An integrated information system to support research on soil erosion mitigation techniques after forest fires

Sistema Integrado de Informação de apoio à investigação de técnicas de mitigação da erosão dos solos na sequência de incêndios florestais

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Abstract

The project RECOVER aims to develop mitigation techniques to reduce soil and water degradation immediately after forest fires. Forest fires are becoming increasingly frequent as a result of climate change and poor forest planning, with deleterious impacts on soil fertility and structure. It erodes the top soil layers, where is located the only nutrient pool of the majority of Portuguese soils. This nutrient mobilization happens during the first autumn rainfall events, and therefore sediment and nutrient exportation typically occurs in the first 4/6 months after fire. The speed at which nutrient loss occurs and the extension of forest fires limits in terms of costs and logistics the solutions that can be taken to reduce soil and water degradation. RECOVER will test a set of feasible solutions to reduce ash flush. This is essential to produce feasible solutions that will be easily adopted by forest managers and forest owners. RECOVER presents an innovative approach based on field surveys of soil and vegetation properties following forest fires, which will be used to perform a GIS database from which the critical spots will be identified. The implementation of an integrated information system (integrating a spatial database, a map server and GIS software) will allow us to store the data collected in the field as well as the information produced through the spatial analysis. This information will be available in a web-GIS portal, complemented with information to producers and all other agents evolved in the forestry management.

Keywords

Forest fires, soil degradation and recovery, GIS database, GIS modeling

Resumo

O RECOVER almeja desenvolver técnicas mitigadoras e estratégias para a redução da degradação do solo e da água imediatamente após os incêndios florestais. A frequência dos referidos incêndios florestais tem vindo a aumentar, fruto das mudanças climáticas e do deficiente planeamento florestal, com severos impactes ao nível da fertilidade e estrutura dos solos. Como consequência aumenta a erosão da camada superior dos solos, onde se localizam, na maioria dos solos portugueses, os únicos nutrientes existentes. Esta mobilização de nutrientes ocorre nos primeiros eventos chuvosos outonais, e, como tal, a exportação dos sedimentos e dos nutrientes acontece normalmente nos primeiros 4/6 meses após os incêndios. A velocidade a que a perda de cada nutriente ocorre e a extensão dos incêndios florestais é uma condicionante em termos de custos e baliza as soluções que se podem implementar para a redução da degradação do solo e da água. O RECOVER testará um conjunto de soluções praticáveis de forma a reduzir a lavagem das cinzas. A metodologia proposta apresenta uma integração inovadora de técnicas quantitativas de campo e irá proceder a análises de percepção junto de todos os intervenientes no planeamento florestal. Tal abordagem é essencial afim de produzir soluções passíveis de se colocar em prática que poderão ser facilmente adoptadas pelos planeadores florestais bem como pelos proprietários florestais. Este projecto apresenta uma abordagem inovadora baseada em levantamentos de campo das propriedades do solo e da vegetação após a ocorrência de incêndios florestais, cujos resultados serão usados para a construção de uma base de dados em ambiente SIG, que servirá para identificar os locais críticos. A implementação de um sistema de informação integrado (conjugando uma base de dados espacial, um servidor de mapas e software SIG) permitir-nos-á armazenar os dados recolhidos no campo bem como a informação produzida através da análise espacial desenvolvida. Esta informação estará disponível através de um portal Web-SIG, complementado com informações para os produtores e todos os outros agentes envolvidos na gestão florestal.

Palavras-Chave

Incêndios florestais, degradação e recuperação do solo, base de dados espacial, modelação SIG

Introduction

The RECOVER (Immediate Soil Management Strategy for Recovery after Forest Fires) project aims to develop mitigation techniques and strategies to reduce soil and water degradation immediately after forest fires. Forest fires are becoming increasingly frequent as a result of climate variability, socio-economic change and unsuitable forest planning, with adverse impacts on soil fertility and structure. One of the most important is the erosion of the top soil layers, where is located the 'nutrient pool' of the majority of Portuguese soils. This nutrient mobilization happens during the first autumn rainfall events, and therefore sediment and nutrient exportation typically occurs in the first 4/6 months after fire. The speed at which nutrient loss occurs and the extension of forest fires, tend to limit, in terms of costs and logistics, the solutions that can be taken to reduce soil and water degradation.

RECOVER will test a set of feasible solutions to reduce ash flush. The proposed approach presents an innovative integration of field measurement techniques and will perform a perception analysis to all those with responsibilities in forest management. This is essential to produce effective solutions that will be easily adopted by forest managers and forest owners.

To manage all data produced during the project (fieldwork and data analysis) will be implemented an Integrated Information System (that includes a spatial database, a map server and other geographical data management tools) that will allow us develop several spatial analysis and to disseminate the results of this project.

Objectives

The aim of this work is to present the methodology applied in the implementation of an integrated information system with GIS technology, and develop a geomorphologic process model using GIS tools.

