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FutureQUEST - the development of an interactive model for exploring regional sustainability in the UK.

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Abstract

This paper centres on research associated with FutureQUEST, one of a suite of projects under the umbrella of Altas^{NW} that aim to investigate and model a range of development processes operating within the North West region of England. The project, funded by the UK Engineering and Physical Sciences Research Council (EPSRC), focuses on the development of a Regional Interactive Sustainability Model which, like the Canadian QUEST model on which it is based, uses an Integrated Assessment, scenario-based approach to allow users to design and explore a myriad of possible futures for the region. The prototype model will consist of an urban development, resources, transport and air emissions module together with the necessary economic model framework. It is aimed at two principal audiences, firstly regional policy makers through providing the facility to investigate and assess different policy options and secondly the general public through providing a user-friendly awareness-raising tool. The software uses an extensive GIS-based database of spatial information about the North West which is also used to produce a series of 3D visualisations of regional and sub-regional data layers and animations of related development processes.

Key words: sustainable development, scenario modelling, Geographical Information Systems.

This paper has been written up as a submission to Impact Assessment and Project Appraisal under the title of *Virtual tools for complex problems - an overview of the Atlas^{NW} regional interactive sustainability atlas*.

Virtual tools for complex problems - an overview of the *Atlas*^{NW} regional interactive sustainability atlas.

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Abstract

The development of computer-based tools to assist with urban and regional policy activities has traditionally focussed on producing predictive models which tend to be limited in terms of inter-disciplinarily, spatial resolution and/or overall flexibility. The problems associated with these limitations are particularly acute when applied to planning for sustainable development, as this requires a holistic framework that can take account of numerous, potentially conflicting objectives and viewpoints. One approach to dealing with the need to reconcile multiple perspectives is to produce a system that allows users to design their own development paths and explore the potential impacts of policy decisions within a range of different sectors. This is the approach taken with the *Atlas*^{NW} Regional Interactive Sustainability Atlas project. *Atlas*^{NW} includes elements that allow users to explore the North West region of England both within the present as a gateway to fostering a greater understanding of developmental issues (*Explorer*) and also into the future using a scenario model based on the Canadian QUEST software (*FutureQUEST*). The final prototype model will consist of an urban development, resources, transport and air emissions module together with the necessary economic model framework and will be targeted at two principal audiences: firstly regional policy makers and secondly the general public through providing a user-friendly awareness-raising tool. This paper focuses on the development of the initial urban development module and offers some preliminary observations from the work to date.

Key words: sustainable development, scenario modelling, Geographical Information Systems.

1. Introduction

Research into computer-assisted techniques for supporting strategic planning and management activities has traditionally focussed on discipline-specific predictive modelling activities (Klosterman, 1997) with limited spatial components (Landis and Zhang, 2000). Such models are somewhat restrictive in view of the increasing demands being made on policy-makers, such as those associated with promoting and planning for sustainable development, characterized by the need to consider multiple and conflicting actors, sectors and objectives (Nijkamp and van de Bergh. 1997) and the need to effectively communicate complex ideas to the general public.

As a consequence, a new breed of models have emerged that reject the principal of attempting to produce a single absolute prediction of the future in favour of the idea of creating numerous alternative visions and identifying what would happen in each case if the underlying assumptions were proved correct (Robinson, 1990; Ravetz, 1998; Klosterman 1999). An important aspect of this approach, which is contrasted to the more conventional forecasting approach in Table 1, is to highlight the inherent uncertainty associated with modelling complex systems (Nijkamp and van de Bergh, 1997). This school of modelling also embraces the ideology of Integrated Assessment in that the flexibility of the models can be used to provide an interface between academic research, actors within different sectors, policy makers and the general public, through a mechanism that allows for the consideration of multiple perspectives within a necessarily multi-disciplinary framework (Kasemir, *et al* 1999). The integration operates at several levels: horizontally across policy sectors; vertically through hierarchical layers of governance; laterally between causes and effects; and cognitively through providing multiple and broader perspectives (Ravetz, 2000a). Applied within an information systems environment, these models can be seen to increasingly embrace aspects of Geographical Information Systems (GIS) and multi-media, also have the further advantage of being attractive, user friendly and generally more accessible to the user, whether this is the policy maker directly or a member of the wider public (Wegener and Fotheringham, 2000; Prastacos and Diamandakis, 2000).

Table 1: Differences between forecasting and scenario-based modeling approaches (after Nijkamp and van de Bergh, 1997).

Forecasting	Scenarios
Focus on quantified variables	Focus on qualitative picture
Model based on quantitative variables	Quantitative & qualitative picture
More emphasis on accuracy/detail	More emphasis on global trends
Focus on partial perspective and certainty	Focused on uncertainty
Results determined by status quo	Results determined by future images
From present to future	From future to present
Deterministic analysis	Creative thinking
Closed Future	Open future
Statistical – econometric tests	Plausible reasoning
From simple to complex	From complex to simple
From quantitative to qualitative	From qualitative to quantitative
Many quantitative temporal data required	Expert information useful
Policy analysis based on past experiences	Analysis of new policies/instruments

An indicative example of an integrated model in this area is the Canadian *QUEST* model which was originally developed at the Sustainable Development Research Institute (SDRI) of the University of British Columbia and which is now being advanced by Envision Sustainability Tools (EST) together with a global network of research partners. The original *QUEST* model provides a holistic framework for investigating personalised visions of the future by integrating sub-modules associated with land-use, economics, natural habitat, housing, water, transportation, air quality and energy together with aspects of governance and social attitudes (EST, 2000). Targeted at the public, it challenges the user to design their own future for the Lower Fraser Basin and therefore acts to foster a wider appreciation of the complexities involved in achieving sustainable development.

In addressing the issue of sustainable development in a UK context, the application and further development of the *QUEST* model provides a key input into an ongoing research project to develop a regional interactive sustainability atlas (*Atlas*^{NW}). The two core elements of the programme, which are the main focus of this paper, comprise the design and development of a *QUEST*-based interactive scenario model for the North West region (*FutureQUEST*) together with the creation of a facility to explore issues and problems within the region through visualisations of regional data and processes (*Explorer*). Funded through the EPSRC Sustainable Cities Programme, the development of these tools pays particular attention to the regional policy context and the identified needs of regional government.

The overall aims of the project are twofold; firstly to apply the scenario-based Integrated Assessment philosophy to practical task of creating a multi-disciplinary systems modelling and visualisation tool for the North West region and secondly to investigate the implications of different perspectives on alternative regional development scenarios.

The final toolbox is enhanced by the additional inter-linked components shown in Figure 1. Each of these will allow the user to investigate particular aspects of individual scenarios in more detail: the *Integrated Sustainable Cities Assessment Method (ISCAM)* model facilitating an assessment of regional trends and accounts (Ravetz, 2000b); and Sustainability North West's *Timeline* allowing the user to call up a databank of scenario-linked semi-hypothetical news & features from the 21st century (SNW, 2000). The package also integrates data and results generated from a sister project, *4-sight*, which focuses on the nature and sustainability of various resource flows operating within the region (Ravetz, 2000a; Lindley & McEvoy, submitted).

