CASCADE

Catastrophic shifts in drylands:

How can we prevent ecosystem degradation?

Folder for stakeholders and general public

SEVENTH FRAMEWORK PROGRAMME

The CASCADE Project

Catastrophic shifts in drylands: how can we prevent ecosystem degradation?

Introduction

The landscape we see around us results from the combination of multiple factors: climate, geo-logy, vegetation, water, human land use and so on. These constantly change over time. When we look at the vegetation in the forest, shrub or grassland landscapes of Mediterranean drylands we may not be aware of adjustments occurring in response to the changing conditions. Each landscape includes one or several ecosystems according to combinations of flora, fauna, soils, microclimates, etc. The components of ecosystems are all linked by nutrient and energy flows, and usually respond in a gradual way to a gradual change. For example, over time increasing grazing pressures may lead to a decrease in vegetation cover.

Under some conditions, ecosystems may seem to remain the same, inert to increasing pressures, until a threshold is passed. In these instances, the vegetation composition may change suddenly. In extreme cases, vegetation may even be lost altogether. Changes in ecosystems are often difficult to understand or predict, but, for example, fragmentation or loss of vegetation cover, and evidence of soil erosion and land degradation, may indicate a threshold is almost reached. When there is a particularly rapid transition of the ecosystem from one state to a new state (maybe a different vegetation structure or species composition) with important ecological and economic consequences, it is known as a "catastrophic shift" or "sudden shift". The study of these "thresholds", "tipping points" and "sudden shifts" in dryland ecosystems is the core of current research in the CASCADE Project.

Partially grazed site at Peyia, Cyprus, and overgrazing close to animal pens (Photo: K. Themistocleous)

Current understanding about the causes and characteristics of sudden shifts in Mediterranean drylands is limited, so it continues to be difficult to predict if or when a shift is going to occur. Where a shift looks likely to be undesirable for land users it is difficult to know whether action can be taken to prevent it from happening. The CASCADE Project will collect experimental data, use them in ecological models, and interpret the results to provide further knowledge on the following questions:

- Why and when do ecosystem catastrophic shifts occur in ecosystems or landscapes?
- Why are some ecosystems or landscapes more resilient (less likely to change) than others?
- What can be done to prevent catastrophic shifts?
- Can degraded ecosystems or landscapes be restored to a former state?
- Is it economically feasible to restore ecosystems or landscapes or would the effort be too high a price?

What causes a "healthy" pattern of vegetation (left) to shift to a degraded landscape? (Photos by S. Kéfi, 2009)

The CASCADE Project on sudden and catastrophic shifts in dryland Mediterranean ecosystems (2012-2017) is funded by the EU's FP7 programme. CASCADE will draw on knowledge advances made in previous EU-funded projects such as DESIRE, LUCIFER, REACTION, and PRACTICE to provide new recommendations for sustainable land management in Mediterranean drylands, under which the chances of catastrophic shifts are reduced.

The challenge for CASCADE

In drylands, sudden shifts can affect all semi-natural ecosystems of forests, shrublands and grasslands. It may be possible to observe subtle changes in species composition and total vegetation cover over time. In addition there are likely to be underlying, less visible changes in the rates of biological and chemical reactions. If thresholds are passed, the whole ecosystem may change state, sometimes irreversibly. The challenge is to understand these thresholds, and their impacts, sufficiently to provide early warnings of impending problems. In this way we can help to avoid land degradation and sustain the livelihoods of the people who depend on the land.

The CASCADE Project approach will use a combination of research methods to address this challenge. Experiments at different spatial scales, from small plots to landscapes, allow us to look at naturally occurring landscapes and ecosystems as well as simulations in specially built experimental plots. Mathematical modelling and computer simulations will allow us to analyse scenarios that depict ecosystem shifts and to identify sustainable land management strategies to prevent undesirable states from occurring.

CASCADE will develop ways to predict how close various dryland ecosystems are to thresholds. We will identify how undesirable shifts can be avoided, how ecosystems can be made more resilient, and how shifts that have already taken place can be managed. These results can then be shared and used by land users, technicians and policymakers for more sustainable management of drylands worldwide. The results of CASCADE will be made available to the public in non-scientific language through media such as booklets, newsletters, meetings, social networks, videos, and on TV, as well as through a web-based harmonized CASCADE information system (CASCADIS).

