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Soil and Water: a larger-scale perspective

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Soil and Water: a larger-scale perspective

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This Thematic Issue is written and edited by the Science Communication Unit, University of the West of England (UWE), Bristol. Email: sfep.editorial@uwe.ac.uk

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EDITORIAL

Soil and water: towards a larger-scale perspective of their relations

Land use changes over time have altered relations between soils and water cycles throughout Europe. There are regions where forests were cut for agriculture or herding, or for industrial, mining, and/or railroad use. Soils were lost, through mud floods, and the water cycles changed so that their present status is one of badlands and/or desert-like areas. Early stages in the path to degradation can now be observed in other parts of Europe, while there are also indications that land use changes in one place can propagate their effects within its own river basin, and further, to affect drought and floods at larger scales.

Consequently, the closely interlinked areas of soil and water have become an urgent issue for European policymakers; highlighted by the EC's 7th Environment Action Programme (7EAP) that calls upon the European Union and the Member States to address soil quality issues as soon as possible. This Thematic Issue aims to provide a review of new research into the links between soil and water issues in Europe to help inform policymakers, including a subliminal message that the soil-water links must be considered at their proper spatial scales.

Most of the articles included in this issue can be broadly divided into two types: papers from water-abundant regions concerned with retaining the soil in their lands, and papers from water-scarce areas, worried about retaining the water in their soils. In both cases, they explore methods to avoid problems caused by intense precipitations, such as mud-flows and/or floods, and how to minimise the leaching of nutrients to aquifers. They also consider how to convince the powers that be (governments and people) to do something about their problems, in their own locations, at reasonable cost.

Soil-water interactions affect a number of European Directives, including the Water Framework Directive (WFD, 2000/60/EC)[1], the Flood Directive (2007/60/EC)[2], the Blueprint to Safeguard Europe's Waters (EC, 2012)[3], as well as other actions derived from the Common Agricultural Policy. Some of the articles mention that certain proposed actions are difficult to apply, or are rarely applied in practice. And here, again, a gap appears between issues and solutions in water-abundant and water-scarce areas of Europe. Finally, if we consider that, to be effective, policies require well-defined (engineering-like), and applicable (cost-efficient) operational procedures, we can conclude that there remains a no-man's land involving processes affecting the soil-water relations which have not yet been duly considered.

Soil retains water: a truism. And some of that water is returned to the atmosphere via the soil itself, or via its vegetation–forests, evapo-transpirating interface. That water vapour can then become part of precipitation somewhere downwind and, thus, contribute to water recycling. Solar heating during the day, and radiative cooling at night: and one has all the ingredients that drive meteorological processes upwards, from the micro-scale, through the meso-, to the larger macro-continental scales. These are the same meteorological processes that govern the amount of water precipitated (downwards) to the soil. Thus, an important question is: at what scales do the soil-vegetation-water cycles become closed?

A second issue concerns soil-water user links, which will necessarily affect policy development. The point here is that the disciplines that deal with water-and-soil related issues evolved along different paths over history. And, correspondingly, they also developed conflicting needs, and non-complementary operational procedures, from way back. Some consider the land-soil used for housing and infrastructures as simply a resource you pay for once, without due regard for other soil-related environmental services. For example, soil's role in precipitation and, thus, in the water resource itself, as well as in other feedback processes in the local-to-global hydrological cycles.

1. http://ec.europa.eu/environment/water/water-framework/index_en.html
2. http://ec.europa.eu/environment/water/flood_risk/
3. http://ec.europa.eu/environment/water/blueprint/index_en.htm

Probably the most common assumption regarding the hydrological cycle is that the 'water resource' is universally provided by precipitation from the large weather systems, from water evaporated over the oceans. In the northern hemisphere this holds true only on the western seaboard of the continents (e.g. European-Atlantic), above ≈ 30º North Latitude. Thus, the notion that the water resource is just 'there', a "heritage" (WFD, 2000/60/EC), and all that is required is to manage it properly, is perhaps the most widely extended fallacy regarding the water cycle. In principle, this single detail underlies some of the difficulties experienced when trying to deal with soil and water issues in Europe.

The geographic fact is rather that Europe straddles two of Earth's catchment basins (Figure 1), the Atlantic and the Mediterranean — each with different precipitation regimes — located at either side of the European Continental-Water Divide (EC-WD), which stretches from Gibraltar to western Russia, and which separates the water-abundant from the water-scarce parts of Europe. In the more western parts of the Atlantic Basin, up to 100% of precipitation is frontal, from water directly evaporated over the Atlantic Ocean (e.g., Ireland, UK, Portugal, western France). Soil — and land-use — properties on either side of the divide will affect the capacity of the surface to retain water (and, hence, to avoid flooding). But further inland, moving towards the EC-WD, evapo-transpiration from the surface can also contribute to the development of convective summer storms, and thus to a second precipitation component involving water recycling.

In the Mediterranean Catchment Basin, there are three precipitation components which change as we move from the EC-WD towards the centre of the Basin. In Spain, the Atlantic fronts contribute some 20% of precipitation right along the mountains that form the EC-WD. The other 80% of precipitation within the same area is provided by summer storms (15 %) and Mediterranean cyclogenesis events, i.e., 'Levanters' to UK sailors (65 %). These percentages change as we move towards Greece and Turkey where nearly 100% of precipitation (summer storms and cyclogeneses) is from water evaporated right within the Basin itself, both from the land surface and from the sea. The right percentages in each basin still need to be determined by isotopic studies of rainwater. The studies that have led to these conclusions are in the paper summarised in '**Land use changes in the Mediterranean may be triggering large weather shifts**', which is included here to provide some larger-scale context for this Thematic Issue.

This work relates the loss of summer storms around the Mediterranean Sea to land-use changes along the

