Spatial Scenarios of Land Use/Cover Change for the management and conservation of Paramos and Andean Forest in Boyacá, Colombia.

Luisa Castellanos Mora Ms.c. moralula@gmail.com
William Agudelo-Hz. PhD. wjagudeloh@unal.edu.co

1 st International Electronic Conference on Forest (IECF) 2020

1. Introduction

Land Use Change

- Key factor in global change, influencing human environmental, and socioeconomic welfare .
- Influence:
  - Climate change
  - Biodiversity
  - Ecosustems stabilitie[4]

Factors

Rise of the human population

Increase in meat demand[5]

Crops and pastures have gradually replaced forests in many places on earth[6]

1. Introduction

Conversion to pastures and crops is constant in Latin América; particularly, the south American tropical Andes have endured an intense agricultural activity, as they have been high populated over the years

In the Colombian Andes, the department of **Boyacá** is one of the main agricultural producers at the national level[7]

Boyacá

High biodiversity and numerous endemic species

Important agricultural producer.

Important for ecosystem services. Holds most of the Andean forest and paramos in the country.

Acelerated forest and paramo transformation

1. Introduction

Boyacá aims to maintain a high sustainable agricultural production while keeping its strategic ecosystems and biodiversity. Along with a high rural population with needs, this represents a complex challenge.

✓ It is crucial to understand potential future patrons that could guide optimal planning decisions in the territory.

Effective tool for managing and planning the use of natural resources → Land-use change scenarios modeling

- Allows to explore where and when certain changes could be expected.
- Provides a look at a potential future, where different pathways of change can be analyzed and support important conservation decisions.

Objetives

Our objectives included:

1) Analyze land-use changes in the Andean forest and paramos of Boyacá from 1998 to 2018.

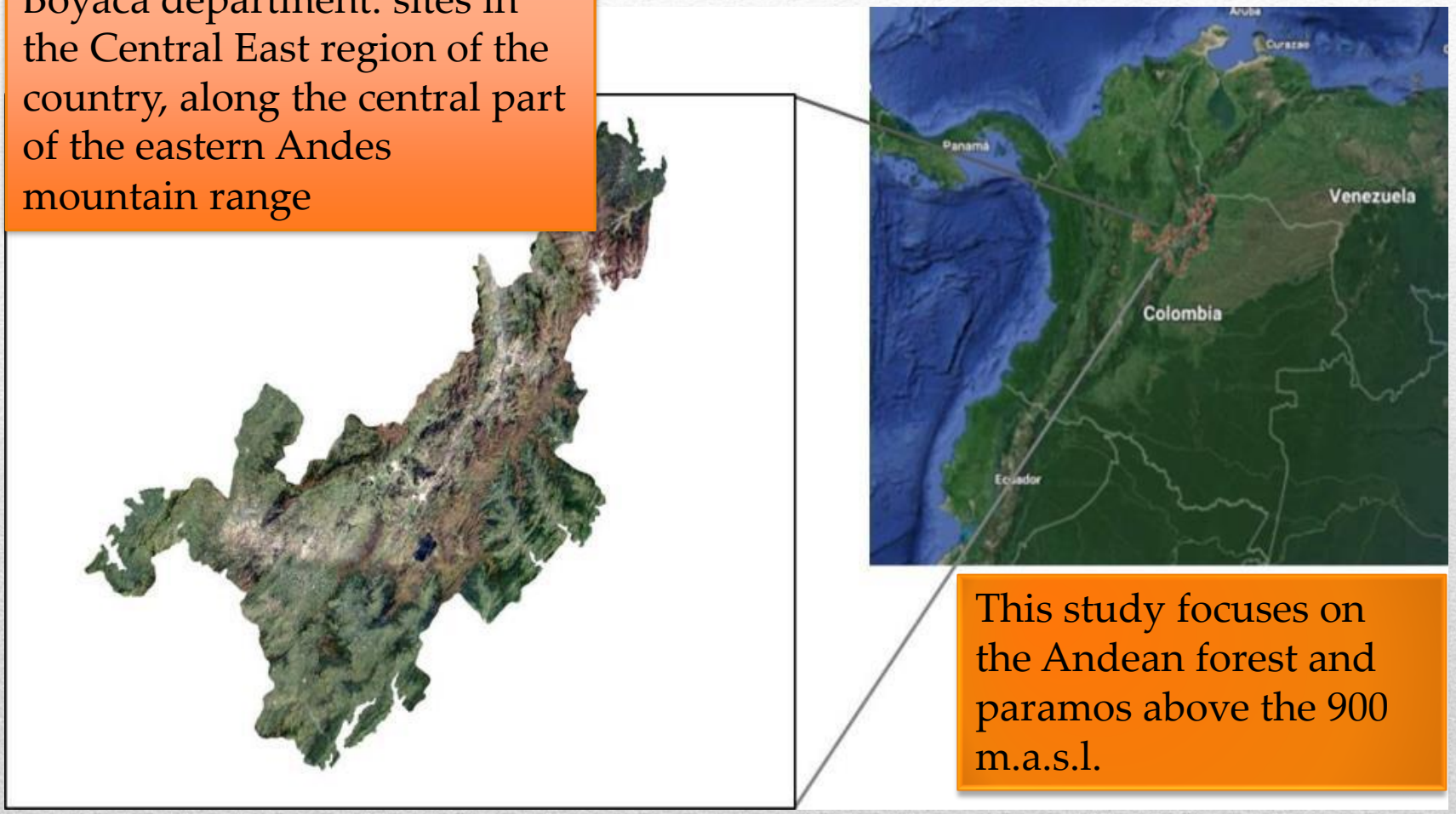
2) Assess the drivers associated with these changes.

