Synthesis Report NRP 48

Virtual Worlds – Real Decisions? The Alps in a Modeller's Nutshell

Thematic Synthesis Report and Outlook, Research Focus V «Virtual Representation»

Ariane Walz, Christian Gloor, Peter Bebi, Andreas Fischlin, Eckart Lange, Kai Nagel, Britta Allgöwer

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For Walter Schaufelberger (May 23, 1940 – September 14, 2008) with deep gratitude

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Thematic Synthesis Report and Outlook, Research Focus V
«Virtual Representation»

National Research Programme NRP 48 «Landscapes and Habitats of the Alps»
Swiss National Science Foundation SNSF

Ariane Walz, Christian Gloor, Peter Bebi, Andreas Fischlin, Eckart Lange, Kai Nagel and
Britta Allgöwer, Zurich and Davos, 2008

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Acknowledgements

Should a synthesis report be written for Research Focus V, «Virtual Representation»?

This question was considered at length not only by the Steering Committee of National Research Programme 48 (NRP 48) but also by the team of authors that wrote the present Synthesis Report V.

Is it possible to sensibly put into words what a computer animation seems to communicate playfully and effortlessly? And what has that got to do with landscapes and habitats of the Alps? A lot – or nothing at all. With regard to the thematic aspect, the analyzed NRP 48 projects having a modelling character are all connected with the Alpine region. If the modelling and technical aspect is the focus of interest, the Alps are no longer relevant. Methods in the area of virtual representation and landscape analysis can be developed anywhere in world – also in the imaginary world.

This split is reflected not only in this Synthesis Report V but also in the projects of Research Focus V of NRP 48. All of the projects more or less swing back and forth between methodological and thematic aspects and accordingly shift perspectives. Not even the team of authors of Synthesis Report V was always clear, never mind in agreement, on which aspect should be given priority.

Synthesis Report V, «Virtual Worlds – Real Decisions? The Alps in a Modeller's Nutshell» is now completed, and we would like to express our gratitude. For one, to the NRP 48 Steering Committee that entrusted this report to us, and for another, to the team of authors, first and foremost to Ariane Walz and Christian Gloor, our two NRP 48 postdocs and the main authors of the report. Without the constructive criticism offered by the entire Steering Committee, namely, by Prof. Wolfgang Haber and Prof. Bernard Lehmann but also without the great efforts of Ariane Walz – who during this period also brought her daughter, Marlena, into the world – and Christian Gloor, who opened up the animated world to us, this final report would never have come about!

We are also very grateful to the Advisory Group for Synthesis Report V. This group not only advised us but also represented the stakeholder groups of NRP 48. It is not self-understood that people with their own full programme of activity will take the time to advise the work of producing a report like this over a longer period and at several meetings, showing interest, sharing well-meaning criticisms, and making valuable suggestions. Warm thanks to Prof. Walter Schaufelberger and Thomas Schneider for serving as the sub-group on computer science & practice, Fred Baumgartner for suggestions from the perspective of the Federal Administration, and Dr. Urs Frei for editing the manuscript. At the second advisory group meeting, the Stakeholder Meeting in Davos on January 19, 2007, Elisabeth Mani-Heldstab, Grosse Landrätin of Davos and Grossrätin of the Canton of Graubünden, took part and contributed valuable input. To her we also express our appreciation!

Representation requires sophisticated and reflected design, no matter whether it is performed in virtual or in analogue format. Without Max Urech, graphic designer and creator of the graphical identity of the NRP 48, Synthesis V would not have come true either. With deliberate typography and artwork he has mastered revealing the abstract and sometimes dry matter to the reader. We would like to thank him from all our heart for his endless enthusiasm, his understanding of the text, his patience and his skills.

Sincere thanks also go to Ellen Russon, academic translator, for taking on such a hard mission and to translate what seems impossible into decent English. Without her thorough engagement, the English edition of Synthesis V would never have made it! The same is true for the careful proof-reading by Katharina Tschopp, vdf Hochschulverlag AG Zurich.

Davos and Zurich, Fall 2007 and Summer 2008
Britta Allgöwer, Overall Responsibility for Final Report Synthesis V

Prologue

«**Orascom Hotels & Development**[1] **(OHD) with headquarters in Cairo**, **Egypt**, plans to build a tourist resort with hotels and vacation apartments and houses. The hotel plan calls for upwards of 3,000 beds, commercial spaces, various sports and wellness recreational facilities, and an 18-hole golf course.»

«**Harbor City Flüelen:**[2] The combination of being located on the lake and being historically a tourist destination with the potential to attract transit passengers could be a great opportunity for the Alpine valley to become a new stopover on the international route. As a development priority, it is proposed to make Flüelen a stopover for train, automobile, and ship travellers. By using the lake site and the potentials of the traffic carriers, a new city area could be built in the form of a harbour city with international travel connections. Flüelen comes to the lake again and becomes an attractive starting point for the future of the historical ring of settlements in the area.»

«**From Magic Mountain to Magic Tower:**[3] The government[4,5] has approved the local planning revision that was passed by voters in Davos on October 31, 2004, which calls, among other things, for the construction of a 105-meter high tower with a hotel and apartments on the Schatzalp. At the same time, the government dismissed the planning complaint that had been submitted against the project.»

These are key sentences in the planning documents for large construction projects in the Alps. Are they harmless paper tigers or inflammatory stuff in spatial planning? Planning games or serious development trends in a sensitive region?

The present Synthesis Report of Research Focus V of NRP 48 does not provide an answer, but it shows possible ways that projects such as those described above could be simulated before they become reality. The title «Virtual Worlds – Real Decisions?» is meant to express the area of tension between planning, modelling, and realization. While in the past we depended on cardboard mock-ups as visualization aids, today it is almost scary to see the multitude of possibilities opened up by the Internet and by the computing capacity of today's personal computers. 3D and 4D planning worlds seem to become child's play. However, the boundaries between reality, fiction, and parallel worlds become blurred. On May 21, 2007, the following announcement appeared in the digital press:[6]

«German bank opens branch in Second Life. Berlin/Munich/Grasbrunn – In the race for optimal company marketing in the virtual, 3D simulated virtual world, Second Life, the German financial services and specialist for elec-

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1 SAWIRIS-Projekt: Richtplananpassung Urserntal (Amendments to the Zoning Plan), Erläuterungsbericht gemäss Art. 47 RPV, Korrekturexemplar Änderungen gegenüber Stand 12.09.06, Herausgeberin Kanton Uri, Justizdirektion, Projektleitung Andermatt, Tourismusresort Benno Bühlmann, Projektleiter, Bearbeitung Ernst Basler + Partner AG, 8032 Zürich, 14.11.2006, pp. 60.

2 Metron: Kurzzusammenfassung der Testplanung 06, pp. 1. REUR – Raumentwicklung unteres Reusstal Bericht Testplanung Juni 06 Marina Uri, pp. 14.

3 Pius App: Die Schatzalp – vom Zauberberg zum Zauberturm. Paper presented at SommerUni Davos 2007 – Die Alpen zwischen Idylle und Grossbaustelle, 20. – 24.08.2007, Davos.

4 Resolution of the Government of the Canton of Graubünden of July 4, 2006 (Protokoll-Nr. 815).

5 http://www.link-gr.ch/wbb2/showthread.php?p=952 (Retrieved June 1, 2007).

6 For example, at: http://www.news.ch oder http://www.nachrichten.ch/detail/275849.htm (Retrieved June 1, 2007).

7 http://secondlife.com/world/de/whatis/ (Retrieved June 1, 2007). Text translated freely from the German-language Home page of the Second Life Web site, referring also to the English-language Home page of the site.

8 Koeppel, D. 2002. Massive Attack. Popular Science (Online), November 2002, http://www.popsci.com/popsci/science/ (Retrieved February 15, 2007).

tronic payment systems Wirecard is now opening its own interactive branch.»

The Second Life Web site reads like a modern adaptation of earlier science fiction literature with its quest for a better world, only that, ironically, Second Life has internalized today's spirit of materialism and claim to doability:

«**Second Life is a 3-D virtual world entirely created by its Residents.**[7] In this incredible online world that is growing explosively you can create or become virtually anything that you can imagine (...) You can design and sell digital creations and perhaps you'll find a perfect parcel of land to build your house or business. You can buy, sell and trade with other Residents using in-world unit-of-trade, the Linden dollar, which can be converted to US dollars at several thriving online Linden Dollar exchanges.»

There is also a blurring of the lines between research and the entertainment industry. Multi-agent technology and ingenious computer graphics make it possible for the monstrous forces of the **Orcs**[8] to march and battle upon an imposing landscape in the «Lord of the Rings» film trilogy. The Orcs – that is, the agents – possess both a giant repertory of movements and even senses that allow them to make «independent» decisions and to navigate the artificial battlefield landscape «intelligently». On the other hand, the academic world is also engaged in research on artificial intelligence and the virtual world. There are interactive 3D applications in medicine, for example for learning endoscopic microsurgery, in architecture, and, more closely related to this synthesis report, in the field of landscape analysis.

Finally, it can be said that grafical and cartografical representation is an old wish, be it for strategic and military reasons or for memories and emotions. It may come as a surprise that 3-dimensional representations played a role in early times already. However, planar representations require much more imagination than 3D models which can be understood intuitively. A stunning and filigrane example for that was elaborated by an unknown artist around 1800. With great skill and care, the Bernese Alps between Interlaken, Haslital, the Brienzergrat and the Breithorn were embeddet into a real nutshell. Today, this treasure of landscape representation and cartography is hosted by the Schlossmuseum Burgdorf.

The present synthesis report, «Virtual Worlds – Real Decisions? The Alps in a Modeller's Nutshell», a thematic synthesis and outlook on Research Focus V of NRP 48, «Virtual Representation», shows the extent to which modelling played a part in National Research Programme 48, «Landscapes and Habitats of the Alps», and takes a look behind the scenes of virtual computer-based planning instruments to draw conclusions for the world of practice.

Davos, Zurich, Sheffield and Berlin, Fall 2007
The authors:
Britta Allgöwer, Ariane Walz, Christian Gloor, Peter Bebi, Andreas Fischlin, Eckart Lange, Kai Nagel

Source: Anonymus, around 1800; Schlossmuseum Burgdorf.

Summary

The present thematic synthesis and outlook on Research Focus V, «Virtual Representation», of National Research Programme 48, «Landscapes and Habitats of the Alps», deals with computer-based modelling, simulation, and visualization of landscapes and landscape-changing processes.

Real landscapes are sluggish. In most cases real changes to the landscape are irretrievable, and there is no room for experiments. That is why it makes sense to test development options and development alternatives in a «virtual world» before final decisions are made. Computer-based models allow the testing of selected mechanisms of our reality in this «virtual world», and the visualization succeeds in communicating the virtual world to us in a way that it can be understood intuitively. For this reason virtual representation of landscape processes using models and visualizations is becoming increasingly important for planning.

The main goal of this synthesis report was therefore to discuss the potential of computer-based models and visualizations for spatial and landscape planning and to show what NRP 48 has contributed to this.

The report presents not only the direct experience coming from NRP 48 research projects in the sense of a synthesis (Chapter 2) but also an extended outlook for better establishing the use of models in planning practice (Chapter 3) and proposes a method for improved development of models for use in practice (Chapter 4).

– **Part 1 (Chapter 2)** of the report describes the models that were developed within NRP 48 and, based on that, shows the current state-of-the-art. Part 1 shows that the models of NRP 48 deliver important contributions towards current issues in landscape research (content, methodological, and technically oriented) and cover a wide range of possibilities in the area of landscape modelling.

The models analyzed are highly complementary in terms of content and methodology, so that there is great potential in their combination. But as the models were not selected systematically, there is no one coherent total outcome.

The models of NRP 48 address the most important topic areas in spatial and landscape planning in the Alps. These include mechanisms and consequences of landscape changes through changing agricultural use patterns and intensive, often tourism-determined, settlement development, as well as changes in potential natural hazards due to global warming.

The NRP 48 research covers also different functional orientations of models. Whereas the function of models in research lies mainly in the explanatory analysis of systems, the NRP 48 projects also developed simulation models, evaluation approaches, and visualization techniques that can be used in planning processes. The different tools can be used in combination or singly.

In order to meet the requirements of scientific research, detailed methodological or technical questions typically stand in the foreground of these projects. Although feasibility and plausibility of the models stand in the foreground, the resulting findings can be of great practical relevance. The models themselves represent prototypes that were developed and tested in the individual case studies.