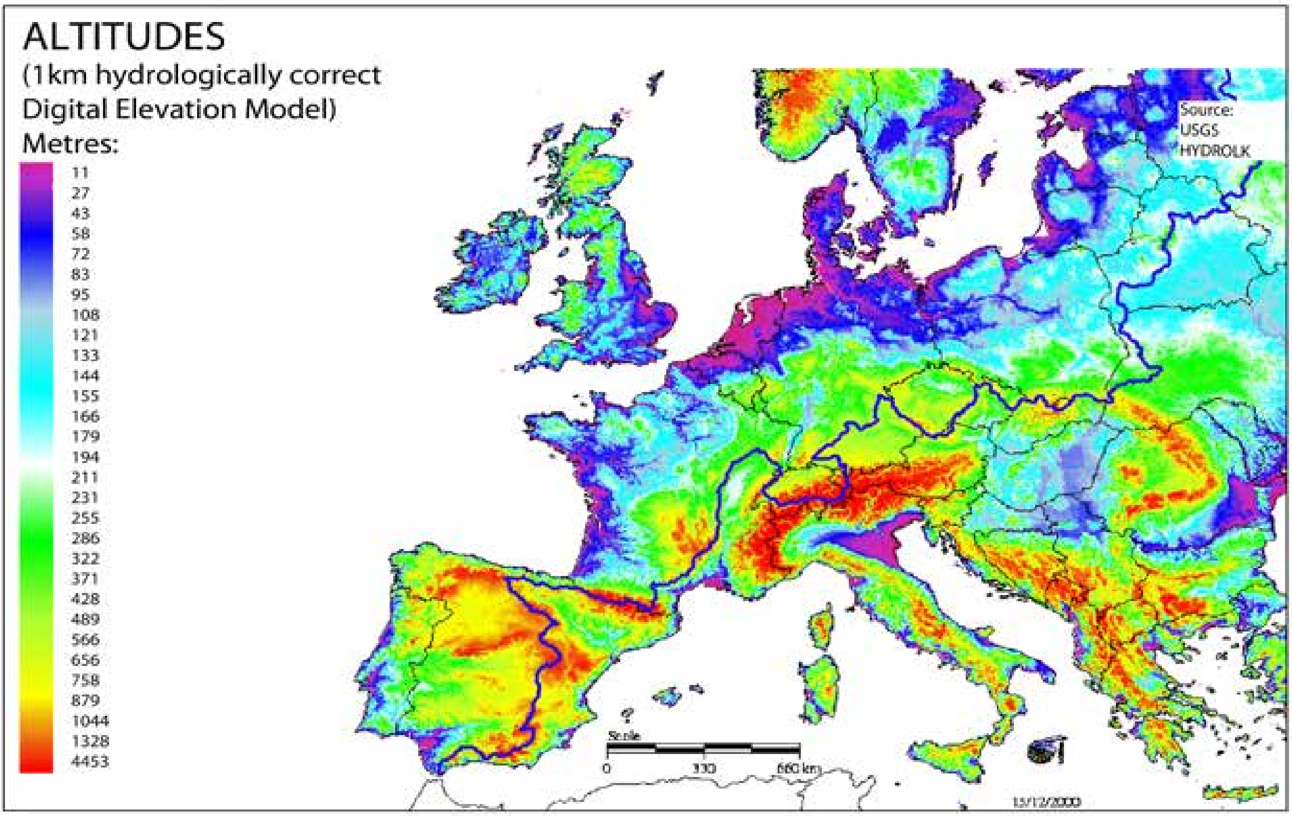

Figure 1: Colour coded altitude map of Europe. The dark blue line marks the European continental-water divide. Original image found in the European Soil Data Centre of the European Commission Joint Research Centre: esdac.jrc.ec.europa.eu. Adapted by Dr. Javier G.P. Gamarra, UN FAO.

coasts in the last century, including draining of coastal marches, urbanisations and water saving measures. It then tracks the path of the non-precipitated (storm) water vapour to torrential rains in Central-Eastern Europe in summer. And further, through larger-scale feedback processes, to possible causes of intense precipitations over the Mediterranean coasts in autumn-winter, and to more intense rains and floods over Atlantic Europe in summer-autumn.

'**Flood risk from modern agricultural practices can be mitigated with interventions**' is a highly readable and descriptive text that reviews changes over the past 50 years in UK land use and management practices, driven by UK and EU agricultural policies. The UK has suffered from severe coastal and inland flooding in recent years, particularly in the winter of 2013-14. There is substantial evidence that modern land-use management practices have enhanced surface runoff generation at the local scale, frequently creating impacts through 'muddy floods'. It also raises fundamental questions about the propagation of soil-land-use perturbations to larger scales.

Small field wetlands, constructed along runoff pathways, offer one option for slowing down and storing runoff in order to allow more time for sedimentation, for nutrients to be taken up by plants or micro-organisms, and for keeping soil out of rivers. Additionally, field wetlands represent a promising option that may contribute to maintaining local hydrological cycles, including summer convective storms, in water-abundant regions – as summarised in '**Artificial wetlands on farmland help to prevent soil loss and recapture agricultural by-products**'.

The following article, '**More than one-third of soils studied in southwest England are highly degraded**' describes field investigations between 2002 and 2011 which identified soil structural degradation to be widespread in SW England, with 38% of the 3,243 surveyed sites having sufficiently degraded soil structure to produce observable features of enhanced surface-water runoff within the landscape. Soil under arable crops often had high or severe levels of structural degradation. Late-harvested crops such as maize had the most damaged soil where 75% of sites were found to have degraded structure, generating enhanced surface-water runoff. Soil erosion in these crops was found at over one- in- five sites.

Land Use and Cover Changes (LUCCs) significantly increase the frequency of mudflows in the silty areas of north-western Europe. Predicting the effects of a range of possible LUCCs helps local authorities choose policies that can help to mitigate the risks to which local populations are exposed, e.g., mud flows. The researchers for '**Who should pay for best management practices to reduce soil erosion?**' find that practical solutions in France respond to both internal (farmers) and external drivers (e.g., CAP requirements), and may require subsidies from a higher level (Europe). Finally, the assessment of the policy effects at the local scale should use spatial databases, including the boundaries of farm areas.

Protection measures are needed to control nutrient leaching from agriculture to the Baltic Sea. Ecological Recycling Agriculture (ERA), as described in the article '**Integrating animal and crop production can reduce nutrient leaching from agricultural fields**', is based on local nutrient resources, integrating animal and crop production on farms or in their proximity. In Finland, three agricultural study catchments were chosen to demonstrate environmental impacts of ERA, in a work that combines experimental measurements and modelling.

Soil erosion by water affects soil quality and productivity, its water-holding capacity, nutrients, organic matter, soil biota and soil depth. It also impacts on ecosystem services such as water quality and quantity, biodiversity, agricultural productivity and recreationalactivities. The article '**New data on soil erosion by water reveals Mediterranean at highest flood risk**' evaluates rainfall erosivity at the European level using models and the best available datasets.

Drought is a predominant cause of low yields worldwide. There is an urgent need for more water efficient cropping systems to deal with large water consumption of irrigated agriculture and high unproductive losses via runoff and evaporation. Identification of yield-limiting constraints in the plant-soil-atmosphere continuum is the key to improved management of plant water stress. However, in the context of this Thematic Issue, the article, '**Research into root systems: key for long-term crop management**', about European farming practices to increase water efficiency, should alert us that, unless the whole water cycle is considered at its proper scale, 'good water management' (i.e., evaporation savings) in one place may disrupt precipitation elsewhere, e.g., at the headwaters of the watershed, and diminish the water resource (precipitation) in the river basin.

In '**Rejuvenating arid badlands: from barren slopes to living forest in 80 years**', we see that badlands can be a major source of sediment, as observed in several European basins, and are witness to poor soil-land management in the past. This paper presents the history of badland generated in the Saldaña region, northern Spain, as well as the main responses after the start of restoration – in terms of vegetation, soil and erosive processes. Eight decades after the restoration project, forest vegetation has covered almost the entire area. This is a practical example that could benefit from a larger scope in terms of its impact on the local water cycle in (currently) semi-arid lands.

Mechanical tillage represents the most common technique of soil management in olive orchards within the semi-arid lands of the Mediterranean Basin. Such practice may result in soil structure degradation which can significantly reduce water infiltration causing runoff and erosion processes. In '**No-tillage management of olive groves can improve soil structure while maintaining yield**', an alternative opportunity is introduced by using cover crops which eliminate most of the disadvantages of conventional tillage.

Small-scale farms in populated countries must produce sufficient quantities of food to meet the ever-growing population needs. In '**Straw covering on soil can increase crop yields and improve the efficiency of water use**' Chinese researchers show how the integrated systems of wheat and maize relay-planting combined with straw mulching can decrease soil evaporation, reduce water consumption, and increase crop yield and water use efficiency significantly, compared to conventional monoplanting of wheat and maize.

All this information could be used to elaborate manual-type procedures, i.e., best practices, for climate change adaptation at the proper scale(s), while bearing in mind that some of the solutions are specific to their hydro-climatic areas, on their respective sides of the European Continental Divide. Thus, after '**Land use changes in the Mediterranean may be triggering large weather shifts**', the contents of the next three articles (**Artificial wetlands on farmland help prevent soil loss and recapture agricultural by-products**', '**No-tillage management of olive groves can improve soil structure while maintaining yield'** and **'Flood risk from modern agricultural practices can be mitigated with interventions'**) would be applicable to the "water-abundant" Atlantic part of Europe, while the contents of the last five articles in the issue are most applicable to "water-scarce" Mediterranean Europe. Information from the articles, **'Who should pay for best management practices to reduce soil erosion?**' and '**Integrating animal and crop production can reduce nutrient leaching from agricultural fields**' describe solutions that could be used in all areas. In the case of the Mediterranean Catchment Basin, however, these procedures are not enough to adapt to the ongoing climate change. This includes the anthropogenic, land-use-driven components of that change, which have affected the hydrological cycles in these lands over history. However, they could be further complemented with additional steps towards the recovery of local water cycles in selected watersheds or river basins.

