PLANNING SUSTAINABLE LAND USE SOLUTIONS

LADSS
LAND ALLOCATION DECISION SUPPORT SYSTEM

Welcome to the second edition of the LADSS newsletter. The purpose of this edition is to provide an update on the progress being made in the development of LADSS and to announce the second LADSS workshop to be held in August 2000 (see back page for details). With the expansion in the numbers of people working on LADSS the newsletter also provides an opportunity to profile the LADSS team.

In the field

In the last newsletter we requested volunteers to participate in the field testing of LADSS. We were quite overwhelmed by the response, especially as we ultimately could only tackle three sites at the level of detail required for the testing and validation exercises. Indeed choosing the test sites was a complex multi-objective problem in itself. We had to balance how "interesting" the land management issues, and biophysical characteristics of the site were against our need to test LADSS capabilities. It was also important for us that the new sites complemented and contrasted with the existing ones at Hartwood, Glensaugh and Altyre in Morayshire. The sites chosen were Balmacara Township, an NTS property near Kyle of Lochalsh, Edinglassie Estate near Huntly in Aberdeenshire

Balmacara, April 1999.

and Faughill Farm, part of the Buccleuch Estates near St. Boswells. Our thanks for their cooperation are thus due to Mr Iain Turnbull of Balmacarra, Mr Malcom Hay and his agents Strutt and Parker of Edinglassie and Mr Drew Guthrie of BQ Farming Partnerships for Faughill.

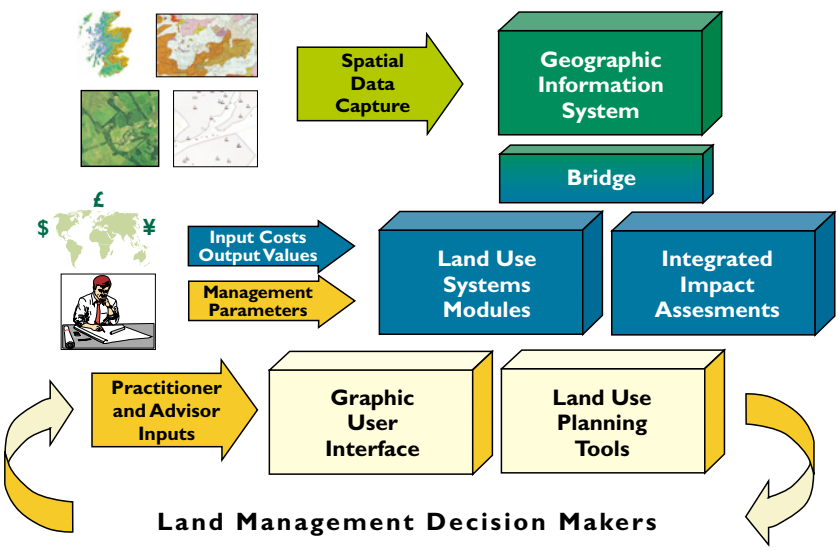
Fieldwork was carried out from March to December (apparently well beyond the field season!) with nearly 1/2 tonne of soil samples being returned to MLURI for analysis.

(Continued on page 2

What does LADSS do?

- Supports ***strategic***, ***farm-scale***, land use planning by suggesting possible combinations of land uses to meet ***multiple objectives***.
- Provides a framework within which the financial, social and environmental consequences of changes in land use may be evaluated.
- Demonstrates an approach to ***integrating spatial data*** and analysis methods with land use ***systems models***.
- Acts as a channel for technology transfer from land use scientists to land management practitioners and to facilitate the incorporation of practitioner knowledge into the models of land use systems.

LADSS Components



Geographic Information System:

The distribution of of bio-physical resources across the management unit is crucial in determining the range of land uses and their spatial pattern.

Land Use Systems Models:

Field-by-field predictions of suitability, productivity and gross margin returns. Currently: arable, livestock, conifer and broadleaf trees

Integrated Impact Assessment:

- Financial (net present value)
- Social (employment - seasonal and long term)
- Environmental (landscape morphological measures).