3) Explore potential future changes throughout the spatial modeling of three pathways for the years 2030 and 2050: i) Trend (Busines as usual) ii) Agriculture expansion and iii) Conservation.

2. Methods.

Study Area

Boyacá department: sites in the Central East region of the country, along the central part of the eastern Andes mountain range



This study focuses on the Andean forest and paramos above the 900 m.a.s.l.

2. Methods.

Land Use/Cover changes

To estimate both quantitively and spatially land use change in the study area

- Classification of Landsat images 5, 7, and 8 L1T.
- Images classification was performed using the Erdas Imagine software 2015, using the maximum likelihood supervised parametric method.

3 land cover images: 1998, 2010, 2018

- Land-use change analysis was performed using the Land Change Modeler (LCM,) in the Idrisi Selva software V. 17.2.
- Changes in land use/cover were analyzed in 11 categories: Andean forest, paramo, secondary vegetation, pastures and crops, thickets, shrubs, rock surfaces, bare soil, urban, forest plantations, and water bodies.
- The analysis was carried out in two periods: 1998-2010 and 2010-2018. Gains, losses, and persistence were calculated in the two periods for each land cover category

2. Methods.

Transition Sub models and Drivers of Change

- We worked seven sub models grouped in two categories:

Degradation

1) Andean forest to pastures and crops.
2) Andean forest to secondary vegetation
3) Paramo to pastures and crops,
4) Paramo to secondary vegetation,
5) Paramo to bushes

Regeneration

6), Pastures and crops to secondary vegetation,
7) Pastures and crops to scrub.

- A group of 36 variables was prepare to be consider as drivers of change discriminated in eight categories:

1) Physical environment, **2)** Accessibility , **3)** Landscape composition, **4)** Landscape structure, **5)** Management policies, **6)** Degradation, **7)** Demographic, **8)** Socioeconomic.

Each transition was model using the MLP (Multilayer Perceptron) method in Idrisi. After running each sub-model, we obtained seven transition maps and their corresponding accuracy values.

2. Methods.

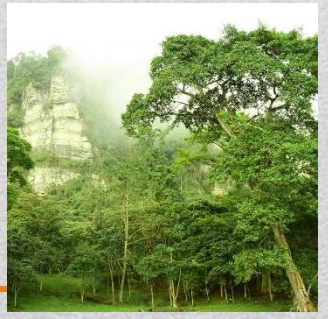
Scenarios construction

- Land use/cover change predictions were done using Markov chains analysis in the Land Use Change Modeler (LCM) in Idrisi.

