Development of an Indicative Forest Strategy with specific reference to Co. Clare[1]

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Summary

An Indicative Forest Strategy (IFS) embodies the idea of putting the right trees in the right places. A study was carried out to develop an IFS with specific reference to Co. Clare. The aim of the study was to provide a scientific basis to assist future policy decisions regarding potential locations of forestry, taking into account factors such as tree productivity and environmental resources. Development of the strategy was based on Geographical Information System (GIS) technology, thereby allowing the input of a large number of varied spatial information types linked to related database information. These can subsequently be displayed, analyzed and queried in an interactive fashion, thereby providing answers to queries posed. Spatial and non-spatial information inputted included soil type, bedrock geology, elevation, infrastructure, existing land uses, available grant aid, water resources, landscape, heritage, and potential European Union (EU) designated special areas of conservation. Such data and the related database information were then subjected to a series of geoprocessing techniques to produce thematic datasets which included yield class, Windthrow Hazard Classification (WHC), site workability and water resource sensitivity. The resulting information was then displayed, manipulated and interrogated in an interactive fashion to answer more complex user defined queries relating to various potential locational scenarios.

Definition of an Indicative Forest Strategy

An IFS is a planning tool which aims to guide the location of grant-assisted afforestation in a structured and coordinated fashion. It offers a platform to monitor the pattern of developments and to evaluate alternatives which arise or which may potentially arise. Most importantly, it allows the decision makers full possession of spatially accurate, relevant and up-to-date information. To be effective, it must be flexible in order to enable it to accommodate the integration of new data with existing data.

It is imperative that accurate and well-planned information is used in the siting of new land uses so as to minimize their impact on the environment. Locating new land uses is a difficult and complex task requiring a multi-disciplinary approach if optimal sites are to be successfully identified.

An IFS is designed to indicate to planners, investors and government agencies areas of interest from a forestry viewpoint. A GIS is probably the most suitable tool for this task, as it allows the user/analyst to spatially locate all the options and to examine their individual and cumulative impact. It is this inherent flexibility that makes the GIS approach so useful.

Success requires that an unbiased strategy be developed to blend forestry into a land use pattern in harmony with agriculture, the environment, the landscape and the public. This strategy must be an impartial assessment of the current needs for forestry. It must allow the most suitable areas to be identified for future forestry development. Using GIS, this system offers a suitable platform capable of analyzing the available data and producing, according to a predetermined series of criteria, a set of proposals indicating where future forestry could achieve the maximum benefit in an overall land use policy. This requires taking a broad view of the current situation and underpinning it with as scientific a basis as possible, so that if and when future conflicts arise, constructive discussion based on facts rather than misinformation, traditional values or folklore can take place.

The objectives of this study, which was focused on Co. Clare, were as follows;

- To assess the feasibility of developing an IFS using GIS technology.
- To assess the impact an IFS planning system could impose on Irish forestry.
- To identify the level and quantity/quality of the available data necessary to complete the study.
- To identify the sources and location of these datasets.
- To provide the decision maker with accurate, relevant and timely information within a system which can evaluate alternatives easily and flexibly.
- To establish a basis from which forestry developments can be assessed.
- To identify the sensitivity of particular areas to forestry development.
- To identify areas where forestry may be actively and positively promoted.

Geographic Information Systems

A GIS is a computerized database of information describing the physical, sociological and demographic data within a physical area. It utilizes two basic types of geographic data, *viz.* locational and statistical. For example, on an aquifer protection map, the location of any water source would represent a point data source, while the volume of water produced and its quality would represent its associated statistical data. A GIS is designed to accept large volumes of spatially related data derived from a variety of sources, including digitized maps illustrating topography, hydrology, population spread and land zonation. A GIS is a flexible tool which uses geography to bring previously disparate data together so that they can be utilized for both analytical and decision making purposes. Once data has been captured, the GIS can conduct spatial analysis based on selected criteria submitted by the user. The system eliminates land areas which do not meet established criteria, leaving areas which, according to the criteria, may be suitable for particular land uses. Such areas can then be easily displayed on computer.

In any planning process, planners require vast quantities of data to assist in the development of a comprehensive yet accurate plan. In this context, when one considers the environment, one is essentially concerned with the intricate spatial structure and the functional and spatial interrelationships between the environmental system components. Land use planning as an environmentally based project is difficult, as it involves many disciplines. Therefore, many disparate data types and sources are encountered, each of which may encompass large volumes of data. The key to the utilization of this data is a system which is capable of acquiring data in a variety of forms and from different sources, and manipulating it into a useful format. Such systems must be capable of storing, analyzing and then easily and accurately retrieving the relevant data on demand.