Background, basis of research, and study areas

Initially, we will identify and trace climate and human-induced changes in dryland ecosystems of southern Europe. The focus is on dryland ecosystems that have crossed a tipping point, or might soon reach one. This investigation will establish a timeline where human activities and climate variations can be linked to measurable signs of ecosystem degradation.

CASCADE will look at six study areas in southern Europe where ecosystem shifts have occurred or are likely to occur, with associated consequences for the vegetation, the animals, and the people living there. The locations of these areas are shown below.

The CASCADE study sites: 1 = Caramulo mountains, Portugal - 2 = Albutera range, Alicante, Spain - 3 = Ayora and Mariola ranges, Spain - 4 = Castelsaraceno, Italy - 5 = Messara valley, Crete - 6 = Pegia, Paphos, Cyprus

The study areas

The study areas have been chosen to demonstrate a range of shifts:

1. The region of the **Caramulo Mountains** in northern Portugal is predominantly covered by forests, and the principal tree species are Maritime Pine and eucalypt. Both of these species are highly flammable. Forest fires occur frequently, increasing the risks of land degradation, erosion and decreasing biodiversity.
2. The **Albatera range** is located in south-east Spain, one of the most desertification-affected areas in Europe. The main ecosystems are semi-arid shrublands, which are mainly used for recreation, but with some grazing by goats and sheep. The most recent actions to restore the landscape have been with multi-species tree plantations.
3. The mountain ranges of **Ayora** and **Mariola** are located in the central to southern part of the Valencia Region, south-east Spain. Many of the moderate to steep slopes are covered by old agricultural terraces that are currently abandoned and degraded. The recent increase in fire incidence has caused a shift in the composition of vegetation communities. The previous woodlands and shrublands dominated by resprouting species have now become shrublands dominated by seeding species.
4. **Castelsaraceno** is in the province of Potenza, southern Italy. The hilly part of the region with vast pastureland for sheep and goats also includes chestnut groves, vineyards and olive groves. Pastoralists face a number of growing challenges that constrain them from exercising their full traditional practices. These include the drying of pastures due to changing climate and the substitution of pasture with shrubs and woods.
5. On the **Messara Plain**, Crete, agricultural and grazing practices have promoted biodiversity, controlled forest encroachment and averted the abandonment of the countryside in a traditional way for centuries. However, the recent growth of agriculture has had a notable impact on natural water resources, including groundwater, as demands for water have increased.
6. The Pafos district of Cyprus includes the **Peyia area** and **Randi Forest**. Both these dryland areas are affected by overgrazing by sheep and goats on the hills and by rapid urban or agricultural land development in the coastal areas. Lack of appropriate management has resulted in overgrazing and caused degradation which may be considered irreversible.

Grasses and shrubs in the Peyia area, Sarcopoterium Spinosa, Cyprus (Photos by K. Themistocleous, 2012)

What causes shifts in dryland ecosystems?

Human activities often play a part in the shifts seen in ecosystems. These can include:

- Unregulated increases in the numbers of sheep, goats or cattle. Free-range livestock can, over time, degrade rangelands due to overgrazing
- for example, people abandoning rural farms and moving away to bigger settlements

Long-term and short-term changes in climate affect:

- temperatures and soil moisture for plant growth
- the frequency of extreme events, such as droughts, floods and wildfires

Rosmarinus Officinalis (K. Themistocleous) and Rainfall exclusion roof to simulate drought (photo: Erik van den Elsen)

Field plot experiments in the CASCADE study areas

In each study site field plot experiments will be carried out to:

- Assess current conditions in healthy, partly-degraded and strongly degraded ecosystems, focusing on the relationships between land management, climate, plants and soil,
- Determine the effects of drought (under shelters) on plant-soil functioning, including better understanding of how plants help and compete with each other, and how these processes affect plant survival and growth.

