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Application of Forest Inventory Databases in Computer Simulations

By

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Summary

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This paper deals with presenting a broad range of possibilities, which can be used with computer equipment by deriving, interpreting and processing forest data. Different rates of generalized data from the forest inventory can be used as a criterion in preparing different solutions. So this data is a strong influence in decision making processes. The paper also presents cost analysis and multi -criteria evaluation methods.

Introduction

Tools that help us in our work are only as efficient as our knowledge, and include work motivation and the quality of the working environment. Information is the third super-power (the first two are substance and energy), however the present flow of development pushes information to the front line. To get, interpret, save and have information always by hand is everybody's ideal, especially scientists. Gathering information using present day information science, represents a high percentage of all costs, as much as 3/4 in some projects. Without field investigation it is impossible to get reliable data regarding the bioindication of forest site pollution.

To acquire data at state or inter-state levels it is necessary to use a wide net of inventory points. This demands a team of trained people with the knowledge for making objective decisions, equipment for storing data and warning the data inputer against big mistakes. The portable computer is one of the tools which is capable of storing relatively large amounts of data, has user-friendly software and is very reliable. In countries with high man-power costs portable computers are already common equipment and practical courses are being run as a part of the

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course content at faculties. With a portable computer for field work it is possible to avoid long and continued data input in the office and the software controls the input by preventing the input of large errors. It is also possible to immediately acquire all the computer applications, data representation and analysis. Finally it is possible to link the data with the geographical information system (GIS) and thereby be able to study influencing factors and their relations.

Mostly three computer databases are used in present forestry praxis and research work in Slovenia. These are: forest inventory database (MIKULIČ 1990) (updated every ten years), digital elevation model (RIHTARŠIČ & FRAS 1991) and forest decline inventory database (BOGATAJ & al. 1994). A relatively extensive database of forest inventory contains forest stand data, sites, volumes, ownership, geological and floor conditions, function of forest etc. A basic cell is a section or a subsection with an average area of 12 ha. With the digitalization of the borders of basic cells we are able to present the information we gathered from the field as a whole area. We are then able to make raster thematic images (maps) which help us to study a variety of topics (site pollution, determine vulnerability specific forest associations and objects of the natural environment, time analysis etc.).

It is also possible to acquire raster thematic images of larger areas. We devised the algorithm which converts data from the forest inventory database to a raster representation. Programs convert data from basic cells (subsections) into raster files the size of which is 25 ha. Accuracy is lowered, but we profit by a land overview in land modeling and also we avoid time consuming digitalization of subsections. Fig. 1 shows a raster image of some forest functions which was acquired by these procedures (KOŠIR & KRČ 1994).

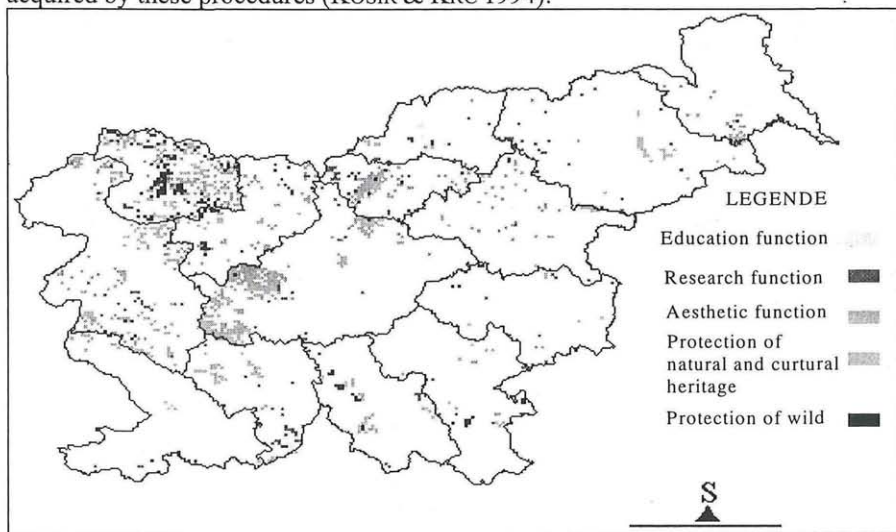


Fig. 1. Raster image of the presence of some forest functions

Forest decline databases can also be used. They contain data for the years 1987, 90, 91, 93, 94 and are collected by recommended methodology for forest

decline in Europe (UN/ECE - ICP Assessment and Monitoring of Air Pollution Effects on Forests, 1994).

Studies that are space concerned often need three dimensional representation and data from a digital elevation model. We can also use the computer database of a digital elevation model which was made using available cartography bases. On the map (1 : 25000) every 100 x 100m Z-coordinate (elevation) was digitalised.

All these possibilities offer access to data which is used in Environmental Impact Assessment (EIA), location decision problems, sanitation studies and a variety of others.