The software used was mostly also implemented as prototype software, in order to be able to provide «proof of concept». To be ready for application in the world of practice, programming work is needed that goes far beyond that required by the research task. This means, too, that the prototypes do not meet the necessary standards with regard to user friendliness, stability, computing speed, and documentation. The information on the assumptions made, as well as the technical backgrounds, would be necessary, however, for interpretation of the

simulation results and for adaptation of the models for other application situations.

This means that the developed models themselves can be used in planning as generally valid tools only to some extent. Many of these models do some justice to the complexity of spatial and landscape planning, but adequate tools for planning practice should chiefly portray well-defined and recurring questions in regional and landscape planning.

- **Part 2 (Chapter 3)** of the report builds the bridge to planning practice, by discussing the reasons why computer-based models are rather little used in spatial and landscape planning and solution approaches. Here it was found that the results of representative international studies on this topic are largely in agreement with the experiences of the Advisory Group process of Synthesis Report V concerning the situation in planning practice in Switzerland.

  The models and visualizations are understood here as important aids in planning. As the complexity of planning issues increases and there is greater pressure for adequate bases for decision-making, the importance of models will grow in the future. Models can support the political process of decision-making by providing additional information. Visualization, in this context, is used mainly as a means of communication. Visualization can display in-dividual interventions in the landscape, such as the steady loss of cultivated land, in a form that can be grasped intuitively.

  Besides a lack of experience in working with models, the use of models has become little established in planning practice mainly due to technical problems, such as the problem of data availability and quality but also the problem of interfaces between software packages.

  In view of the development since the 1990s, improvements in the area of data availability and quality are likely to be made soon. The overall good data situation in Switzerland could be further improved for planning tasks by means of the targeted combining of datasets. Regarding the problem of interfaces, NRP 48 projects were able to contribute solutions for integration of different software environments as well as different models.

  Models that specifically address well defined planning questions can be optimized technically in a way that they can serve as tools in the world of practice. But modelling can also be used as a method for structuring problems that are more unclear and confusing. In that case, the accent is not on the model as a tool but instead on the process of modelling and the (often collective) learning process connected with it. For this, mostly participatory methods were developed in the research and used in the framework of case studies. These are usually initially qualitative approaches that for individual, clearly delineated sub-questions fall back upon numerical models. And finally, modelling can also be a valuable method in planning practice and administration for the analysis of data that is often difficult to capture. Here, too, it is the process of modelling that stands in the foreground.

  The effort required must stand in a sensible proportion to the gain that is achieved through the use of models and visualizations. As many visualization tools (for example, Visual Nature Studio, Simmetry 3d, LandXplorer, or also ArcGIS 3D Analyst) can be used quite comfortably today, visualizations are being used increasingly in planning. Here, in addition to computer-based editing of photographs, also 3D visualizations are being used that are based on abstract data, such as land use mapping or construction plans.

  Due to the technical problems and lack of experience with models, the use of models today often requires great effort and expenditure for planning practice. For this reason, the use of models in the near future will most probably be concentrated in the area of large planning projects. The large construction project planned by Orascom Hotels & Development (Cairo) in Andermatt, the «Harbour City» Flüelen, the Gotthard Base Tunnel, the proposed Porta Alpina railway station in the Gotthard Base Tunnel, or the expansion of the Grimsel reservoir through a giant dam project are all projects that would have a complex, multilayered impact on the affected regions and their landscapes. In the framework of such large projects models can be used sensibly and profitably today. In these projects, participatory, qualitative modelling, for example, could represent a helpful step in the planning process, whereas individual issues could be examined using numerical models that have been developed as tools for the purpose.

In addition to the computation of information bases in the decision-making process, realistic visualization is an important aid in planning. It is particularly valuable for communicating changes that can be expected in the future and that may be «creeping changes» taking place over a longer time span. Realistic 3D visualization is an important aid to illustrative and impressive communication of the results of complex landscape simulations. This holds especially for public relations work, but depending on the matter at hand, it can also be useful to specialists as an aid to visual imagination. The use of seriously documented and communicated models for estimation of the future look of the landscape can lessen the danger of misuse of this effective means of communication.

Improved cooperation between practice and research could also reduce the problem of the lack of experience and thus also the methodological problems and scepticism in dealing with models in planning. Master's theses and doctoral dissertations completed in the context of real planning projects improve the transfer of know-how and train specialists for work in the field.

Finally, we propose comprehensive guidelines for the use of models in planning as a kind of identification key. The guidelines are meant to serve as an easy way for interested planners to learn about the possibilities and methods of modelling and visualization and to be able to use them profitably in planning practice.

– **Part 3 (Chapter 4)** of the report presents a method for improved development of computer-based models and accompanying software for practice. Presenting a number of examples, Part 3 explains how virtual planning and landscape analysis instruments work and how they can be designed and implemented jointly in a dialogue between user and developer. The formulation of use cases or applied examples is a way to optimize the match between the requirements and functionalities of a model in the sense of a tool and within the range of technical possibilities. This approach has been used in software development for decades but up to now has not found its way into landscape model development.

When formulating use cases, extensive applications are divided into the smallest, detailed steps, and step-by-step, made-to-measure software specifications are formulated. With this, the communication aspect can be taken into account, and for another, the technical practicability of the formulated requirements can be tested.

A «teaching» example is presented in order to illustrate in detail the application of one of the NRP 48 models to a hypothetical planning question. Taking the example of the Schatzalp tower in Davos, it is demonstrated how a complex and convoluted issue can be subdivided into well-defined aspects. At the same time, this example documents the time effort that is required in order to apply models that were developed in a case study to other regions or slightly different questions. This illustrates quite clearly also the technical challenge involved in developing transferable models.

Further examples taken from NRP 48 research projects and their hypothetical use in specific applications show what contributions the models can make for planning. Typical planning situations are presented in which the models are used. The selected use cases comprise ecological issues that are relevant for the natural scenery (example: migration patterns of larch bud moths) as wells as aspects of local planning (example: changes in zone planning). And finally, a prominent use case on subsidization of agriculture illustrates how the NRP 48 models presented can be combined in terms of content.

The examples presented show that the NRP 48 research projects cover important challenges of current spatial and landscape planning in the Alps to a large part but that the technical transfer (mostly) does not (yet) meet the demands of planning practice.

1 Introduction

1 Introduction

1.1 Motivation

What is a landscape; what is a habitat? Where does landscape begin, and where does it end? How can landscapes be represented virtually, if we can hardly or only with great difficulty describe in words their multidimensionality and complexity, never mind quantify them adequately?

The present synthesis report on Research Focus V of NRP 48, «Landscapes and Habitats of the Alps», does not claim to provide comprehensive answers to the question above. But it does aim to show, despite all limitations, how landscapes and habitats can be simulated and virtually represented. What is more, it aims to show what computer-based virtual landscape analysis and planning instruments would have to be like, and what the present research findings of NRP 48 could contribute towards those instruments.

Here the report deals with both computer-based modelling and computer-based visualization. For when we speak of «virtual worlds», the two (independent) techniques are often combined (Koll-Schretzenmayr et al., 2004).

To do this, the report bases on the modelling-oriented projects in NRP 48, but it also considers the widely diversified specialist literature. It also takes a look behind the scenes of software development. In this look behind the scenes we approach complex modelling procedures using short, easy-to-understand narratives, which are referred to as «use cases» in the language of software engineering.

The content of the report concentrates on the methodological discussion. Geographically, it is restricted mainly to the Swiss Alps, because the research projects examined deal almost exclusively with this region, or parts thereof. Interest centres on the modelling techniques and approaches that were used and applied, and on the extent to which in future modelling and visualization could be used in spatial and landscape planning in the Alpine region. Although the approaches implemented in the different projects are not necessarily restricted to the Alpine region, the difficult topographical conditions present a special challenge for modelling and visualization that requires specific handling.

The realization of spatial and landscape planning concepts often fails due to the fact that the public as well as decision-makers can scarcely imagine the repercussions of deciding or not deciding, and they frequently underestimate future developments. But many problems are only discernible in the longer-term view. As political processes are oriented to the short term, models can provide a means of stronger and better-founded consideration of longer-term developments.

The present report aims to examine current research issues in landscape modelling and analysis, to show how the research findings can be used in the world of practice, and to show what requirements products must fulfil to be suitable for practical use.

1.2 Importance of this report for research on the Alps

As mentioned above, with regard to methodology, this report is not bound to the Alps. The field of landscape analysis and planning instruments could be examined taking the example of any type of landscape. Naturally, more complicated topographies place higher demands on models and data, and the example of the Alps shows this clearly.

Because the Alpine region is facing great changes, both clearly noticeable ones and also more creeping changes, methodological issues in modelling and virtual representation as tools in spatial and landscape planning for this region are of great importance. Upcoming large projects call for modelling and simulation as possible instruments in planning. In this connection, think of the following, for example: dam projects, transit through the Alps, the elimination and establishment of natural parks, decisions on second home construction, or decisions on investments in winter tourism against the background of expected climate change. Besides large projects, also gradual changes in land use patterns have an effect on the landscape, triggered, for example, by new agricultural policies or by changes in tourist or recreational behaviour. These changes are not caused directly by individual, direct interventions in the landscape but instead affect the landscape gradually due to numerous, quasi-independent individual decisions.

The projects mentioned above and landscape-relevant decisions in agricultural, land development, and tourism policy as well as the associated decision-making processes can be supported by means of suitable planning instruments. These instruments make it possible to simulate and depict in images different future scenarios in virtual worlds. Whether the correct decisions are then made for the real world is another question, and one that this report cannot answer.

1.3 Advisory Group

To firmly anchor the function of the synthesis report on Research Focus V as a bridge between research and practice, the Advisory Group was designed to be a stakeholder group, made up of representatives from the economy, administration, politics, and research. The purpose of two of the three meetings of the Advisory Group was to identify and communicate the needs and interests of different stakeholder groups. This Advisory Group process is documented in the Appendix, and the results of this cooperation, along with a review of the relevant literature, form the basis of Chapter 3 below.

1.4 Target audience

This synthesis report is written for users of computer-based virtual planning and landscape instruments and for all those who would like to implement these instruments in the future. With this, the report is targeted in particular to government agencies and offices that deal with spatial and landscape planning as well as to the corresponding private planning offices and consultants.

In addition, the report is for decision-makers in politics, government, and the economy that would like to gain an overview of and become familiar with the possibilities of these instruments.

1.5 Goals

The main goal of this synthesis report is to show the potential of computer-based models for spatial and landscape planning. This main goal is to be achieved through the following three part goals:

- **Sub-goal 1**
  Present the range and breadth of the models that were developed in the context of NRP 48, under consideration of various characteristics, and, based on that, show the current state-of-the-art.

- **Sub-goal 2**
  Identify expectations placed in computer-based instruments and problems in their use in practice, and from the range of approaches in the NRP 48, carve out contributions towards solving the problems.

- **Sub-goal 3**
  Introduce a way to support targeted development of computer-based instruments for use in practice and explain it with the aid of selected examples.

1.6 Questions

The following catalogue of questions defines the goals of Synthesis Report V specifically and in this form also represents the basis for the final conclusions. The catalogue picks out as central themes both the contributions and the significance of NRP 48 research projects in the area of computer-based instruments and present and future possible applications of these instruments in spatial and landscape planning.

- **Sub-goal 1**
  - What insights do the NRP 48 research projects deliver in the area of modelling, computer-based simulation, and virtual representation?
  - With regard to applicability, what are the most important research areas in the field of computer-based landscape modelling for the future?

- **Sub-goal 2**
  - Are modelling, simulation, and visualization techniques useful aids for solving existing problems in spatial and landscape planning? If so, in what way do they make a contribution?
  - Can we identify characteristics of research models that make them suitable also for practical applications?
  - What are the prospects of computer-based modelling, simulation, and visualization techniques for practice? What are the next steps towards making them easier to use in practice in the future?

- **Sub-goal 3**
  - How can the needs of potential users directly influence the development of a model?

1.7 Organization of the report

The organization of the report in three parts follows the three sub-goals above.

The first part of the report (Chapter 2) is a critical appraisal of those research projects in NRP 48 that focused on modelling and computer-based visualization techniques. First, the projects and their contribution towards modelling are presented in brief. Then, the range that these models cover with regard to various characteristics is shown and the contribution of these NRP 48 research projects towards landscape modelling is evaluated.

The second part of the report (Chapter 3) outlines the needs of practice, based on the relevant literature and on the cooperation with stakeholders in the Advisory Group. After clarifying needs, problems in using computer-based models in practice are examined and possible contributions of the research towards solving them are shown.

