Expert survey on economics of land management
Evaluating socio-ecological effectiveness of rangeland management

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1. Socio-ecological costs and benefits of land management

One of the major aims in WP8 is to assess the socio-ecological effectiveness of sustainable land management (SLM) strategies for simultaneously enhancing land users' wellbeing and ecosystem functioning (Tasks 8.2 and 8.3.). We ask you as regional experts for support in evaluating the following aspects:

- Rangeland productivity
- Converting vegetation cover to livestock productivity
- Economic costs and benefits at household level
- Ranking of grazing sites
- Critical thresholds for degradation and restoration shifts

We consider the socio-ecological effectiveness of a particular SLM strategy to be determined by financial attractiveness and ecological effects. Better understanding the socio-ecological effects of SLM strategies can provide essential new knowledge suitable to guide land management decisions and policies in specific ecological conditions. As an overview, we will evaluate socio-economic costs and benefits and the ecological effects of SLM strategies:

- **Socio-economic costs**: Investment costs (e.g. costs to fence an area or purchase additional fodder)
- **Socio-economic benefits:** Changes in livestock productivity (e.g. meat and wool production).
- **Ecological effects**: SLM directly generates changes in the pressure on and state of an ecosystem and may affect the chance of restoration and risk of degradation.

We will use a rangeland resilience model (Schneider and Kefi 2016) to evaluate the ecological effects of land management. We discussed the opportunity to parametrise the rangeland resilience model in relative terms according to the study sites in Randi/Cyprus, Crete/Greece, Castelsaraceno/Italy and Albatera/Spain[1] to take advantage of CASCADE's potential for comparative analysis. These study sites differ in the levels of aridity, soil characteristics, livestock density etc. – ideally they can be ordered along a gradient that can be captured in the model simulations.

The evaluation of ecosystem services, degradation levels and restorability performed in WP 5 is a useful starting point to distinguish a range of parameter values which best represents the respective sites. The model uses a 0-1 parameter scale, for example to depict poorest to optimum environmental conditions, enabling comparability across study sites (spatial) and within sites (temporal). Depending on the sites, a large relative change in a parameter may however mean only a small absolute change in real world processes and outcomes. In discussing the effects of land management, the qualitative insights derived from the model need to be translated back to real-world values and implications to explore development scenarios and inform policy recommendations.

We will focus on SLM strategies with immediate effects, such as controlled grazing, supplementary feeding or fencing, potentially implying long-lasting effects and regime shifts.

[1] The Albatera site is a heavily degraded shrubland which may have undergone a degradation shift (D5.2). Although current management strategies at Albatera relate to tree plantation, this site may serve to discuss potential management scenarios related to ecosystem restoration.

We assume that SLM directly affects the livestock pressure and vegetation cover (state of ecosystem) captured in the model.

2. Rangeland productivity

First, the rangelands' carrying capacity is an important characteristic to be considered. It will help to relate parameter values in the model (e.g. perennial vegetation cover and livestock density) to real world values.

Table 1 Carrying capacity of rangelands

	Carrying capacity					
Study site: Reference (ungrazed)	**PERENNIAL vegetation**			**ANNUAL vegetation**		
	PERENNIAL vegetation cover (%) [a] (average)	**Dry matter above-ground biomass of PERENNIAL vegetation** [b] (kg/ha) (average)	**Share of palatable PERENNIAL vegetation** (%) (average)	**ANNUAL vegetation cover** (%) [a] (average)	**Dry matter above-ground biomass of ANNUAL vegetation** [b] (kg/ha) (average)	**Share of palatable ANNUAL vegetation** (%) (average)
Randi, Cyprus						
Messara, Greece						
Castelsaraceno, Italy						
Albatera, Spain						

[a] maximum potential vegetation cover without grazing, *Note:* Figures in Sect. 5 in D5.2 show total aboveground biomass at reference sites. Are there also data available for *perennial* above-ground biomass?

[b] maximum potential biomass without grazing. *Note:* Fig. 2 in D5.2 shows total aboveground biomass in reference state. Are there also data available for *perennial* above-ground biomass?

[c] maximum potential livestock density that can be sustained indefinitely given optimal vegetation cover and biomass defined in previous columns

Second, the actual rangeland productivity provides insights into the ecological effects of degradation and restoration efforts useful to evaluate the model results. The plant cover and biomass data given in D5.2 (Tab. 6, p. 81) relate to TOTAL cover and biomass going beyond perennial plants (*Remark: I noted differences between the data in Tab. 6 and the data given on page 41*). Are there also data available for perennial vegetation cover and above-ground biomass at degraded, restored and managed sites? Can you estimate the average share of palatable plants in perennial vegetation? Can you already oversee when the missing data for Messara will become available? This would be helpful to fill the following tables.