When studying the loss of summer storms in the Mediterranean, I found the reduced precipitation signalled a change in the quality of land use in the catchment basin. Evapo-transpiration from the soil and vegetation on the surface used to provide the additional amount of water that triggered storm formation, and this change seems to signal the loss of vegetation within the catchment area, showing how a direct link exists between the dominant weather systems and local soil-land-use decisions. The messages here are: (1) that water evaporated mainly over the coastal plains and slopes, is (or can be) recovered at the headwaters some 60 to 100 km inland, and (2) that it establishes a direct relationship between soil-surface properties, including water content, and the water cycle at the river basin scale.

Knowledge of these phenomena opens the door to 'cultivating summer storms' or, really, to recovering part of the old precipitation regimes, i.e., before the land was altered. In the Mediterranean, the effects of coastal land-use changes (e.g. massive soil sealing by urbanisations) could be compensated by re-forestation along the airmass' path to the storms' focal areas, and similarly in other parts of Europe. This, however, requires disaggregating the precipitation by weather types, at a scale no smaller than the river basin, to find which components of precipitation respond to what changes in evapo-transpiration from the soil-vegetation, when, and where within the same basin.

If we start with these premises, it becomes clear that the solutions and phenomena described within this Thematic Issue are not only aids for adapting to a changing climate, but also describe decisions that can and will affect weather systems on a macro scale.

In summary, soil and water are crucial environmental media that interact in many ways. For soil, water can be both a threat or a boost for fertility. For water, soil is a regulating agent, a buffer that prevents the consequences of weather peaks. It not only helps avoid flooding or droughts, but supports the water cycle.

The year 2015 has been designated the International Year of Soils by the UN – with one major aim being to promote awareness about the profound importance of soil for human life among society and decision makers. In time, this should help support decision makers to create effective policies for the sustainable management and protection of soil resources for the future.

Finally, I would like to acknowledge, with thanks, the help of the SfEP editorial team and the constructive comments of the EC scientific officer.

Professor Millán Millán,
Emeritus Director of the Centro de Estudios Ambientales del Mediterráneo (CEAM), Valencia, Spain.

Contact: millan@ceam.es
Theme(s): Climate change and energy, Soil, Water

Land use changes in the Mediterranean may be triggering large weather shifts

Land use changes over the last century in the Mediterranean area may be sparking shifts in weather patterns there, across Europe, and around the globe, suggests a new study. The findings bring to light new complexities that can be integrated into climate models and predictions.

"Coastal regions miss out on needed rain during summer months, increasing desertification, but receive intense storms during autumn, spring, and winter. Meanwhile, inland regions experience flooding during the summer. Current models dealing with atmosphere-land-ocean exchanges are not able to take into account these processes and, as a result, could be projecting false conclusions about weather and climate."

The European Commission launched and partially funded[1] several major field studies on weather and climate in the 1970s, following the UN Stockholm Conference on the Environment. The data were collected using methods such as meteorological towers, tethered balloons, and measurements taken via aircraft. During this research, scientists observed a decrease in the frequency of summer storms in the Western Mediterranean Basin. This observation was not however a central part of the studies; now, years later, researchers have re-analysed the data with that detail in mind. This latest analysis was part-funded by the EC's CIRCE[2] project.

They found that the lack of summer storms in the Western Mediterranean Basin starts a series of events leading to the accumulation of water vapour and air pollutants in layers above the sea, called an Accumulation Mode. This cycle can last several days and reoccur several times a month in the summer. Each cycle ends with severe storms and potential flooding in Central Europe, instead of rainfall in the Mediterranean area. Consequently, this shift results in droughts in parts of the Mediterranean countries during those summer months.

The researchers conclude that these weather and climate pattern changes are a result of land use changes along the coasts and mountain regions of the Mediterranean. Starting a century ago and continuing until the present day, marshes have been drained of water and forests have been felled. Urbanisation has also resulted in large amounts of soil being covered with homes, cement, and asphalt. This results in less water evaporation, which causes summer storms to move farther inland, instead of dropping their water and recycling it within the coastal Mediterranean system. Intense rains put these areas farther inland at risk from increased flooding, soil erosion, and even water contamination from pollutants held with the water vapour.

Because significantly less fresh rainwater is falling in the Mediterranean and then flowing into the sea, the salinity of the sea can actually increase as well. This changes the Atlantic–Mediterranean salinity valve at Gibraltar and can induce intense storms in Atlantic Europe in summer and autumn or even shift weather patterns in the Gulf of Mexico. Another effect stems from cloud layers creating a greenhouse effect and increasing the sea's surface temperature off the Mediterranean coast. This feedback process can resurface months later by causing intense storms on the coast in autumn, spring, and winter.

In sum, land use changes in the Mediterranean contribute to harsh fluxes between desertification and flooding in areas of Europe. Coastal regions miss out on needed rain during summer months, increasing desertification, but receive intense storms during autumn, spring, and winter. Meanwhile, inland regions experience flooding during the summer. Current models dealing with atmosphere-land-ocean exchanges are not able to take into account these processes and, as a result, could be projecting false conclusions about weather and climate. The researchers recommend actions such as intense reforestation of destroyed areas, and call for further research to allow for better forecasting of extreme weather events.

1. The experimental data used for this work were obtained from a range of European projects; see original paper for details.

2. Climate Change and Impact Research: the Mediterranean Environment (CIRCE) was supported by the European Commission under the Sixth Framework Programme. See: http://www.iddri.org/Iddri/Circe-Overview.pdf

Source: Millán, M. M. (2014). Extreme hydrometeorological events and climate change predictions in Europe. *Journal of Hydrology*. 518: 206-224. DOI: http://dx.doi.org/10.1016/j.jhydrol.2013.12.041.

Contact: peoconnell@ncl.ac.uk
Theme(s): Agriculture, Land use, Water

Flood risk from modern agricultural practices can be mitigated with interventions

In the face of substantial evidence that modern land-use management practices have increased runoff at the local scale, a new study reveals changes in local land use management practices can reduce the risk of local flooding. However, there is little evidence so far that these local increases in runoff culminate in large-scale flooding effects. To address this lack of evidence, the researchers present a model that maps the downstream rate of flow back to its source areas. .

"..there is a pressing need for new models and approaches that allow flood predictions at multiple scales, and which take into account the role that human activity plays in soil and water functioning."

Agriculture and land-use management in the UK has changed immensely since the end of the Second World War, driven by UK and EU agricultural policies. In an effort to become more self-sufficient in food production, modern agricultural practices have led to changes such as increased field size, the use of large farm equipment, and elimination of buffer zones (areas of land, lying next to a waterway, kept in permanent vegetation) and hedgerows. Those changes in farming methods have resulted in more deeply compacted soils, unchecked runoff, lines left from ploughing, and cracks in the soil. Factors such as compaction prevent the soil from being able to hold more water and lines and cracks in the soil concentrate the water flow — therefore speeding up the flow of water on the soil's surface. This in turn increases the volume and speed of water flowing into waterways and heightens the risk of flooding.

These observed changes have prompted a large number of studies on their scope and also on possible mitigation strategies. This study has comprehensively summarised those works to identify best practices. Research has identified several possible interventions to mitigate or avoid small-scale impacts. Examples include the establishment of hedgerows, the creation of natural buffer zones and temporary overland flow ponds. These agricultural practices can all decrease the amount of runoff at the farm level, but the appropriateness of a specific intervention depends on soil type and other characteristics.

While research on how local land management affects local-scale flooding is abundant, the same is not true for large-scale flooding. Research on a larger scale has not produced evidence that local effects of land management combine to have an effect on more large-scale flooding. As the scale gets larger, more variables must be taken into account, which is problematic. It is difficult to test the large-scale effectiveness of farm-level interventions because, among other issues, current models do not account for how soils are affected by interactions with vegetation and soil organisms responsible for maintaining the structure of soil, diurnal and seasonal cycling, freezing and thawing, the stresses imposed by farm animals and vehicles, or various forms of artificial drainage. This is why the researchers warn that a lack of evidence at the large scale does not mean there are no large impacts. Furthermore, although numerous hydrological models are available, there is a lack of agreement among scientists about which are most useful. This contributes to the lack of useful answers about the impacts of land management on the flow, sediment, and water quality of large-scale catchments worldwide.

