Brazil

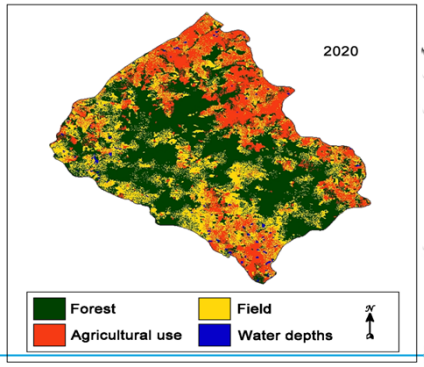


Table 4. Total area of the simulated classes for 2020.

| Class | Area 2020 (ha) |
|---|---|
| Forest | 16954.11 |
| Field | 9143.37 |
| Agricultural use | 9031.59 |
| Water depth | 231.3 |

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## Evolution of use and coverage of micro-basin of the Arroio Grande with the simulation for the year 2020

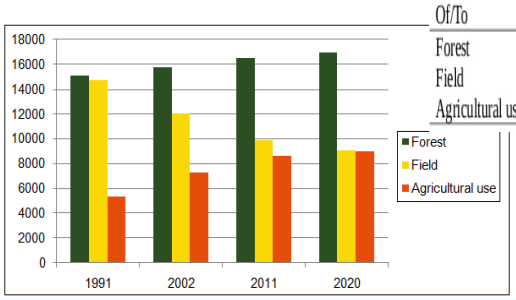


Table 5. Conversion Class of 2011 to simulate the year 2020 (ha).

| Of/To | Forest | Field | Agricultural use |
|---|---|---|---|
| Forest | | 1106.82 | 167.58 |
| Field | 1085.22 | | 1942.56 |
| Agricultural use | 407.7 | 1512.72 | |





## CONCLUSION

Dynamic models for simulating land use and land cover, as well as the use of platform Dinamica EGO, consists in very important tools for studies dedicated to the exploration of future scenarios.

The simulations for the years 2002 and 2011 reached similarity indices above 0.95%.

## ( … conclusion)

The scenario for the year 2020 showed little change indicating:

- an increase of 2.64% in forest areas;

- an increase of 4.38% in the areas of agriculture;

- a decrease of 8.19% of the fields;

- This dynamic may indicate a tendency to stagnation in the areas of agriculture.



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## References

Pedrosa (2004)
Burrough and McDonnel (1998)
ROCHA; SOUZA; TENEDÓRIO; 2001
(RODRIGUES, SOARES-FILHO and COSTA, 2007)
HENDGES, 2007; PEREIRA; BENEDETTI; ALMEIDA, 2011

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**Thank you for your attention!**

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