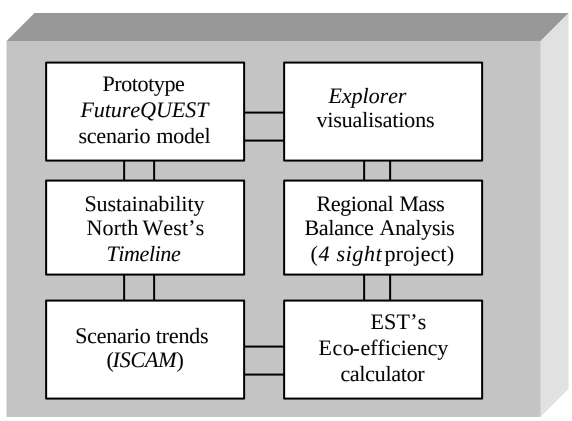


Figure 1: Components of *Atlas*^{NW}

The project is timely in that regionalism and sustainable development are both high priorities for the 21st century. The UK Sustainable Development Strategy, first published in 1994 and revised and updated in 1999, aims to achieve high and stable levels of economic growth whilst ensuring: the prudent use of natural resources; social progress that recognises the needs of everyone; and the effective protection of the environment (DETR, 1999; DoE, 1994a). In reaching these goals, the Strategy recognises the need for integrated policies and 'joined-up' thinking which can make a positive link between sectors and break negative cycles which tend to re-enforce damaging trends, such as between the location of housing and the need for car travel and those between transport, health and the environment (DETR, 1999). Accordingly, it will also be crucial to find more appropriate pathways to future development patterns and tools such as those proposed here can go some way to testing the myriad of potential ideas and explore the full range of potential knock-on effects. Indeed, it is for just such visioning exercises and "experimental demonstration projects to test and disseminate good practise in creating sustainable developments" that the UK Round Table on Sustainable Development have identified a critical need in achieving successful sustainable development (UKRTSD, 2000 p. 16).

The UK strategy also sees a crucial role for regional government and associated agencies in providing the thrust of the sustainability strategy and this 'meso-planning' role of regional governance provides an essential gateway between UK guidance and local implementation (Gibbs and Healey, 1997). The North West has been seen to exhibit a considerable enthusiasm for such a regional approach through the activities of the Government Office (GONW), North West Development Agency (NWDA) and North West Regional Assembly (NWRA) (GONW, 1999). The publication of the North West's draft regional planning guidance (NWRA, 2000) emphasises a fundamental requirement for sustainable patterns of growth and change which concentrate growth in existing regional centres, promote urban renaissance and create an accessible region. The planning framework also incorporates a regional transport strategy which will influence the preparation of both LA Development Plans and local transport plans in a consistent and coherent manner. The NWRA work strongly complements the guiding principles outlined in the NWDA strategy which identifies a huge potential for achieving sustainable growth to benefit all communities in the North West (NWDA, 2000).

The North West region (see Figure 1) is a particularly interesting testbed for the work from a number of perspectives. In addition to the keenness with which regional governance for sustainable development has been embraced and the identified potential for future growth, the region also faces some of the greatest contrasts in the whole of the UK. The North West has a strong tradition of innovation and industrial development which, together with proximity to some of the UK's highest quality landscapes makes for wealth and a good quality of life for many of it's 6.9 million citizens (NWRA, 2000; NWDA, 2000). However, the deep divisions between the beneficiaries and those in communities with serious concentrations of unemployment and social exclusion make the need for a sustainable vision for all particularly crucial and a significant practical challenge. The key will be to turn the traditionally negative aspects of the region such as clusters of high unemployment and high derelict land densities (some 25% of all derelict land in the UK is located within the North West (GONW, 1999)) into positive resources. All of the regional Strategies recognise that while immediate action is necessary to halt negative patterns of change, successful solutions to reversing such patterns can only be implemented over the long term (GONW, 2000; NWRA, 2000; NWDA, 2000).

The vision of sustainability proffered by UK government institutions is clearly only one perspective on the problems and opportunities associated with planning for the future. The tools within *Atlas*^{NW} will allow regional government to explore the potential outcomes of the various policy pathways that they suggest as mechanisms to realise these goals but it will also enable them, and other users, to examine the possible consequences of entirely different approaches. In this way, the model equally facilitates the building of 'Business As Usual', 'Deep Green' or entirely 'Unsustainable' scenarios all of which are useful in better understanding and ultimately supporting the route that is eventually chosen.

