Temporal evolution of ecosystem services in Sierra Nevada (Spain)

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1. Introduction, objectives and study area

Anthropogenic activities and land use changes are the main drivers of global change in Sierra Nevada National Park ecosystems. Human activities have important consequences on ecosystem structure and function which can take decades or centuries to become apparent. The variation in anthropogenic use have conditioned the capacity of mountain ecosystems to produce ecosystem services over time, resulting in trade-offs between provisioning and regulating services.
The main objective is to analyzed the co-evolution of provisioning and regulating services and the trade-offs between both of them in Sierra Nevada since 1956 to the present. The results show that there is a trade-offs in the evolution of provisioning and regulation services.

2. Methodology

The study

We analyze land use changes and trade offs in **provisioning and regulating services** between 1956 and 2007 in Sierra Nevada (Fig.1).

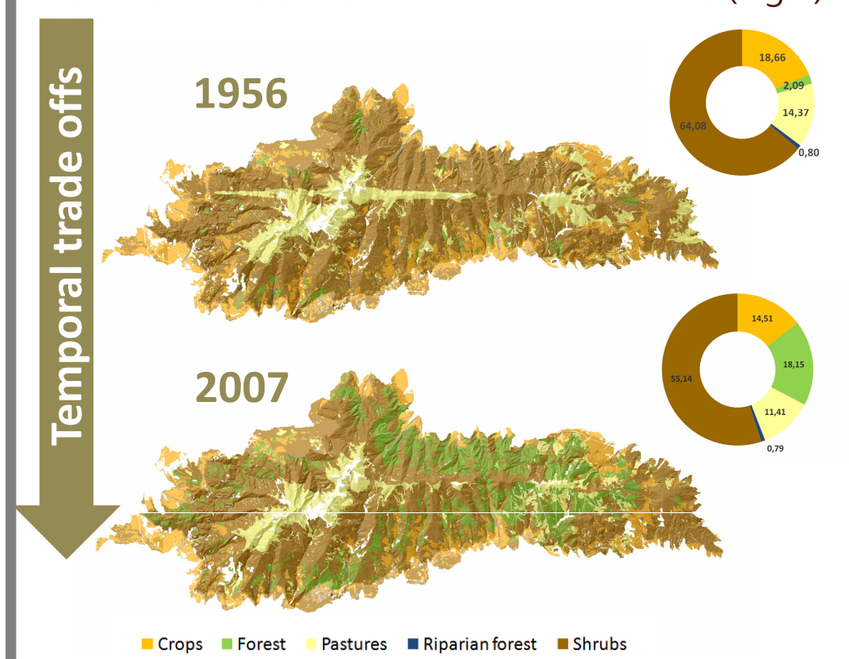

Fig.1: Land use changes between 1956 and 2007 in Sierra Nevada

Variables and study units

We use the watersheds at Sierra Nevada as study unit . There is a total of 92 watersheds. (Fig.2).

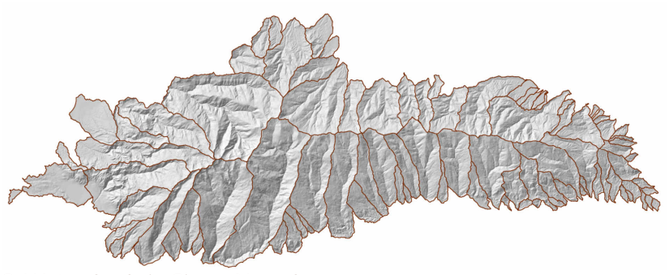

Fig.2: Watersheds in Sierra Nevada

The variables used for quantification Ecosystem Services per watershed in both periods are:

- Provisioning services
  - Agricultural products (kilograms)
  - Surface area for livestock (hectares)
- Regulating services → Runoff (litres)

In order to analyze the changes in ES we calculate de diference of this variables $V_{2007} - V_{1956}$

Assessment of variables

To quantify the **production of the variety of agricultural** we obtained from official statistics the harvest yield of the variety of crops by surface unit.

Assessment of variables (cont.)

In order to estimate the **potential livestock** along the time period, we evaluated the evolution of areas of **pastures** used by the cattle.
Regulating services was evaluated with **WiMMed model**. WiMMed (Watershed Integrated Model in Mediterranean Environments) is a physically-based, fully distributed hydrological model. It uses hourly and daily meteorological data, along with certain physical properties of the soil and subsoil and type of vegetation to perform the spatial interpolation and temporal distribution of meteorological variables as the **runoff.** The vegetation is an input in the model that affects the interception and infiltration capacity.

Hypothesis and statistic model

The hypothesis is that there is a trade-offs in the evolution of provisioning and regulation services. In this sense, if the provisioning service increases, the regulation service is expected to decrease. In order to check it we analyzed:

•The relationship between the increase or decrease of different types of ES in each basin.