Land Use Planning Tools:

These evolve patterns of land use with the *fitness* of individual patterns set by how well they achieve land managers' goal(s).

All three sites had aerial photographic coverage flown on some of the most spectacularly clear days of last year. An infra-red video camera system was also experimentally deployed for the last flight of the year and is proving both difficult to analyse and highly rewarding for the effort (see the example of integrating the data from the two sensors on page 3). Analysis of the field surveyed data is beginning (as of May 2000) with experiments to determine the impact of sampling density on accuracy of soil mapping and the potential role of remote sensed data in enhancing or substituting field sampling being investigated.

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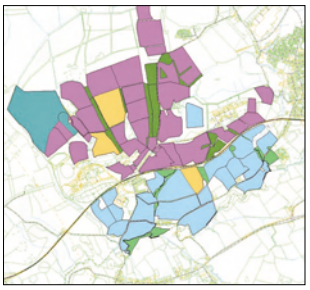
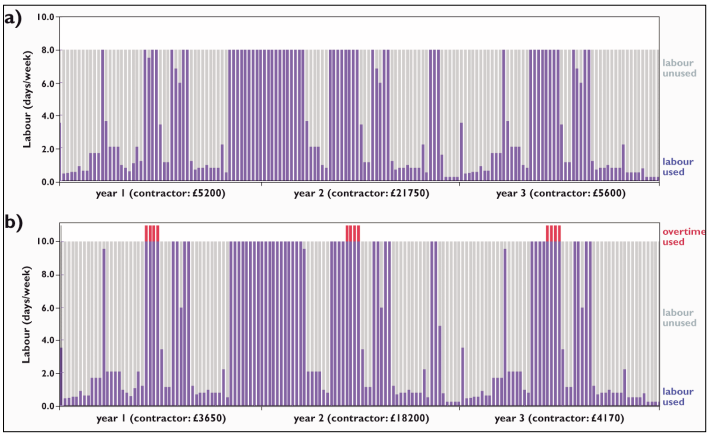
In the light of the comments made at the first LADSS workshop three system development areas were prioritised: social impact assessment, adding a broader range of land use modules and implementing multi-objective land use planning tools. Substantial progress can be reported in all three areas.

Social Impact Assessment

The LADSS social impact assessment module assesses the amount and type of employment required by a pattern of land use both week to week within the year and over the long term. The prediction of labour requirement takes into account numbers and types of machinery available and uses a calendar approach to set the windows when jobs may be undertaken and deadlines by which they must be completed. The system



Example of a land allocation plan and annual labour profiles showing available farm labour. The profile shows when additional labour must be employed and when there are opportunities for farm labour to seek off-farm employment.



Patterns of weekly labour required in the first three years for the same land allocation plan with two levels of on-farm labour availability: a) One full time worker and one part time (3 days per week) worker; b) Two full time workers with eight hours per week overtime available. In both cases contractors are used for activities which cannot be scheduled to farm staff. Contractors' costs are shown for each year (woodlands were planted in year 2).

can cope with full-time, part-time, seasonal and contractor labour. Outputs from the module include the financial costs and profiles of availability and utilisation for all resources.

Additional Land Use Systems Models

With the appointment of Mike Rivington (see The people building LADSS on page 6) we have begun to undertake a review of existing models of land use systems (or their components) relevant to LADSS applications. While the review has

Faughill, October 1999.

yet to be completed it is becoming clear that while there are many excellent models available there are serious issues translating models built in a research context into cost effective decision support tools. Mike has, however, found some American colleagues with generic models that may be reparameterised for Scotland. In a further significant development we will undertake from 2001 the integration of LADSS with the HillPlan decision support tool, developed over the last four years at MLURI. This will allow us to begin to look at some of the issues facing Estates and farms with extensive semi-natural grazings.