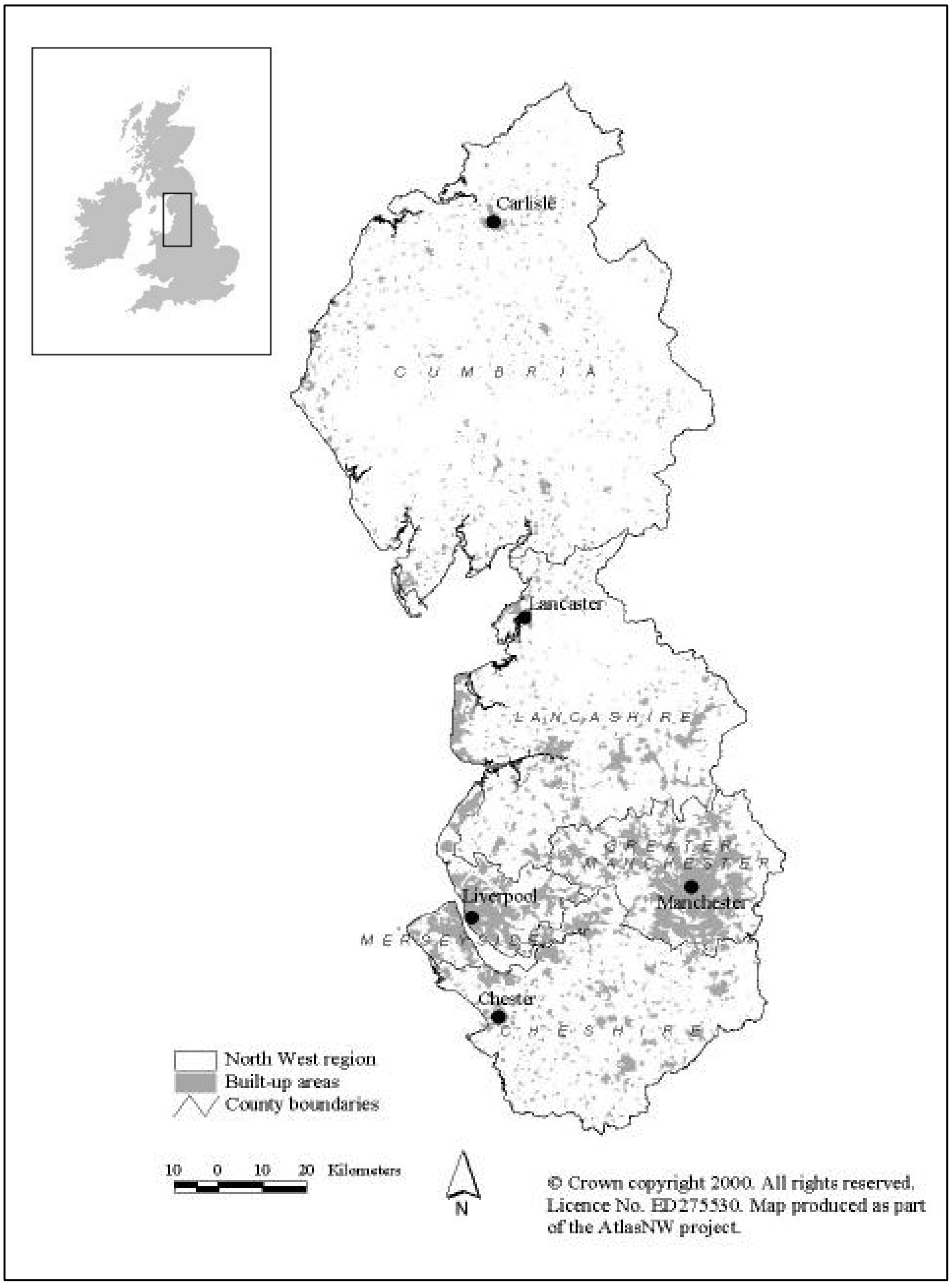


Figure 1: Study area - The NW region of England

The work described in this paper attempts to draw together thinking on the current nature of urban and regional developmental processes and use these as the basis for exploring potential future scenarios and their environmental, social and economic impacts. Although the study uses the North West region as the initial testbed for the work, it is intended that the framework will be applicable to different spatial scales of investigation as well as directly to other UK regions.

2. The *QUEST* scenario model applied to the North West region

A key element of the *Atlas*^{NW} programme is the development of the *FutureQUEST* scenario model for the North West region, which enables users to explore different futures from the base year of 1995 through to 2035. An overview of the stages in developing a scenario is shown in Figure 2. The user begins by specifying a series of 'values and beliefs' for the particular scenario being developed which will be used to identify broad characteristics to be applied throughout the 40 year modelling period. As can be seen from Figure 3, these settings include aspects of the environmental, social and economic context for the scenario: the role of technological innovation, general levels of ecological resilience and the degree to which the general public will respond to emerging environmental issues. The user is also required to determine the nature of population and economic change for the scenario, selecting either the general trends to be observed or alternatively by the input of more specific values to be adhered to throughout that particular model run.

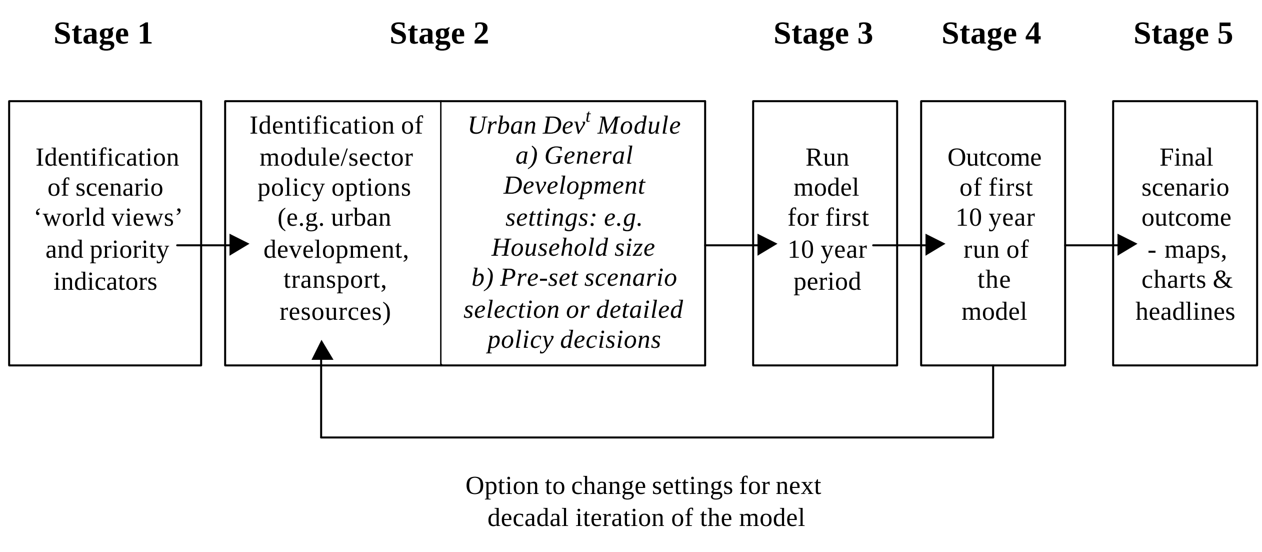


Figure 2: Stages in the development of a future development scenario in *Atlas*^{NW}'s *FutureQUEST*.

The next stage is to specify a series of goals/targets for the scenario which become the indicators against which the user can judge the scenario results, for example one of the many goals a user could select is that of a reduction in the use of natural or greenfield land for new residential development. At the end of the scenario the degree to which the user's goal has been achieved is reported back through charts and text headlines. At present, the user can specify six indicators from the range of available sectors which will allow a more holistic view of the relative success of the scenario against the initially identified aims. Careful tailoring of indicators used in the model with those used as headlines for monitoring activities at national and regional scales will make it possible to investigate how potentially successful different policy choices may be. The ability to present this in such a way as to make the ideas and concepts accessible to the general public is also important in fostering understanding of the complex problems and potential solutions as well as acting to better engage the general public's ownership and participation in implementing the policy solutions that are eventually decided upon.

Before making choices **After making choices**

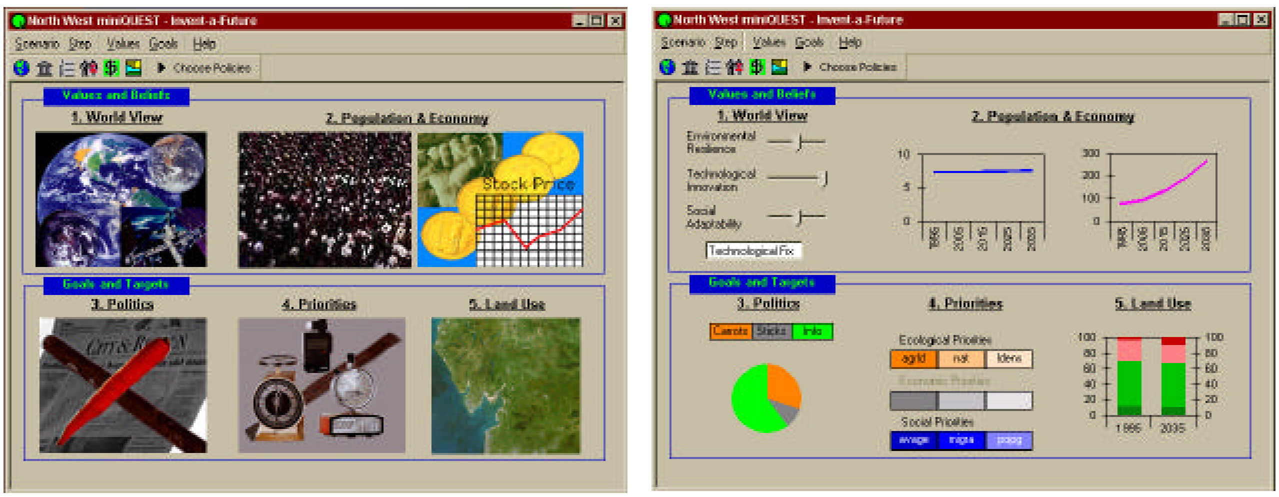


Figure 3: Interface for setting the values/beliefs and goals/priorities of a *FutureQUEST* scenario