•A multiple linear regression where changes in runoff (regulating services) was the dependent variable and changes in agricultural products and surface area for livestock (provisioning services) were the independet variables.

3. Results

The trade-offs in the evolution of provisioning and regulation services occurs in the 81% of the watersheds of Sierra Nevada (Fig.3)

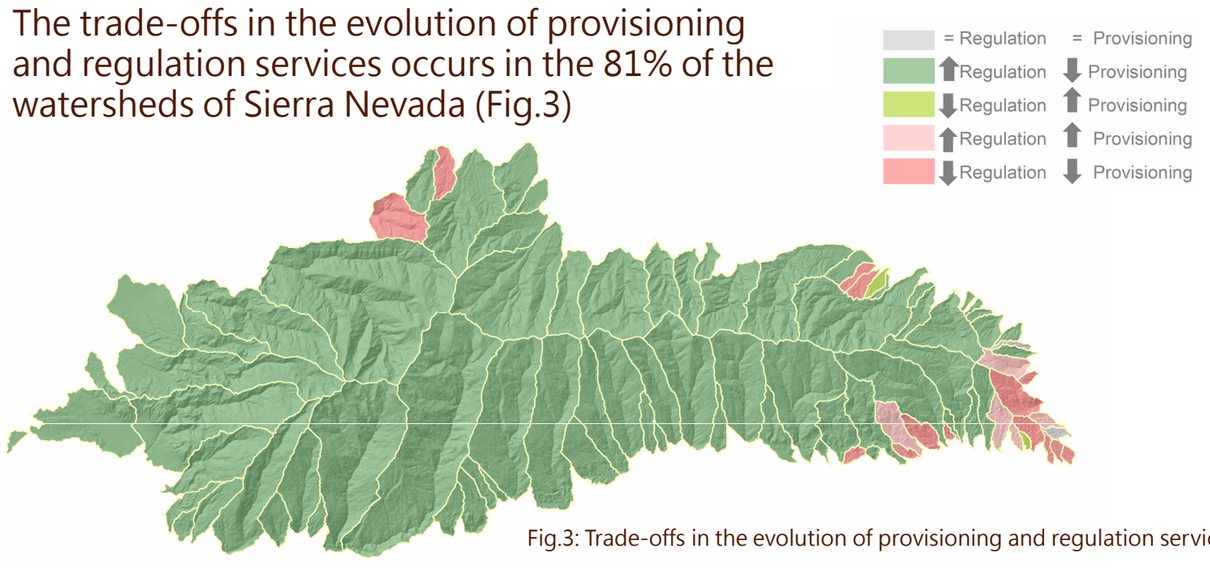

Fig.3: Trade-offs in the evolution of provisioning and regulation services

The multiple linear regression determines that there is a direct relation (R^2 = 0,78, sig < 0,001) between agricultural products and surface area for livestock with runoff (Fig.4). Higher values of agricultural products and surface area for livestock means best provisioning services. Higher value of runoff means worse regulation services.

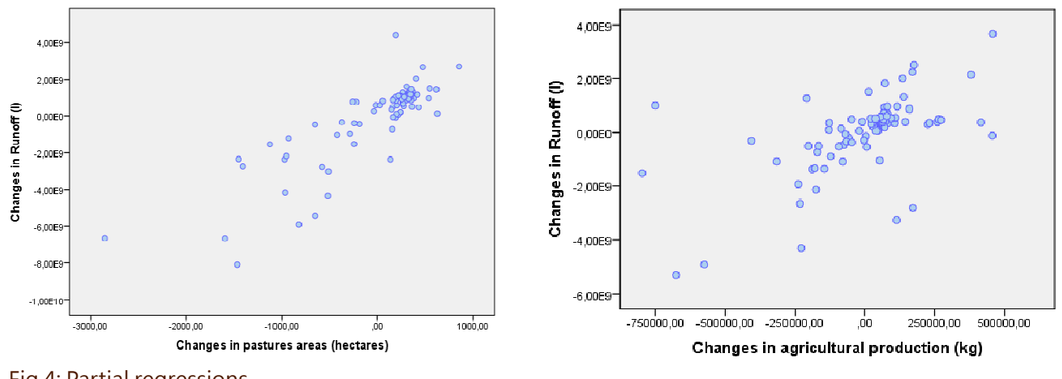

Fig.4: Partial regressions

4. Discussion and conclusions

•In the majority of basins there is a trade-off in the evolution of provisioning and regulation services in the comparison made between the soil uses in 1956 and in 2007. The few exceptions encountered are mainly located in small basins where small changes in soil uses can have important impacts over the hydrology.
•WiMMed model alows us to generate hydrological variables (impossible to measure on the field) to assess regulation ecosystem services.
•We found a significant linear relation between agricultural production and pasture surface and hydrological variables. Higher provisioning services imply worse hydrological regulation services.

5. References

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