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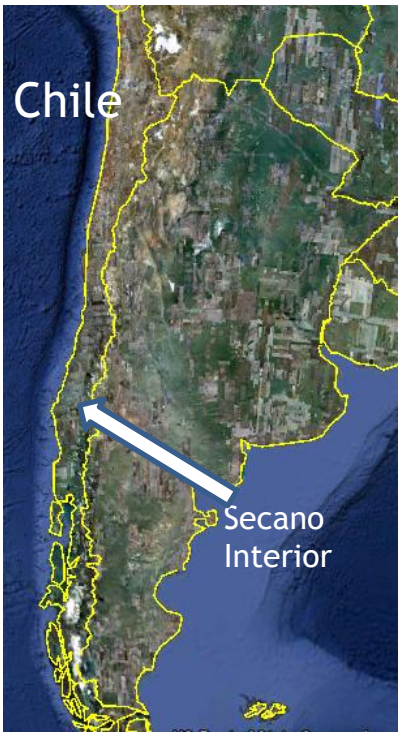
A global initiative to combat desertification

A publication from the DESIRE project - funded by the European Union's 6th Framework Program 'Global Change and Ecosystems'

Info-brief 7

Focus on research in Chile and Mexico

Soil erosion must be halted



Google Earth images show the locations of these DESIRE study sites

The DESIRE sites in Mexico and Chile have similar climatic and environmental characteristics, close to those of Mediterranean Europe. These drylands require careful management to conserve water and avoid soil erosion and degradation.

Cattle rearing has been a traditional land use in the Cointzio watershed area of Mexico, but the increase in numbers of grazing cattle has resulted in reduced vegetation cover and widespread soil erosion. Local communities are being encouraged to help monitor soil loss and introduce a variety of new enterprises that are more sustainable, both environmentally and economically. In central Chile intensive wheat growing over the centuries, has resulted in widespread soil erosion by water. The benefits of conservation tillage for avoiding erosion have been explored, and the management practices proposed by DESIRE look very promising.

Each page is from a DESIRE PhD student:

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For more information and contact details see: The DESIRE Harmonised Information System: www.desire-his.eu and DESIRE website: www.desire-project.eu

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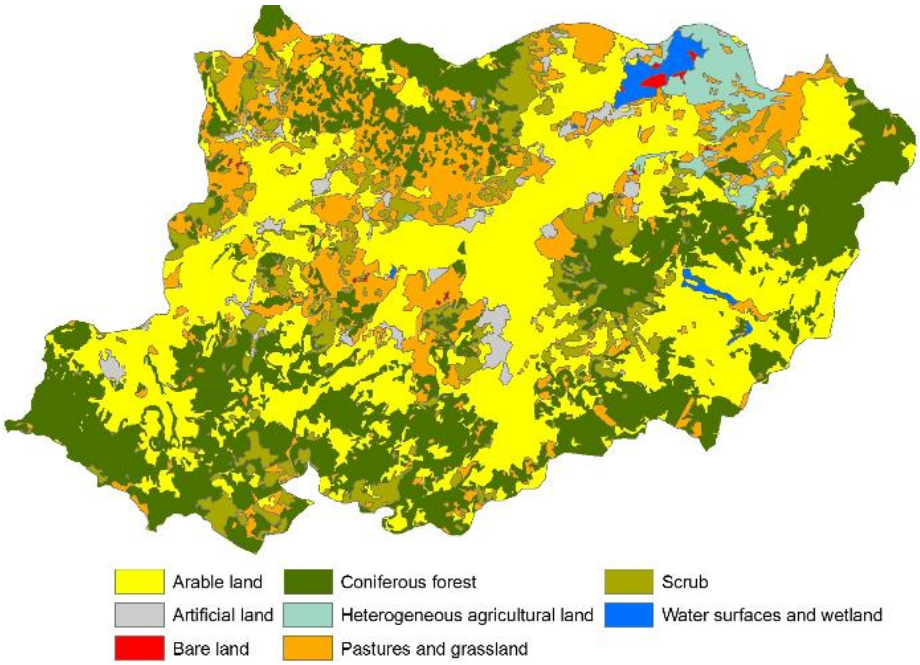
A global initiative to combat desertification

SIXTH FRAMEWORK PROGRAMME

The DESIRE study sites in Mexico and Chile

Land use/cover 2008 PESERA classification



Land use in the Cointzio watershed, Mexico

Location of Secano Interior drylands, Chile

Soil erosion in Mexico (Carvaca, La Cienega and Chile…

Promoting community-based monitoring approaches for the measurement of sediment fluxes in rivers by Clément Duvert

Societal and scientific context

In the mountainous regions of central Mexico, recent land use changes have caused an intensification of soil erosion. Such land degradation leads to unwelcome on-site impacts (e.g. reduction in the area of arable land), and off-site impacts (e.g. soil washed away, siltation of reservoirs), a situation particularly acute in the volcanic region of Michoacán. Against this background, a research team comprising scientists from both Mexican (UNAM, UMSNH, SEMARNAT, CP) and French (IRD) institutions visited local communities to discuss and study soil erosion and associated problems in the Cointzio catchment (630 km^2), close to the city of Morelia (Michoacán).