Table 2 Actual rangeland productivity

Study site	PERENNIAL vegetation			ANNUAL vegetation			Livestock density (number/ ha) (average)		
	Vegetation cover (%) (average)	**Dry matter above-ground biomass (kg/ha) (SD)** (average)	**Share of palatable vegetation (%)** (average)	**Vegetation cover (%)** (average)	**Dry matter above-ground biomass (kg/ha) (SD)** (average)	**Share of palatable vegetation (%)** (average)	Sheep	Goat	Cattle
Randi, Cyprus									
Degraded									
Restored									
Messara, Greece									
Degraded									
Restored (Odigitri)									
Castelsaraceno, Italy									
Overgrazed									
Fenced									
Under-grazed									
Cleared									
Albatera, Spain									
Degraded							NA	NA	NA

Third, information on meat, wool and milk production is important to calculate financial attractiveness, i.e. economic benefits and costs. Is leather production also relevant in some sites?

Table 3 Production of meat, wool and milk

Livestock type	Share of total herd used for produce (average) [a]			Annual production (average)		
	Meat (%)	Wool (%)	Milk (%)	Meat (kg/head)	Wool (kg/head/year)	Milk (l/head/year)
Randi, Cyprus						
Sheep						
Goat		NA			NA	
Cattle		NA			NA	
Messara, Greece						
Sheep						
Goat		NA			NA	
Cattle		NA			NA	
Castelsaraceno, Italy						
Sheep						
Goat		NA			NA	
Cattle		NA			NA	
Albatera, Spain --- in absence of grazing on study site, an estimate at regional level would be useful.						
Sheep						
Goat		NA			NA	
Cattle (used?)		NA			NA	

[a] E.g. only a certain share of animals may be sold/slaughtered and calves are not milked.

3. Converting vegetation cover to livestock productivity

The rangeland resilience model provides data on perennial vegetation cover as an output variable describing an ecosystem's state. To derive financial attractiveness, this needs to be translated to livestock productivity. Therefore, an essential question is how can we best convert perennial vegetation cover to perennial above-ground biomass and livestock productivity in our study sites? While some initial insights may be derived from Tables 1 and 2, it would be great if you could identify conversion factors reflecting our sites. For example in Andalusian alfa grass steppes, 1% of cover by alfa grass corresponded to 380.4 kg dry matter/ha (Gauquelin et al. 1996). These very high values resulted from absent or limited human impacts and relatively favourable annual rainfall (370 mm). In contrast in sub-desertic steppes in North Africa characterised by different precipitation and temperature patterns, 1% perennial vegetation cover correlated with 43 ± 3.6 kg dry matter perennial phytomass/ha and 80-100 ± 25kg for alfa grass steppes only (Le Houérou 1987).

Table 4 Conversion of perennial vegetation cover to above-ground biomass

Study site	**Cover-to-biomass (above-ground) conversion factor** (kg dry matter/ha per 1% perennial vegetation cover)	**Reference if available** (otherwise expert knowledge assumed)
Randi, Cyprus		
Messara, Greece		
Castelsaraceno, Italy		
Albatera, Spain		

To further convert available above-ground biomass in livestock productivity, it is important to identify feed requirements. Productivity determinants include animal-specific requirements, animal weight, growth rate and activity level. Moreover, we would need information on the average daily feed requirement per livestock unit (LU) and the contribution of complementary fodder bought on the market (and tree pruning?) to total feed requirements in order to determine livestock productivity and potential rangeland degradation. Information on the price of complementary fodder will inform the evaluation of costs and benefits.

Another aspect related to livestock productivity is the conversion of livestock units (LU). Can you suggest suitable conversion factors, e.g. cattle = 1, sheep = 0.1 and goat = 0.1. Again, a reference would be valuable.

Table 5 Livestock feed requirements

Livestock type	**Daily livestock feed requirements** (kg dry matter/Livestock Unit*day) (average)	**Reference if available** (otherwise expert knowledge assumed)	**Contribution of complementary fodder to total livestock feed requirements** (%) (average)	**Farm gate price of complementary fodder** (€/kg) (average)
Randi, Cyprus				
Sheep				
Goat				
Cattle				
Messara, Greece				
Sheep				
Goat				

Cattle				
Castelsaraceno, Italy				
Sheep				
Goat				
Cattle				
Albatera, Spain --- in absence of grazing on study site, an estimate at regional level would be useful.				
Sheep				
Goat				
Cattle (used?)				

4. Economic costs and benefits at household level

An important aspect in evaluating financial attractiveness relates to economic costs and benefits at a household level. Here we assume a typical land user representing a given case study region and ask you for information about prices of produce at the farm gate, labour requirements, size of livestock herds and costs for hired labour as well as other investments in livestock (e.g. veterinary).