Once the general settings have been completed, the user is required to make specific choices in relation to each of the interlinked modules contained in the model. The modules are intended to represent all of the main aspects of activity in a locality which can be seen as synonymous with the range of policy and governmental activities operating within an area. In this way the model provides a useful mechanism for policy makers to explore and test the further ranging consequences of different policy directions by making a critical link between these sectors. Whilst the model does not, and indeed cannot, make absolute predictions of the impact of particular activities on all spheres of development, it does allow users to explore what may occur in different sectors given a particular set of circumstances and this will then provide a guide for more rigorous testing of the specific nature of the possible outcomes.

Work on the modules for *FutureQUEST* is still ongoing and the final prototype will include a sub set of the full range of potential modules, exemplified by those included in the original *QUEST* model (EST, 2000). This subset will include modules on urban development, economics, resources, transport and air emissions each with their own input screens representing sector specific policy choices.

On completion of the policy settings, the model is run for the first decade of the scenario in order to determine the outcome of that particular group of user settings within the context of the imperfect assumptions used to generalise the real world development processes themselves. Outputs are reported back to the user in the form of maps, charts and headlines relating to the priorities identified at the outset and the user can chose to either continue with the same set of policies or make further modifications with every iteration of the model until the current scenario end-date of 2035.

In applying the *QUEST* model to the UK, it has been necessary to generate a set of algorithms that approximate some of the main development processes, pressures and constraints together with data layers that describe the characteristics of the region in 1995, used as the reference point for scenario generation. The first stage of creating the prototype *FutureQUEST* model has involved the development of a core urban development module and work is now ongoing to integrate this with the other sector specific modules.

As with the different perspectives on achieving sustainability, there are also alternative views about the relative importance of individual sectors in terms of the logistics of modelling the development system itself and it has been traditional to take economics as the core element that then drives issues in other sectors. In this work, the core driver has been taken as urban development, specifically residential choice behaviour, which then affects changes in other sectors such as transport and resource use.

It could be argued that there are a number of advantages from taking such an approach. Firstly, residential change is a process which is both inherently spatial and inherently visual and as such is a useful starting point for a model of this type. Related to this, it is a process that all users can readily identify with and therefore is perhaps less exclusionary than many other approaches. Finally, it is also essentially holistic in that it encompasses aspects of lifestyle and values together with recognisable economic issues such as employment.

2.1 The Urban Development Module

The theoretical basis for the urban development module is to model potential changes in the population surface of the North West region over iterative 10-year periods. Changes between the start and end of the decade in question are largely determined using the basic push/pull scheme shown in Figure 4 with the nature or relative importance of each process determined interactively by the user. Development processes have been generalised either as push factors that act to displace population from an existing location or as pull factors that act to attract population to a new location. Each factor has a set of alternative algorithms selected through the user’s response to a particular question on the model interface and these determine either the direction or the strength of a particular process. In terms of the former, the selection of a particular setting may, for example, result in shaping development towards existing regional centres or the user could alternatively choose to favour development in smaller sized settlements. In terms of the latter, determining the relative strength of a process, the user would make a selection which affects the degree to which the process will influence development. One example of this is to consider the relative impact of high crime rates as a disincentive to development, the user can experiment in creating a scenario where fear of crime is minimal or alternatively make crime one of the principal determinants for the pattern of regional development. The user has the facility for ultimate control of scenario 'design' and can chose to create future scenarios which aim to be sustainable or, if desired, even unsustainable. As has already been suggested above, it could be argued that both pathways are equally useful in fostering a better understanding of the complexities of links between cause and potential effect through a virtual, experimental platform.

Table 2 illustrates the range and nature of push factors included in the module with considerations such as proximity to heavy industry, high crime rates and high unemployment all acting to make an area unattractive to its current population and to potential migrants. Reference to the data layers associated with each parameter allows the generation of a composite index of 'unattractiveness' relating to the specific conditions and user inputs for any one model run. This in turn can be mapped to indicate the likelihood of particular cells losing population (represented as a reduction of one density class from the base population density layer). Conversely, pull factors, such as those associated with proximity to amenities, employment and a high standard of living act to make an area attractive to potential new residents and the generation of an associated index then identifies cells that are the most likely to gain population (represented as an increase of one density class from the base layer) under the settings of any individual scenario.

In addition to the push/pull framework identified in Figure 4, the model also takes account of the additional influence of processes operating on the region as a whole and estimates the consequences of wider demographic and migration trends. Where the user specifies accordingly, account is also taken of factors such as the location of green belt and other land-use protection policies in determining the final distribution of population at the end of any iteration of the model.

The urban development module currently consists of some 30 data layers describing different social, economic and environmental parameters which influence patterns of urban development at the regional scale. The precise composition and nature of each of the layers to be included in the urban development module of *FutureQUEST* is currently being finalised and an indicative list of the current contents is given in Table 2. These have been grouped into themed categories in order to help the user to identify the aspects of the particular processes being affected. Table 2 also provides an indication of the data and methods used in the generation of the data layers associated with each developmental process.

The original input data have been collated from a wide range of local, regional and national data providers and stored within an extensive GIS-based database. Where necessary, the input data have then been manipulated and analysed using a suite of GIS functions, including overlay, network analysis and buffering in order to create suitable layers of information that are spatially resolved to a grid of 500m x 500m. This grid resolution, illustrated in Figure 5, is considered to generate data layers of sufficient detail to create meaningful representations of the region's characteristics whilst still allowing the model to process data in real-time in response to the wide variety of possible policy packages specified by the user. Whilst the input data would support the use of a finer grid resolution, for example the use of a 200 x 200 m grid, which corresponds to the resolution of available population data (see Table 2), this would result in a substantially increased processing time which was considered problematic in terms of the intended audience(s) for the final model. These data layers are converted and subsequently interrogated by the model through an Access database, which is then used as the basis for mapping the scenario results.

It is important to emphasise that the data layers are intended to provide a guide to the characteristics of the region rather than a snapshot of reality. Whilst input data are as accurate as possible and sourced to reliable data providers, the process of translating these into the information accessed by the model is an imperfect process. In some way, the use of a 500m grid representation helps to reduce the tendency to view data as reality but it is also important that the final model is as transparent as possible concerning the methods used to generate data layers and their limitations, as indeed it will be in terms of the generalisations required to translate incredibly complex development processes into a limited series of simplistic arithmetic equations.