The third part of the report (Chapter 4) presents an approach to the development of computer-based instruments from software engineering. On the basis of examples from NRP 48, possible procedures are discussed and, for illustrative purposes, a hypothetical application situation is presented in full run-through as a demonstration. The CD accompanying this synthesis report contains visual aids in the form of films on this example.

In the summary (Chapter 5), the questions listed in section 1.6 are answered individually with reference to the elaborations presented.

1.8 Definition and delimiting of key terms

To ensure a common understanding, some key terms used repeatedly in this final report have to be clarified: What topic areas does landscape research comprise? What problems are dealt with by spatial and landscape planning? What is a model, and in connection with this, what is the focus in this synthesis report? What is a simulation? What is a scenario? How is the term scenario used?

Landscape research

Landscape research studies diverse factors that influence the landscape and that are themselves influenced by the landscape. Landscape research investigates in a particular segment of the landscape the entire complex system of interrelationships between communities, their environmental conditions, and their development over time. Landscape research sees human beings, who capitalize on, change, and use the landscape, as a part of in this complex system. Landscape research cuts across disciplines; in addition to specialists in biology, pedology (soil science), hydrology, and other natural scientific disciplines, also specialists in regional planning, agriculture, and tourism, psychology, history, and other social scientific disciplines contribute to the field.

In the last ten years, there have been great efforts in landscape research to develop models that enable the simulation of landscape changes and evaluation of the effects on humans, animals, and plants. This work focuses in particular on the estimation of the consequences of human interventions and of climate changes on ecological systems. Many of these models are based on geographic information systems (GIS) and on remote sensing data (aerial photographs from aircraft and satellites).

Spatial and landscape planning

Spatial planning is a government task that is laid down in the Federal Law on Spatial Planning (RPG). The primary aims are economical use of the limited land area and settlement of the land according to the desired spatial development (Art. 1 RPG), in order to ensure in the long-term preservation of the habitat and a variety of land uses.

The goal of spatial planning is to balance the different needs and interests of people and the environment and in this way to see to it that development in Switzerland is sustainable development – that is, that it is economically, ecologically, and socially balanced development.

Spatial planning comprises all spatial planning by the government at all administrative levels and in all areas related to it, such as traffic, environment, economy, society, and many more (BRP and EJPD, 1998).

Landscape planning deals with consideration of the natural resources on which life depends in all planning decisions and thus also with the use, protection, and design of open spaces in the landscape and in settled areas (BSLA, 2005). Landscape planning is an integral component of spatial planning (for example, when preparing bases for decision-making on designating building zones and no-construction zones), but it can also be independent planning (such as nature conservation concepts) or a component of environmental impact assessments. In addition, landscape planning makes an important contribution in the form of advisory planning for conservation of the countryside (for example, in connection with road projects).

Model

A model is a simplified representation of reality, reduced to essential aspects. When perceiving our reality we often use models, although we usually do not do so explicitly, and we are usually not even aware that we are doing so. The exact form that the models take is determined by our previous knowledge, our perspective, and the situation in which we find ourselves. What «the essential aspects» are and how they are represented in the model changes depending on the question and the field of application of the model. The same holds for explicit models as they are used in research and practice.

The range of models is accordingly large, as in addition to purely mental models, using which, as mentioned, all perception of reality begins, it encompasses also physical and computer-based models. Computer-based models play a central role in education and research, for deliberate reduction of the complexity of reality is often necessary in order to portray the most important relations and to deliberately view individual aspects in greater detail. Using physical and computer-based models, it becomes possible to play with reality and to conduct experiments that would not be possible in the natural world.

Mental, physical, and computer-based models are used in landscape research. An example of current research in the area of mental models is the investigation of changing concepts of the interaction between people and landscape, which is a central topic in landscape research (Tress and Tress, 2001). An example from a research project in NRP 48 is examination of differences in concepts of the landscape that can make decision-making processes, or communication between various interest groups within these processes, much more difficult (Droz and Miéville-Ott, 2005). These mental models are largely the topic of NRP 48 Synthesis Report I, «Alpenlandschaften – Von der Vorstellung zur Handlung» (Alpine landscapes – From imagination to action) (Backhaus et al., 2007), on Research Focus I, «Processes of Perception and the Representation of Landscapes and Habitats in the Alps».

Physical models are used especially in natural scientific-oriented landscape research. An example of a physical model is a representation of river systems, with which experiments can be conducted on flooding, restoring to nature, or (control) structures.

Computer-based models are the subject of Synthesis Report V. They are mainly used in landscape research for the purpose of explaining, simulating, or predicting and assessing the effects of landscape changes. Computer-based models allow simulation of the reaction of the system represented, in dependency upon individual influencing factors. This makes it possible to experiment with systems that can not be reconstructed physically. This is especially necessary where the systems are too static (that is, their changes are too slow) to be represented in a physical model (for example, forest or climate development) or when the interaction with people is the essential part of the system. Using the computer-based model, virtual experiments can be conducted in order to gain insights into the system modelled and its reaction to various influencing factors.

Computer-based models are also used for simulation of the future. Researchers experiment with alternative future scenarios, and the reaction of the system to changed, plausible future input parameters is depicted. The models estimate, for example, the long-term consequences of changing climate conditions or the repercussions of a policy decision. By providing this information they can make a substantial contribution to decision-making. Although there are also analog simulation models, in this Synthesis Report V we always refer to computer-based simulation models.

When drawing up a computer-based model it is important to set clear objectives. According to the goals, decisions can be made as to what scenarios and factors must be examined in order to generate usable findings. At the same time, there has to be a certain extent of generalization, and the degree of detail must not be too high, because otherwise the time required to build the model and to calculate each experiment increases.

Simulation

Simulation is a true-to-life representation of processes, resources, and sequence of events, for the purpose of estimating developments and assessing changes without having to intervene in the real process. The Association of German Engineers (VDI) defines simulation as follows (VDI, 1993): «Simulation is the emulation of a system with its dynamic processes in a virtual model, to gain knowledge and identify situations that are transferable to the real life model.»

Simulations are usually based on dynamic models with a temporal component. Originally, in physics, differential equations were used. In landscape modelling, however, time discrete simulation is usually sufficient to produce the connections between system states and specified points in time.

The time range of simulations in spatial and landscape planning is usually several decades, starting with the present time and extending into the future. Validation of the model, however, usually starts out from a well-documented state and from there simulates the past, so that the real development can be compared to the results of the simulation.

Visualization

Visualization means that information or connections are put into the form of an image or other form that is simple to grasp. Visualization is a means of communication, whereby the information can be either abstract (diagrams and figures) or realistic (for example, photorealistic landscape visualizations).

Landscape visualization techniques include «static» visualizations such as photographs and digitally retouched images as well as «dynamic visualizations» such as films and computer animations. In planning practice, digital photomontages are usually used (2D image data). These can be highly realistic. In recent years 3D data are being used increasingly to generate truly 3D landscape models («virtual worlds»), in which the observer can move around freely (Lange, 1994). While this kind of visualization is more challenging technically, it is characterized by an understandable methodology, in which the landscape visualization is based on a digital terrain model and 3-dimensional individual objects that can be combined with high-resolution textures such as digital orthophotos or facades of buildings (Graf, 1995).

A great advantage of 3D visualizations is that the approach is largely transferable, so that also changed, or for example simulated, data sets (input in some standard formats) can be rendered into realistic images. 3D visualizations thus provide a technique for connecting simulation models with realistic graphic representation.

In spatial and landscape planning, visualizations are used to clarify relationships that arise from a given data set but that are not necessarily directly imaginable visually. In this way, the visual impression that is caused by an intervention or creeping changes in the landscape becomes accessible for the planning process (Lange, 1994). In addition, within a modelled landscape segment, different variants of planning can be generated in a simple manner for comparative purposes, and they can be shown in various perspectives. As data becomes increasingly accessible and use of the corresponding software becomes more and more established, the use of visualization is increasing also as a means of communication in participatory planning processes (Lange et al., 2005).

Scenario analysis

In the technical jargon, a scenario is a hypothetical sequence of events constructed under consideration of causal relationships and for the purpose of describing possible developments.

Scenario analysis is a method of representing and analyzing possible developments that is used in industry, the military, and policy development but also in spatial and landscape planning. One of the first areas in which scenario analysis was used was in the *think tanks* on military issues of the U.S. government in the 1960s (Kahn and Wiener, 1967). Other prominent examples are the Shell Scenarios for strategic corporate planning (for example: Shell, 2001), the economic study «Limits to Growth» published by the *Club of Rome* (Meadows et al., 1972), and the climate scenarios of the Intergovernmental Panel on Climate Change (IPCC).

A central goal of scenario analysis is to consider uncertainties that affect the system under view and that are scarcely estimable. In working with models, with little known input parameters scenarios are developed that represent plausible and often simplified descriptions of the future. Note that they are thus not (definite) predictions.

Besides plausible developments of the system under examination, what is usually developed is a projected course or chain of negative developments as a negative extreme scenario and a projected course or chain of positive developments as a positive extreme scenario. The two extreme scenarios show the range of potential developments with regard to the uncertainties considered. It is assumed that actual future development will be located somewhere between these two extremes (see Figure 1-1).

Scenarios are often used in landscape modelling, because the changing future conditions can be estimated only with great uncertainties. Due to their complexity, all relevant influencing factors and their mutual interactions are thought through consistently, in order to derive input values for the simulation. This can be done either according to strict, formal criteria or also relatively informally and intuitively (Scholz and Tietje, 2002; Wiek et al., 2006).

A scenario analysis can be used for both descriptive/exploratory or also normative/strategic purposes (van Notten et al., 2003). «Descriptive and forecasting exploration scenarios» (van Notten et al., 2003) focus on the question of how future developments will look. In contrast, the normative/strategic approach is oriented towards a desired development in the future and asks, «How can such-and-such a state be achieved?» In spatial and landscape planning, the status quo is usually taken as the starting point and following the descriptive/exploratory approach, potential developments for the future are derived, or simulated, if models are used.

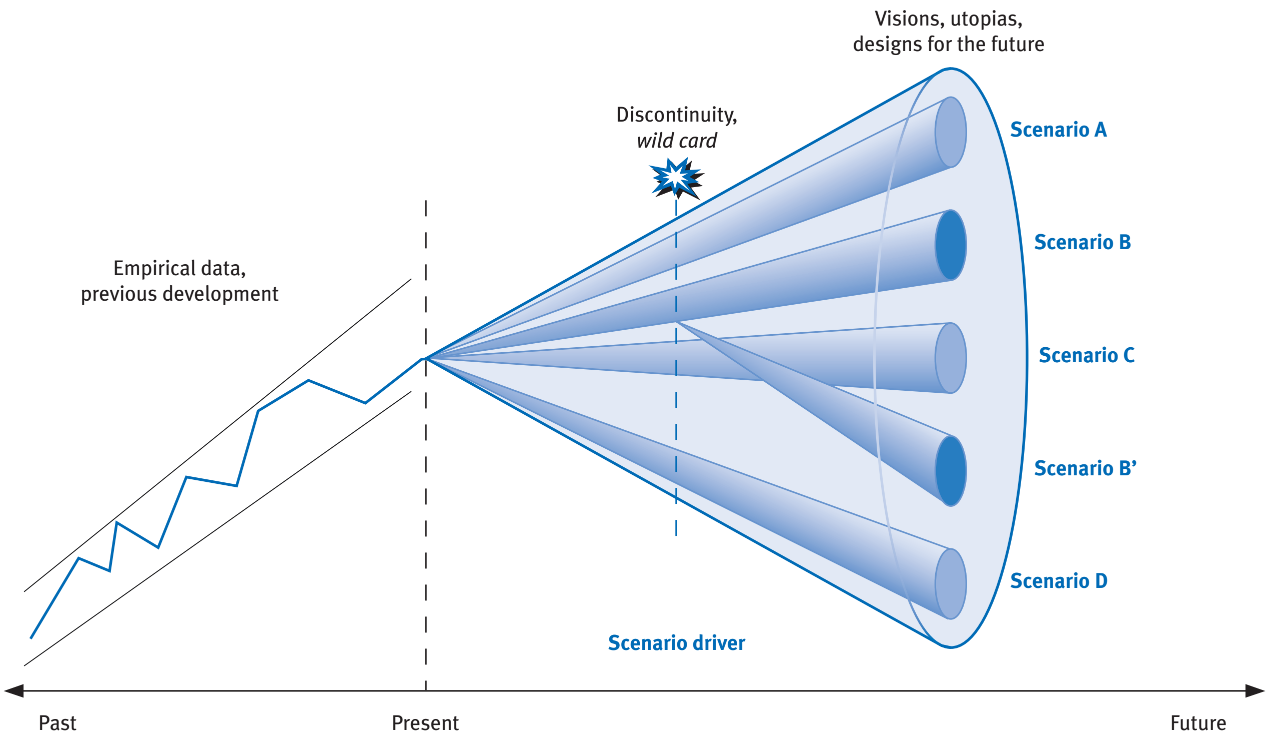
In the present synthesis report, we use the term scenario if alternative input values or data sets for the simulation can be derived on the basis of potential future developments.