Multi-Objective Land Use Planning Tools

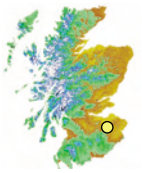
One of the primary goals of LADSS is to assist land managers in making complex multi-objective planning decisions. To this end a number of innovative multi-objective land use planning tools have been implemented. These tools search for a number of alternative allocations that show how one objective trades-off against another, for example financial versus environmental benefits. Ideas behind the tools are explored on page 5 and the evaluation of the tools is to be the subject of the LADSS workshop (see back page).

On the Internet

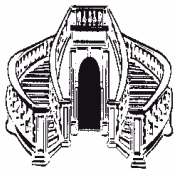
To complement the LADSS newsletter we have put together a LADSS website (http://www.mluri.sari.ac.uk/LADSS.htm). The site details why we are developing LADSS, an outline explanation of the systems structure, implementation details and copies of papers giving scientific details. The web pages also present LADSS examples that cannot be easily accommodated within paper media. The site also links to suppliers that have helped in the development of the system and academic/land management practitioners participating in LADSS development.

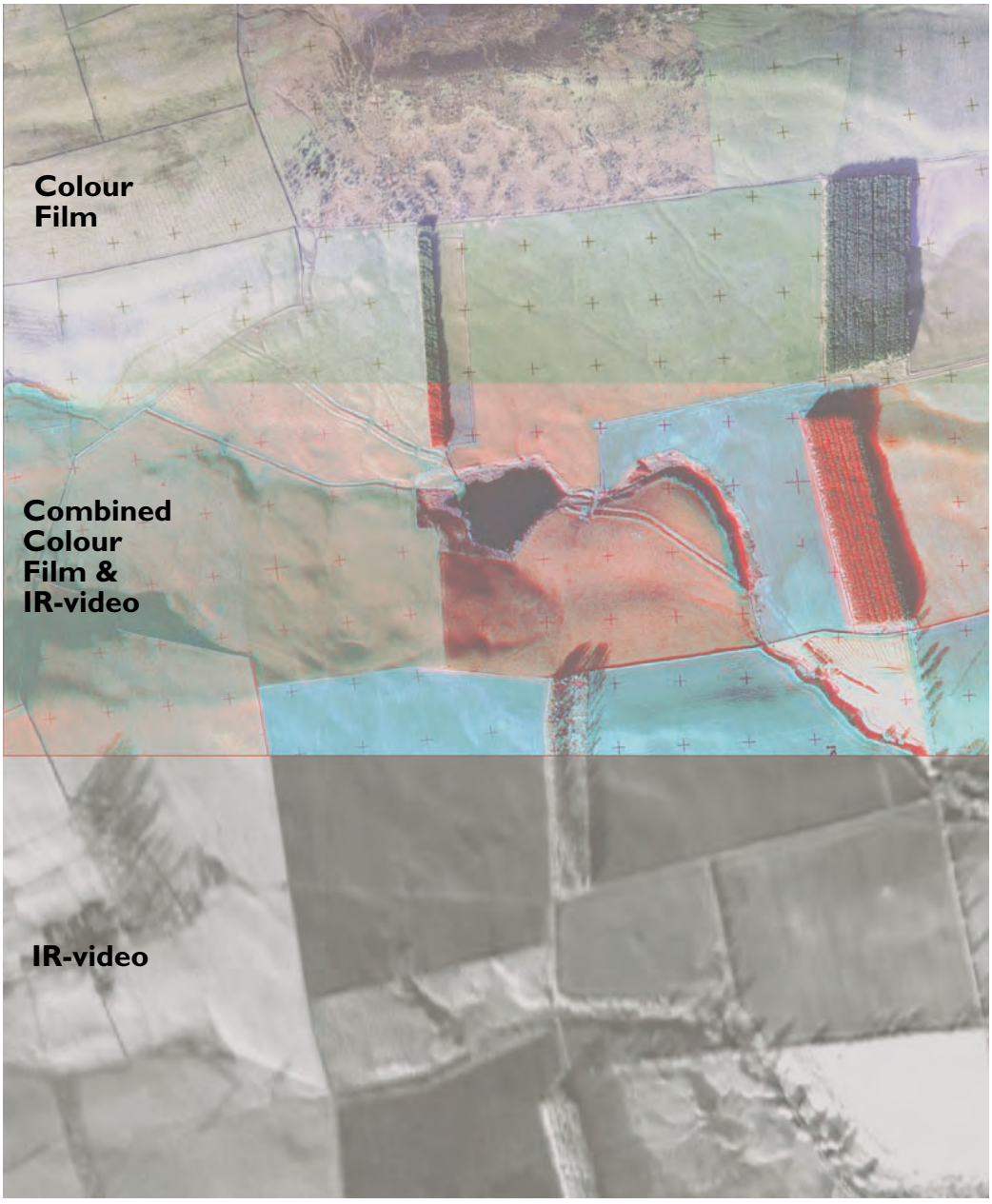
Edinglassie, June 1999.