Dramatic erosion of soils, and loss of land for crops

Data acquisition

Part of this scientific effort was concentrated on a better understanding of the sediment transfers: sediment washed from hillslopes and through the river network to end up in reservoirs. A first step towards the implementation of better adapted land conservation practices is to provide accurate estimates of suspended sediment flux in upland catchments. We therefore carried out an intensive monitoring study of water and sediment fluxes within five contrasting areas of the Cointzio catchment. The objectives were (i) to quantify sediment loss at the catchment scale and compare the sensitivity to erosion among the study sites, (ii) to characterize the variability of fluxes in order to optimize sampling designs, (iii) to deduce relevant community-based monitoring strategies for the rural areas of Mexico.

Towards optimized community-based monitoring strategies

Concerning (iii), statistical techniques were used to evaluate the sampling frequency required to get reliable estimates at the five sites. We showed that the choice of an appropriate sampling time during the day would allow reduction of the frequency of measurement, due to a marked sub-daily variability in sediment fluxes. This result should lead to the proposal of useful decision-making tools to the local stakeholders, for the implementation of collaborative river monitoring procedures in ungauged catchments. This would allow collection of comprehensive databases on soil loss and land degradation, but also on the chemical and biological quality of rivers. Local communities can use this knowledge to determine where they can reduce the erosion of soil and sediments.

Measuring sediment and discharge in channels

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Relation between land use and soil degradation in the Cointzio basin, Michoacán, México by Adriana Ramos

Studying the effects of land use on degradation

Soil degradation caused by human activities is one of the principal environmental problems of the 21st century. The Cointzio basin, in the Michoacán state of México, presents areas severely affected by land use change. The consequences are the loss of soil and nutrients, gully formations, decrease in soil fertility and productivity, plus contamination and reduced water availability.

Landscape of the Cointzio basin

Land uses in Cointzio basin: growing maize, beef and dairy farming, and newly-planted avocado orchards

Andisol soils under a cover of (a) pine trees and (b) maize

Characteristics of the soils

The main physical and chemical characteristics of soils of the Cointzio basin under different land uses (pine forest, pine and oak mixed forest, and various agricultural uses managed for more than 50 years) were studied. The degree of soil degradation was assessed using key indicators such as the depth of soil available for crops (A horizon), soil colour, size and structural stability of soil aggregates, organic matter content, bulk density, resistance to penetration and pH.

Results of the assessment

First results show that soils that are not degraded have a thick surface A Horizon, with high organic matter content, a good structure based on aggregates, and low bulk density. In contrast the agricultural soils have a shallow A horizon (<30 cm) with little organic matter content and a paler yellowish colour. There is high resistance to penetration (> 2 Mpa), and formation of plough pans below 30 cm depth, that are a product of agricultural cultivation and grazing of cattle.

Minimizing soil degradation

To reduce the effects of soil degradation, organic residues and rotation of crops may be used, plus conservation tillage with mulch to reduce the runoff, loss of soil, and loss of nutrients and to increase infiltration of water. But the most important thing is to convince farmers to reduce numbers of cattle which are the main cause of soil erosion in this area. Beef and dairy farming may be replaced by other sustainable agro-economic practices such as production of *Agave* for commercial uses.

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Implications of conflicts and synergies between regional and local environmental management planning

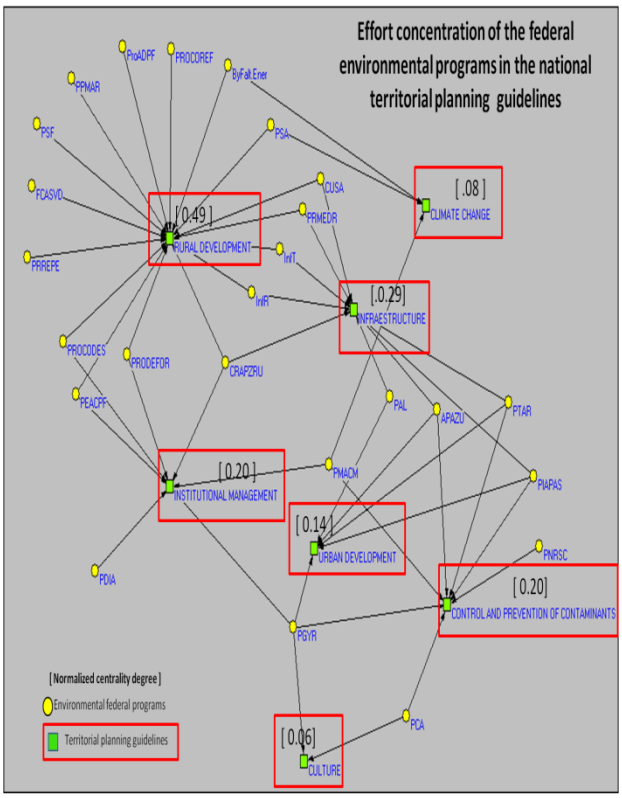
by **Daniel** González

Background

Land degradation related to land use change and inappropriate agricultural practice is increasing in Mexico. In the Cointzio catchment (630 km^2), where the typical environmental degradation processes of central México are evident, regional and the local land use plans are currently implemented, according to the territorial environmental policies recognized by the existing legislation. However, we have identified spatial inconsistence between the ecological strategies among the different scales and approaches of the land use plans. In addition, the financial resources for environmental issues are insufficient in the study site area.