The researchers suggest that this type of large-scale catchment modelling should be the next step in hydrological research and have provided an example: Using multiscale data (which is rarely available) from the flooding that inundated the city of Carlisle in 2005, the researchers used a 'Source-Pathway-Receptor model' to generate a map. This model tracks 'packets' of water from the source to the site of flooding through a network of channels, and can indicate where most of the water came from for a particular storm peak. This type of catchment experimentation is key to attribute land management practices and public policies to the impacts of floods, the researchers say.

The vast majority of catchment areas in the UK have already been changed by impacts of human activity — so the researchers say textbook descriptions of natural hydrological functioning no longer apply. Moreover, interventions at the small scale may have big impacts on the larger scale, but knowledge of these connections is limited. Hence the researchers say that there is a pressing need for new models and approaches that allow flood predictions at multiple scales, and which take into account the role that human activity plays in soil and water functioning. They advise that greater coherence, and more definitive standards — and a large-scale approach, such as in the 'Source-Pathway-Receptor model' — should be directed toward the creation and use of models in hydrological research.

Source: O'Connell, P. E., Ewen, J., O'Donnell, G., & Quinn, P. (2007). Is there a link between agricultural land-use management and flooding? *Hydrology and Earth System Sciences* 11(1): 96-107. DOI: 10.5194/hess-11-96-2007.

Contact: m.ockenden@lancaster.ac.uk
Theme(s): Agriculture, Soil, Water

Artificial wetlands on farmland help to prevent soil loss and recapture agricultural by-products

Small field wetlands are a simple and effective way to reduce soil erosion and nutrient pollution, recent research suggests. The authors adapted Norwegian designs for the UK environment and created a series of small rectangular lakes on the edges of agricultural fields. After three years, the wetlands had prevented tonnes of soil from leaving the land, and helped alleviate some of the nutrient run-off that would have affected neighbouring waterways.

"Field wetlands help to collect earth that gets washed from fields by rain, and provide the possibility for excess nutrients to be filtered by micro-organisms before reaching larger water courses. They also help to prevent flooding, and create a habitat for waterfowl and amphibians."

Soil degradation, erosion and nutrient pollution are major problems caused by industrialised agriculture. In the UK, the Department for Environment, Food and Rural Affairs (Defra) has estimated the financial costs of flooding and pollution from degraded soil to be at £0.2–0.3 billion per year, while excessive quantities of nutrients such as nitrogen and phosphorus can have damaging effects on wildlife in freshwater ecosystems. Improving inland water quality is one of the key aims of the European Water Frameworks Directive.

Field wetlands are artificially constructed water bodies, such as lakes or ponds, ideally positioned on unproductive areas of farmland and in the path of existing water run-off channels. They help to collect earth that gets washed from fields by rain, and provide the possibility for excess nutrients to be filtered by micro-organisms before reaching larger water courses. They also help to prevent flooding, and create a habitat for waterfowl and amphibians.

The researchers noted that this technique has not been widely adopted in the UK, partly because of preconceptions that field wetlands need to be large to be effective — previous research has suggested that they should occupy 2% of a water catchment area. However, this study looked at the use of wetlands with a smaller footprint, taking up between 0.025 – 0.1% of each catchment area, which is equal to $2.5m^2$–$10m^2$ per contributing hectare.

Over the course of two years, 10 small field wetlands were constructed in four farms in Cumbria and Leicestershire. One of the farms had sandy soil, one had clay-heavy soil, and two others were silty. Surveys of the depth and type of sediment deposited into the sites were taken together with measurements of the levels of nitrogen, phosphorus and carbon. It was found that the soil type of the farmland had a big impact on the quantity of sediment that was collected in the wetlands — over a three year period, the sandy site accumulated 70 tonnes, the silty sites 40 tonnes, whilst the clay-based site collected just 2 tonnes. There were many factors that influenced these results. If heavy rain happened to fall on a field at a time when there were no crops, sediment run-off would increase dramatically. Also, some soil types are inherently more susceptible to erosion than others — sandy soils are more prone to wash away from rain than clay soils.

The nutrient analysis showed that the smaller the particle sizes of the sediment, the higher the concentration of nutrients collected in the wetlands. However, the overall levels of nutrients in the collected sediment were not significantly different to those in the fields. This means that the deposited soil can be recycled, but would not be useful as a fertiliser.

In addition to the reduction of excessive and harmful inputs in the agricultural process, the researchers say that small field wetlands are an affordable and effective form of sustainable water and land management, particularly in areas where the construction of larger wetlands would be problematic. Larger wetlands are still preferable, however, as they allow longer times for sediment and nutrient accumulation from water runoff. In a comparison between two Swedish studies, the annual accumulation of phosphorous was 0.2 kg per hectare for a small field wetland (0.3% of the catchment area), and 2.8 kg per hectare for a large field wetland (2% of the catchment area).

The response from farmers involved in the study was very positive, as it gave new purpose to waterlogged land, and the continual accumulation of sediment was a visual reminder of the wetland's effectiveness.

The researchers acknowledge that recent policies are starting to encourage better farmland management practices, but these systems need to be adopted on a much bigger scale if they are to have a significant impact on rural water and soil quality.

Source: Ockenden, M.C., Deasy, C., Quinton, J.N., Surridge, B. & Stoate, C. (2014). Keeping agricultural soil out of rivers: Evidence of sediment and nutrient accumulation within field wetlands in the UK. *Journal of Environmental Management* 135: 54 - 62. 10.1016/j.jenvman.2014.01.015

Contact: rc.palmer@btinternet.com or richard.p.smith@environment-agency.gov.uk
Theme(s): Soil, Agriculture

More than one-third of soils studied in southwest England are highly degraded

An extensive field investigation discovered that 38% of soils in southwest England show signs of enhanced surface water runoff due to soil degradation. The study also revealed which types of fields and soils are linked to the most or least degradation.

"Better soil health would allow plants to take up more fertiliser, grow better root systems, and access more water; it could also help in preventing localised flood events."

Damage to soil causes water runoff across the landscape instead of being infiltrated properly by the soil. Poor land management is known to cause these problems. Runoff has the potential to increase flooding, contaminate surface water with fertilisers and microbes, clog watercourses and also decrease the amount of water seeping down into the aquifer.

Between 2002 and 2011, an assessment of the health of soils was carried out using visual and manual examination of 3 243 samples, over 31 catchments. The researchers checked the amount of soil damage in relation to runoff. Samples were taken during the winter and spring months to ensure the soils were at an optimum moisture level for study. In each sample researchers looked at the surface condition of the soil, degree of soil erosion and enhanced runoff where present, the structure of the soil profile, and the moisture levels, among other characteristics.

Overall, 38% of sites showed high or severe degradation with signs of erosion and runoff, 50% displayed moderate damage, and only 10% had low levels of damage. Cultivated sites posed a large problem, with 55% of those sites having high or severe damage, while less than 10% of permanent grass sites had high or severe damage.

Fields with maize or potatoes, or other late-harvest crops, were the most damaged, with 75% of those sites showing degradation. In fact, one in five of those sites had serious rill and gully erosion. They found that winter cereal crops, like wheat and barley, also caused problems, with 60% of sites from those fields displaying high or severe degradation.

The study was also able to pinpoint which types of soils are more sensitive to farming practices. Soils that showed the most signs of damage were cultivated brown sands, brown earths and loamy stagnogley soils: soil types that cover more than 50% of southwest England. Due to their good agricultural qualities some of these soils are overexploited in crop production and as a result become highly degraded, resulting in greater surface runoff, surface water pollution, localised flooding and reduced winter rains seeping through the soil to refill the aquifer (recharge rates). Conversely, chalk- and limestone-based soils showed the least amount of degradation, with less than 20% of sites with those soils suffering from damage.