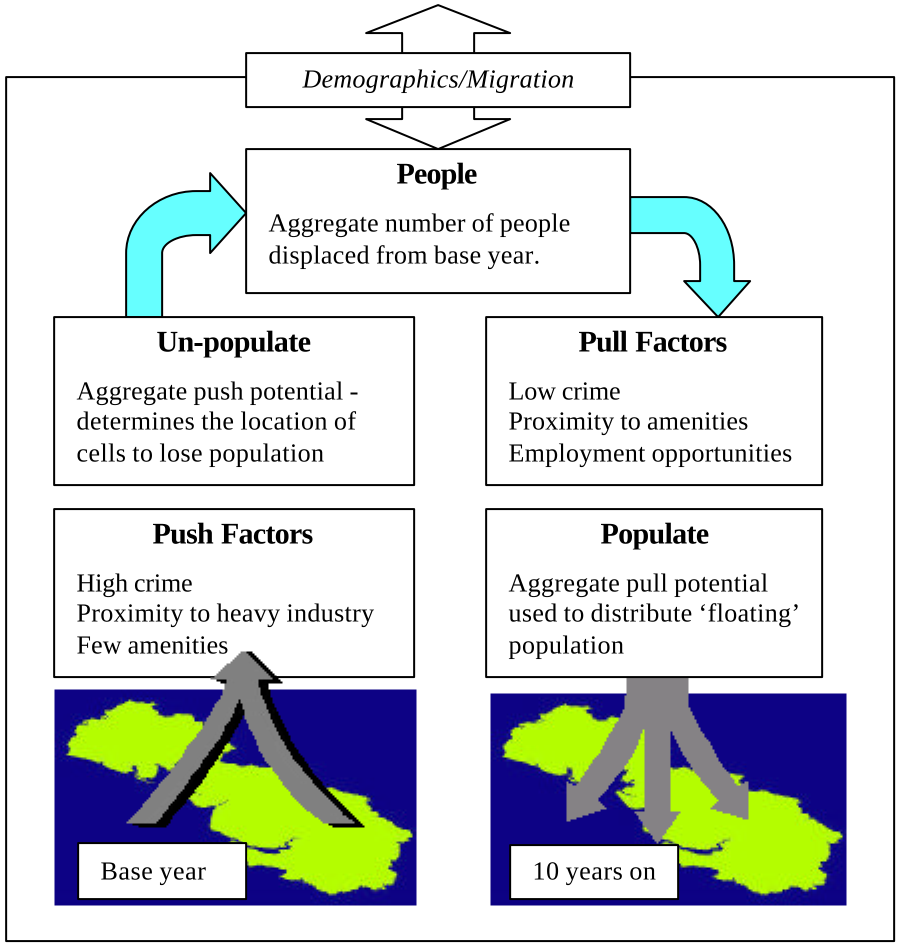


Figure 4: Basic premise of the urban development modelling process in *FutureQUEST*

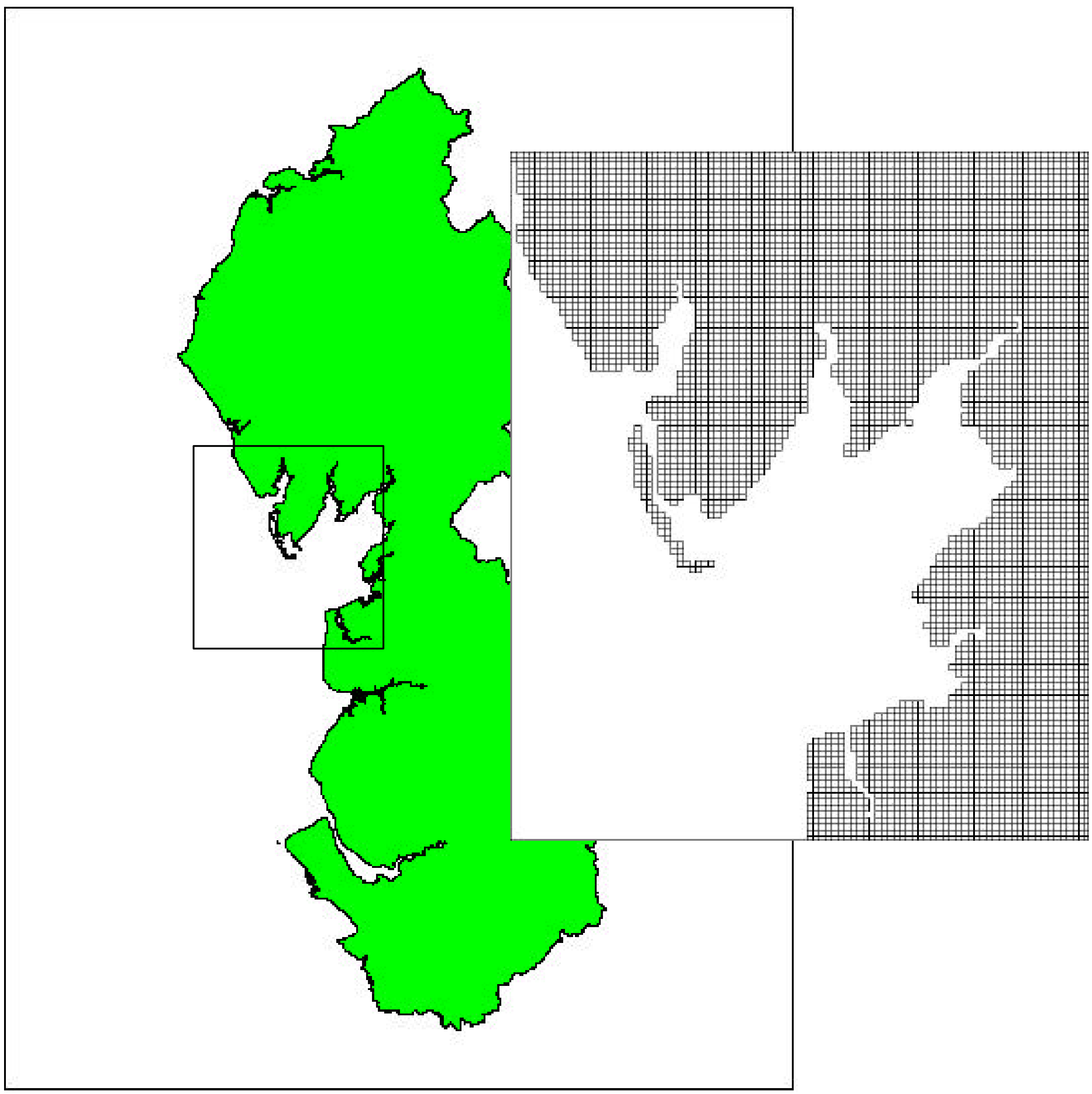


Figure 5: The grid used to represent the North West region.

Table 2: Summary of the interim composition of data layers in the Urban Development Module.