Trend Scenario. Observed trends in Andean forest and paramos during 1998 and 2010 will continue the same for 2030 and 2050. No conservation actions nor incrementation in crop and pasture area was considered.

Agricultural expansion scenario. Contemplates a 12% increment of the arable land. Transition probabilities from secondary vegetation, Andean forest and paramo to pastures and crops were incremented in 2%, 5% and 5% respectively. Does not apply any conservations actions, leading to lost and degradation of Andean forest and paramos.

Conservation. Assumes the implementation of conservation measures, like restauration projects, protected areas expansion and payment for ecosystem services, allowing regeneration processes. Transition probabilities from pastures and crops to secondary vegetation and Andean forest were incremented in 4% each, for a total regeneration increase of 8%.



3. Results and Discussion

Land Use/Cover Change

Land cover change between 1998 and 2010 (%). Persistence, losses, and gains for 2010 in hectares. Annual exchange rate (%) (gain or loss per category)

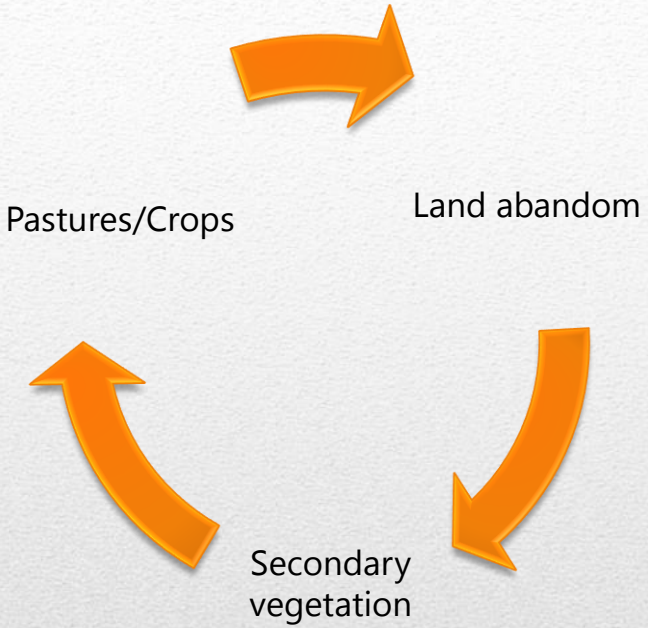
Land Cover	1998%	2010%	Persistence	Gain	Loss	Annual exchange rate
Pastures-crops	39	34.7	597.986	66.736	145.721	-0.9
Secondary Vegetation	10.4	17.1	131.37	197.228	66.978	4.2
Andean Forest	29.2	24.8	432.893	41.716	122.853	-1.3
Paramo	11.4	10	137.739	54.583	78.923	-1
Bushes	3	7	43.385	90.011	14.392	7

Land cover change between 2010 and 2018 (%). Persistence, losses, and gains for 2018 in hectares. Annual exchange rate (%) (gain or loss per category)

Cobertura	2010	2018	Persistence	Gain	Loss	Annual exchange rate
Pastures-crops	34.7	41.8	610.661	191.458	54.062	2.3
Secondary Vegetation	17.1	17.6	175.805	161.41	152.792	0.3
Andean Forest	24.8	18.4	319.771	33.725	154.837	-3.7
Paramo	10	10.1	146.634	47.91	45.688	0.1
Bushes	7	6.5	72.253	52.238	61.143	-0.9

3. Results and Discussion

Land Use/Cover Change



- Considerable gain from land dedicated to crops and pastures by reducing forests and Paramos.

- Increase in agricultural activities impacts natural cover in the Andes. (Armenteras et al., 2010; Josse et al., 2011; Aide et al., 2019; Redo & Aide, 2012).

- Repetitive and systematic pattern. Crops-pastures and secondary vegetation replace each other by land abandonment.

3. Results and discussion

Transition sub-models and drivers of change

- Variables that intervene the most in the land use change dynamics were:

The digital elevation model,
Distance to secondary roads,
Distance to national protected areas.