Buccleuch Estate - Evaluating Low-cost Aerial Photography / Videography



Example: **of the imagery created by the fusion of data from colour aerial photographs and infra-red video.**

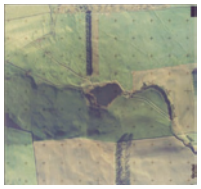




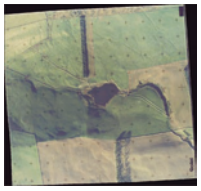
The process: Ortho-Rectification

In this process the raw images are corrected to a base map (either the O.S. 1:2500 or 1:10,000 scale). This process removes distortions introduced by the attitude and movement of the aircraft, the shape of the underlying terrain and the optics of the camera. The individual images are then combined together in a mosaicing process to create the complete photo-map.

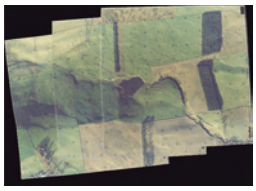
Original



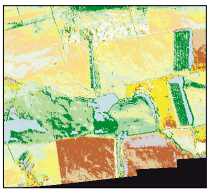
Ortho-Rectified



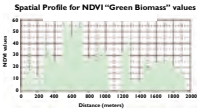
Mosaiced

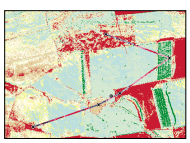


Applications:

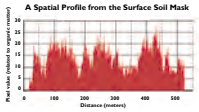


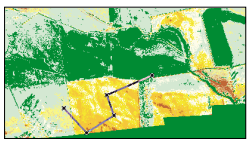
Land Cover





Biomass Estimation





Surface Organic Matter

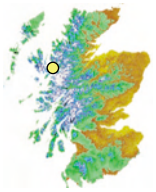
Instrumentation: Technical Specification

- Colour Photography was obtained using a Rolleiflex 6006 metric camera, with a Zeiss Planar f2.8/80mm lens, with Kodak Vericolor 400 film.
- Infra-red images were obtained using a PULNiX TM-765i camera (2/3" ccd array 756x581), with a Cosmicar f1.5/8.5mm lens, using a Kodak Wratten 88a filter. Video was recorded on a Sony GV-S50E - portable Video8 recorder.

