ModMED

Modelling Mediterranean Ecosystem Dynamics

FINAL REPORT

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Seed dispersal

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Introduction

This section outlines the approach adopted by the ModMED project to modelling the long-distance dispersal of seeds at the landscape level. This approach has been implemented as a process model component which works with the Landlord spatial modelling system.

The vast majority of seeds produced by individual plants are dispersed only very short distances and are distributed within a few metres of the parent plant. This dispersal is modelled at the community level. However, a small proportion of seeds may be distributed much greater distances through the landscape. In the ModMED approach, the community-level models pass information on the numbers and species of seeds that leave the local communities for long-distance dispersal and this process is handled by the landscape-level model. The landscape in turn then re-distributes these seeds to other community-level models elsewhere in the landscape. Thus, some rasters in the landscape are sources of seeds, and all rasters are potential recipients of seed rain. The ModMED landscape therefore effectively seed model takes a map of seed production from the community-level models and delivers a map of seed rain to the community-level models.

The distribution pattern generated is influenced by landscape factors, such as the windiness of the source site, the presence of animal vectors and species-specific factors, such as the distance carried by wind and the animals which are distribution vectors. Although the mechanisms of distribution for some species are well understood, there is no particular need to represent them explicitly in the modelling. Indeed, for the ModMED problem, it was easier to treat the mechanisms implicitly. We characterised each species in terms of the types of dispersal pattern which the mechanisms produced, not the mechanisms themselves.

Dispersal patterns

The model recognises three types of distribution pattern:

Uniform distribution

Seeds released at a location are distributed uniformly among all of the rasters in the landscape. This would be used where there was some uncertainty about the ecology of the distribution, but it was known that the seeds manage to disperse almost everywhere. This may also be an appropriate model for the dispersal of plants that are widespread in the landscape, but are generally present at too low a density for explicit modelling at the community level. Alternatively, it could be used where the seeds arrive all over the modelled area in large numbers for known ecological reasons: the uniform distribution is faster and easier to compute than a large diffuse pattern.

Diffuse distribution

This pattern would be most clearly applicable for wind-dispersed species. The size of the area over which the seeds are distributed will be affected by the aerodynamic characteristics of the seeds and the general windiness of the conditions. An example of a species with such a pattern is *Cistus creticus*. In the model, seeds are dispersed in a circular pattern with the source location at the centre of the circle. There is a density gradient along the radius of the circle, so that the number of seeds falling declines with distance from the source. The size of the dispersion area can be affected by the windiness of the dispersion source site.

Transported distribution

This type of distribution pattern would be the likely result of an animal dispersal. For example, if the seeds of a species are picked up by some animal which then released them elsewhere later - the distribution is related to the distribution of the animal, and not just to the location of the original seed source. *Fagus sylvatica* exhibits this type of distribution.

Up to three different types of animal can be used in the model for each seed species. The seeds are distributed according to the patterns of distribution of the animal types.

Each seed species distribution pattern is calculated as a mixture of the three patterns. For example, the seeds of *Euphorbia dendroides* could be distributed in a mixture of patterns: 50% transported (by animals) and 50% diffuse (by wind).

A separate instance of the dispersal module component is created in Landlord for each species. The module is then configured so that the dispersal pattern generated is appropriate for that species. The following example shows how the different dispersal patterns could be combined. The seeds in this example are released from only a few areas, but the result of the distribution is to spread them over the landscape. Figure 4 below shows the dialog box for defining the diffuse pattern. Several different mathematical models are available which can be selected and parameterised as appropriate for each species. If a map of wind exposure is available then the module can be configured such that seed dispersal distances are greater from the more exposed locations than from sheltered sites. A map of seed deposition is then produced