GIS is an enabling technology for integrating and analyzing large and complex datasets. A GIS can also be used as a means of deriving and implementing different forms of geographical, inductive or predictive models. GIS technology has been used in many instances to integrate disparate datasets to 'unlock' pertinent information, at both a regional and national scale, e.g. the development of a land cover map for Scotland. The wealth and variety of information which can be stored in a GIS create the potential for a wide range of integrated analyses and evaluations with relevance to many aspects of land use planning.

Development of the Indicative Forest Strategy for Co. Clare

The initial development of the IFS for Co. Clare focused on the collection of baseline datasets. As this was to be a simulated land use planning process in which site location played a significant part, both the economic viability and the environmental acceptability of potential sites needed to be assessed and combined. Soils play a major role in any land use planning process. In forestry, soil is the growing medium providing both nutrition and anchorage. The soils dataset therefore occupies a place of special significance as it acts as the basis for the development of the strategy. The data source used was the Teagasc (An Foras Taluntais) National Soil Survey. This was digitized from six inch scale maps into ArcCAD™ and stored at half inch scale. Other relevant datasets collected included Coillte Teo. inventory datasets, Office of Public Works (OPW) datasets relating to Natural Heritage Areas (NHAs) and National Monuments, and datasets relating to county infrastructure and watercourses.

As the strategy's development was aimed at providing information to decision makers, large quantities of data needed to be collected. Data capture represents the largest single phase of GIS development. As such, it is one of the most time consuming and therefore costly sections of any GIS-based study. The success of a GIS project depends to a large extent on both the quantity and the quality of the data being utilized. Data collection normally involves digitizing, scanning and textual data entry. In this study, these tasks were completed separately using a variety of software packages, including AutoCAD™, ArcINFO™ and PC-ArcINFO™ (for digitizing), ArcSCAN™ (for scanning), and FoxPro™ (for textual data entry).

Effective utilization of data required the development of a structure and methodology to integrate the datasets usefully. A methodology was therefore developed which permitted the GIS simulation of the IFS land use planning process. This can be summarized as follows.

1. A selected objective is defined.
2. This definition is translated into GIS goals.
3. Data collection is undertaken to meet these goals.
4. The datasets are integrated to a common base.
5. The data is analyzed to produce a coherent result.

The definition of objectives is an essential section of any GIS-based project, as it enables the system designer to accurately identify the minimum number and type of datasets necessary for successful completion of the objectives. This provides focus and avoids the collection of unnecessary data.

The utility of these datasets was tested in the case study, the objective of which was to find suitable locations for 'commercial' afforestation developments in Co. Clare. This can be thought of as being a particular objective set within the overall context of the pilot IFS for Co. Clare.

Definition of objectives involves the establishment of parameters within which suitable forestry locations can be defined. The factors that govern site location include the projected productivity, site workability, the type and level of grant assistance available, and the likelihood of the crop reaching maturity. To succeed in identifying afforestation sites and to achieve a suitable balance, certain threshold levels were established for each of these parameters. These constraints define the objective more concisely. In this instance, 'commercial' was set at an arbitrary yield class ≥ 16 m^3/ha/yr, Windthrow Hazard Classification (WHC) ≤ 4, elevation < 330 m, and slope $\leq 15°$. Thus, the initial datasets included yield class, WHC, elevation and slope.

Defining the objectives in GIS terms

The translation of objectives into GIS goals is accomplished by the process of developing a series of relevant questions. These queries are structured in a specific fashion so that they exclude excess data as the process progresses. For example, the translation for the question "Where are there highly productive sites for forestry?" involves querying the datasets to spatially locate areas with a yield class ≥ 16 m^3/ha/yr. All areas with a yield class below this threshold level are then excluded from any subsequent search. Further questions are posed so as to further refine the searching process, e.g. "Identify any of these sites with a WHC $\leq$ 4.".

Data collection

Data capture represented over 60% of the project development time. The datasets developed to answer the expected range of questions included topography, soils, water resources, existing land uses, and infrastructure and environmental information. From these baseline datasets, other information was derived to produce a series of thematic maps which address the questions posed in the siting criteria. The derivation of each of these coverages involved the use of several other coverages which, following combination through polygon overlay and dissolving techniques, generated new datasets.