All images were rectified using Erdas OrthoBase 8.3/8.4

PULNiX

Balmacara Township - Evaluating Site Survey Strategies

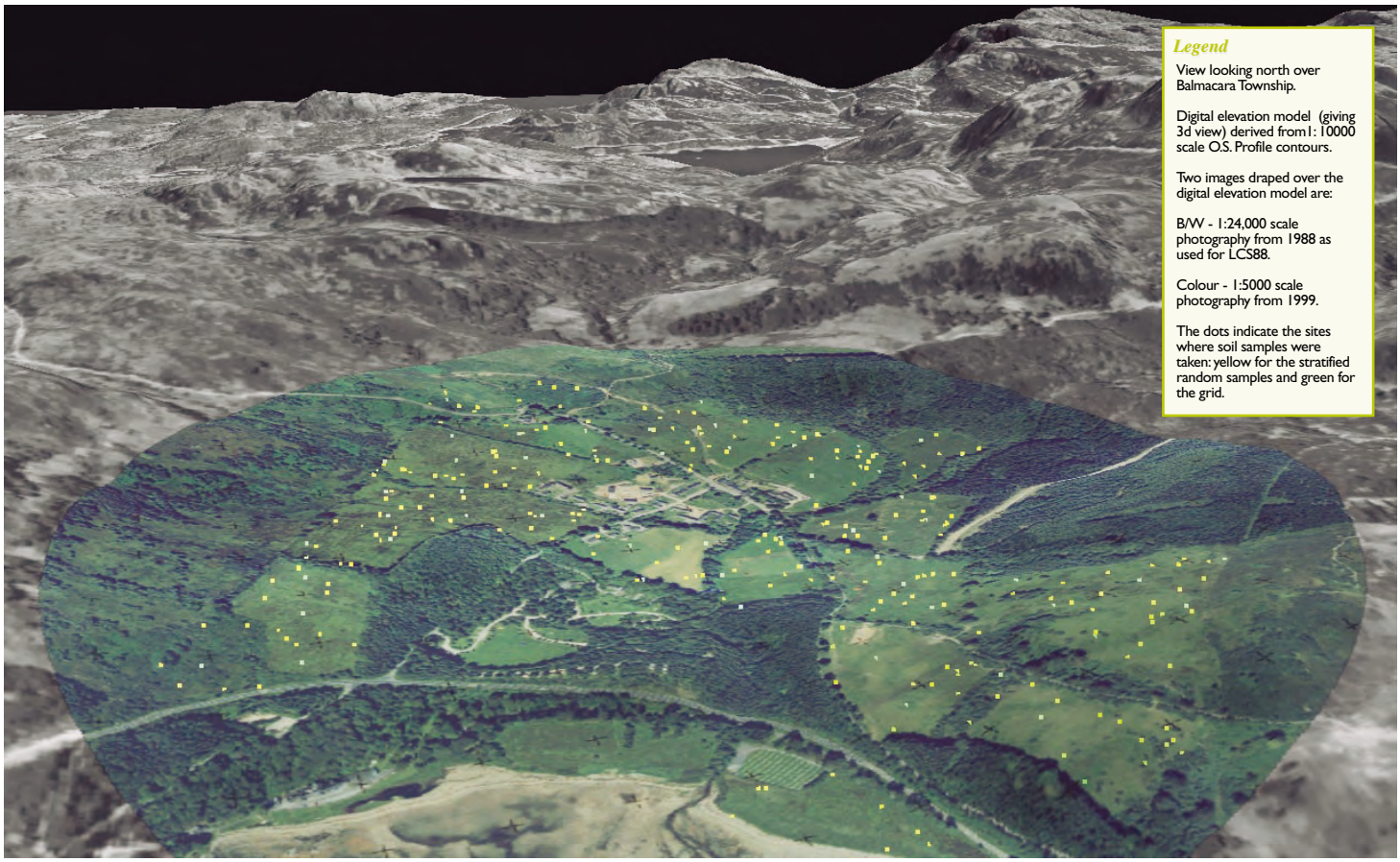


Issue: ***Up to 80% of the cost of GIS-based planning tools is in the cost of acquiring the spatial data required for the analysis.***

Example: ***The data sets being evaluated as sources of quantitative, field scale spatial soils and topographic data***