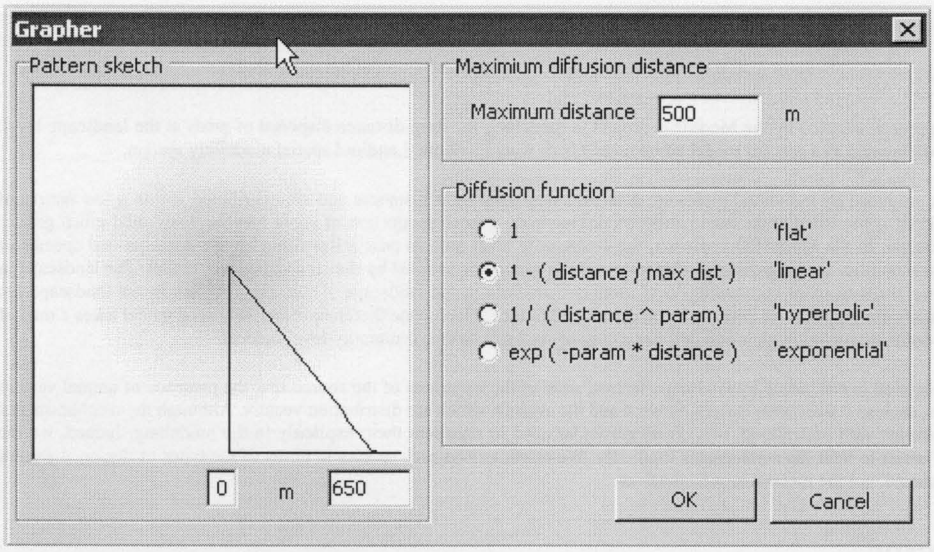


Figure 4 The dialog box for parameterising the diffuse model of seed dispersal.

Example of application: *Eucalyptus globulus* diffusion in Tapada de Mafra, Portugal

Introduction

This report describes the work developed by Duncan Heathfield e Carlos Loureiro in December 2000, as the first attempt to apply the ModMed Landscape Seed Flow Model. We used information available for the Tapada de Mafra area (Figure 1), in SW of Portugal, related with the increase of soil occupation by *Eucalyptus globulus*. A general description of the Tapada can be found in the report by Fillipe Catry *Projecto de elaboracao de cartografia digital de ocupacao do solo para a tapada nacional de Mafra e area envolvente*, Estacao Florestal Nacional 1999/2000.

The information about soil occupation in the study area was in a GIS (Geographic Information System) developed by the project "Project de elaboração de cartografia digital de ocupação do solo para a Tapada Nacional de Mafra e área envolvente. Estação Florestal Nacional 1999/2000", and include the 834 ha of the Tapada, and surrounding area in a total of 6000 ha, for the years 1967, 1974 and 1995. This information is in ArcView 3.2 GIS, and was imported to Idrisi for Windows, to create the images used in Landlord spatial modelling

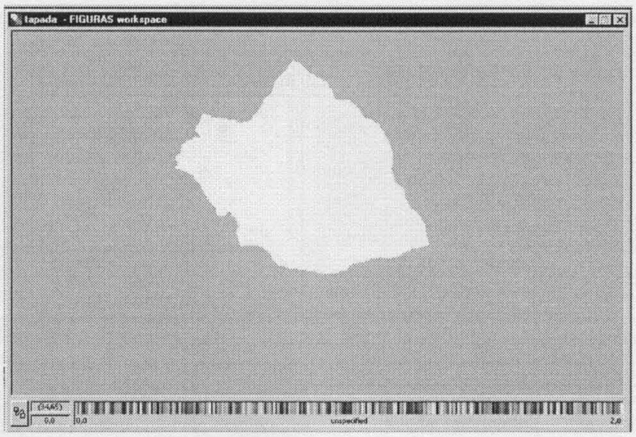


Figure 1 – Study area and the Tapada area in central position.

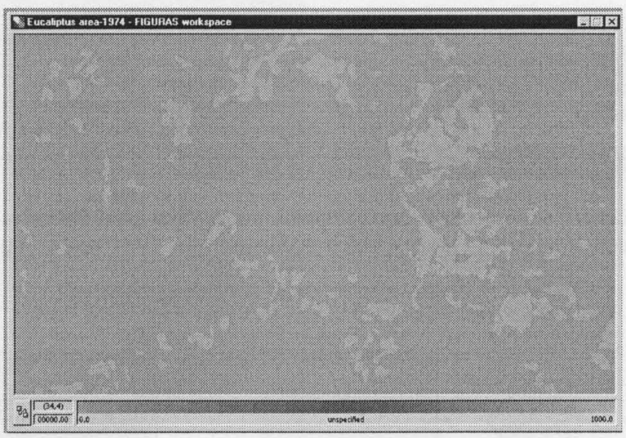


Fig. 2 – Distribution of Eucalyptus areas

The area of *Eucalyptus globulus* (Figure 2) had increased in the last 30 years. Outside the Tapada area, that increase comes from new plantation and from the occupation of abandoned lands. Inside Tapada the introduction of the species comes from the seed dispersion produced in the eucalyptus stands outside.