Important to explain the transitions in the Andes (Redo et al., 2012, Aide et al., 2019)

Greater deforestation probability in unprotected areas (Colombian Andes). Greater probability of transformation, at a greater distance from a protected area.

Etter (2006), positive relationship between the presence of roads and the deforestation of the forest for agriculture.

- Socioeconomic variables; agricultural density, number of households and conflict overuse were the most frequent variables explaining land use change.

Not to used as explanatory variables of land use change.
This research included and explored a wide variety of socioeconomic variables, seeking a more comprehensive approach. In general, they occupied medium and low positions of influence, but they intervened in the changes.

3. Results and Discussion

Spatial explicit land use scenarios for 2030 and 2050

Land Cover	Ref. Year	Trend Scenario				Agricultural Expanssion Scenario				Conservation Scenario			
	2010	2030		2050		2030		2050		2030		2050	
	% Area	% Area	% C	% Area	% C	% Area	% C	% Area	% C	% Area	% C	% Area	% C
Pastures and Crops	34.7	29.66	-14.45	27.68	-20.17	31.40	-9.43	29.42	-15.15	28.27	-18.45	26.29	-24.16
Secondary Vegetation	17.1	28.26	64.92	32.68	90.65	28.26	64.91	32.67	90.65	29.65	73.00	34.06	98.74
Andean Forest	24.8	18.65	-24.67	15.65	-36.79	17.41	-29	14.41	-41	18.65	-24.67	15.64	-36.80
Paramo	10	6.10	-39.17	4.54	-54.78	5.60	-44	4.03	-59	6.10	-39.17	4.54	-54.78
Bushes	7	10.88	56.32	13.02	87.11	10.88	56.35	13.02	87.10	10.88	56.35	13.02	87.10

Important reduction in Forest and Paramo

Highest loses in forest and Paramo

Highest reduction in pastures and crops. Greatest regeneration.

3. Results and discussion

Spatial explicit land use scenarios for 2030 and 2050

Scenario with greatest impact on forest and paramos: Agricultural intensification.

Jants et al., (2015), greater loss of natural cover (-85%) in an Esc. RCP 8.5 for the tropical Andes at 2100. Higher value of loss of natural cover compared to other scenarios

Shows the greatest fragmentation, especially in the Paramos. Implications: loss of connectivity, degradation of ecosystems, loss of biodiversity (Armenteras et al., 2003; DeFries et al., 2005)

The conservation scenario presents the lowest values of decline in the Andean paramo and forest

Still, they are worrying and are similar to the losses values of trend scenario. Degenerative processes are occurring at very accelerated rates.

Tota-Bijagual-Mamapacha and Pisba Paramos:

Most affected in the three scenarios by the loss of their area and high probability of transformation.