Urras Nàiseanta na h-Alba

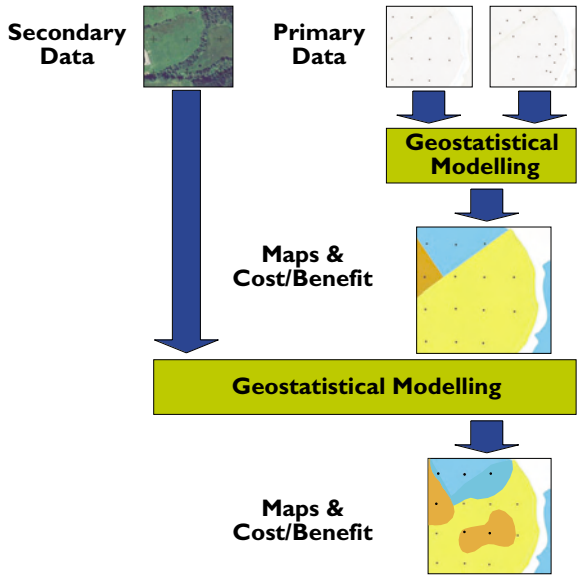
The National Trust for Scotland



A cost/benefit analysis is being carried out to determine the minimum ground survey density consistent with the level of accuracy required by LADSS.

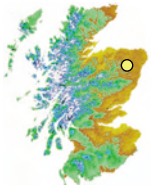
This will have three phases:

- Primary data sources are from a programme of field sampling (stratified random soil sampling, located using dGPS and portable GIS, with a further grid-based validation set).
- Geostatistical analysis of field samples to create maps of soil/ topographic properties using a range of sampling densities - validated against the grid samples.
- Geostatistical analysis of the same data but incorporating secondary data from The Macaulay Institute's corporate data sets (e.g. LCS 88), remote sensing (e.g. low cost aerial photography/ videography) and land manager records. Can these sources reduce the cost or enhance the accuracy of maps?



Positioning Resources Ltd

Edinglassie Estate - Multi-Objective Land Use Planning



Issue: *- does the land manager want the DSS to provide a* ***single solution or to aid in understanding the trade-off between multiple conflicting goals?***

Support decision making: *- exploit the fact that the land use planning tools maintain multiple alternative solutions (shown as the numbered points on the graph below) while they search for optimums. The set of solutions found defines the structure of the trade-off between objectives.*

STRUTT & PARKER

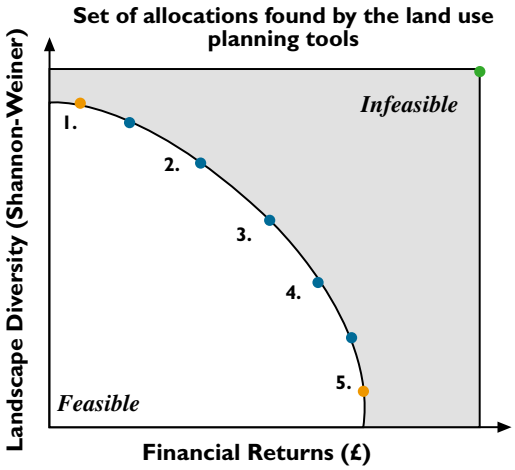
THE ROBERT GORDON UNIVERSITY ABERDEEN

Two goals: maximize financial returns and diversity of land cover.

- Utopian solution (optimal for both goals but cannot exist as goals conflict)
- Single goal optima - may be found by both single and multi-objective methods
- Solutions found only by the multi-objective land use planning tools - define the trade-off between objectives

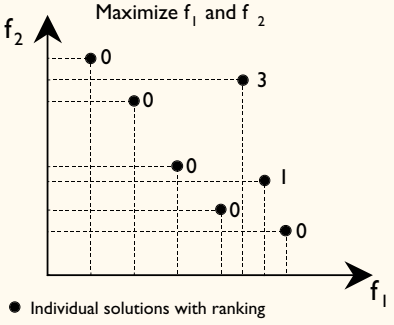
Approaches to multi-objective land use planning

- All goals equally important (normalization)
- Fixed relative importance - (weights -how to set?)
- Sophisticated translation - valuation of environment
- **Robust methods - using rankings (Pareto optima)**



Pareto Optimality: how to rank solutions with more than one evaluation

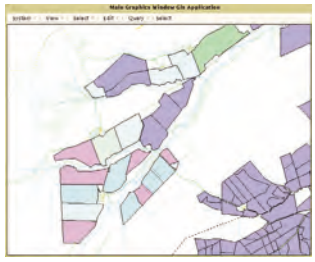
The Pareto-rank of an individual solution is the count of the number of solutions that it ***dominates***. A solution dominates another if it is superior in every evaluation.