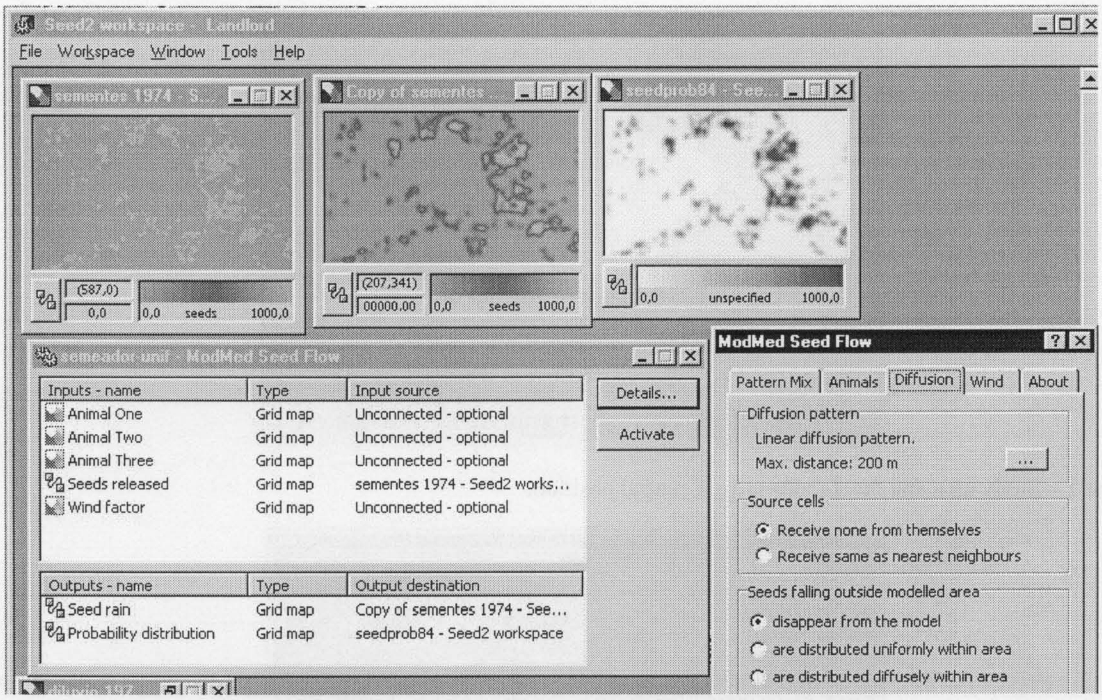
Before 1974 there was no sign of eucalyptus inside Tapada de Mafra. So, we use the 1974 eucalyptus distribution for the surrounding area as input for the seeds released.

According to Goes (1977), the production of seeds in adult eucalyptus stands is in average 3 to 5 kg per ha. The average number of seeds per kg is 400 000, and the germination capacity for that specie is usually near 70%, in nursery. We assumed a value of 2 kg per ha, because we don't have information about the age of the stands, and probably some of them are more young and heterogeneous. We consider only 5% of the seed as having capacity of originate a young tree (4 per m^2). For the maps that we used, with a resolution of 250 m^2/pixel, we get some thing like 1000 seeds per pixel

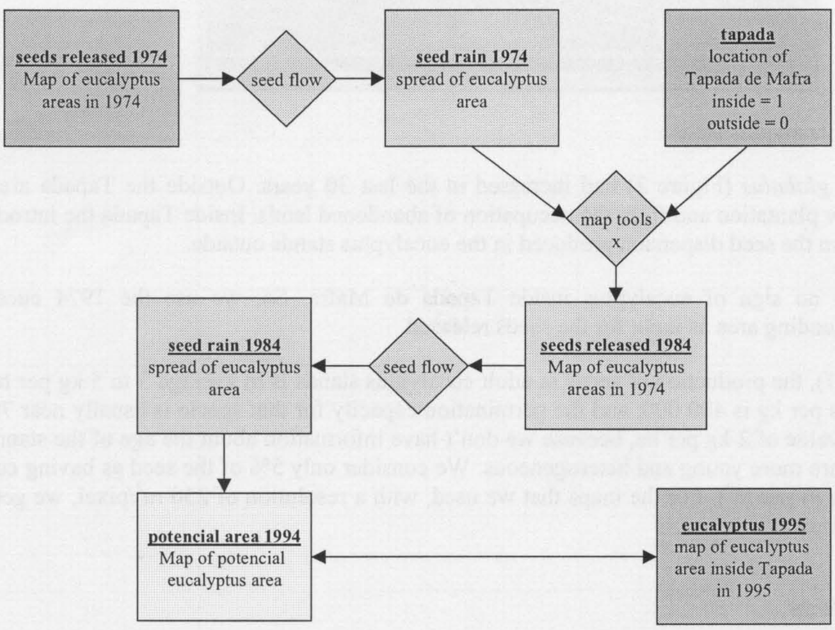
Modelling assumptions

From this scenario we developed two seed flow process, representing a ten years interval each.