Cost analysis

The decision process often needs not only basic data: in many cases data has to be derived or in some way extracted. A specific procedure is used to get information we require. We can already get some useful conclusions in preparing input data. Examples of such data are: gravity fields, haul direction ways, watersheds, crest point extraction etc. Cost analysis is very useful and a frequently used one. A raster image of friction that affects movement through space has to be created. Base costs of movement through space has to be determined (for example movement on an even, smooth surface). Due to the surface of the cell and study areas we are able to define multiple base costs belonging to each raster cell. Isotropic and anisotropic cost analysis have to be separated. With isotropic analysis friction has to have an identical effect in any direction. Costs of movement are

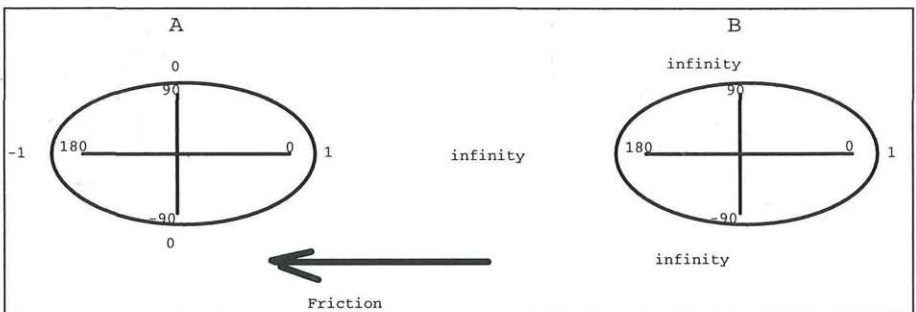


Fig. 2. Friction influence on movement of phenomena that have their own motive force(A) and friction influence on movement of phenomena with no motive force of their own (B)

calculated in terms of distance equivalents. This means that total costs are calculated as a sum of friction, containing cells on way from points to destinations. In anisotropic cost analysis friction has different effect in different directions. The moving force through space is functionally related with the direction of movement, that is with different angles (angle between moving and friction direction). There are two different modules for the analysis of anisotropic cost. We have the possibility to simulate the movement of phenomena that have their own motive

force (Fig. 2 case (A)) and movement of phenomena that have no motive force of their own (for example gravity force, wind force, water flow force etc.). Fig. 2 shows these two kinds of movement and a possibility for friction regulation by different difference angle.

Model type (A) can be used for variety of transport and allocation problems, while model type (B) is convenient for air pollution simulation, efficiency of noise protection, flow of dangerous poisoned liquid, fire spreading, calamity of mischief-makers, pest controls etc.

Multiple -criteria evaluation method

When we have sufficient information on a suitable computer media which have to be in a correct database form, we can use the algorithms which help us in the decision making process. A method by which computer procedure has been written is a method called Multi-Criteria Evaluation (MCE). The method is based on decision theory by which a logical decision arrives at a choice between alternatives. Criteria are a bases for decisions. Criteria can be of two kinds: factors and constraints. Factors are measured on a continuous scale. They detract from the suitability of a specific alternative under consideration. Constraints limit the alternative under consideration. The procedure by which criteria are combined to arrive a particular evaluation is known as a decision rule. Decision rule combines criteria into single composite index for comparing or evaluating different

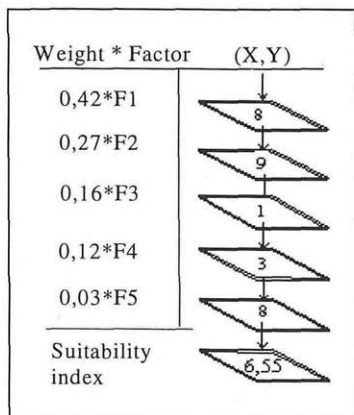


Fig. 3. Weighted linear combination

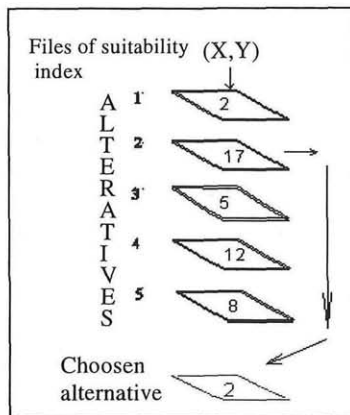


Fig. 4. Procedure of choosing the best method alternative

alternatives. To meet a specific objective it is frequently the case that several criteria are needed for the evaluation. A very common procedure for multi -criteria evaluation is a weighted linear combination where each factor is multiplied by a weight and then totaled to arrive at a final suitability index. The procedure for arriving at the suitability index (Fig. 3) follows several different possibilities of choosing one of the alternatives. Relations between alternatives may be complementary (non conflicting) where a specific space can serve several functions

at the same time or conflicting where alternative solutions compete for available land since it can be used for one or the other, but not both. Fig. 4 shows a simple case of choosing the best alternative.

The main point of Multi -Criteria Evaluation represents a question on how to combine information on the criterion in a final suitability index. The creative point of the method is choosing the best criterion, and its standardization that is positively correlated with suitability and weight development for factors. A variety of techniques exist for the development of weights. Some types of software (IDRISI) are using the pairwise comparison method which compares the relative importance of the two criteria involved in determining the suitability for the stated alternative. Rating is provided on a continuous scale. Weights are derived by taking the principal eigenvector of a square reciprocal matrix of pairwise comparison between the criteria.

Conclusion

We have to obtain representative data which is professionally represented and predict possible events to avoid the situation of self-sufficiency of databases and cases where just financial pointers and subjective decisions have the final weight in deriving at a decision. Minimally, we have to be familiar with tools and methods, which help us in providing stronger bases for our decision. Rational management and simplification has to be guided in specific professional borders (limits), as this is the only way for a proper and accurate understanding of our arguments.

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