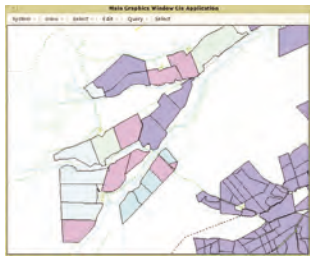
References:

- Keith B. Matthews, Susan Craw, and Alan R. Sibbald. (1999) *Implementation of a spatial decision support system for rural land use planning: integrating geographic information system and environmental models with search and optimisation algorithms.* Computers and Electronics in Agriculture (23) 9-26.
- K.B. Matthews, Susan Craw, I. MacKenzie, S. Elder, and A.R. Sibbald. (1999) *Applying Genetic Algorithms to Land Use Planning*. In: G. Petley (ed.) Proceedings of the 18th Workshop of the UK Planning and Scheduling Special Interest Group. Universty of Salford, Manchester, 15th - 16th December 1999.
- K.B. Matthews, S. Craw, S. Elder, and A.R. Sibbald , I. MacKenzie. (in press) *Applying Genetic Algorithms to Multi-objective Land Use Planning.* To appear in: D. Whitley (ed.) Proceedings of the Genetic and Evolutionary Computation Conference (GECCO 2000). Las Vegas, USA, 8th - 12th July 2000.

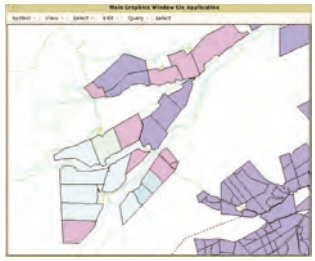
1. Optimum Diversity



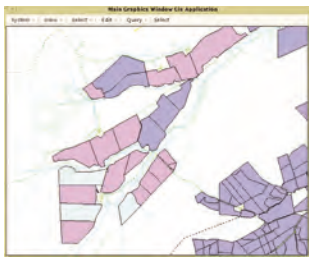
2. Diversity Compromise



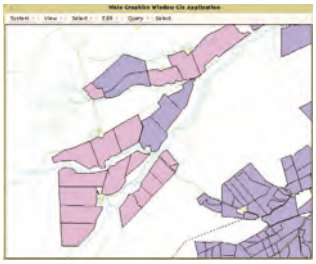
3. Equal Compromise



4. Financial Compromise



5. Optimum Financial



The People building LADSS

Alan Sibbald has led developments in land use decision support since before LADSS existed. Indeed Alan's first decision support tool, a spatially referenced model for land allocation to grazing sheep and Sitka spruce plantations, was published in 1979. Alan coordinates the Integrated Land Use Systems and Policy Analysis project at MLURI of which LADSS forms a part. Alan has a background in livestock systems and agroforestry research and combines this with interests in how land managers can best make use of decision support tools.

Keith Matthews has worked on the LADSS project since 1993 initially as the sole researcher on the project and more recently leading the LADSS team. Keith is a graduate in Geography from Aberdeen University with a Masters degree in Geographic Information Systems from Edinburgh University. Keith continues to have a hand in all aspects of LADSS design and implementation, but is now concentrating on the development of the multi-objective land use planning tools with colleagues at The Robert Gordon University.

Kevin Buchan joined the LADSS team in May 1999 as an information technology specialist. He is a graduate in computer science from The Robert Gordon University and thus has a background in the planning, implementation and testing of software. Kevin has been responsible for engineering the existing components of LADSS to facilitate future developments and has recently completed the implementation the social impact assessment. Kevin's next task is to complete the implementation of the LADSS environmental impact assessment component.