We use a linear diffusion pattern, to a maximum distance of 200m, source cells receiving none from themselves, no wind effect.



Starting from the initial scenery new scenarios were created in every ten years (necessary age eucalyptus to reach the cut age), 1974-1984 and 1984-1994. The expected occupation for 1994 was compared with the cartography of 1995.



Results

A relative coincidence is verified in the points of entrance of eucalyptus in the Tapada's area. There is however some differences in the dimension of the foreseen areas and verified.

Some of that difference can be attributed to eventual cuts, to controlling the expansion of the specie.

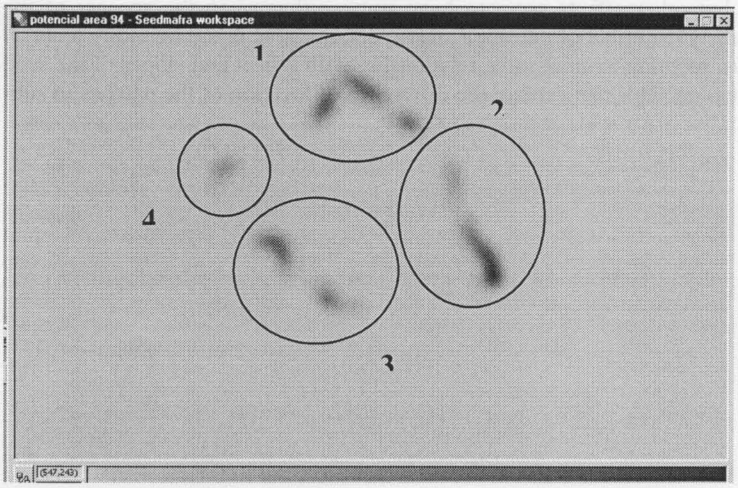


Figure 4 – Predicted eucalyptus areas

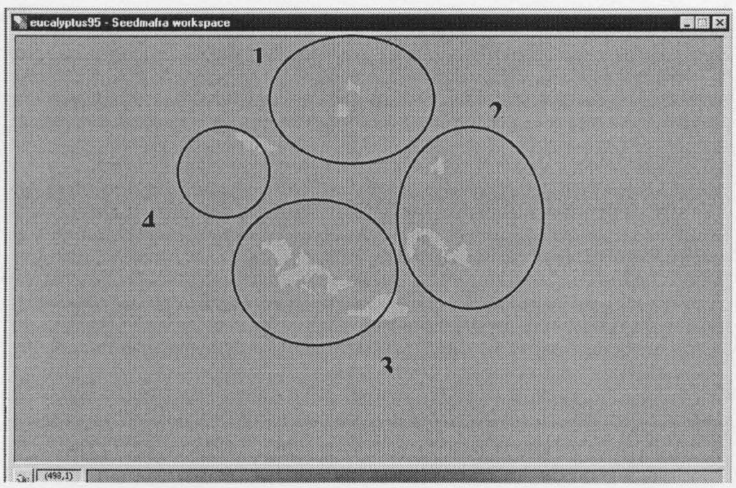


Figure 5 – Eucalyptus areas in Tapada de Mafra, 1995

Analysing the distribution of the eucalyptus patches, we can consider 4 sub-areas. In the areas number 1 and 2 the expected area is superior to the area in 1995. In the peculiar case of number 2 there is a larger penetration of eucalyptus patch inside Tapada. This stand in U presents some coincidence with the valley and the water line, and is inside the burning area of 1981 (see Using the fire model for Mafra). In the area number 3 we found the largest patch, and it is the one that more approaches the forecast. This area coincides with areas of bushes, having also been affected partly by the fire in 1975. In the area 4, although the emergence of a eucalyptus stain is confirmed, this appears slightly moved away, being positioned closer of the water line.

It seems also that exist some relation with the soil occupation. For instance, the substitution of certain shrub areas for eucalyptus seems to be superior to the expected, as well for *Quercus suber* areas (less tree cover), as the inverse is verified for areas of *Pinus pinea*.

Some known alterations and not refered in the cartography, as the case of the forest fires in 1975 and 1981, can be in the origin of areas with higher occupation than expected.

The effect of the wind was not tested, but other effects seem to have some influence in the success of the implantation of new eucalyptus areas, namely the effect of the slope and aspect, decisive in the humidity tenor. It the case of the areas located in the valleys, seeming to exist some relationship with aspect and slopes of the seed reception areas, and probability of germinating. This can explain the difference of location of the patches in sub-areas 2 and 4.