Southwest England's high rainfall, sloping fields, and choice of crops probably put it at a higher risk for soil degradation caused by farming practices than the rest of the country, the researchers concluded. Numerous techniques to avoid compaction of the soil or to reduce soil compaction are available, therefore decreasing runoff, but are often under-utilised or are not being carried out adequately. Topsoil lifting and subsoiling (which breaks up soil at a greater depth than ploughing) — both serving to loosen soil layers without turning it over — are options, as is avoiding traffic, e.g. for spreading manure or slurry, when the fields are too wet. However the use of increasingly large and heavy machinery is causing a higher risk for increasing soil compaction.

Better soil health would allow plants to take up more fertiliser, grow better root systems, and access more water; it could also help in preventing localised flood events. The researchers say it is important for land users to be able to properly identify the characteristics of soil damage in order to make educated decisions about soil management.

Source: Palmer, R. C., & Smith, R. P. (2013). Soil structural degradation in SW England and its impact on surface-water runoff generation. *Soil Use and Management*. 29(4): 567–575. DOI:10.1111/sum.12068.

Contact: pmartin@agroparistech.fr
Theme(s): Agriculture, Soil, Water

Who should pay for best management practices to reduce soil erosion?

Worsening soil erosion in north-western Europe may be the result of a switch from traditional dairy farming to cash crops. However, even if all dairy farming ceased, reductions in runoff of up to 76% can be achieved if best agricultural practices are employed, at a cost of approximately €45 per hectare for the first three years, new research from the Austreberthe watershed in France suggests.

"Rates of soil erosion vary depending on the form of agriculture. Dairy farming, for example, using mainly permanent pasture, is showing hardly any soil erosion, whereas most arable farming allows for bare soils during the cycle, prompting higher rates of runoff..."

Mudflows — mudslides that can smother roads and houses — are a serious problem in north-western Europe. They are the result of soil erosion in agricultural areas upstream of towns and cities and cause substantial damage. Rates of soil erosion vary depending on the form of agriculture. Dairy farming, for example, using mainly permanent pasture, is showing hardly any soil erosion, whereas most arable farming allows for bare soils during the cycle, prompting higher rates of runoff, which may result in concentrated erosion downstream.

For this study, researchers examined the effects of changing agricultural practices on soil erosion in the Saussay agricultural catchment, part of the Austreberthe watershed, in northern France. In this region, rather than traditional dairy farming, agriculture is increasingly turning to crops such as wheat and oilseed rape, which entails the conversion of pasture land into arable land.

The researchers created three scenarios: 1) the baseline: farming practices as they were in 2007: at this stage the share of grasslands was 25% and arable land was 75%; 2) no dairy: all dairy production in the area ceased by 2015; and 3) no dairy with best practices: dairy production ceased by 2015 but farmers funded to carry out best management practices to prevent erosion. Best practices include: 'catch' or cover crops (fast-growing crops grown between successive plantings of the main crops, which prevent the soil being left bare); grass buffer strips grown in the fields to prevent erosion; potato micro-dams — barriers between furrows to encourage rainwater to infiltrate into the soil rather than to run off; and hoeing (a fragmentation of the soil surface crusts which have very low infiltration rates, which reduces runoff). The researchers then used a model to calculate runoff volume in December and May under the three scenarios.

The effect of the best practices was clear; the no dairy scenario led to a significant increase in runoff volumes, as expected (+37 % in winter and +54 % in spring). However, the no dairy with best practices scenario achieved runoff volumes that were even better than the baseline of 2007. Reductions in runoff for the no dairy with best practices were -62% in winter and -82 % in spring, compared to the no dairy scenario (and -47 % in winter and -76 % in spring compared to the baseline).

The researchers then calculated the costs of implementing the best practice for the entire Austreberthe watershed. The total cost was estimated to € 640 000 year (with a range of € 540 000 and € 773 000) over the first three years, approximately € 45 per hectare. The researchers did not calculate the benefits of less soil erosion but these could include a reduction in silting of waterways and harbours, fewer fertility losses and greater fertility and crop yields.

As the cost of funding such measures is often borne by local taxes, the researchers also investigated how much local residents were willing to pay for reduced soil erosion. They used data from a parallel study which surveyed 220 residents in a nearby watershed. Although they acknowledge that using data from Austreberthe residents would have been preferable, they feel that the similarities of the two watersheds means they would give very similar results. For example, both areas are river basins of tributaries of the Seine and have high population densities that are at risk of mudflow inundation.

The results showed that individual residents would be likely to pay around €22.63 per year for a 15-year erosion prevention programme; this would equal €395 000 a year for the whole of the Austreberthe watershed. Although this is not sufficient to cover the full costs the researchers point out that the cost of the programme can be reduced by half by using European subsidies from the second pillar of the Common Agricultural Policy.

Source: Martin, P., Ronfort, C., Laroutis, D., Souchère, V. & Sebillotte, C. (2014). Cost of best management practices to combat agricultural runoff and comparison with the local populations' willingness to pay: Case of the Austreberthe watershed (Normandy, France). *Land Use Policy* 38: 454–466. DOI: 10.1016/j.

Contact: kirsti.granlund@ymparisto.fi
Theme(s): Agriculture, Chemicals, Land use, Marine ecosystems, Soil, Sustainable consumption and production, Water

Integrating animal and crop production can reduce nutrient leaching from agricultural fields

Nutrient leaching, the movement of plant nutrients from soil to water, can have negative effects on aquatic ecosystems due to eutrophication, which reduces the oxygen available in water, causing species and habitat loss. Ecological Recycling Agriculture (ERA), which is based on ecological principles and integrates crop production and animal husbandry, may limit this effect. This study investigated ERA'S impact on agricultural fields in Finland, showing that the practice can reduce nitrogen leaching and may help to achieve agricultural nitrogen reduction targets.

"There is a pressing need to reduce nitrogen leaching from agricultural areas to surface waters. This study suggests that Ecological Recycling Agriculture could be an effective method to achieve this, as it can reduce excess nitrogen in agricultural soils and nitrogen leaching."

When water enters soil, it dissolves the nutrients within and transfers them to the water supply. When water percolates through soil, these dissolved nutrients can be transferred into deeper layers. This process, termed nutrient leaching, contaminates groundwater and can have negative effects on aquatic ecosystems. For instance, nitrogen, which is introduced to soil mainly by fertilisers, contributes to the eutrophication of water bodies, with many negative consequences for aquatic life.

This is a significant problem in the Baltic Sea, where the influx of nutrients from catchments (areas of land that are connected to bodies of water) has caused the water to become severely oxygen depleted. Although nutrient loading has been on the decline since the 1980s, the ecological status of the Baltic Sea has not significantly improved, suggesting that more reductions are necessary.

Achieving this requires countries bordering the Baltic Sea to apply agricultural practices that optimise nutrient use. One such practice is Ecological Recycling Agriculture, or ERA, which can be defined as a system, such as a farm(s), in which at least 85% of total nitrogen used is produced by the system[1].

More broadly, ERA involves balancing crop and animal production, so that the material used for nitrogen fixation and to improve soil fertility can also be used as fodder, and the plant nutrient in manure is distributed over the entire farm during crop rotation. This type of farming, which also uses no pesticides or chemical fertilisers, can achieve a high level of self-sufficiency. According to Baltic Ecological Recycling Agriculture and Society (BERAS), ERA has three key principles: crop rotation, balanced animal stock, and self-sufficiency in resources[2].

A key element of ERA is placing animal and crop production near to each other. This proximity is important, as nutrient leaching is often due to the fact that livestock and plant production are located in distant areas. Due to higher application rates next to the centres of livestock farming it tends to accumulate in soil locally. In fact, the distance between crop and animal production is thought to be the main reason for the high nitrogen load in the Baltic Sea. In this study, part funded by the EU's Baltic Sea Region Programme, researchers assessed the environmental impacts of ERA in three agricultural catchments. The catchments were all in Finland (which borders the Baltic Sea): Lepsämänjoki, where crops are grown; Yläneenjoki, where animals are bred; and Lestijoki, a dairy production line.