Joanne Tapping is responsible for both the field data collection and the analysis of the aerial photographic data flown for each of the test sites. Joanne joined the LADSS team in 1997 for a summer job after graduating from Aberdeen University with a degree in Environmental Science. Three years later Joanne is now responsible for the part of the LADSS project looking at alternative strategies for rapid low-cost site characterisation. This involves the evaluation of the density of ground sampling required to meet minimum standards of accuracy, and the analysis of the role of remote-sensed data in reducing the need for more expensive ground survey.

Mike Rivington is the most recent addition to the LADSS team joining in late 1999. Mike is a graduate in Ecological Science with a Masters Degree in Resource Management, both from Edinburgh University. Mike's previous projects cover a diverse range of topics from modelling Mediterranean climate to monitoring kiwi (the bird) populations in New Zealand. His role in the LADSS project is to evaluate existing models that may be integrated with LADSS to extend the range of land use systems represented.

Gary Wright has been collaborating with the LADSS team on developing low-cost site characterisation methodologies using remote sensing for nearly four years. The team has thus been able to draw on Gary's 17 years of remote sensing analysis experience across the range of sensors from ground based radiometers, airborne and satellite systems and across a very broad range of applications. Over the last year Gary has been primarily concerned with the creation of the infrared video camera rig used as part of the LADSS aerial survey.

Andy Dalziel has a background in agriculture and in running livestock and agroforestry systems experiments. Andy thus provides the LADSS team with a practical land-management reality check. Over the last eighteen months Andy has also developed the models upon which the LADSS social impact assessment is based. In the next year Andy will continue to add further land management activities to the LADSS social impact module particularly specifying the land management calendars for the new land use systems models.

Announcement and call for expressions of interest in attending the 2nd LADSS Workshop.

It is planned to hold the 2nd LADSS workshop at MLURI in August 2000. The primary purpose of the workshop will be to evaluate the utility of LADSS multi-objective land use planning tools, but there will also be a session outlining progress since the last workshop. The workshop is open to anyone with a practical or academic background in land management planning, however, the number of places is limited given the strongly participative nature of the programme so early expressions of interest is advised. We will also be seeking a balance in the participants' background and experience.

The workshop will last one day and follows the format of the first meeting. Following an update on LADSS progress, participants will be asked individually to produce land use plans for one of the LADSS test sites. Plans for two single goals will be considered followed by a multi-objective plan. The farm information available to participants will be that available within LADSS. Information packs on the site will be sent out prior to the meeting. Following the individual planning, the workshop will divide into small (4-6 person) groups each encompassing a range of land management perspectives to discuss and produce a consensus (where possible) multi-objective plan. These group deliberations will be moderated using a soft systems facilitator/reporter approach ensuring that all opinions are expressed. The multi-objective land use plans derived by LADSS for the site will be presented and participants given the opportunity to compare the plans produced by individuals, the groups and LADSS.

Provisional Programme

10:00 - 10:15 Welcome and introduction to the workshop
10:15 - 11:00 LADSS Update
11:00 - 11:15 Coffee
11:15 - 12:15 Individual land use planning tasks
12:15 - 13:15 Lunch (provided)
13:15 - 14:30 Multi-perspective land use planning tasks in groups
14:30 - 15:15 Plenary discussion of the solutions
15:15 - 15:30 Tea
15:30 - 16:00 Presentation of the LADSS plans
16:00 - 16:30 Evaluation of individual, group and LADSS plans
16:30 Depart MLURI

Expressions of interest should be sent to:

Keith Matthews via:

Mail: Integrated Land Use Systems Programme,
Macaulay Land Use Research Institute,
Craigiebuckler, ABERDEEN, AB15 8QH.

Tel: 01224 318611 Fax: 01224 311556

Email: k.matthews@mluri.sari.ac.uk

WWW: http://www.mluri.sari.ac.uk/LADSS/wshop.htm