The scenarios can be scenarios that address conditions that develop externally and do not have a direct influence on the system under examination (for example, the effects of WTO negotiations on regional mountain agriculture). In this case, a scenario analysis can show what consequences arise out of the new constellation of external conditions and whether there is a possible need for action.

But the scenarios can also be scenarios that analyze alternative actions by local decision-makers (for example, deciding between various building investments). In this case, possible future effects of a decision, such as effects on the landscape, are assessed. Models and computer-based tools can compare different decision variants and their consequences, allowing identification of the most sensible variant in the long term.

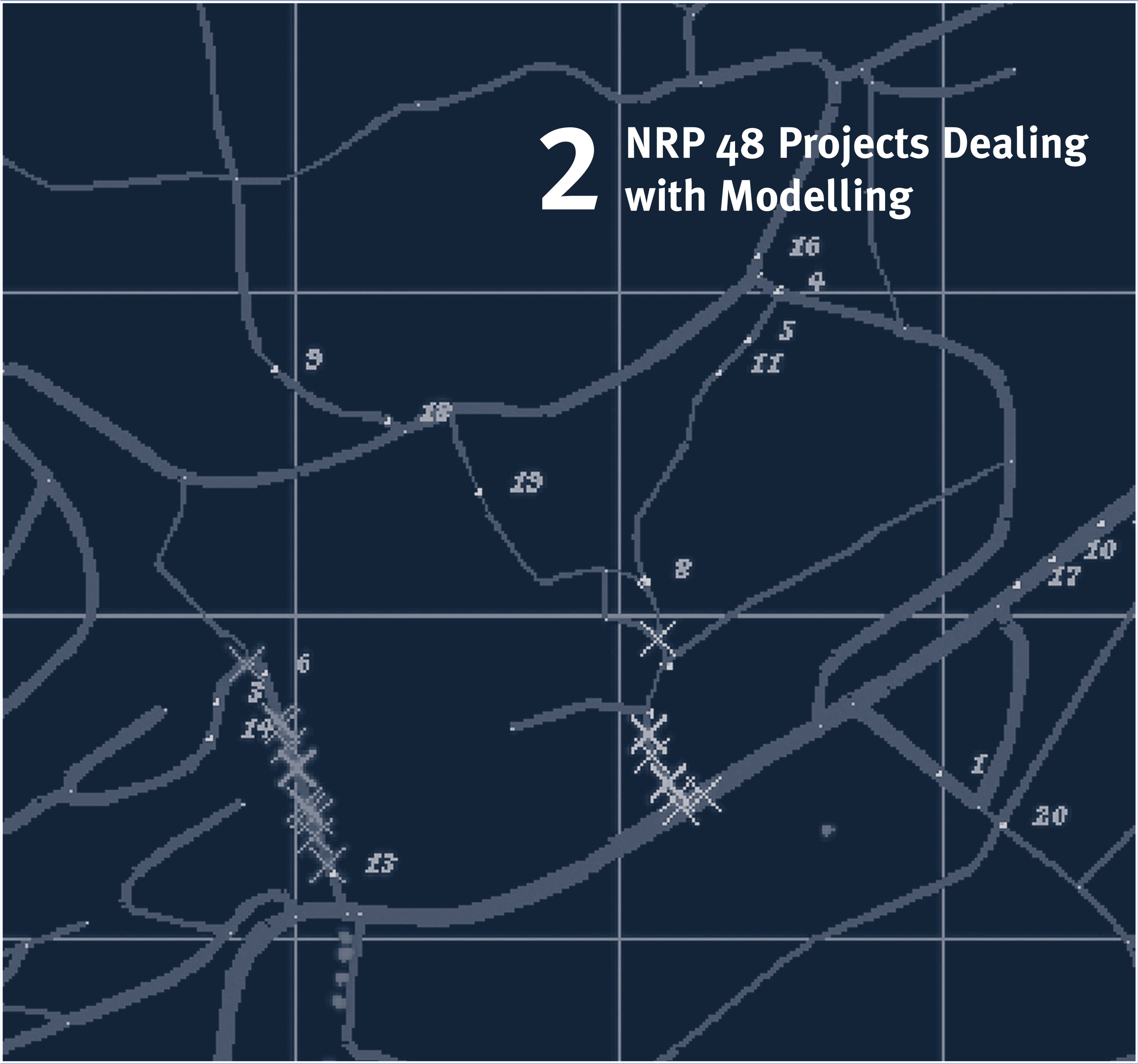
Figure 1-1

Range of scenarios in a scenario analysis, shown as a scenario funnel



Source: Translated from Graf und Klein (2003).

2 NRP 48 Projects Dealing with Modelling



2 NRP 48 Projects Dealing with Modelling

This chapter presents a synopsis of the relevant projects in NRP 48 and appraises their contribution against the background of current landscape research. The projects selected all relate to modelling. How do they differ? What parallels can be identified as to methodology and/or content? Are the models complementary in terms of methodology and/or content? Do their results complement one another, or can the models themselves be combined? To what extent do the models relate directly to the Alpine landscape?

2.1 The projects

The present synthesis report bases on 13 projects within NRP 48 (see Table 2-1). Six of the projects focus directly on development and simulation using computer-based models. They form the core content of this synopsis. The other seven projects complement the modelling projects with regard to content and methodology. They extend the synopsis to include important individual aspects that are not covered directly by the modelling projects, and they are foundations for future models. Here, the seven projects can only be described very briefly and their contributions to this synthesis report carved out. The reference list contains publications stemming from the NRP 48 projects that provide further and more detailed information. Additional documents can be found on the National Research Programme 48 Web site at www.nrp48.ch.

As shown by the arrangement of all of the projects listed in Table 2-1, this synthesis report concentrates on simulation models as described in section 1.8. What simulation models can contribute to decision-making processes and how they can be optimally integrated in decision-making processes is the subject of Synthesis Report V. Here, an important aspect is also the communication of simulation results. Computer-based methods, together with highly developed visualization techniques, allow the creation of attractive communication media (Bishop and Lange, 2005; Lange et al., 2005) that can be used effectively in addition to the pure content information provided by modelling.

In the projects ALPSCAPE, ALPSIM, GISALP, IPODLAS, SCHUTZWÄLDER and SULAPS, shown highlighted in blue in Table 2-1, the development of simulation models was a central component of the research. These projects form the core content of the present synthesis report. While simulation models were used in the projects ECOSYSSERV and ERREICHBARKEIT, the research focus was not on prediction but on approaches to valuation of landscape changes and on retrospective analyses. In the other projects, some important foundations for modelling were worked out, such as capturing the rate of observed landscape changes and systematization of driving forces of landscape transformation in the TRANSFORMATION project.

In the following, the projects listed in Table 2-1 are described in brief. The projects highlighted in blue, in which the development of a simulation model was of central importance, are described first and somewhat more fully.

Table 2-1

Overview of the NRP 48 projects examined in this Synthesis Report V

The projects highlighted in blue are the six projects that focus on the development and use of computer-based simulation models and that form the most important content bases of this report.

Abbreviated Name Heads of projects	**Project Title**
ALPSCAPE Bebi	Vulnerability of the Alpine landscape and habitat: Simulation of future landscapes and development of support tools for regional decision-making
ALPSIM Schmid	Planning with virtual Alpine landscapes and autonomous agents
GISALP Haeberli	Spatio-temporal information on rapidly changing climate-sensitive high-mountain environment as a strategic tool for communication, analysis, participative planning and management for the intensely developed tourist region of the Upper Engadine
IPODLAS Allgöwer	Knowledge-based dynamic landscape analysis and simulation for Alpine environments
SCHUTZWÄLDER Brang	Required levels of tree regeneration in forests protecting against natural hazards: Model-based indicator development
SULAPS Pfefferli	Sustainable landscape production systems: A demand-oriented agricultural approach
ALPRO Schwarzwälder	Multi-criteria screening of landscape development projects as a management tool for participatory consensus finding
ECOSYSSERV Grêt-Regamey	Spatially explicit valuation of ecosystem services in the Alps as a support tool for regional decision-making
ERREICHBARKEIT Axhausen	Transport infrastructure, tourist behaviour and spatial structure in landscapes and habitats of the Alps
FLOOD'ALPS Gobat	Floodplains of the Alpine arc between security and biodiversity: Changes in the representations, decisions and management
SOZIALES UMFELD Droz	Landscape's social field: Representation and legitimacy in the use of the mountain habitat
TRANSFORMATION Pfefferli	Transformation rates of Alpine landscapes and surrounding areas: Potential threats and benefits to people and selected species
WASALP Baur	Forest expansion in the Swiss Alps: A quantitative analysis of bio-physical and socio-economic causes with an emphasis on structural change in agriculture

Alpscape

In the Alpscape project, models from several disciplines are combined to simulate regional development of the study area, the Alpine region of Davos, in the framework of a participatory process (Bebi et al., 2005). Alpscape, as an integral model, combines individual sub-models: a regional Input–Output Model (Wegmann and Kytzia, 2005), a Resource Flux Model, a spatially explicit Land Use Allocation Model (Walz, 2006) and an Ecosystem Service Validation approach (Grêt-Regamey et al., in press). This conglomeration of models is then used to simulate various future scenarios (Lundström et al., 2007). Through simulation of scenarios using the different models, the effects on the Alpine region of Davos can be assessed on the basis of several indicators (Bebi et al., 2005).

The scenarios were developed in close cooperation with key stakeholders in the local community in politics, tourism and business and with representatives of the general public (Figure 2-1). In order to show a broad range of problem areas and uncertainities for the future, scenarios were developed for three issues: a) climate change and potential effects on winter tourism, b) changes in mountain agriculture due to changes in agricultural policy and the liberalization of markets, and c) the option to organize a mega-scale sports event (Von Ballmoos and Bebi, 2003).

The results of the simulation were presented and discussed intensively at a final meeting with the representatives of the local community. Although the results were not particularly surprising to most of the participants, people's responses were quite strong. The results were then presented at other events, and they played a part in the development of the model for the Alpine region of Davos (Thalmann, 2006).

Alpsim

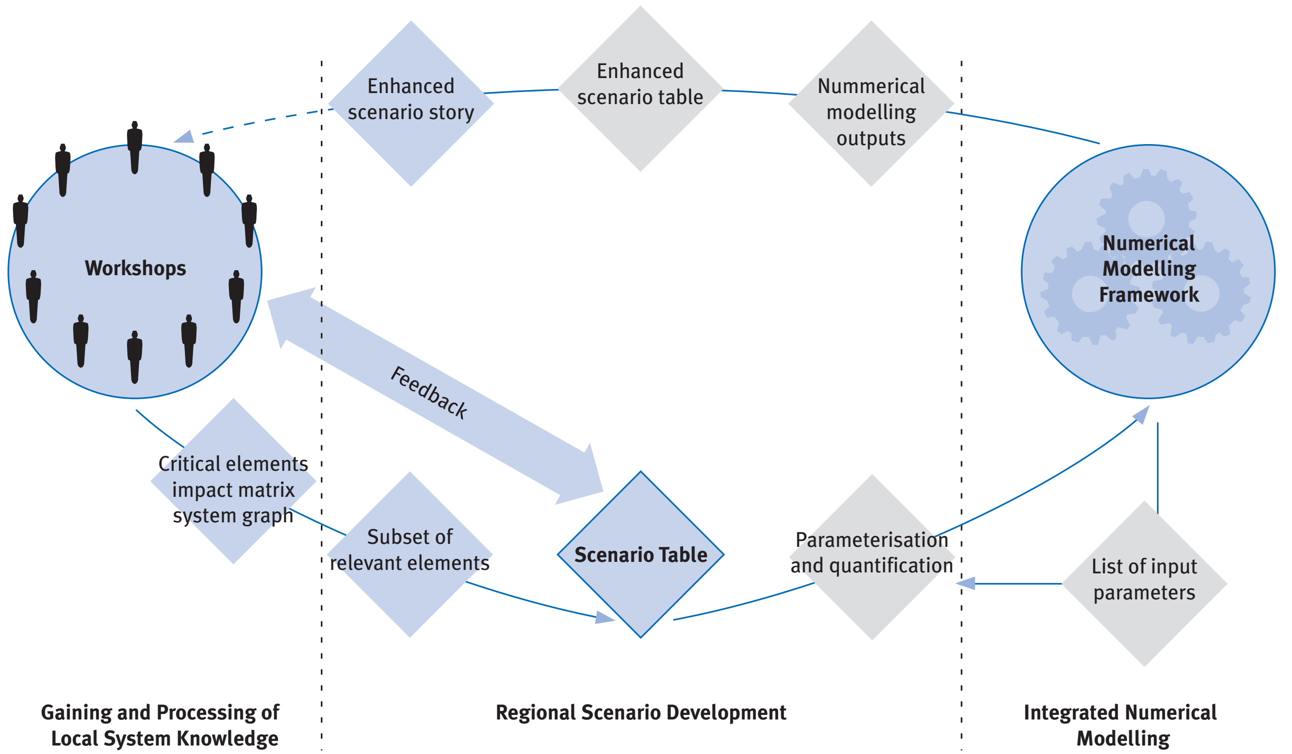
The goal of the Alpsim project was to explore the feasibility of using multi-agent systems to simulate the behaviour of hikers in tourism and recreation areas in the Alps (Cavens and Lange, 2004; Gloor et al., 2004). The long-term research goal was to clarify the feasibility of using multi-agent simulation as a tool to provide insight into the reactions of visitors and local residents to changes in the landscape and in this way to draw conclusions for the tourism industry (Cavens and Lange, 2004). In order to develop the tool, techniques were adapted from both traffic simulation and environmental psychology. The visual attractiveness of the landscape was not to be evaluated in a static manner from one standpoint (as in a picture) but was instead simulated as the visual experience of a hike through the landscape (that is, as a succession of images, as in a film) (Figure 2-2).