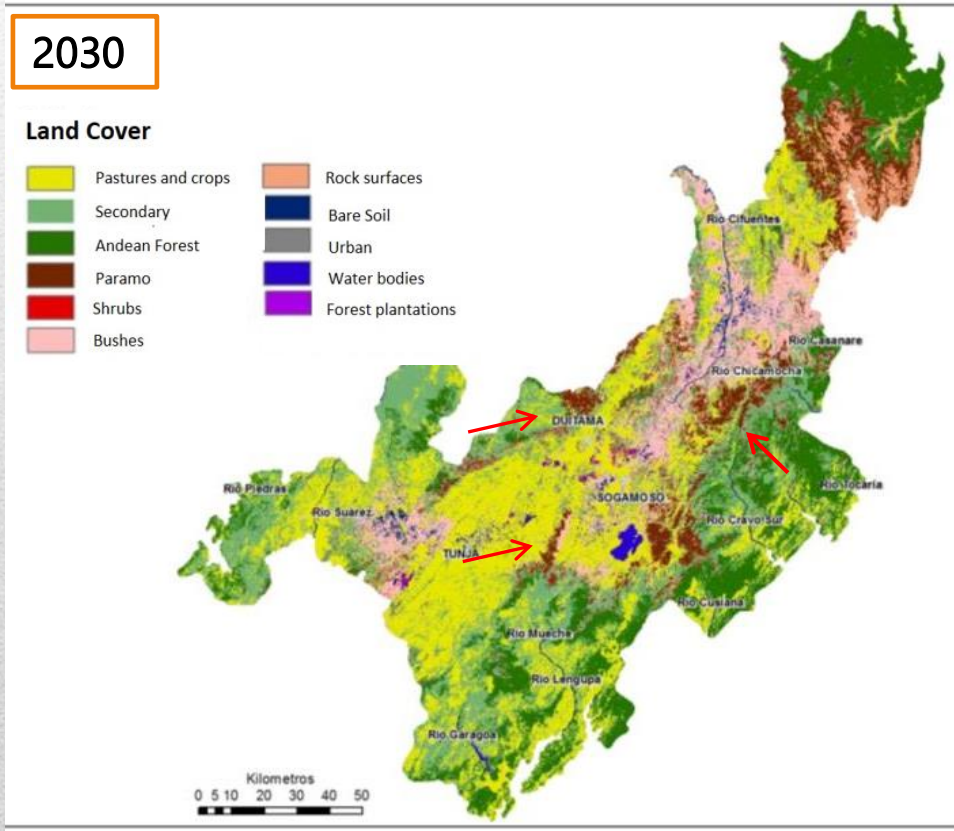
3. Results and discussion

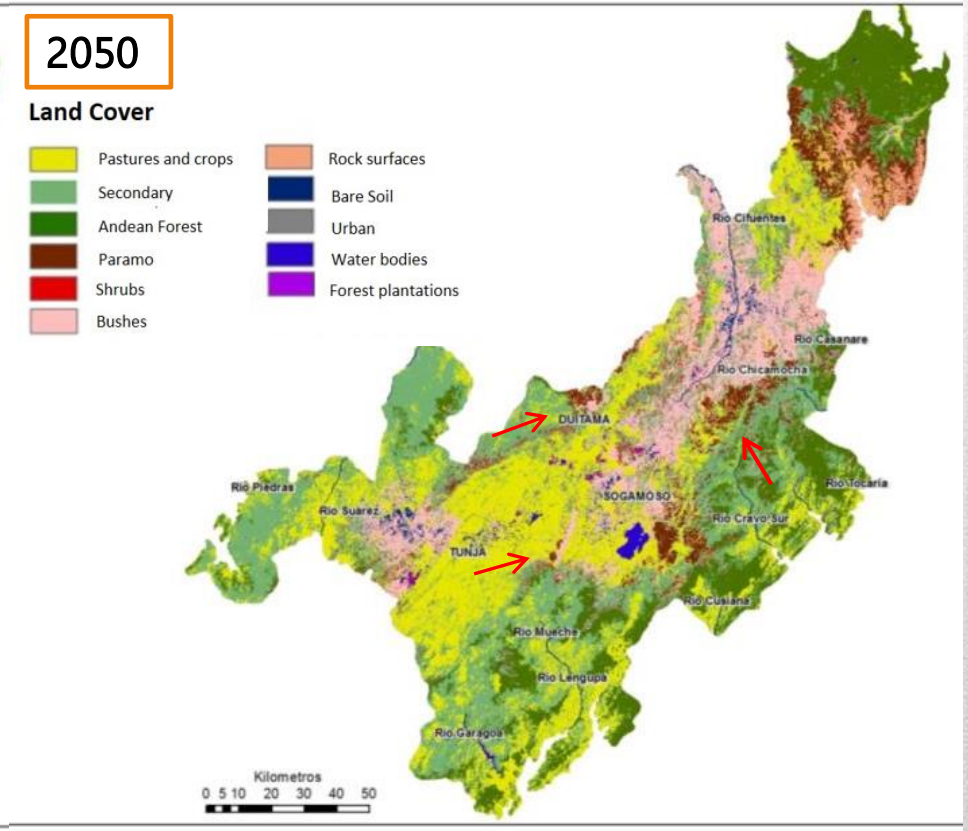
Trend Scenario

- High transformation in :