Group	Layers/processes included		
	Layer name	Process	Data Layer
General Develop-ment Issues	Population density & land-use	The base line population density and land-use layer. This is used as the starting reference and modified at the end of the scenario.	Population density data generated from the UK Census of Population (1991) 'surpop' data (MIMAS, 1999a; Bracken & Martin, 1989) modified to 1995 using district level data (ONS, 1993, 1997). Land-use data have been taken from a variety of sources including the Countryside Information System (DoE, 1994b), Forestry Commission (2000), Farming & Rural Conservation Agency (FRCA) (2000a), English Nature (2000) and the Environment Agency (Lindley, 1998; Environment Agency, 2000).
	Clustering	The tendency for one population density type to attract similar population densities.	Generated individually from the base population density data layer for each model run using an algorithm to determine the average density of the neighbours to any particular cell.
	Settlement Size	Allows the user to specify a preference for relatively larger or relatively smaller settlements.	Urban size and extent generated from the UK Census of Population Key Counts for Urban Areas (based on EDs associated with contiguous urban areas) (MIMAS, 1999b)
	Proximity to settlements	Allows the user to specify a preference for areas relatively close to or remote from existing settlements.	Surface describing the relative influence of settlements generated from the population weighted geometric centroids of the urban areas definitions used in the Settlement Size layer.
Social Issues	Crime risk	The degree to which crime levels acts to modify residential location choice.	District level data describing the relative cost of insurance premiums in the region as a proxy for crime risk (Wong, 1999).
	Proximity to heavy industry	The degree to which proximity to heavy industry acts to modify residential location choice.	Surface describing relative proximity to Part A processes (Lindley, 1998; Environment Agency, 2000), airports and docklands generated using a basic Euclidean buffering approach.
	Social Deprivation	The degree to which levels of social deprivation act to modify residential choice.	Generated from ward-based calculations of the Carstair's deprivation index (MIMAS, 1999c).
	Population change	The degree to which historical population trends act to modify residential choice.	Generated from district level population trend data (ONS, 1993, 1997).
	Rural Amenity	The degree to which proximity to rural amenity affects residential location choice.	Generated from the Countryside Agency's Countryside Character Areas (English Nature, 2000).
	Health	*The degree to which general health levels act to modify residential location choice.*	*To be generated from regional health statistics.*
	Derelict Land	*The degree to which the relative density of derelict land affects residential location choice.*	*To be generated from derelict land data from the 1993 Survey of Derelict Land (DoE, 1993) and the National Land Use Database (NLUD, 2000).*
Economic Issues	Business service ratio	The degree to which business characteristics affect residential location choice.	District level data describing the relative proportion of business services as a proxy for employment opportunities (Wong, 1999).
	Employment change	The degree to which trends in employment act to modify residential location choice.	District level data describing relative changes in employment (Wong 1999).
	Labour skills index	The degree to which employment characteristics affect residential choice.	District level data describing the skill characteristics of employment (Wong 1999).
	Average earnings	The degree to which levels of average earnings in an area act to modify residential choice.	District level data describing relative levels of average earnings (Wong 1999).

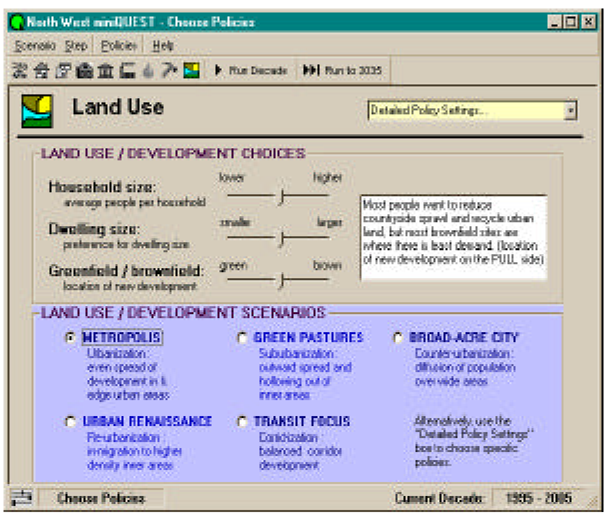
Table 2: Summary of the interim composition of data layers in the Urban Development Module (cont.)

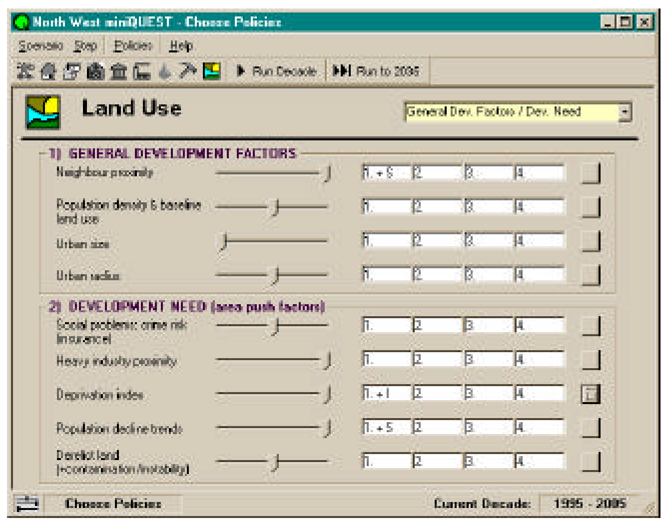
Group	Layers/processes included		
	Layer name	Process	Data Layer
Accessib-ility Factors	Urban hub access	The degree to which accessibility to urban areas influences residential location choice.	Accessibility surface generated from a car travel-based network analysis of proximity to the region's main urban hubs.
	Airport access	The degree to which accessibility to airports influences residential location choice.	Accessibility surface generated from a car travel-based network analysis of proximity to the region's international airports.
	Road network access	The degree to which accessibility to the road network influences residential location choice.	Accessibility surface generated from a basic Euclidian distance buffer of motorway junctions and primary road corridors.
	Rail network access	The degree to which accessibility to the railway network affects residential location choice.	Accessibility surface generated from a car travel based network analysis of proximity to main and local railway stations.
Capacity factors	*Derelict Land*	*The degree to which derelict land can be translated into increased land availability and therefore affect developmental processes.*	*To be generated from derelict land data from the 1993 Survey of Derelict Land (DoE, 1993) and the National Land Use Database (NLUD, 2000).*
	Vacant land	*The degree to which vacant land can be translated into increased land availability and therefore affect developmental processes.*	*To be generated from vacant land data from the 1993 Survey of Derelict Land (DoE, 1993) and the National Land Use Database (NLUD, 2000).*
	Buildings for re-development	*The degree to which vacant buildings can be translated into increased land availability and therefore affect developmental processes.*	*To be generated from data on vacant buildings from the 1993 Survey of Derelict Land (DoE, 1993) and the National Land Use Database (NLUD, 2000).*
Land-use constraints	Rural Protection	The degree to which rural protection legislation protects areas from development.	A composite representation of the region's protected areas, including: National Parks, Green Belt (County Councils, Local Authorities and Unitary Authorities in the North West region), Areas of Outstanding Natural Beauty, SSSIs, Nature Reserves (English Nature, 2000).
	Agricultural class	The degree to which agricultural land will be protected from developmental pressures.	Generated from the Ministry for Agriculture Forestry and Fisheries (MAFF) Agricultural Land Classifications (FRCA, 2000b).
	Flood/other natural hazard risk	*The degree to which development is constrained by the risk of flooding.*	*To be generated from flood risk data due to be released by the Environment Agency (2001)*
	Topographic effects	*The degree to which development is constrained by the effects of natural topography.*	*To be generated from slope and altitude data generated from Ordnance Survey contour data.*
	Greenfield/ brownfield land	The degree to which development is modified by the availability of brownfield land.	Generated from the base population density layer to indicate built-up areas.
Policy incentives	NS/EW development axes	The degree to which implementation of the NWRA's potential spatial development axes affects development.	Generated from approximate representations of the spatial extent of the three spatial development axes given in the NW Regional Planning Guidance (NWRA, 2000).
	EU/other structural programmes	*The degree to which implementation of the region's structural programmes affects development.*	*To be generated from EU and structural programme designations in the region.*

Note: *Items in italics are planned additions to the current version.*
Data layers also use feature data from a range of Ordnance Survey digital data products (Strategi, Meridian, Panorama) supplied under OS License No. ED275530.