Please indicate the conversion factor from milk to cheese here: …

Table 6 Farm gate price of produce, subsidies and net income/animal

Livestock type	**Farm gate price (average)**				**Subsidies received per head or hectare of land** (€/year) [b]	**Total net income per animal** (€/year)
	Meat or meat products (€/kg)	Wool (€/kg)	Milk (€/l)	Cheese (€/kg) [a]		
Randi, Cyprus						
Sheep						
Goat		NA				
Cattle		NA				
Land area	NA	NA	NA	NA		NA
Messara, Greece						
Sheep						
Goat		NA				
Cattle		NA				
Castelsaraceno, Italy						
Sheep						
Goat		NA				
Cattle		NA				
Land area	NA	NA	NA	NA		NA
Albatera, Spain --- in absence of grazing on study site, an estimate at regional level would be useful.						
Sheep						
Goat		NA				
Cattle (used?)		NA				
Land area	NA	NA	NA	NA		NA

[a] See conversion factor from milk to cheese

[b] Please use specific rows to indicate if subsidies are received per animal head or hectare of land

Table 7 Labour requirements and costs for livestock keeping

Livestock type	**Daily labour requirements** (hours/head*day) (average)	**Number of animals kept per household** (number/house-hold) (average) [a)]	**Number of hours dedicated to livestock keeping** (hours/day) (average)	**Total costs for hired labour per year** (€/year) (average)	**Wage rate for hired labour per hour** (€/hour) (average)	**Labour require-ments for processing cheese, meat and other products** (days/year) (average)	**Capital costs per year**, e.g. land rent, veterinary, stable maintenance, equipment, milk tank, membership farmers' association (€/year) (average)
Randi, Cyprus							
Sheep							
Goat							
Cattle							
Messara, Greece							
Sheep							
Goat							
Cattle							
Castelsaraceno, Italy							
Sheep							
Goat							
Cattle							
Albatera, Spain --- in absence of grazing on study site, an estimate at regional level would be useful.							
Sheep							
Goat							
Cattle (used?)							

[a)] If animals are usually kept in combination, please indicate typical herd composition below.

If animals are usually kept in combination, please indicate the typical composition of herds:

- ... sheep,
- ... goats and
- .... cattle

Are there any capital costs that arise only occasionally, e.g. construct a stable? If so, please indicate purpose, lifetime and amount of capital costs:

- Purpose:
- Lifetime (years):
- Amount (€):

5. Ranking of grazing sites

Information on climate, soils and other environmental conditions useful to rank the grazing sites is available across the grazing sites (see below excerpts of D5.2) which serves to rank the sites along an aridity gradient, for example. This ranking can be directly related to loss of ecosystem services, with a higher loss in more arid areas (see D5.2, p. 9). However, the aridity index is very similar in Messara and Randi. Therefore, it may be useful to rank the sites according to aggregated environmental conditions, for example combining climate and soil properties. Soil properties may further differentiate the sites in Messara and Randi.

Would you have a suggestion of how to rank the grazing sites depending on combined environmental conditions?

Table 8 Ranking of grazing sites according to environmental conditions (Note: 1 = max, 4 = min)

Study site	**Aridity**	**Soil**	**Climate**	**Others**
Randi, Cyprus				
Messara, Greece				
Castelsaraceno, Italy				
Albatera, Spain				

Excerpt from D5.2 → Table 1. Climatic characteristics of the six CASCADE field sites (extracted from D2.1, Daliakopoulos and Tsanis 2013).

	Albatera	Castel-saraceno	Messara	Randi
Climate	Semi-arid	Humid	Dry sub-humid	Dry sub-humid
Average annual rainfall (mm)	267	1289	503	489
Average mean temperature (ºC)	18.0	9.1	17.9	19.5
Aridity Index (mm/mm)	0.16	1.05	0.31	0.29
PET (monthly)	136.0	102.5	136.0	141.5

NOTE: This is not consistent with aridity definition by UNEP (1992)

Excerpt from D5.2 → Table 2. Summary of main characteristics of the six CASCADE field sites (extracted from D2.1, Daliakopoulos and Tsanis 2013).

	Albatera	Castelsaraceno	Messara	Randi
Elevation	225-310 m	972-1284 m	100-230 m	90-230 m
Bedrock	Dolomites, conglomerates and sandstones	Limestones and dolomites	Limestones and marls	Marls
Soils	Calcisols, Cambisols and Fluvisols	Regosols	Cambisols and Luvisols	Calcaric regosols
Land use	Agriculture (52%) and shrublands (24%)	Cropland, pasturelands and forests	Croplands and shrublands	Croplands and shrublands
History	Abandonment of rainfed croplands, alpha grass harvesting and wood gathering. Afforestations	Land abandonment (especially after 1990s)	Overgrazing and overexploitation of water resources	Agriculture and grazing

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