To model each tourist as an individual agent, a synthetic population was created that reflects current visitor demographics. The agents are given different individual goals and expectations. The agents were given «plans» for the day and introduced into the simulation with no «knowledge» of the surroundings. The agents executed their plans, receiving feedback from the environment as they moved throughout the landscape. At the end of each run, the agents' actions were compared to their expectations. If the results of a particular day's plan did not accord with their expectations, it was changed slightly for subsequent simulation runs. These modifications were based on the agents' own experience but, depending upon the learning model used, also on the experience of the other agents in the system.

This project had a strong computer technology component. Besides the presentation of the framework and its modules, the computational aspects of implementing hiker simulation were explored. Through the use of new techniques, developed specifically for hikers in the Alps, it was possible to simulate an area of 15 km^2 and larger on a single PC. The actual simulation of the agents was a mixture

Figure 2-1

Concept for integrating the integral modelling in a participatory process through the development of regional scenarios in the ALPSCAPE project



Source: Walz et al., 2007

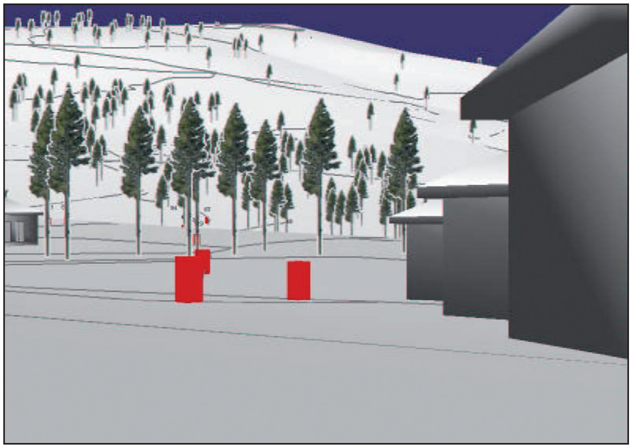
of continuous-space and cell-based models. The individual hikers could take any position and move in any direction, but the information on their surroundings was contained in a cell-based grid. The individual cells could be as large as 250 m x 250 m, which is many times larger than a person's normal step length. Only by implementing methods for saving on computation and memory resources could the entire area be simulated.

In the case study for the recreational area served by the town of Schönried in the Gstaad-Saanenland region, the results of a survey of hiker preferences and demographic data were used for modelling the agents. In the simulation it was then tested whether the landscape offered sufficient options for meeting the needs and expectations of the hikers (Cavens und Lange, 2004; Cavens et al., 2003). Three scenarios were simulated in order to test whether the agents reacted to changes made to the landscape as predicted. The first scenario shows the status quo and was used to calibrate the model. The second scenario starts out from the assumption that all gondolas and chair lifts and the like are shut down for the summer, and in the third scenario, meadows have become reforested as a result of changes in the agricultural policy. The tests show that the model provides a good platform for conducting experiments for the formulation of further studies. But they reveal as well that the current state of research does not yet allow us to understand the reasons for tourist behaviour and to better calibrate the model.

Figure 2-2

Excerpt from a simulation run in the Alpsim project

Shown here are some virtual agents (shown as red blocks) hiking from their hotel to the top of a mountain.



Source: Gloor et al., 2003.

Gisalp

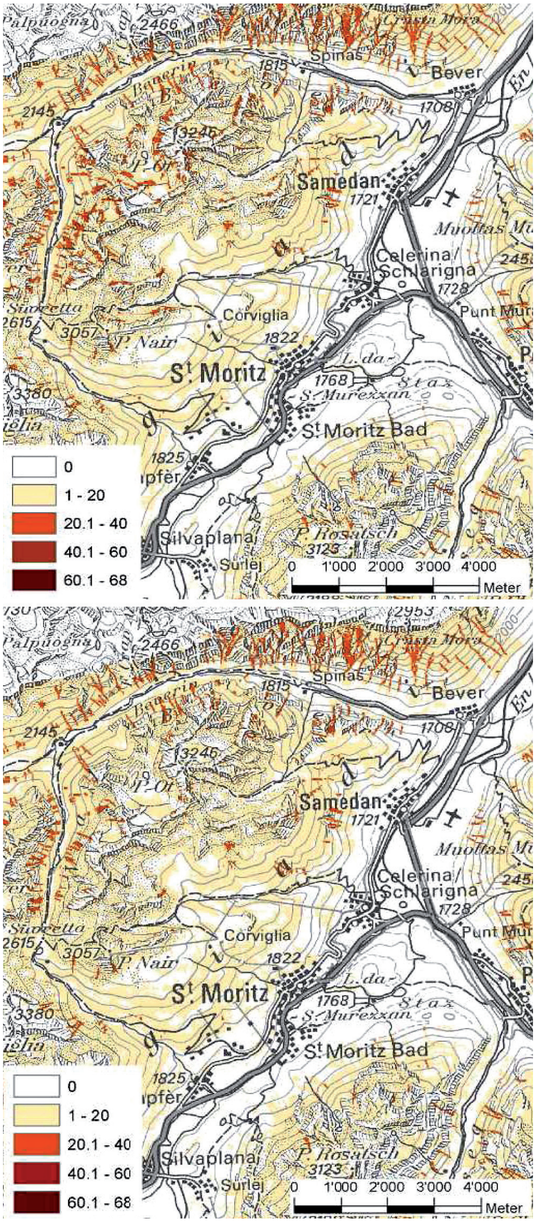
The goal of this project was to use a combination of existing vegetation-mapping, geomorphological, glaciological and pedological models to assess the natural hazards potential and the scenic beauty of the landscape of a region. Bringing the models together as modules in an integrated system requires a consistent data model in which data formats and data flows between the modules are coordinated. All of the individual modules can be started for a certain point in time (2000, 2025, 2050, 2075 or 2100) and, where needed, can access the results of the other modules (Rothenbühler, 2006). The combined model was implemented to assess a climate scenario in the Upper Engadine across a time span of 100 years. This made it possible for the first time to model not only a single landscape object or a single natural hazard process but also to view the high Alpine region of the Upper Engadine as a synthesis of the four areas mentioned above. It shows, for example, what changes occur in recently glaciered landscape segments or also in today's permafrost area as a result of rising temperatures and what resulting events can be triggered by the combination of climate-determined changes. As an example, the project mentions an ice avalanche that reaches a glacial lake and triggers a landslide (Figure 2-3).

A comparison of the changing mountain areas makes it possible, for one, to say something about the speed, spatial distribution, and acceleration of the changes occurring. For another, based on the simulations, landscape areas can be identified where human land use could be adversely affected by climate-determined changes in the natural hazard potential or in the attractiveness of the landscape (Rothenbühler, 2006).

Figure 2-3

Simulation results of the Gisalp project

Here showing the results of the Murdisp module for assessing the landslide area in the year 2000 (up) and in the year 2100 (below).



Source: Rothenbühler, 2006.

Ipodlas

Ipodlas stands for «Interactive Process Oriented Dynamic Landscape Analysis and Simulation». The goal of the Ipodlas project was to merge the domains of spatial modelling (based on GIS), temporal modelling (temporal simulation systems based on systems theory) and real-time visualization (based on virtual reality), which up to now have been used separately.

The project focused mainly on the simulation of ecological processes, together with the design of intuitive and appealing visualization procedures demonstrating the results. In addition to the elaboration of the theoretical background, the development of Ipodlas was based on real-world case studies that were suitable to provide the proof of concept for the theoretical framework. The data and models came from the project applicants' long-term research projects and dealt with aspects of alpine forest ecosystems dynamics: a) migrating insect populations and b) wildland fire propagation. Based on these case studies, three closely linked PhD dissertation projects were carried out that developed the specifications and the required functionalities of the Ipodlas software system (Isenegger et al., 2005; Isenegger, 2006). This set-up made it possible to explore cross-scale modelling and simulations with different data and models and to link them to flexible visualization procedures. As the term «scale» largely depends on the topic it deals with, we introduced a system that allowed the different scale levels to be distinguished systematically. According to that, 0 stands for the «valley or landscape level (e.g. the Upper Engadine Valley)», -1 for the single «(forest) stand» and the +1 scale may extend as far as «up to the entire Alpine arc».

The case study of migrating insect populations demonstrated how larch bud moth populations (*Zeiraphera diniana* GN., *Lep., Tortricidae*) were influenced by space and time. It was found that landscape features and terrain-dependent wind patterns clearly influence the small-scale distribution patterns of migrating insect populations at the valley level. The same effects also emerged when we characterized the large-scale spatio-temporal behaviour of migrating larch bud moth populations throughout the Alpine arc, where we investigated whether distinct insect populations migrate in synchrony with each other or with a time lag (Price et al., 2006; Price, 2006). To illustrate these processes, a new visualization approach was developed that transforms the larch bud moth population dynamics into «clouds» of flying individual insects. Thanks to the development of a new 3D rendering technique, the viewer (user) can follow the migrating larch bud moths in dependency upon features of the landscape and terrain and across different scales. In this system, the larch stands get different colours showing the degree of defoliation. The colours of the larch bud moth clouds depict how the migrating insect sub populations leave the defoliated larch stands and how they swarm to new, not yet infested stands (Wu et al., 2006a, 2006b).

The case study of wildland fire served to demonstrate, for one, the behaviour of flames and smoke in physical models (Figure 2-4). For another, dynamic texturing methods were explored and developed to visualize flames and smoke as realistically as possible. The study comprised both the single flame level and the fire front level, which is relevant at the landscape scale (Wu, 2007).

The concepts and techniques developed within the Ipodlas project are considered to be generic enough to simulate and visualize other natural processes successfully.

Figure 2-4

Simulation and visualization of a forest fire, within the framework of the IPODLAS project

Source: Wu, 2007.

Schutzwälder

The goal of this project was to gain a better understanding of the long-term development of protection forests in the Alpine region of Switzerland, which protect against natural hazards, and to develop a tool for long-term assessment of the protection function of the forests against rockfall. To do this, existing simulation models of forest dynamics and models of the protective effect of different forest stand structures were coupled, tested for their suitability to assess the protective function of forests and some functions specifically adapted in order to develop a prototype of a tool for managing mountain forests.

In addition to the coupled simulation model, which mainly served scientific evaluation (Stoffel et al., 2006; Wehrli et al., 2005, 2007), a less detailed model was developed that depicts longer periods of time and includes further aspects, such as silvicultural interventions, natural disturbances and estimation of the cost effectiveness of alternative management strategies (Brang et al., 2004). This second model is a useful tool in the context of decision-making processes, and it has already been introduced to the world of practice in further education courses (see www.wsl.ch/forschung/forschungsprojekte/schutzwaldmodell).