Plant and soil experiments to compare treatments on a constructed slope (Photo: Larger scale experiments A.M.Urgeghe)

Results from field plots will be incorporated in experiments at a larger spatial scale, where research will examine the:

- Effects of plant growth patterns and some of the reasons for sudden shifts
- Feedbacks and relationships with plant diversity
- Ways in which shifts in ecosystems might be reversed

The landscape scale

Finally at the landscape scale the objectives will be to:

- Examine the details of changes in dryland landscapes and ecosystems that have experienced severe degradation and sudden shifts
- Identify how landscapes and ecosystems might be restored if they have suffered from sudden shifts or degradation

Developing soil-water-plant models

A large amount of data will be collected, and integrated soil-water-plant models will be developed and applied, to confirm and discover details of relationships. The models will provide new insights into ecosystems and degradation processes, and help to suggest appropriate land management options. In this way resilience to climate change, disasters and other risks may be enhanced.

Discussions between researchers and farmers in southern Spain. (Photo by G. Schwilch)

Natural ecosystem management recommendations

Good practices to manage natural resources will be identified and evaluated together with land users and other stakeholders. Focus will be placed on understanding how various practices affect the resilience of ecosystems towards change or shifts, plus the sustainability of these practices over time and space. Guidelines will be prepared on best practices for natural resource management. All recommendations will be formulated and reviewed with the help of stakeholders, including land users and local policy makers.

Scenarios and upscaling of preventive and restorative measures

The final part of CASCADE research will be to provide scenarios of preventive and restorative measures for places beyond the study areas.There will be four activities:

- Analysis of available adaptation strategies of the local land users across several degradation states
- Scenario analysis of promising sustainable land management strategies, scaling up in time and space
- Scenario analyses with policy makers in order to improve cost-effective decision-making
- Formulation of policy recommendations for preventive and restorative dryland management

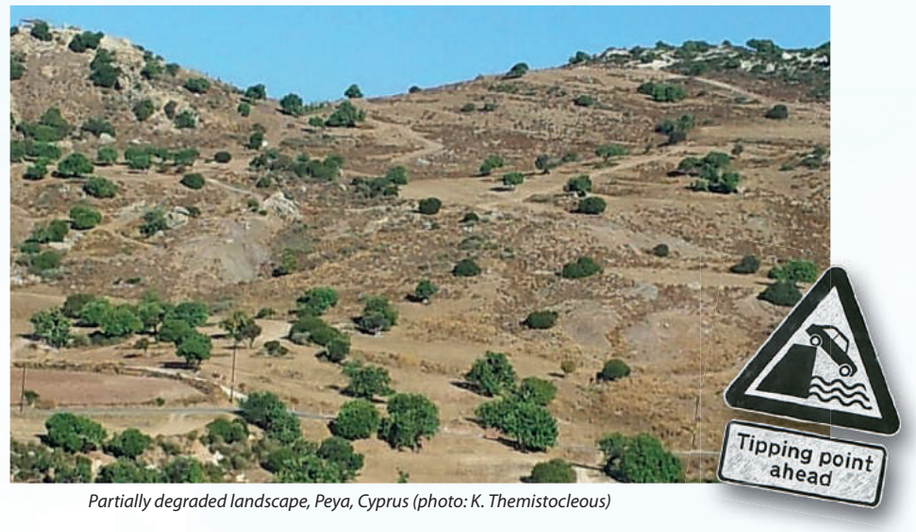
A tool for looking at who benefits and who loses out under different scenarios, and by how much, will be linked to the soil-water-plant models. Special attention will be given to the best timing of measures that prevent degradation processes. When the models have been applied, and analyses concluded, the CASCADE recommendations will be evaluated through interviews with land users, community focus groups and experts, and through meetings with regional and national policy makers.

Communication and dissemination

Good communication is essential to optimise the value of research. This means that research partners and the wide range of stakeholders will be continually kept informed of progress, and that research results will be published publicly as quickly as possible. All information and results released to the public domain will be kept on an online information system (CASCADIS, see http://www.cascade-project.eu/) and be updated throughout the project.

The way forward

CASCADE research partners are looking forward to pooling their expertise and making the most of experimental opportunities. The ultimate aim is to prevent sudden shifts in dryland ecosystems. This is in accordance with international efforts, specifically from the United Nations Convention to Combat Desertification (UNCCD). The UNCCD are committed to global restoration of degraded areas and avoidance of further land degradation. CASCADE will help to support the UNCCD's aim for a "land-degradation neutral world".



Partially degraded landscape, Peya, Cyprus (photo: K. Themistocleous)

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