Tota-Bijagual-Mamapacha, Pisba,

Guantiva-La Rusia



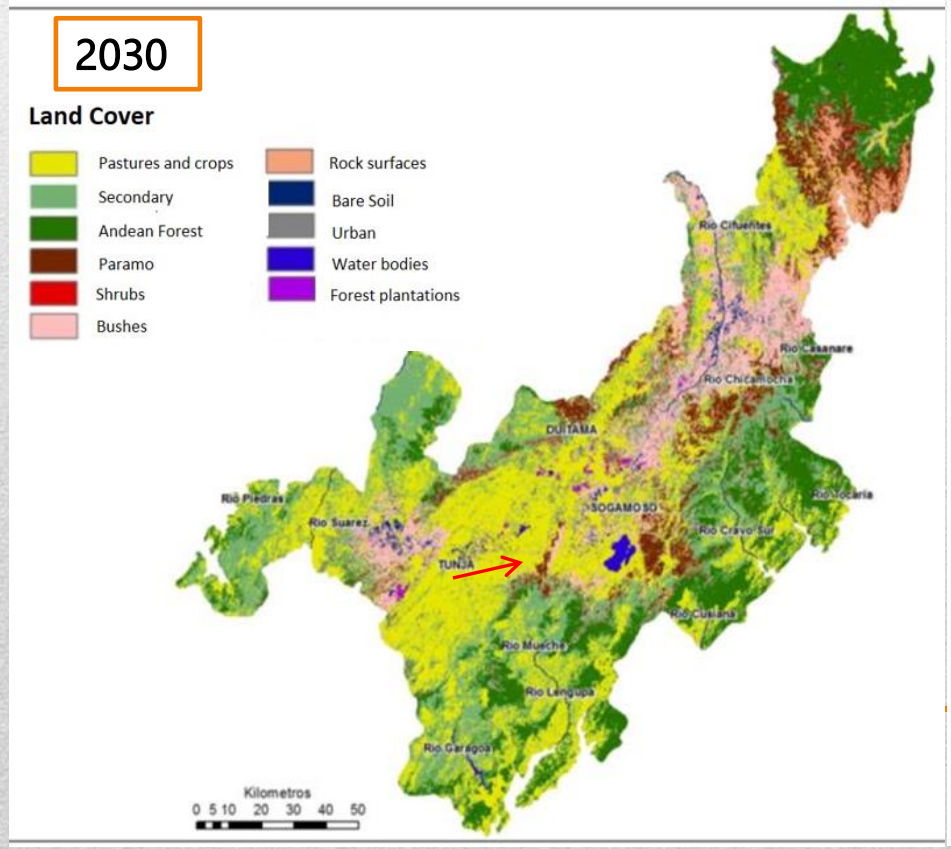


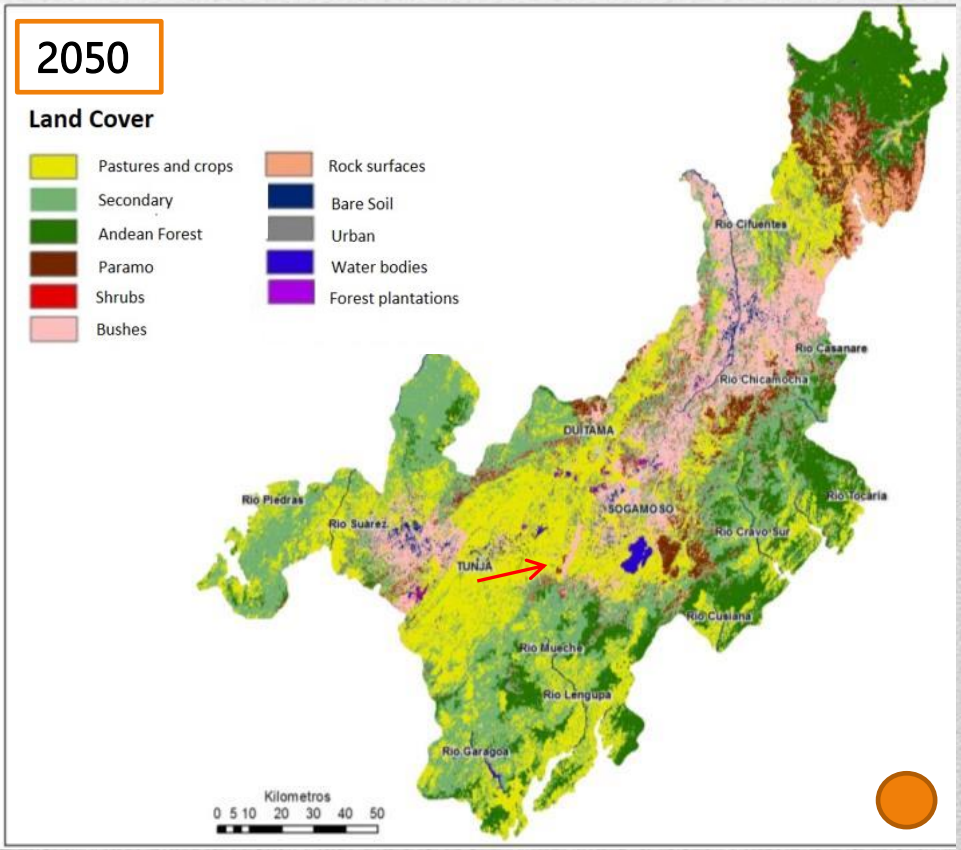
3. Results and discussion

Agricultural Expansion Scenario

- Forest around paramos importantly reduced .
- Most affected paramo : Tota-Bijagual

- Paramos reduce to small patches surrounded by pastures- crops and secondary vegetation.