The ultimate goal is to produce a tool that allows, to those with responsibilities in managing burned areas, the identification of the critical areas where interventions must be made to obtain the best conservation results at the lowest price, which will have a significant impact on soil conservation, vegetation recover, and therefore on ecosystem functioning. It will also reduce significantly the downstream impacts of ash wash.

Methodology

Since the start of the project (2007) and during the years of 2007 and 2008, there were no large or high intensity forest fires in central Portugal, condition for the normal development of this project. To overcome this problem, the solution was to chose an area in monitorization for a long time: Vale Torto catchment (Penedos de Góis) in Açor Mountain. It's a small (8,9 ha) schist and quartzite catchment, covered by shrubs and located in the municipality of Góis, Coimbra.

The project includes an initial phase of collecting and processing information related to the variables identified for the study and defining the data model to implement and organize the spatial database.

The survey of the study area (Fig. 1) allowed its three-dimensional modeling and the establishment of a surface runoff/flow modeling.

Also the land use and soil components (structure, texture, moisture, porosity, etc.) characterization, at the slope scale, as well as forest fires factors analysis (intensity, recurrence…), will be used and integrated in the geographic database, allowing the definition of the variables required in the model.
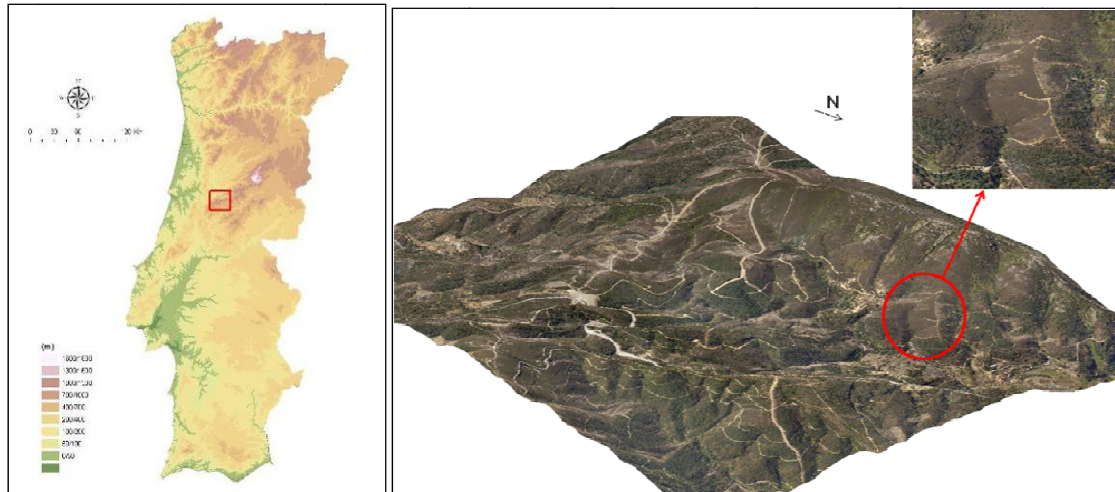
Figura 1. Study area – Vale Torto (Penedos de Góis) in Açor Mountain

Results

The modeling process of environmental variables has been developed following the need to make explicit its spatial component. Thus, it has been preferred the integration of GIS technology, due to its ability to integrate such models, as well as its efficiency in managing and analyze large amounts of information and, above all, for their capacity to relate this information based on their spatial expression.

Given the intimate relationship between geomorphological processes and the area in which they trigger, we consider it appropriate to apply the methodologies of modeling provided by GIS spatial analysis of erosion processes operated in the aftermath of forest fires.

Thus, following the installation and monitoring of erosion plots in various sectors of the slope in mountain areas occupied with production forest in central Portugal, will be produced a wide range of information concerning several parameters which combine to the genesis of the erosive geomorphological dynamic mentioned above.

In this sense, the development process of modeling these same variables will allow the measurement of possible interrelationships between them and the definition of behavior standards that can lead us to a predictability of those processes, in order to determine the validity and effectiveness of remediation techniques, however, implemented during the project.

The implementation of the modeling process, conducted with the use of technology in geographic information systems (GIS), will be based on information gathered, its validity and reliability, which is stored and structured in a database integrated in the GIS. The results will be available through a web-GIS portal.

Conclusions

The information included in the geographic database will develop a variety of modeling operations, initially directed at the study plots, leading to the development of predictive scenarios. The modeling results will then be generalized to the shed in order to ascertain the validity of extrapolating data and the ability to produce useful indicators of general trends for the decision on the proper techniques to mitigate erosion on burned areas.

This spatial database will be a key component of the Integrated Information System, which, at a later stage, is complemented with a component of spatial analysis (GIS desktop, to develop the processes of data modeling) and a spatial data server, allowing the implementation of a Web-GIS that will provide the results obtained on the Internet.

Aknowledges

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