The models used are simulation models in the sense used in this synthesis report. The simulated scenarios feature for the most part alternative silvicultural measures. With the simulation of their effect on the protection function of forests, the second, less detailed model in particular is a useful tool supporting optimization of silvicultural interventions.

Sulaps

In this project the effects of changed agrarian policy and economic conditions on mountain agriculture and the cultural landscape were analyzed using an agent-based model (Lauber, 2006; Lauber et al., 2004). The model simulates the behaviour of individual farms on the basis of an optimization approach and shows, through interlinking the farm models with each other through a leasehold market module, effects on land use in a spatially explicit manner. For identification and calibration of the individual agents, business/economic data and information on the individual cultivated land parcels were gathered for every single farm in two mountain regions, Albula and Surselva. The structure of the land use patterns was then assessed using landscape metrics (Killer, 2005).

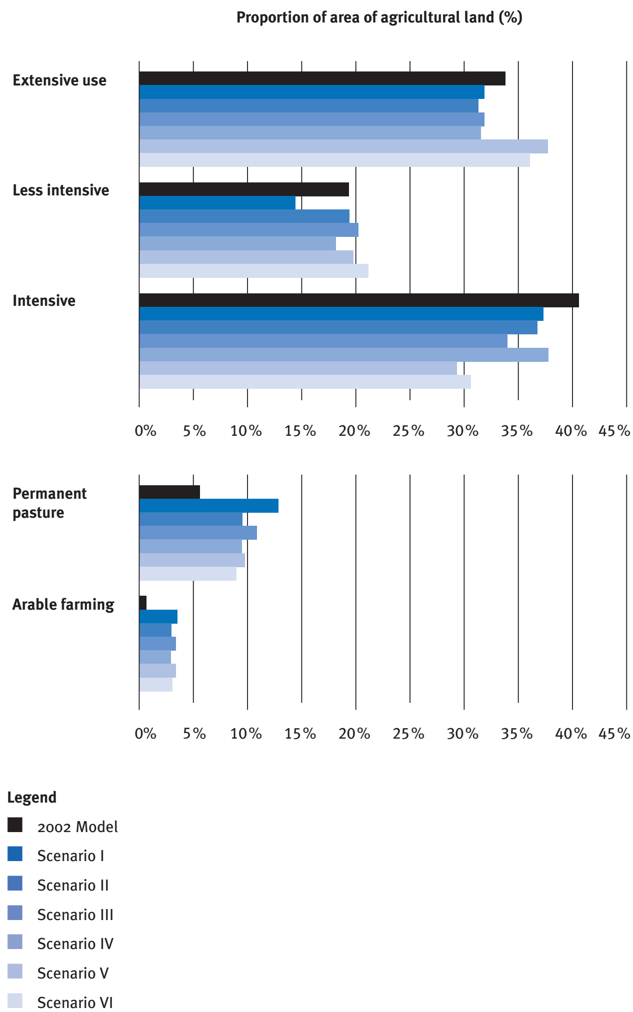
The calculated scenarios include assumptions on reduction of direct payments, liberalization of the Swiss agricultural market and regulation of land abandonment (decision not to cultivate). In the case of the liberalization scenario, for example, approximately 20 % of the original 63 farms would be given up, while the farm sizes of the remaining farms would increase. For all of the scenarios, the simulations show a decrease in area used for agriculture, work hours in farming and farming income, as well as an increase in the number of organic farms (Lauber, 2005).

The Sulaps model is a typical simulation model according to the understanding of this synthesis report. It simulates the reaction of regional agricultural structures on the basis of scenarios for a time period of 10–15 years. The simulated changes are shown using a set of indicators, such as for example the intensity of land use (Figure 2-5). The model can thus generate information bases and decision support for agricultural policy and sustainable development in the Alpine regions in Switzerland.

Figure 2-5

Simulation results of the Sulaps project

Here showing the percentage of agricultural land utilization according to type of use in the year 2002 (permanent pasture; farmed) and for six scenarios for the future.



Source: Lauber, 2005.

ALPRO

The goal of this project was to develop and test methods for evaluation of the impacts of landscape development projects in the Swiss Alps, for purposes of early identification of conflict potential during the planning phase. For this, discrete choice experiments were conducted (Baumgart, 2005), and an instrument for evaluation of landscape-altering development projects using benefit value analysis (Schwarzwälder and Kooijman, 2005) was elaborated. In discrete choice experiments, the monetary value of the landscape's visual properties was estimated on the basis of digitally altered photographs (Figure 2-6), while the benefit value analysis worked with non-dimensional values but included an extensive range of decision criteria (35 in all). Although ALPRO is based implicitly on a model of interaction between landscape and society, it is not a simulation model but instead a computer-based evaluation tool for landscape development projects that can be used, for instance, to facilitate participatory consensus-finding processes (Schwarzwälder and Kooijman, 2005).

Figure 2-6

Visualization of potential future settlement developments from the ALPRO project

Using photomontages as the basis for benefit value analysis; shown here is Mürren in Berner Oberland.

Settlement today

Scenario 1: Hotel complex

Scenario 2: Chalet estate

Source: Schwarzwälder and Kooijman, 2005.

Ecosysserv

In this project several ecosystem services provided by mountainous regions were valued using a spatially explicit approach (Grêt-Regamey et al., in press). The monetary value of the individual landscape functions for society was determined. The value of avalanche protection by forests was determined on the basis of a risk analysis (Grêt-Regamey and Straub, 2006), and the monetary value of the scenic beauty value of the landscape was determined using a willingness-to-pay approach (Grêt-Regamey et al., 2007). In a second step, the effects of a climate scenario on these ecosystem services were assessed. For this, various simulations were carried out, such as on avalanche run-out areas, floodplains and forest cover expansion, which then in turn served as a basis for another valuation of the ecosystem goods and services. Although several simulation models were used and in part also developed within this project, research interest focused less on simulation and more on the spatially explicit valuation of the changed landscapes in terms of ecosystem services.

Erreichbarkeit

The project examined the question of how improvements in the transport infrastructure affect the scenic beauty and the use made of the Alpine regions. Accessibility was studied nationally, regionally, and locally – also in conjunction with surveys in the regions studied (Simma and Axhausen, 2003; Tschopp et al., 2003a, 2003b, 2005). To calculate large-scale accessibility, models at national level were used and further developed. These are not landscape models in the narrower sense, but the accessibility of a region plays an important role in its future development. This relationship was also quantified within the framework of the Erreichbarkeit project. In this way the project contributed towards the development of simulation models for accessibility and created a basis for assessment of large-scale patterns of future land use changes.

Flood'Alps

This project examined the relationship between human constructions (embankment, drainage) and biodiversity in Alpine river systems (floodplains) (Bullinger-Weber and Gobat, 2006; Bullinger-Weber, 2007; Gremaud et al., 2004; Weber et al., 2004). Using research approaches from four disciplines, morphological, hydrological, social and legal aspects of future measures to ensure security and conservation of biodiversity could be derived. This created the basis for future modelling; however, no modelling has been implemented as yet.

Soziales Umfeld

The ethnological approach of this project views the potentials and weaknesses of various actors in landscape planning (Droz and Miéville-Ott, 2005). The authors propose a «social» field that is constituted of two axes, the «capital» axis (= financial means that an actor can pay) and the «intervisibility» axis (= the capacity to concretely modify the physical aspects of landscape). Negotiation processes on landscape issues are shaped by the positioning of the actors on this field and by their perception of landscape, the object of the negotiations. The findings on the dynamics of these two factors during a negotiation process are in future to serve design of a tool for facilitating decision-making processes. This project underlines the importance of mental models as well as their usability (deliberate usability) for future decision processes.

Transformation

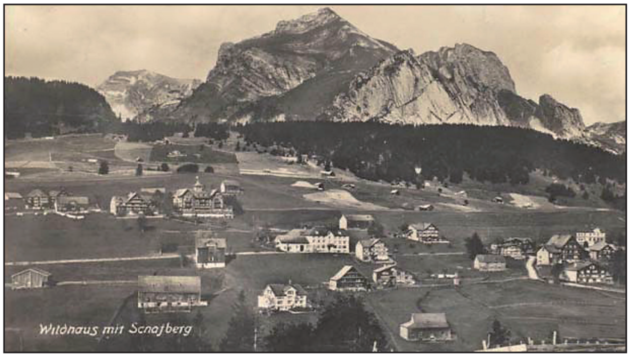
How quickly is the landscape changing? How do people deal with it? How does nature react? These three questions were examined in this project using three complementary approaches in the areas of: visible landscape changes, the perception of these changes and the associated changes in habitats (Felber, 2005; Lütolf, 2006; Schneeberger, 2005). In all three of these sub-studies, the approach was mainly retrospective (Figure 2-7), in order to work out bases for future decision-making. The project generated important bases for landscape simulation and the assessment of landscape changes. Especially the findings pertaining to assessment of transformation rates of Alpine landscapes in the past 150 years (Schneeberger et al., 2007b) and the identification and systematization of driving forces of landscape change make an important contribution towards future simulation models (Schneeberger et al., 2007a).

Figure 2-7

Retrospective comparison of the landscape from the Transformation project

Here showing Hotel Acker in Liesighus.

1920 © Photoglob AG, Zurich



1960 © Foto Anna, Wildhaus

1980 © Foto Anna, Wildhaus

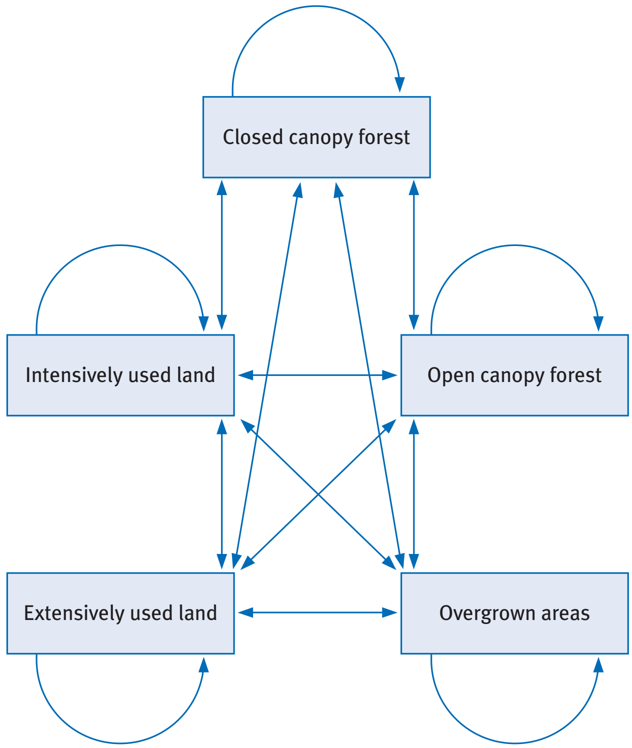
Source: Felber, 2005.

WASALP

This research project aimed to explain the pattern of regeneration of forest on abandoned agricultural land in the Swiss Alps. There were three research approaches to explain the forest regeneration: a) an analysis of regeneration of forest at a spatial resolution of 100 m x 100 m (1 hectare) based on characteristics of the natural environment (Rutherford, 2006), b) an analysis based on structural characteristics of municipalities (Gellrich et al., 2007), and c) an analysis on the farm-level based on interviews of individual farmers on decision criteria for the abandonment of agricultural land (Gellrich et al., 2008). In all three cases statistical models were developed, primarily to explain the observed forest regeneration processes (Figure 2-8). But they were also used in part for the simulation of the forest expansion in Switzerland as a whole (Bolliger et al., 2007). An other example is the use of the models for the simulation of land use changes in the macrochore of Davos within the ALPSCAPE project and their application when simulating reforestation processes in all of Switzerland (Walz, 2006).

Figure 2-8

Land cover and land use transitions, as analyzed in the WASALP project



Source: Rutherford, 2006.

2.2 Features of the projects

Section 1.2 above makes it apparent that the modelling projects in NRP 48 cover a wide range of orientations, as to both content and methodology. In the following sections, the projects are discussed and grouped according to various aspects.

Considering the multitude of characteristics that models can have in landscape research (see, for example, Briassoulis, 2000), it is not surprising that the projects in NRP 48 do not cover the wide range of possibilities completely or systematically.