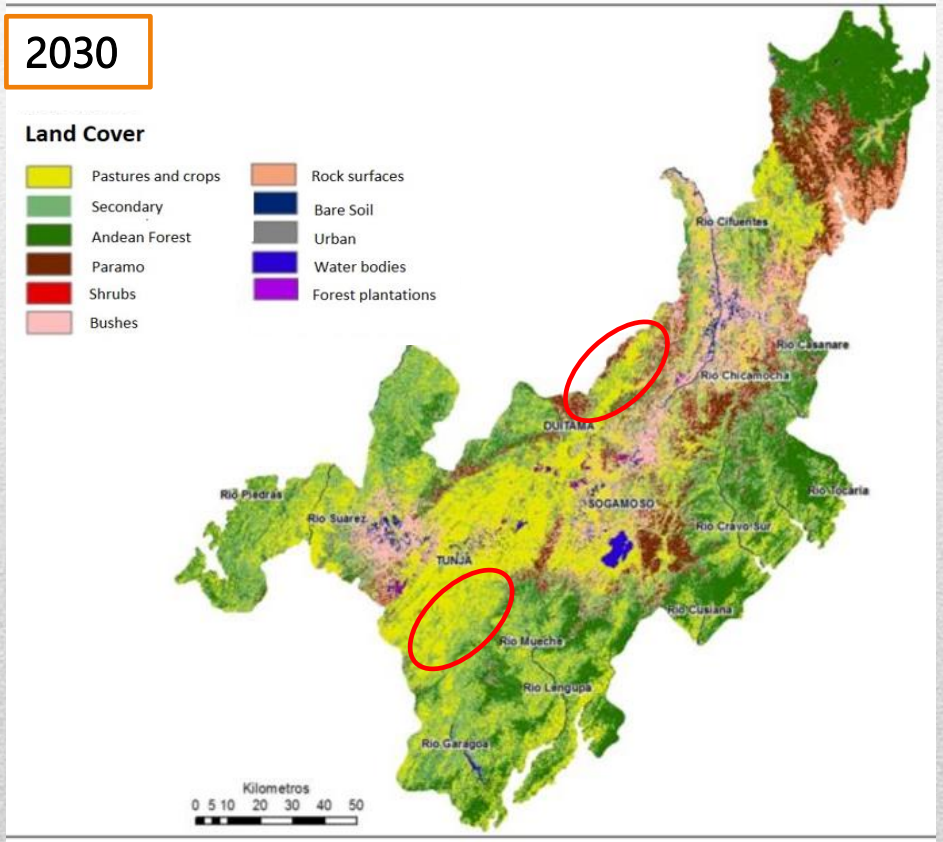


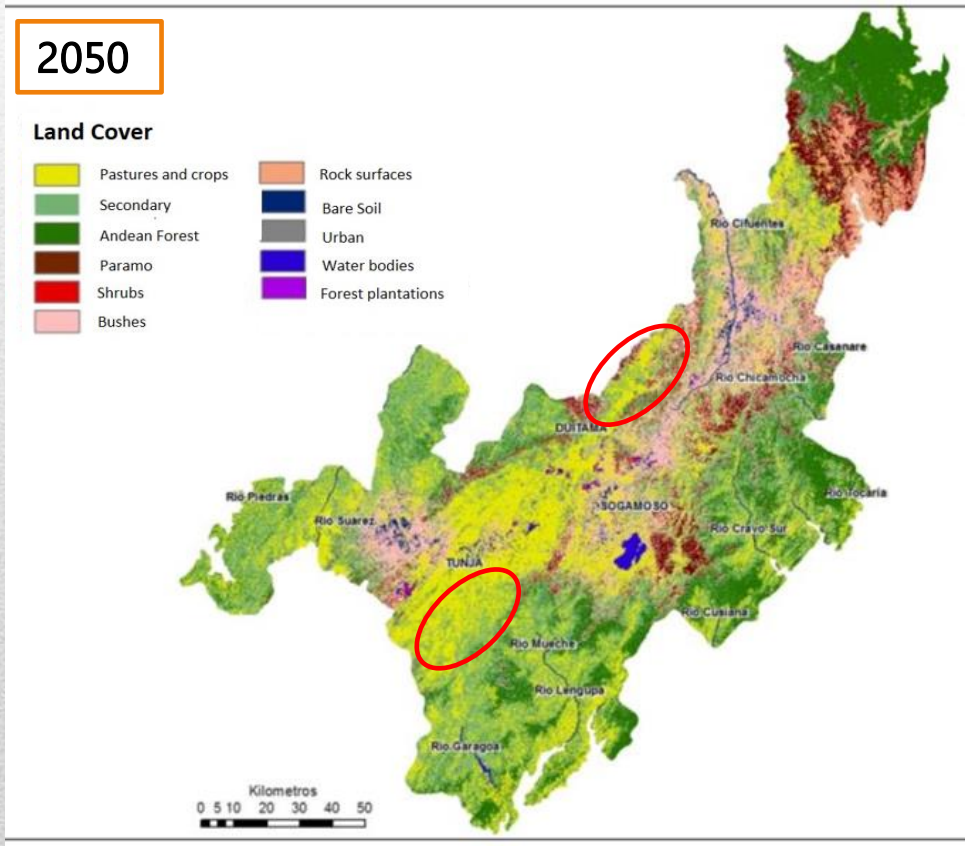


3. Results and discussion

Conservation Scenario

- Same critical transformation áreas, but more severe in paramos and andean forest.





4. Conclusions

- In 20 years (1998-2018), a gradual loss of Andean forests and paramos was observed in the study area. Also an increase in secondary vegetation and a dynamic between crops-pastures and secondary vegetation, that agrees with a cyclical pattern previously reported in the South American Andes.

- The most recurrent explanatory variables that influenced the transitions in the study area belonged to three categories: physical-environmental (DEM), accessibility (distance to secondary roads), and management policies (distance to national protected areas). Overall, the socio-economic variables obtained medium and low positions of influence in the transitions, but they were recurrent in the changes; therefore, it is recommended to include and explore this type of variables in future investigations.

- The scenario with the most drastic values of forest and paramo loss was the Agricultural Intensification scenario, while the Tendency and Conservation scenarios showed similar loss values. Tota-Bijagual-Mamapacha and Pisba turned out to be the most affected paramos in all three scenarios, thus, it is recommended to increase conservation efforts in these areas (e.g. restoration or PES initiatives).

Thankyou for your atention

Luisa Castellanos Mora. Independent Researcher ; moralula@gmail.com

William Agudelo. National University, Bogotá, Colombia ; wjagudeloh@unal.edu.co