Nitrogen leaching from the catchments was simulated using a model, which was run based on the existing farming conditions and under hypothetical ERA conditions. As well as agricultural nitrogen losses, the concentration of nitrogen in streams was calculated to give a broader picture of how ERA affects nitrogen leaching. The simulations showed that ERA can decrease nitrogen losses. The maximum inorganic nitrogen concentrations in streams and the average amount of nitrogen loss from agricultural fields were lower compared to the existing production method, which, unlike ERA, depends on inorganic fertilisers. In two of the catchments (Lepsämänjoki and Yläneenjoki), the decrease in nitrogen losses would enable them to meet national water protection targets for agricultural production (a 30% decrease in nitrogen loading from fields).

There is a pressing need to reduce nitrogen leaching from agricultural areas to surface waters. This study suggests that ERA could be an effective method to achieve this, as it can reduce excess nitrogen in agricultural soils and nitrogen leaching. The researchers also suggest that ERA could be used to achieve the nitrogen reduction targets for agriculture set by the Baltic Sea Action Plan.

1. Source: http://orgprints.org/5949/1/GranstedtA.pdf
2..Source: http://www.beras.eu/implementation/index.php/en/2012-02-09-21-53-40/ecological-recycling-agriculture-era

Source: Granlund, K., Rankinen, K., Etheridge, R., Seuri, P. & Lehtoranta, J. (2015). Ecological recycling agriculture can reduce inorganic nitrogen losses – model results from three Finnish catchments. *Agricultural Systems* 133, pp.167-176. DOI: 10.1016/j.agsy.2014.10.015.

Contact: panos.panagos@jrc.ec.europa.eu
Theme(s): Water, Soil, Natural hazards

New data on soil erosion by water reveal Mediterranean at highest flood risk

Comprehensive data analysed in a new study show how extensive rainfall can erode soils across the EU and Switzerland, revealing that Mediterranean regions have the highest risk for erosive events and floods. The resulting dataset can also be used for disaster planning and relief.

"Dry soils that experience heavy rainfall, even if infrequent, are the most susceptible to erosion... This means the Mediterranean region has the highest risk of erosive events, flooding, and at the same time even water scarcity."

Rainfall is one of the principle causes of soil erosion. It breaks apart soil, dislodges it from its surroundings, and washes it away as runoff. These mechanisms have an effect on how much water the soil may hold, how fast water flows over the soil, and even on the soil depth. In a much broader sense soil erosion can negatively affect plant growth and agricultural yields, as well as water quality, and recreation.

The erosive force of rainfall can be quantified as 'rainfall erosivity'. In equations estimating soil losses due to water erosion it is termed 'R-factor'. It takes into account the duration, magnitude and intensity of precipitation, Because soil erosion is difficult to document at a large scale, the R-factor is crucial when scientists attempt to model larger areas to test for the possibility of soil loss. However, because a lot of the data on rainfall erosivity are lacking, their models are usually not good predictors.

To try to give other scientists better data to use in models, these researchers created a database and maps to better depict rainfall erosivity in Europe. They combined and analysed datasets from across all EU Member States and Switzerland, from a total of 1 541 rainfall monitoring stations1. To be included in the project, a dataset had to include results taken over a lengthy period of time and have taken recordings very frequently. The average length of collection was approximately 17 years, ranging from seven years to 40. The frequency of recordings occurred at intervals ranging from once every five minutes to once an hour.

The erosive force of rainfall — 'rainfall erosivity' — combines the influence of the duration, magnitude and intensity of precipitation. The study found that the average R-factor for the EU and Switzerland is some 700 MJ mm ha−1 h−1 yr−1. The higher the R-factor, the greater the risk for soil erosion and the lower the R-factor, the less likely the risk). With above 1000 MJ mm ha−1 h−1 yr−1 the Mediterranean and Alpine regions feature one of the highest values in Europe, while the Nordic countries have moderate values below 500 MJ mm ha−1 h−1 yr−1.

Dry soils that experience heavy rainfall, even if infrequent, are the most susceptible to erosion. Mediterranean soils match those conditions and were thus found to have a high erosivity density - a measure of erosivity per rainfall. This means the Mediterranean region has the highest risk of erosive events, flooding, and at the same time even water scarcity — because of the infrequent but very intense and erosive nature of local rainstorms. On the other hand, wetter areas can also have a high erosivity density and be at risk from landslides and wetland erosion, especially if factors such as soil texture, structure and organic matter content add to their susceptibility.

The comprehensive dataset and maps resulting from this study offer a unique opportunity for further research, the authors say. According to them this data can be used to plan for relief after a flood disaster or used to plan mitigation techniques by prioritising the areas at highest risk. This information is also useful for assessing landslide and flash flood risk, as well as strategically planning agricultural policies and recovery from forest fires.

1.Data are available from the European Soil Data Centre: http://esdac.jrc.ec.europa.eu/content/rainfall-erosivity-european-union-and-switzerland

Source: Panagos, P., Ballabio, C., Borrelli, P., Meusburger, K., Klik, A., Rousseva, S., Tadić, M. P., Michaelides, S., Hrabalíková, M., Olsen, P., Aalto, J., Lakatos, M., Rymszewicz, A., Dumitrescu, A., Beguería, S. & Alewell, C. (2015). Rainfall erosivity in Europe. *Science of The Total Environment*. 511: 801-814. DOI: http://dx.doi.org/10.1016/j.scitotenv.2015.01.008.

Contact: gernot.bodner@boku.ac.at
Theme(s): Agriculture, Soil, Water

Research into root systems: key for long-term crop management

Water scarcity is an important cause of low crop yields worldwide. Yields could be significantly improved by focusing attention on unproductive water losses and improving retention of plant-available water in soils, and particularly the largely unexplored interactions between soils and roots. A new review of scientific literature sets out key soil management measures for crops under drought conditions.

"Increasing efficient plant use of available soil water can reduce water requirements for irrigated agriculture. A key to efficient water use is to address the still high losses via runoff and evaporation."

Both land conversion and water use for crops are approaching their planetary limits[1]. Although Europe suffers less from drought than many other areas of the world, the European Commission estimates that by 2007 at least 11% of Europe's population and 17% of its territory had been affected by water scarcity, while the cost of droughts in Europe over the past 30 years was estimated at €100 billion. The EC released a 2007 Communication highlighting the need to address the challenge of water scarcity and droughts in the EU for both environmental and economic reasons, especially in the context of climate change. The communication set out several steps, including a yearly European assessment using the Water Information System for Europe and the development of a European Drought Observatory.

The researchers looked at the main aspects of climate, soil and plant interactions that determine yield in water-limited environments. The main focus was on which approaches to agricultural water management can best alleviate problems related to drought and increase yields. A secondary focus was to identify areas of plant water use that are still poorly understood by crop sciences and therefore underutilised in cropping system management.

It is suggested that new approaches to enhancing water productivity are needed if crop yields are to be improved sustainably. Increasing efficient plant use of available soil water can reduce water requirements for irrigated agriculture. A key to efficient water use is to address the still high losses via runoff and evaporation. This is particularly relevant for drylands, which require water saving to ensure stable yields, and which make up 24% of Europe's land.

The soil subsystem is highly affected by tillage and crop rotation. Water efficiency can be addressed with short-term measures, such as cover cropping, or mulching — adding a layer of material on top of the soil to protect it, such as organic matter, living vegetation or a non-crop mulch such as plastic foil or geotextile (permeable fabric which, when used with soil, is able to separate, filter, reinforce, protect, or drain). Using conservation tillage or no-tillage systems and inputting organic matter can also improve soil water storage capacity over the longer term. Two important soil properties that condition the water storage capacity are soil structure and organic matter content, elements that are essentially influenced by plant-soil interactions.