2.2.1 Classified within landscape research

The projects view landscapes and habitats as well as landscape and habitat changes from various perspectives. Here, the most important perspectives are:

- The causes and circumstances (driving forces), that lead to changes in landscapes and habitats (Erreichbarkeit, Sulaps, Transformation, Wasalp),
- The patterns and processes through which landscapes and habitats change (Alpscape, Gisalp, Sulaps, Transformation, Wasalp),
- The evaluation of landscape changes (Alpro, Alpsim, Ecosysserv, Flood'Alps), and, finally,
- Methodological/technical possibilities for combining existing models and computer-aided techniques in landscape research (Alpscape, Gisalp, Ipodlas).

These perspectives are largely complementary, and, if the content and temporal/spatial orientation is the same, they can often be combined. The close cooperation between different NRP 48 projects underlines this. For instance, a project may focus on causes and conditions and on identifying patterns of changes (such as Wasalp). The findings are then used for simulation of future changes (Alpscape), and, finally, the simulated landscape can be evaluated and compared with the original landscape (Ecosysserv).

2.2.2 Object of study

The object of study of the projects ranges across numerous and diverse topics, such as:

- Landscape change through structural change in agriculture (Alpscape, Sulaps, Wasalp),
- The influence of accessibility and regional development on the landscape (Alpscape, Erreichbarkeit),
- The influence of fauna on the landscape and effects of landscape changes on wild animal habitats (Ecosysserv, Ipodlas, Transformation),
- The effects of changed use or layout/design on biodiversity (Flood'Alps, Sulaps),
- The effects of natural hazards on the landscape and the protection function of the landscape itself (Ipodlas, Gisalp, Schutzwälder), and, finally,
- The changes in recreational behaviour and the tourism potential due to landscape changes (Alpsim, Alpro, Ecosysserv).

The range of topics as the object of study in the projects shows, for one, that landscape modelling can be used profitably in many different areas. For another, it indicates that landscape models already address very specific questions. Only if the focus of the question is the same can a model be used also in another situation. For applications in similar but not exactly the same situations, the model has to be modified accordingly.

2.2.3 Methodological approach in modelling

The modelling in the projects comprises a wide range of current methodological approaches. Basically, the projects can be distinguished as statistical models, simulation models, evaluation models and data models, this being determined mainly by the objectives of the projects. Each of these categories comprises theoretically a multitude of alternative modelling approaches. In the context of the projects within NRP 48, this great variety is clearly shown especially by the simulation models, although even there it is not systematic and complete.

– Statistical models generated new insights on the spatial distribution of landscape changes caused by a reduction of agriculture in the Alpine region (Wasalp). They also formed the basis for one of the simulation models (Alpscape).
– Simulation models were implemented for simulation of future scenarios and for evaluation of alternative policy measures and management strategies. They operated on the basis of statistical models (Alpscape), physically based sub-models (Gisalp, Schutzwälder), biological/empirical connections (Ipodlas, Schutzwälder) or empirically based multi-agent systems (Alpsim, Sulaps). Table 2-2 shows an overview of the methodological features and the object of study of these simulation models.
– Models for systematic evaluation of interventions and changes in the landscape included criteria catalogues, bases for weighting and, finally, evaluation itself, which was based on either monetary values (Alpro, Ecosysserv) or non-dimensional values (Alpro).
– The development of a new types of data models supported the integration of existing part-models (Gisalp) as well as functionally and technically separate software products (Ipodlas).

2.2.4 Spatial and temporal scales

Landscape models use different spatial and temporal scales. The spatial scales used in the framework of NRP 48 range from the national level (Erreichbarkeit) to the entire Alpine region in Switzerland (Ipodlas, Wasalp), the regional and local level (Alpscape, Gisalp, Ipodlas, Sulaps, Transformation), individual forest stands (Schutzwälder) and single trees (Ipodlas).

Although the projects cover a large range spatially, the local to regional level clearly dominates (Alpscape, Alpsim, Sulaps, Transformation). One reason for this is that landscape changes are noticed mainly at this level (Transformation). Nevertheless, the processes of landscape change represented often have their origins in several hierarchical spatial levels (Transformation). For this reason, for example, the goal of Ipodlas was to overcome the focus on a single level and to integrate several scales.

The temporal scales of the models are determined by the phenomena of landscape change that they depict. Depending on whether the object of study is structural change in agriculture, forest development or climate change, the projects examine temporal ranges of 10–50 years at different resolutions. The Transformation project is an exception, in that it captures the rate of landscape change over a time period of approximately 150 years.

How the temporal dimension (resolution and duration) was realized in the models varies greatly across the projects. Whereas in the Alpsim project hikers' decisions were modelled at very high temporal resolution, the Ipodlas project simulated the migration patterns of larch bud moths on a yearly basis across several decades, and the Alpscape project simulated landscape changes at 12-year intervals over a period of 50 years.

2.2.5 The most important scenarios for the Swiss Alps

In most of the modelling projects within NRP 48, the influence of future scenarios on the landscape was simulated. Three topics emerged as particularly important for the future of the Alpine region:
– Climate change and its consequences for the Swiss Alpine region, whereby the projects examined in particular the frequency and intensity of Alpine natural hazards (Gisalp) and possible changes in winter tourism (Alpscape).
– Agricultural structural change and its consequences for the Alpine landscape, whereby already observed land use changes were projected into the future using statistical and agriculturally based models (Alpscape, Sulaps).
– Settlement and infrastructure development, whereby these were studied several times in connection with evaluation of change and regional developments in tourism (Alpscape, Alpro, Ecosysserv).

Table 2-2
Substantive and methodological features of the six simulation models

Project	Object of study	Methodological approach	Spatial scale	Temporal scale	Implementation	Visualization	Inclusion of stakeholders
ALPSCAPE	Tourism	Agent-based model	Local	1 week	Automated	Film, photorealistic rendering	–
ALPSIM	Regional development, structural change in the landscape	Integrated model: combination of approaches from various disciplines	Local	50 years	Individual parts partly automated; the combining of the models quasi manually	Tables with indicator values and maps	Local stakeholder representatives, scenario development and discussion of simulation results
GISALP	Natural hazards	Integrated model: combination of several already existing models	Regional	Not defined	Automated	Maps	Data and financial support from cantonal authorities
IPODLAS	Migration patterns (larch bud moth), spread of wildfires	Population genetics model, forest fire model, smoke models, cloud models	Multiple scales: Local, regional, Alpine region	Cycles of 7–10 years or Hours/days (fire)	Concept for integrating GIS, temporal simulation and visualization, as well as automation	Film or real-time demonstrations	«Simulated stakeholders», such as tourism authorities or firefighters
SCHUTZWÄLDER	Assessment of the protection function of forest stand structure	Combined model, process-based	Forest stand	Several decades	Automated	–	–
			Forest stand	150 years	Automated	–	–
SULAPS	Structural change in agriculture, biodiversity	Agent-based model	Local	10–15 years	Completely automated	Indicator values and maps	–

For the future, it can be assumed that these three developments will be dominant influences on the Alpine landscapes of Switzerland and will not only have ecological consequences but will also affect the scenic beauty and attraction of the landscapes.

2.2.6 Data sets of the projects

The data sets also cover a wide range of possibilities:

- Existing data sets, covering in part several decades, were used mainly for development of statistical and empirical models (Alpscape, Erreichbarkeit, Ipodlas, Transformation, Wasalp). These were long-term data sets and data collected by Federal Offices, such as the Swiss land use statistics (Swiss Federal Statistical Office).
- In part, the data was gathered within the projects themselves. The gathering of data on, for instance, the current social or economic situation of a region or a farm (Alpscape, Sulaps), the mobility behaviour of tourists (Erreichbarkeit), landscape preferences (Alpro, Alpsim, Ecosysserv) or changes in biodiversity (Flood'Alps) cover a large range of contents and methods. The data collected were used directly for model building (Alpscape, Alpsim, Sulaps) or lend themselves as a basis for future model building and verification (for example, Flood'Alps).
- Several projects used in addition local knowledge from local actors (Sulaps, Wasalp). In the Alpscape project based on this data, for instance, numerical modelling was combined with participatory scenario analysis.
- Finally, a wealth of already existing scientific literature represented an important source of information and data for the projects viewed in this report.

2.2.7 Purpose of the models

The purpose for which a model is built is an especially important feature, showing its potential for spatial and landscape planning practice. It makes clear how greatly the objectives of models and thus their possible function in decision-making processes can vary. Here, four functional foci of the models are distinguished: explanation, prediction, evaluation, and visualization. They can be directly assigned to the functions within the planning process described in section 3.2.5. For example, simulation models that provide predictive analyses are typically utilized for decision support.

- **Explanatory analysis**
  Particularly the Erreichbarkeit, Flood'Alps, Transformation and Wasalp projects belong to the explanatory approaches. They work to a large part retrospectively and focus on generating insights. In some of the projects the models are analytical/explanatory (for example, statistical models in Wasalp), but in part the models also utilize other methods (for example, informal interviews with experts in Transformation). The knowledge gained can be very important in spatial and landscape planning and serve to guide thinking in real-world decision-making. Explanatory and analytical models are used primarily in research and are seldom used in practice. A main reason for this is that most of the knowledge gained is generated not when using but when developing the model.
- **Predictive analysis**
  Prediction is understood as estimating or assessing the future developments of a system. Prediction is the primary goal of simulation models that estimate these developments across time on the basis of theoretical considerations and empirical analyses.

  If the systems are complex systems, whose future development is characterized by great uncertainties, prediction in the narrower sense is not possible. Simulations are then often used in the framework of exploratory scenario analysis (see also section 1.8). This allows experimentation with varying framework conditions, which would not be possible to do with real landscapes and regions. The scenario analysis then shows what developments can be reckoned with under what circumstances.

  With the NRP 48 research projects, predictive analyses and simulations were developed for optimization of management strategies (Schutzwälder, Sulaps) and as bases for discussion of future visions (Alpscape).

- **Evaluation**
  Assessment approaches aim to develop systematic and, if possible, regionally transferable methods for evaluating landscape changes. This can be assessment of the attractiveness of a landscape (Alpro, Ecosysserv) but also assessment of other characteristics, such as evaluation of avalanche protection or flooding protection through mountain forests (Ecosysserv). Here, an important aspect is the comparability of two possible states, for which reason the approaches work either with non-dimensional values in the sense of indicators or with monetary values (Alpro, Ecosysserv). Assessment approaches have a great potential to contribute towards objective decision-making in the world of practice.
- **Visualization**
  In addition to analysis and simulation of landscape changes, increasing computing capacity is also making possible ever more complex visualization techniques. In particular, the coupling of dynamic models with photo-realistic visualizations is an important research challenge today (Alpsim, Ipodlas). Highly developed 3D visualization techniques allow representation of complex simulation results in the form of illustrative and easily understood images or films. These techniques represent the useful combining of simulation models and communication media, which are used with success also in spatial and landscape planning.

The four purposes mentioned above can be fulfilled largely independently. In the case of computer-based models they are often also used in combination. Analysis of the past, which is typically assigned to the explanatory approaches, frequently forms the basis for developing instruments for prediction. Prediction, in turn, is a basis for visualization and the assessment of possible future developments.

In Figure 2-9 the relevant NRP 48 projects have been assigned to these purposes according to their main emphasis. The classification is only a rough one, as most of the projects can not be assigned in a clear-cut manner to one purpose only; many of them cover several purposes (for example, Sulaps) or aim at a combination of various purposes (for example, Ipodlas).

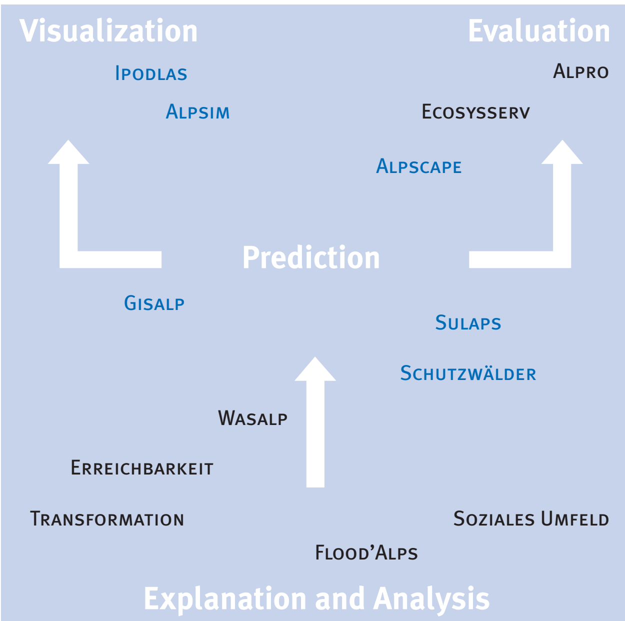
2.2.8 Communication and visualization of the findings

The form and the technology in which the modelling results are expressed and communicated vary greatly among the projects. Some of the projects generate several, some very complex, indicator values (Alpscape, Sulaps), some work with distribution maps (Alpscape, Gisalp, Sulaps), and others work with highly developed visualization products such as realistic animations and films (Alpsim, Ipodlas). This range shows the weighting of two complementary aspects in computer-based landscape modelling: the generation and communication of knowledge.