The model is currently designed with two levels of interface (Figure 6), a detailed interface which will allow modification of the individual settings for each parameter and a more basic interface that groups parameter settings within pre-set scenarios. The latter is particularly useful in engaging the wider public and encouraging exploration of a range of potential policy options.

The particular pre-set scenarios can be tailored to particular requirements but are presently designed to test the relative impacts of alternative development scenarios that could be considered within the North West region. For example, the NWRA and NWDA place considerable emphasis on the role of urban renaissance and it would therefore be particularly interesting to review the potential impacts of running these scenario choices. The potential influence of different aspects of urban renaissance can also be explored by modifying the individual parameter settings through the detailed policy screens. Whilst it is not intended to predict the outcome of such a scenario path, this activity does promote a better comprehension of the meaning of urban renaissance and what may occur given a suite of complimentary policies aimed at achieving development patterns focussed on existing urban centres.





The basic urban development module user input screen consisting of:

- general settings
- pre-set scenarios
- link to more detailed screens

The more advanced user input screens allow modifications to each of the process parameters (in Table 2) individually for each 10-year run of the model

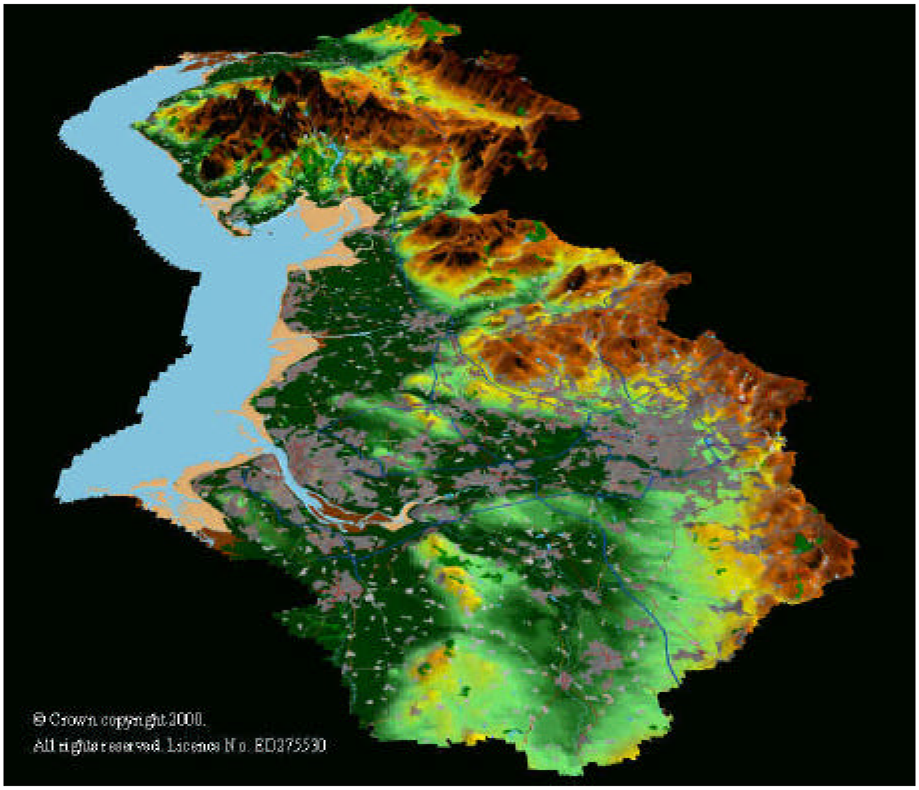
Figure 6: The basic and more detailed interfaces in the *FutureQUEST* urban development module

3. *Explorer* – investigating the present-day characteristics of the North West as a key to the development issues facing the region.

Graphical representations of large volumes of data, such as 2D and 3D maps together with associated charts, graphs, tables and images, have been found to be beneficial to human cognitive performance through making these data accessible, manageable and comprehensible (Medyckyj-Scott, 1994). The use of GIS–based visualisations to communicate information about the North West region therefore represents an extremely valuable element of the *Atlas*^{NW} work and reflects the opinion that "one of the most important contributions to spatial modelling by GIS is their visualisation capability" (Wegener and Fotheringham, 2000, p.266). In addition to using GIS in the creation of the input database for the *FutureQUEST* model, it has also been used as the basis for a present-day digital atlas of the region which can, through ongoing development, be linked more closely with the model outputs and eventually with the modelling process itself.

Explorer has a web-based navigation tool (currently under development) which provides a gateway whereby users can view themed visualisations describing the salient characteristics of the North West region. Users can opt to view data as a standard 2D or pseudo 3D representation and also select the geographical perspective to take. For example Figure 7 shows a pseudo 3D representation of the region's topography upon which various thematic drapes can be viewed. These can include the data layers referred to in the *FutureQUEST* scenario model, such as areas of social deprivation, protected areas and areas of flood risk or they could be representations of the original input data provided by the data providers listed in Table 2. Figure 8 illustrates how 3D extrusions can be used to provide different perspectives on the region, in this case different angles, both literally and conceptually on the population pressures of the North West region. Finally, the interface will provide a link to a series of semi-hypothetical animations of the potential future development patterns of selected social, economic and environmental processes within the region. In this way it is intended that users can be guided into a greater appreciation of developmental issues facing the region.

The *Explorer* system will also include a narrative describing the generation of the map, data layer or animation in question together with an indication of the level of certainty with which it should be treated. This is important in emphasising the inherent uncertainties associated with each visualisation which may not otherwise be obvious to either the lay or the expert viewer (Pickes, 1995; Monmonier, 1991) In doing this, *Explorer* will help make data more available, accessible and transparent to the public and further foster debate and user engagement in relation to the range of issues that affect the region both today and into the future.