The researchers emphasise that traditional approaches to optimising crop systems, such as adjustment of the date of sowing and crop density, are approaching limits in their ability to increase yields. These interventions could be better implemented according to the local and regional environmental site conditions (for example by using decision support models), but they say further research is unlikely to deliver large scientific novelties. Likewise they do not expect that further yield increases could be obtained by emphasising traditional breeding traits such as harvest index. They noted a substantial evidence gap in feedback processes between the plants and the soil and postulate that research into these areas might result in new agronomic approaches for yield increases. Gaps include the investigation of different aspects of interactions between soil and plant roots. In addition, unlike many traditional breeding measures, which target adaptation of crops to regular seasonal dry periods, a deeper understanding of dynamic feedback mechanisms has the potential to be used to increase crops' stress resistance to unforeseeable, intermittent droughts (abnormal dry periods).

The authors of this review conclude that, in order to increase yields in the longer term, tillage systems can be changed towards mulch-based conservation tillage and new varieties of crops with higher stress resistance could be bred by focusing on the plant roots. Measures such as mulching and modifying the time of sowing are suitable farming practices to allow for the adjustment of cropping systems to site constraints. Furthermore, research into root systems and their interaction with the surrounding soil will add to better crop management in the long-term. In both cases, due to the variability in conditions where crops are grown, clear identification of the main aspects of the climate, soil and plant in limiting yields in a particular area is the necessary basis to identify the most efficient agricultural management adaptations

1. http://vzj.geoscienceworld.org/content/12/4/vzj2013.02.0041.abstract

Source: Bodner, G., Nakhforoosh & A., Kaul, H.P. (2015). Management of crop water under drought: a review. *Agronomy for Sustainable Development* 35(2): 401-442. DOI: 10.1007/s13593-015-0283-4

Contact: jnahev@iaf.uva.es
Theme(s): Soil, Land use, Forests

Rejuvenating arid badlands: from barren slopes to living forest in 80 years

A reforestation project has revitalised its surroundings just 80 years after its inception. In the late 1920s, the Saldaña badlands in northern Spain were a barren region, with a thin layer of intensely weathered soil, and only 5% vegetation cover. Now that cover has increased dramatically to 87%, the soil quality is improving, and the water flow in the area has stabilised, bringing greater environmental security to the local community.

"In under a hundred years, mass erosive processes have been drastically reduced, as well as their major consequences, such as landslides and mudflows."

Badlands' are a geological term for dry, eroded terrain, often featuring steep slopes, which are associated with landslides, high rates of sediment disposal, minimal vegetation and concentrated runoffs that lead to flash flooding. However, the Saldaña badlands were not always so degraded — in this case, it was not geological processes that made the terrain barren, but the cumulative impact of at least 18 centuries of human activity.

This recently published study of this region, which was supported in part by the European Erasmus Mundus 17 Programme, analysed historical documents, maps, photos, and video of the 3.17 km^2 area to create an account of how the badlands came to be, and conducted field analyses of the soil quality, vegetation cover and erosive processes to help determine the success of the reforestation project that started as recently as the 1930s.

Evidence suggests human presence on the landscape began around 12 000 years ago, but increased substantially during the time of the Roman Empire. Over the centuries, the combined pressures of war and agriculture led to intensive deforestation of the original forests. By 1472, populations downstream noted the negative effect that deforestation had on the quality of their water supply, but the situation continued to get worse, and by 1751, the slopes were described as a 'degraded mountain'.

In 1928, the forest restoration project conducted by the forest engineer José Mª Ayerbe was initiated. Between 1932 and 1936, 3 000 trees were planted per hectare, including Scots Pine (*Pinus sylvestris*), elm (*Ulmus campestris*) and acacia (*Robinia pseudoacacia*) species, and hundreds of check dams (small temporary structures across water channels, used to slow the water flow) and wattle fences (a traditional technique that weaves small branches between large sticks) were constructed to help slow the movement of water and sediment.

The first major socio-economic success of the project was acknowledged in the early 1960s. The Saldaña-Osorno road was frequently blocked by mud flows and landslides during heavy rains in the past, but the restoration project put a halt to these disruptive events. Further restoration work was carried out on the land in 1963.

Desk and field analyses show that, since the turn of the century, the changes in the Saldaña badlands have produced substantial benefits. Forest vegetation now covers nearly the whole area, and evidence of soil regeneration is indicated by an increase in organic matter from leaf litter increased soil moisture, and the presence of species such as earthworms and fungal mycelium. The researchers found that sediment yield from the land diminished by three orders of magnitude compared with the 1940s, which helps to keep the nearby Carrión River free of suspended mud and silt. The rate at which water is absorbed into the ground is also 43 times greater on the forested slopes than bare slopes, greatly reducing the risks of flash flooding.

In addition, the biodiversity of the badlands is increasing. Species which can be found in established habitats of the region are now returning, including Pyrenean oak (*Quercus pyrenaica*), a local variety of wild peony (*Paeonia broteroi*), and the edible mushroom, saffron milk cap (*Lactarius deliciosus*).

Although the landscape has shown dramatic results in its overall regeneration, analysis of the soil suggests that the recovery is not yet complete in terms of the evolution of the soil structure. Therefore pH, bulk density and erodibility of soils sampled from the vegetated areas are not significantly different than soils from the degraded areas. However, vegetation cover, leaf litter and check dams in the restored areas compensate for this and have arrested the most severe erosion processes.

Overall, the main objectives of the original restoration project seem to have been achieved. In under a hundred years, mass erosive processes have been drastically reduced, as well as their major consequences, such as landslides and mudflows. The researchers suggest that other landscapes with similar problems could be recovered in a similar way.

Source: Navarro Hevia, J., Carlos de Araújo, J. & Mongil Manso, J. (2014). Assessment of 80 years of ancient-badlands restoration in Saldaña, Spain. *Earth Surface Processes and Landforms* 39: 1563-1575. DOI 10.1002/esp.3541

http://onlinelibrary.wiley.com/doi/10.1002/esp.3541/abstract

Contact: assunta.palese@unibas.it
Theme(s): Agriculture, Soil

No-tillage management of olive groves can improve soil structure while maintaining yield

Non conservative tillage techniques, such as milling and harrowing, are the most common way to manage soil in Mediterranean olive orchards. A new study confirms the value of alternative methods based on the use of spontaneous cover crops which can significantly improve soil structure and reduce erosion whilst maintaining yields

"The study highlights the environmental benefits of using the spontaneous natural vegetation cover rather than tillage under dry conditions. These include the increase of soil organic carbon, improvement of soil structure and reduction of soil and water losses…"

The olive tree is one of the most widespread crops in the Mediterranean basin. The trees are good at adapting to limiting environmental conditions such as drought and infertile, stony and steep soils. They have therefore historically been grown on marginal lands. Soil water availability is the major constraint to olive productivity.

Tillage reduces competition to the crops from weeds, helps with the burying of fertilisers and aims to reduce soil water evaporation. However tillage can result in degradation of soil structure and severe soil erosion processes, reducing uptake of water, especially for olive trees on steep slopes. When this is combined with the high temperature of the Mediterranean, this can also result in high loss of soil organic carbon, a major factor in soil health.

The use of cover crops can improve ecosystem services of olive orchard systems by reducing many the negative aspects deriving from tillage. Cover crops can reduce loss of rainwater by runoff, retain the moisture of the soil below and reduce soil erosion. All these have relevance to the EC's cross-compliance concept of keeping land in good agricultural and environmental condition, a precondition for farmers receiving a direct EU subsidy.

The study was carried out from 2007–2009 in a mature olive grove in Southern Italy. Two management systems were put in place. In the 'conventional system' (CS), the surface was tilled two to three times per year, keeping the soils clear of grasses, and trees were heavily pruned every two years, with pruning material removed from the orchard.

In the no-tillage 'sustainable system' (SusS), natural vegetation cover was allowed to accumulate and left on the ground surface after being mowed. The trees were lightly pruned once a year, and the pruning material also left on the ground as mulch. Measurements of the impacts on the soil structure, hydraulic conductivity (the ease with which water flows through the soils) and the water content of the soil were taken. The yearly yield of eight trees was recorded for each system.