To satisfy suggested constraints, the first coverage to be developed was yield class. This was completed by intersecting Coillte properties with the soils map, and then selecting all those subcompartments with Sitka spruce (*Picea sitchensis* (Bong.) Carr.), 100% canopy cover and a pre-1976 planting year. These were then grouped by soil type. Coillte yield class figures for each of these subcompartment was recorded and a weighted average yield class calculated for each soil type, using the Statistical Analysis Program (SAS) to narrow the yield class range subsequently attributed to each soil type. These values were then related to the soils database and a coverage of extrapolated yield class values developed. The yield class coverage was then queried to identify all areas with a yield class $\geq$ 16 m^3/ha/yr. This represents the first thematic map produced from the process.

Integration of datasets

Most siting studies begin with a defined geographical study area and are limited to the siting of a particular facility within that area, e.g. the siting of an electricity power station within a particular county. In this study, however, the siting was not restricted to a single site, but instead encompassed a host of potential sites. A top-down approach was used. This approach is typical of siting studies encompassing large areas which can only be reduced to more manageable site specific areas by applying screening criteria. The screening criteria eliminate unsuitable/ineligible areas, thereby reducing the original area to successively smaller land units.

In this study, screening criteria which satisfy the minimum requirements for successful commercial afforestation were developed. These factors can be thought of under two headings, *viz.* technical and environmental.

As previously described, potential sites for commercial afforestation had to satisfy the technical threshold criteria yield class $\geq$ 16 m^3/ha/yr, WHC $\leq$ 4, elevation < 330 m, and slope $\leq$ 15°. Adherence to these criteria enabled the identification of sites capable of generating a positive long term financial return. Short term cash flow difficulties associated with forest establishment can be alleviated by obtaining State grants from the Forest Service, provided such afforestation conforms to various specified environmental constraints (these constraints are addressed in the second phase of the study).

During the first phase, the datasets for yield, stability, elevation and slope categories for the entire county were mapped and screened for sites which satisfied the technical criteria specified above. This was completed by preparing a series of thematic coverages for each constraint. These were then overlaid on a half inch (1:126,720) base map, and a composite coverage of all overlays prepared as one coverage. This coverage represents all the areas which met the technical constraints set. This first stage served to reduce the study area to more manageably sized land units. In quantitative terms, it reduced the study area from 347,418 ha to 119,441 ha.

During the second phase, a similar screening process was applied to these smaller land units to determine the extent of land available for commercial afforestation within the county. This was completed by identifying and quantifying the extent of environmentally sensitive areas and then excluding such areas from consideration for planting. A series of polygon coverages which included NHAs, rivers (buffered to 10 m), roads (buffered to 1 km) and designated views (buffered to 1 km) within the study area were developed.

These environmental polygon coverages were sequentially intersected with the coverage of technically suitable areas to identify the exclusion zones. During this procedure, the technical coverage was reduced in a stepwise fashion involving the gradual removal of all areas with environmental restrictions. These environmental and planning constraints are similar to the Forest Service grant aid criteria. By adhering to these constraints, therefore, the remaining sites are not only deemed suitable from the technical and environmental perspective, but also qualify for Forest Service grant assistance. The net result is that 100,085 ha within Co. Clare are deemed suitable for commercial afforestation, according to the particular criteria laid down for this test case.

Discussion

It is envisaged that this system could operate from a national to a townland level, thereby offering the Forest Service a recognizable yet more comprehensive and structured format to assist in the assessment of grant applications. It may also improve the monitoring and assessment of the development of the private estate. As part of an integrated planning structure, the system is both updateable and expandable. Similarly, it can be utilized for database analysis of both existing and future afforestation. For example, by including the recently commissioned Private Woodlands Inventory in a digital format, the Forest Service can identify on a spatial basis where grant assistance has been used in planting. It can also answer questions posed by the EU regarding the effectiveness of the Ireland's forestry programme, by literally illustrating advances made on the ground and by identifying where the next batch of funding is to be applied. Planning will no longer have to be completed on the basis of pages of statistics - it can now be visualized. At a national level, a completed IFS including all relevant datasets can be used to plan for the industry as a whole, for example, by answering questions relating to the current and future availability of timber and the optimum location of processing facilities. These and similar questions can be assessed in a scientific manner without unnecessary political influences being imposed.