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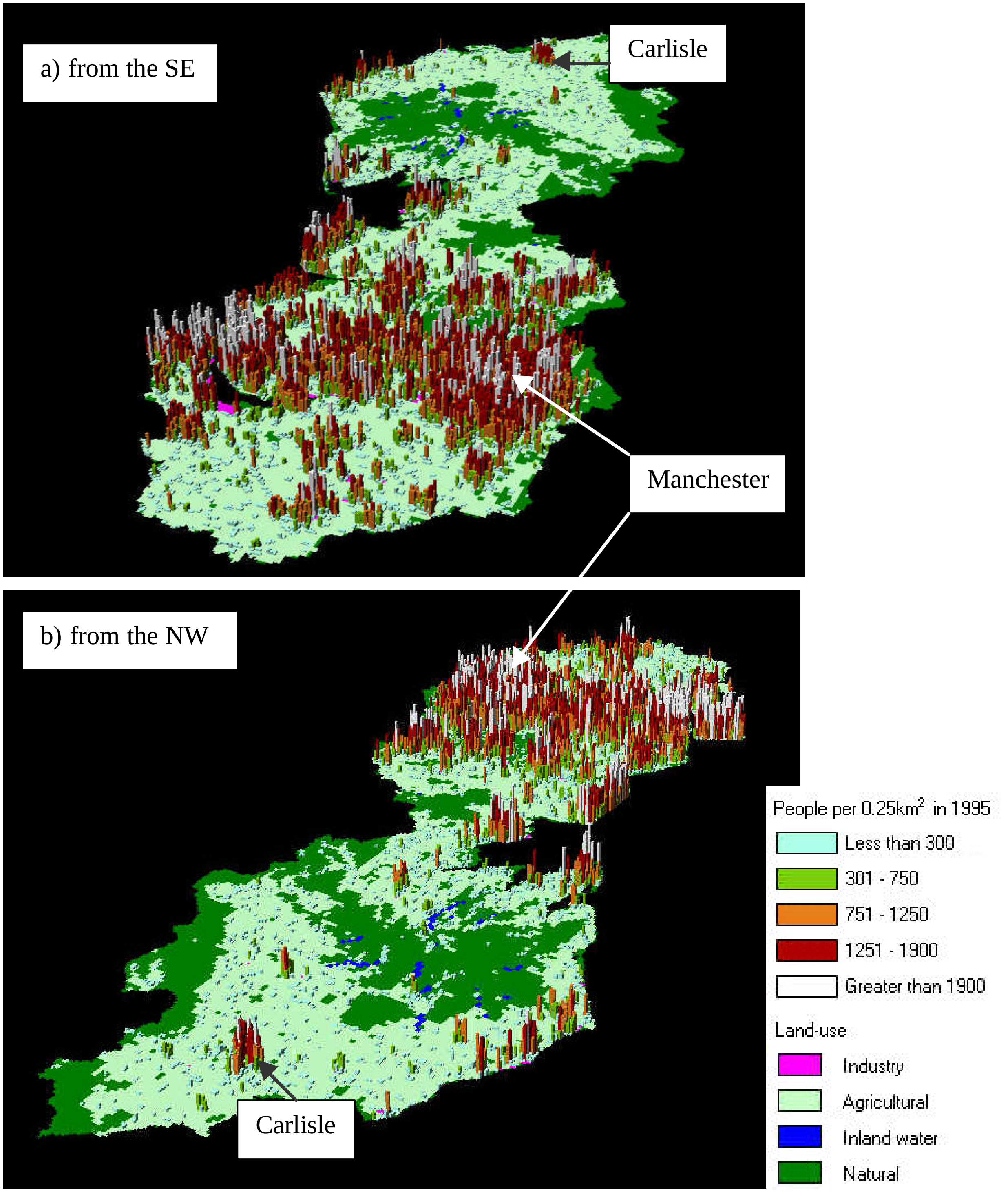
Produced by the Regional Research Laboratory, School of Geography, University of Manchester, for *Atlas*[NW].

Figure 7: Natural topography of the North West region with a drape of urban areas and the major road network.



Produced by the Centre for Urban & Regional Ecology (CURE), School of Planning & Landscape, University of Manchester, for *Atlas*[NW].

Based on: population density data generated from the UK Census of Population (1991) 'surpop' data (MIMAS, 1999a; Bracken & Martin, 1989) modified to 1995 using district level data (ONS, 1993, 1997); and land-use data from a variety of sources including the Countryside Information System (DoE, 1994b), Forestry Commission (2000), Farming & Rural Conservation Agency (FRCA) (2000a), English Nature (2000) and the Environment Agency (Lindley, 1998; Environment Agency, 2000).

Figure 8: Two views of the population distribution of the North West region in 1995 a) from the South East and b) from the North West

4. Preliminary observations, conclusions and future directions

The various components of the *Atlas*^{NW} project represent discrete but integrated tools that each deal with different facets of planning, interaction and education for sustainable development at the regional scale. In linking these with current thinking on sustainable development policy in the North West region, even at the current developmental stage the *Atlas*^{NW} shows considerable promise as an innovative and powerful system for exploring and disseminating information to a wide audience of policy-makers and the public. Nevertheless there are two important limitations to the model in its current form that warrant further comment.

The first limitation is that of the eternal quandary of how to best represent inherently complex and variable characteristics and processes. Clearly, the development of any model requires facing the challenge of representing complex patterns and processes with limited data and incomplete knowledge. In terms of an integrated model of this type this challenge becomes particularly acute as the development of model algorithms and associated base data must attempt to find a balance between the need to be representative and the need to generate results over acceptable timescales. In addition to the sheer number of parameters that are necessary to achieve an adequate picture of regional development processes, many are also inherently 'fuzzy' in nature and are particularly difficult to represent using current data analysis and manipulation tools. For example, the generation of a data layer showing 'crime risk' and its application to locational decision-making could take many forms, from the very sophisticated to the relatively simplistic but none could be classed as an absolute representation of reality. In view of this, the model provides an open and transparent framework whereby the user is invited to view the data within what is traditionally the 'black box' of the model workings and can interactively determine the degree to which the process itself will contribute the final scenario results. In this way, it is hoped that the problems and uncertainties of both the input data layers and the modelling process can be effectively communicated to the user who will be able to make their own value-judgements about scenario outcomes.

The second issue relates to another fundamental modelling constraint, the need for a systems boundary. In this case the model region is that defined by the existing administrative framework and although a government defined region is useful in that it represents a coherent management and planning structure (albeit only in terms of one 'layer' of the full structure) it is unsatisfactorily restrictive in terms of a complete appreciation of the externalities of developmental processes which to not respect such artificial constraints. In practical terms, the case of the North West region is fortunate in that the government region also represents something of a 'natural' region being bounded by the Irish Sea to the West and the Pennines to the East but it is of course in no way a completely 'closed' system. Further developments to the Atlas project to produce a suite of nested models at different scales of investigation, as is currently planned, would be one way by which the impact of this problem could be reduced.

A further planned development to the *Atlas*^{NW} is to develop an inter-linked Planning Support System (Harris and Batty 1993; Klosterman, 1997, 1999) which will interface with a full version of the *FutureQUEST* scenario model and associated *Explorer* visualisations and provide a suite of data management and analysis tools for strategic planning and management activities. Such a development will take a further step towards using the database to promote further analytical capabilities at the regional scale such as the monitoring and holistic assessment of sustainability indicators. When considered as a full 'toolbox' package, each of these discrete tools has added value and will produce framework that goes some way to taking a genuinely holistic outlook to the challenging goal of achieving sustainable development.

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