A clear improvement was found in the SusS management system compared to the CS system. SusS had improved water movement, deeper water infiltration to the soil layers and higher storage capacity of rainwater, especially in autumn-winter. The researchers attribute this to the vegetation cover slowing down the spread of rainwater onto the soil and a better soil structure allowing rain capture both earlier and to deeper soil layers — especially important to olive trees under rainfed conditions.

In the CS system, on the other hand, important aspects of soil degradation were detected. The tillage made the soil more vulnerable, breaking apart the bonds between aggregated parts and rearranging particles to form a 'sealed' surface layer of soil, which meant water could less easily infiltrate the surface, resulting in increased surface runoff and soil erosion.

The olive yields were not statistically different between the two systems. They appeared to be most affected by annual rainfall pattern and alternate bearing behaviour (sequential years of higher and lower yields). However, the authors point out the importance of good management of cover vegetation, such as mowing at the right time (early spring) to avoid competition for water with the olive trees during drought-sensitive periods.

The study highlights the environmental benefits of using the spontaneous natural vegetation cover rather than tillage under dry conditions. These include the increase of soil organic carbon, improvement of soil structure and reduction of soil and water losses, all without any loss of yield. The researchers conclude that the well-managed use of spontaneous or seeded cover crops should be strongly recommended by policymakers as an alternative to conventional practices such as tillage.

Source: Palese, A.M., Vignozzi, N., Celano, G., Agnelli, A.E., Pagliai, M. & Xiloyannis, C. (2014). Influence of soil management on soil physical characteristics and water storage in a mature rainfed olive orchard. *Soil & Tillage Research*. 144(96-109): DOI: 10.1016/j.still.2014.07.010**.**

Contact: Chaiq@gsau.edu.cn
Theme(s): Agriculture, Soil, Water

Straw covering on soil can increase crop yields and improve the efficiency of water use

Straw from previous harvests can be used to help increase crop yields and improve the efficiency of water use in arid regions, finds a new study from China. By testing different techniques to improve water efficiency, the researchers found that the most effective method involved using straw to cover the soil when growing maize and wheat together in the same growing season.

"...out of the three types of straw management tested, the no-till straw covering is the most effective way to increase crop yields while improving water use in arid regions."

In north-western China small-scale self-sufficient farms are important producers of maize and wheat crops. The two crops are typically farmed in an intensive relay system, where wheat is planted in strips early in the spring and maize planted between the wheat later in summer. This style of planting optimises land use and has been shown to increase crop yields.

However, the system requires a high level of water to operate effectively. Freshwater availability is low in this part of China, — 760m^3 per capita per year — a figure that is 25% below the internationally recognised level for water scarcity[1].

In this study researchers looked at whether integrating straw mulching — when straw is chopped and spread on the soil surface — with the relay system could maintain the efficiency of production while decreasing the water requirement. In previous studies the use of straw mulching has increased crop establishment and grain yield; however this technique had never been tested within a relay planting system before.

The researchers tested both monoculture and relay planted growing systems (polyculture) over three years. In the monoculture systems maize was grown in 2010, followed by wheat in 2011 and maize again in 2012 — to replicate rotational growing techniques sometimes used in the region. In the relay planting system wheat was planted in March each year and maize in April. The plots were irrigated in accordance with local guidance for water treatment.

Four water conservation treatments were tested on both the monoculture and relay systems: no-till straw standing, where no ploughing occurs and straw from the previous harvest is left standing (25cm high) in the field; no-till straw covering, where no ploughing occurs and chopped straw is evenly spread on top of the soil; tillage with straw, where straw is mixed with the soil during ploughing; and conventional tillage, where the soil is ploughed and straw removed from the soil.

The results confirmed that the relay planting system produced superior yields to the monoculture planting. The use of straw mulching resulted in a reduction in water evaporation from the soil and a reduction in the amount of water used by the plants. In particular, no-till straw standing and no-till straw covering slows the movement of air at the soil's surface and reduces the amount of water evaporating. In addition, no-till straw covering also reduces the amount of competition for water between wheat and maize strips.

The authors conclude that out of the three types of straw management tested, the no-till straw covering is the most effective way to increase crop yields while improving water use in arid regions.

Source: Yin, W., Yu, A., Chai, Q., Hu, F., Feng, F. & Gan, Y. (2015). Wheat and maize relay-planting with straw covering increases water use efficiency up to 46%. *Agronomy for Sustainable Development*, 35(2): 815-825. DOI: 10.1007/s13593-015-0286-1

1. Addressing China's Growing Water Shortages and Associated Social and Environmental Consequences http://elibrary.worldbank.org/doi/abs/10.1596/1813-9450-3895

Further Reading.

You may also be interested in reading the following publications from Science for Environment Policy

News Alert articles

Increasing aridity will disrupt soil nutrient cycles in global drylands

The drying of soils under global warming could disrupt the balance of nutrients in large areas of the Earth's land surface, according to new research. The study focused on 'drylands' – arid areas with low levels of rainfall – which support over 38% of the world's population. Such nutrient imbalances could diminish the provision of ecosystem services, such as food production and carbon storage, the researchers say.

http://ec.europa.eu/environment/integration/research/newsalert/pdf/360na1_en.pdf

Do warming and drought have lasting effects on soil ecosystems?

Despite the substantial impacts warming and drought can have on soil bacteria and fungi, these are not sustained if external conditions re-stabilise, a new study suggests. Small-scale experiments in five countries across Europe to show that even if warming and droughts continued for over a decade, there were no lasting effects on key properties of soils, such as growth rates, when the soils were allowed to re-stabilise in a laboratory over seven days.

http://ec.europa.eu/environment/integration/research/newsalert/pdf/351na5_en.pdf

Water demand for crops may rise in northern Germany under warmer climate (

By 2070, there may be insufficient water for irrigation to ensure yields and profitability for some crops currently grown in northern Germany - if the IPCC´s worst case climate change scenario becomes a reality - new research warns. To reduce future demand for water under a changing climate, the study suggests that farmers grow different crops and change their management practices.

http://ec.europa.eu/environment/integration/research/newsalert/pdf/climate_change_insufficient_water_for_crops_northern_Germany_392na4_en.pdf

Research provides insight into the impacts of droughts in dry Alpine forests

The impacts of drought on European trees are of high concern, especially under a changing climate. New research has indicated that, if summers become continually drier, sensitive species, such as larch and spruce, will suffer reduced growth in some Alpine areas. This could potentially compromise ecosystem services provided by forests in these areas.

http://ec.europa.eu/environment/integration/research/newsalert/pdf/342na6_en.pdf

European flooding costs could increase almost five-fold by 2050

Extreme and catastrophic floods in Europe, such as those seen in 2013, currently occur approximately once every 16 years, but this may increase to once every 10 years by 2050, according to new research. The study also suggests that annual average economic losses caused by extreme floods could reach almost five times higher than 2013 values.

http://ec.europa.eu/environment/integration/research/newsalert/pdf/372na7_en.pdf

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Thematic Issues

Flooding (June 2013)

Flooding can cause profound and lasting effects on people, business and agriculture. This Thematic Issue brings together recent research that provides insight into changes in European flood risk policy, that could help policymakers deal with the projected increases in flood risk.

http://ec.europa.eu/environment/integration/research/newsalert/pdf/40si_en.pdf

In-depth Reports

Ecosystem Services and Biodiversity (May 2015)

Ecosystems provide a multitude of benefits to humanity, from food to recreation. In our latest In-depth Report, we explore four core facets of the ecosystem services concept: the links between biodiversity and ecosystem services; techniques for mapping and assessing ecosystems and their services; valuation of ecosystem services and the importance of considering all services; and biodiversity as part of an interconnected system.

http://ec.europa.eu/environment/integration/research/newsalert/pdf/ecosystem_services_biodiversity_IR11_en.pdf

Soil Contamination (September 2013)

After more than 200 years of industrialisation, soil pollution has become a widepread problem in Europe. This In-depth Report draws on current research and case studies from a number of scientific disciplines that investigate the interaction between contaminated soils and human health.

http://ec.europa.eu/environment/integration/research/newsalert/pdf/IR5_en.pdf

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