The system's scientific basis can also be used to assess areas falling below commercial forestry threshold levels, and whether or not such areas warrant special investigation or exclusion from grant assistance programmes. For example, by further development of the yield class and WHC datasets, it would be possible to identify areas where it would make good silvicultural sense to plant. This system would contain all the necessary scientific data to support the Forest Service in decisions regarding specific grant applications, e.g. the exclusion of areas with a high WHC. As a management tool, inspectors could access this information at an early stage of individual applications, thereby avoiding unnecessary expenditure of time and resources on developing uneconomic and ineligible applications.

One of the more recent Forest Service developments, in which forestry contractors are encouraged to monitor and manage recently developed sites, could also be assessed, monitored and easily updated. In the near future, it may be possible for more progressive contractors to provide their applications in a digitally-compatible format, thereby reducing the processing time for grant applications. This would allow the Forest Service more time to plan for the future and to integrate forestry as a land use.

A planner equipped with easy access to relevant information is in a better position to make decisions about future development, i.e. land use planning. Planners therefore require timely and accurate information on existing land cover and land use. A GIS can be utilized to consider the impact of previous and current trends in land use by evaluating the environmental, biological and socio-economic developments. The analysis of changes in the land cover results in the provision of statistics which can be inputted into models. Analysis of land use changes can also illustrate changes in respect to individual factors or groups of factors, e.g. the impact of woodland removal on the population of a particular species of bird, and the downstream effect on other elements of the ecosystem. Planners can establish associations between the individual land use components by overlaying land uses and by comparing their interactions and changes. This often helps planners to decipher how decisions producing land use change are made in relation to associated resources and environmental issues.

The ability to conduct spatial analysis is one of the most significant functions of a GIS. These functions can be used to answer a variety of questions, presenting solutions in map, tabular or graphical form. Typical questions suited to GIS analysis include "Where?", "How much?" and "How far?". This analysis operates by producing maps of particular phenological features. These maps are referred to as being thematic as they display information about a single subject or theme.

The ability for planners to assess the future impact of their actions is an essential element in today's land use planning process. An inherent flexibility offered by a GIS is the ability to assess several potential scenarios, to identify the most appropriate combinations, and to explore their consequences. Irreversible mistakes can be anticipated and therefore prevented. Potentially, this provides planners, policy makers, resource managers and decision makers with a powerful tool for understanding the possible consequences of their actions and decisions. It is this facility which makes the IFS completed on a GIS basis so useful. If the EU decided to alter its forestry policy, the IFS system could easily accommodate the changes and examine the resulting impact. This would offer the Forest Service hard facts to argue their case in favour or against potential changes.

Conclusion

This paper indicates some of the potential of an Indicative Forest Strategy. It is not necessarily a 'big brother system', but rather a dynamic management planning tool. Its potential development is considerable as its flexibility, expandability and usability are easily integrated into every facet of research and management. The particular case study described identified 34% of Co. Clare as being 'technically' suitable for afforestation. Common problems facing forestry, however, are the increased environmental pressures and public awareness regarding the environment. As public opinion becomes more organized and vociferous, forestry needs to make its decisions on the location of new afforestation as transparent as possible. An IFS offers a forum within which a variety of opinions can be discussed, assessed and objectively examined.

This paper outlines just one of many possible scenarios within the overall structure of the IFS for Co. Clare. With adequate definition of the objectives and subsequent data collection and manipulation, any number of potential scenarios can be analyzed, e.g. the quantitative result of a hypothetical EU policy decision to enforce a 25 m riparian buffer zone, and which counties would be most affected. In the future, the area of water sensitivity and the natural buffering capacity of the bedrock geology will play an important part in locational decisions.

It is expected that with a completed database, the Forest Service will be able to assess incoming grant applications not only on an individual basis but also as components of an overall forestry development strategy. This will permit assessment right through from the townland level to the regional, provincial and national level.

A further development could be the implementation of GIS-based Environmental Impact Assessments. The data generated from these studies could be assimilated into a GIS to be used for future analysis and planning purposes.

Following the described methodology permits the development of a dataset capable of answering specific questions. In the Co. Clare case study, Sitka spruce was examined. However, Doulgas fir (*Pseudotsuga menziesii* (Mirbel) Franco), Japanese larch (*Larix kaempferi* (Lamb.) Carr.), Norway spruce (*P. abies* (L.) Karsten) or broadleaf species could equally have been studied. It is intended that the developed methodology will be utilized for other species and that a weighted system be established to indicate site-species preferences. Similarly, the methodology can be applied to other land uses or a series of land uses. Ultimately, a complete, integrated land use planning process could be developed on such a computer-based GIS.

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