It is therefore necessary to identify the conflicts and synergies in the vertical structure of the institutions involved in the environmental context. This will allow us to prioritize the programs with potential positive impact in the territory, according to the local environmental demand.

Severe erosion, Cointzio



Example graph at federal level. (Software: Pajek, 2010)

Strategic approach

The main strategy for this study was to carry out a census of the implemented programs (productive, conservation, protection, mitigation or restoration) within each environmental management unit. Then these were characterized, each according to whether or not they related to the proposed strategies and environmental guidelines, stipulated or not in either the regional or the local management plan.

Using the tools and theory of the analysis of social networks, it was possible to compute an index of centrality to express the concentration of efforts in a given environmental policy by each level of the environmental authorities. The comparisons of these efforts allowed us to identify potential spatial conflict in achieving the goals of the local management plan, especially focused on actions of restoration and mitigation of degraded soils.

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Mitigation of water erosion in no tillage systems in the Mediterranean zone of central Chile

by Ingrid Martínez

Mitigation measures are needed to reduce and avoid serious soil erosion and gullying

Conservation tillage techniques

In the Mediterranean climate region of central Chile, with 690 mm of annual rainfall (80% concentrated in winter and autumn), water erosion and inappropriate agricultural management are the major cause of soil degradation and desertification. As a result, about 46% of the land is affected to some level by erosion. 78% of these soils are moderately and highly eroded. In this scenery, the use of conservation tillage techniques is extremely necessary to mitigate water erosion in these highly vulnerable areas.

No tillage with contour ploughing in runoff plots of 1000m²

An oat-wheat rotation under different conservation systems: no tillage (Nt),Nt+contour ploughing, Nt+barrier hedge, and Nt+subsoiling were compared to conventional tillage.

Runoff storage tank

Retaining crop residues on the surface maintains soil water content

During four years of experimental study (2007-2010), the results showed that crop residues maintained on the soil surface on the conservation tillage system, maintain a higher soil water content in the profile (0-100 cm) than conventional tillage. However, the high values of soil compaction (>2000 kPa) reduced yield because the roots are not able to penetrate the soil and use that increased availability of water. The higher productivity of wheat was observed in no tillage + subsoiling and lowest when this technique was not performed. Therefore, a change in soil structure is necessary to obtain high yields in these compacted soils.

The runoff coefficient during the rainfall period was more than 50% in conventional tillage, while in conservation tillage it was between 20-30% in the first month after sowing, and less than 7% the following months. Reduced runoff is important since soil erosion will also be reduced.

I. Martínez, PhD student at Universidad de Concepción, working in the field

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New crop rotation for the rehabilitation of soil fertility in Mediterranean agriculture farming systems

by Soledad Espinoza Trincoso

The nitrogen contribution of legumes can decrease the costs of nitrogen fertilization, when used in rotation with cereals

Are expensive fertilizers necessary for cereal growing in the Secano Interior?

In the region of central Chile with a Mediterranean climate, which is important for cereal production, fertilizers account for about 40% of total production costs. Of that fertilizer, 60% is nitrogen (N) fertilizer. Since 2007, due to large increases in the price of fertilizers (especially urea), the production of cereal crops has become increasingly expensive and less economic. Therefore alternative, economical and more sustainable sources of nitrogen, particularly the biological nitrogen fixation by legumes, have been investigated.

Leaching of nitrates, tested using capsules of ceramics (lysimeters)

In Cauquenes, we set up two experiments, one on a cereal – pulses rotation and the other on a legume pasture – cereal rotation.

Rotation 1: Three grain legumes (*Pisum sativum*, *Lupinus angustifolius* and *Lupinus luteus*) and green manure (*Avena sativa* + *Vicia atroporpurea*) have been evaluated in rotation with wheat

Rotation 2: Two mixtures of annual legumes and different lengths of pasture periods are being tested in rotation with wheat

Legumes can be used to provide nitrogen for cereals

During the three years of experimental study, the results showed:

- The use of leguminous crops (annual forage and grain), can reduce N leaching losses in the soil profile between 40 and 13 ppm NO_3^-, when compared with the expensively fertilized control.
- Using isotopic techniques, it was verified that the real contribution of biological nitrogen fixation in the different rotations (annual forage and grain) ranged from 15 to 39 kg N fixed in each ton of dry matter produced.
- Yields of wheat grown following after grain legumes were between 59% for *Avena sativa* + *Vicia atroporpurea* (1950 kg ha^{-1}) and 79% for *L. angustifolius* (2623 kg ha^{-1}) compared to the control with nitrogen fertilization (3328 kg ha^{-1}). Results from *P. sativum* and *L. luteus* were not statistically different to those from L. *angustifolius*.

Total biomass in wheat, second year rotation (cereal-grain legumes)

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