Abbildung 2-9

Rough classification of the modelling projects within NRP 48 according to purpose

The projects marked in blue delivered important foundations for this synthesis.



Source: The authors.

2.3 Evaluation of the total contribution to research

Here we want to evaluate the NRP 48 models with regard to their contributions towards current research and possible practical application.

2.3.1 Complementary approaches and combination of approaches

From the point of view of research, the combination of different modelling approaches is interesting and desirable with regard to both method and content. The wide range of modelling features in the different projects and thus the multitude of possible combinations show that the potential for combination of approaches is high, both in general and also based on the models developed in NRP 48.

To combine modelling approaches fruitfully, numerous factors have to be coordinated with one another. Besides content, one of the most important criteria is the temporal and spatial resolution of the data.

The cooperation in the Alpscape, Ecosysserv and Wasalp projects is a good example of combination of different modelling approaches: After the Wasalp project had developed statistical models on the development of forest expansion, the models were then used in the Alpscape project for development of a regional simulation model. The spatially explicit simulation results from the Alpscape project, finally, delivered the basis for the valuation of ecosystem services in the Ecosysserv (for example, Grêt-Regamey et al., 2008). This sequence made sense, in terms of both content and method, and it definitely generated insights. But the spatial resolution of the data exchanged between the models proved to be problematic. The data had to be modified through the aid of additional studies and modelling steps.

2.3.2 Technical advances in the combination of approaches

The technical problems that frequently made the work with models difficult and time-consuming included in particular interface problems between different data formats and software environments. In the area of spatially explicit data, which are especially relevant for spatial and landscape planning, data management is largely taken over by geographic information systems (GIS). Dynamic modelling often takes place in an independent, time-based development environment, and for visualization a third instrument is utilized (Bishop, 1998; Isenegger et al., 2005). Optimization of these interfaces is considered to be an important contribution towards applicability of the models in practice (Vonk et al., 2005).

NRP 48 delivered two important contributions on the interfaces problem. With regard to the conversion of data, which is often necessary between different models, GISALP made a contribution by developing a uniform data model for different natural hazards models. The IPODLAS project developed a software architecture concept that already can directly connect the areas data management/GIS, dynamic (over time) modelling and visualization, which represents an advance in the area of bringing together software environments that are mostly used separately.

2.3.3 Potential uses in practical application

One of the declared objectives of NRP 48 was the specific promotion of new methods that could be developed and made applicable for practice. For the modelling projects, therefore, the question arises as to whether, besides the actual research results, the models developed can be applied in the world of practice. For most of the projects, and for a number of reasons, this is possible only with a great deal of additional effort.

The specific question researched in each of the projects is very important for application of the models in practice (see also sections 2.2.3 and 3.3). There are definitely questions that come up again and again in planning processes and where answering those questions could be made objec-tive and simplified by means of models. An example of a tool of this type is the simpler model that was further developed in the SCHUTZWÄLDER project (Brang et al., 2004, 2006).

However, that kind of tool was not developed in most of the projects of NRP 48. Instead, most of the models developed represent a kind of content and methodological prototypes. Assuming that a question is suitable, these models can, as case studies, be applied methodologically to other regions (see also section 3.2.4). If necessary, they would have to be calibrated once more and validated for other regions (for example, ALPRO, SULAPS).

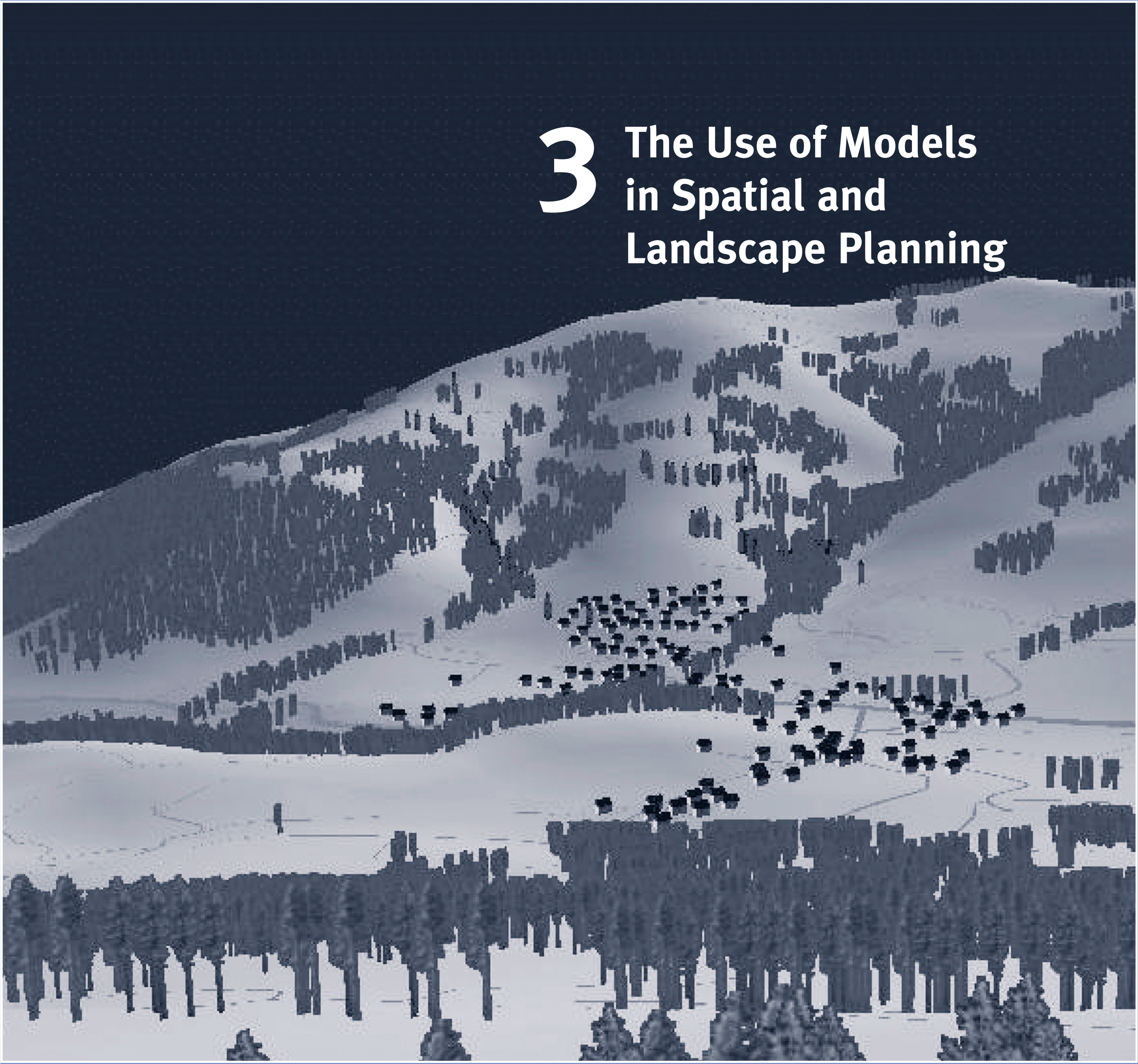
However, these prototypes do not fulfil the prerequisites for application in planning practice. To provide a model as a planning tool, it is absolutely necessary that the model has a user-friendly design, stable programming and comprehensive documentation that explains the model assumptions and possibilities for adapting the tool for another region (Vonk et al., 2005).

NRP 48 demanded usability and also transdisciplinarity (see Fry, 2001; Klein et al., 2001). For this reason, in most of the projects potential users were included early on. Contact with decision-makers or government agencies was often initiated as the ideas for the projects were being worked out (for example, GISALP), and the participation of local residents took place in the form of workshops (for example, ALPSCAPE) and/or information events (for example, SULAPS) during the project. Nevertheless, there was only partial success in maintaining regular contact over the entire course of a project. Often the expectations of the researchers and the practical world grew apart. As in so many other transdisciplinary research projects (Mittelstrass, 2003), it became clear that despite all efforts by the NRP 48 projects, these were primarily research projects that, beside expectations from practice, had to satisfy also basic research and the needs of higher education.

Another reason why the potential for use of the models in practice was not yet developed fully was the initial prospect that there would be a special implementation phase of NRP 48. The project designs in many cases therefore planned for development of a method and production of a prototype in a first project phase, while the research results were to be implemented for practice or the public in a second phase of the project.

Finally, in the individual case, also targeting marketing is an aid to establishing the use of a method as a tool. This is shown by the example of the ALPRO project, which produced an attractive brochure on the evaluation instrument developed (Schwarzwälder and Kooijman, 2005).

3 The Use of Models in Spatial and Landscape Planning



3 The Use of Models in Spatial and Landscape Planning

Since the 1980s numerous computer-based, spatially explicit models have been developed for spatial, landscape and also urban planning. Although visualization techniques have already become relatively well established in planning practice (Bishop and Lange, 2005), the literature as well as our work with the experts in the Advisory Group confirms that the models are scarcely used in planning practice despite intensive research activities (for example, Geertman and Stillwell, 2004; Stillwell et al., 1999). This does not mean that models are of no value for planning practice. On the contrary, very positive experiences with their use have been reported (for example, Costanza, 1998; van den Beld, 2004).

In this chapter, the most important expectations and problems with regard to the use of models in planning practice are touched upon, possible solutions developed and the possible contribution of the NRP 48 research examined. It is found that the NRP 48 research projects (see Chapter 2) deliver important contributions towards the solving of several central problems.

3.1 Expectations regarding virtual planning instruments

In recent years numerous institutions and researchers have worked to develop and improve planning instruments (for example, Bishop, 1998; Klostermann, 2001; Landis, 2001; Waddell, 2002; Wegener, 2001). The results of this research have been reported in a number of volumes (Brail and Klostermann, 2001; Geertmann and Stillwell, 2003) and they show the range and possibilities of planning instruments.

At the same time, a few works are also available that deal directly and empirically with the needs of planning practice. Cockerill et al. (2004) and Vonk et al. (2005), for example, examined the acceptance of models in planning practice in large-scale studies.

The authors stress that the vast majority of participants surveyed in the studies were convinced that models are useful tools in planning and the policy process connected with it (Cockerill et al., 2004). Nevertheless, the tools have been hardly used in planning practice up to now (see, for example, Stillwell et al., 1999). The main reasons why development activities for planning support systems for spatial and landscape planning exceed their actual use are said to be that planners are not yet sufficiently familiar with the potential and application of models and that the technical complications are often great (Vonk et al., 2005).

The findings of these studies also reflect the point of view of the Advisory Group of Synthesis Report V (see Appendix, Documentation of the Advisory Group process). It, too, sees the great potential of virtual planning instruments, but it also finds that the use of models, with the necessary modifications and required data, is connected with a great deal of expense both in time and money and that many users do not want to take on that expense. Despite individual doubts, the Advisory Group assumes that virtual planning tools will be used in practice increasingly in the future, as they can accommodate the increasing complexity of the decisions and the corresponding need for planning foundations as well as allow for improved transparency of planning processes.

Uses of planning instruments

For application in practice it is important to distinguish among various functions that computer-based planning instruments can have within the planning process. For instance, a distinction has to be made between instruments that yield results that are used internally as a basis for decision-making and instruments that deliver results that are used for communication to the public or decision-makers. This corresponds largely to the differentiation between models and visualizations, as they are handled in this synthesis report (see section 2.2.7). It represents besides a fundamental feature that allows the finding of the right tools for the particular needs (see section 3.2.5).

Multiple layers and complexity

The ability to represent different kinds of consequences of decisions and to simulate alternatives is the great potential of model-based planning instruments and can thus meet a further important expectation held by practitioners.

But here, the expectation that the models will integrate multiple layers can be problematic, for complexity often demands a combination of various modelling approaches and approaches stemming from different disciplines. With regard to sustainable development, for example, the world of practice would like to see tools that combine economic models with environmental impact models. Even if these connections can be created in individual case studies under extensive assumptions (for example, Grêt-Regamey and Kytzia, 2007), in general the more complex the model, the more the uncertainties and accompanying assumptions involved will increase. The transparency and transferability of the model suffers, and it becomes also more and more difficult to develop the model further into a planning instrument.

Nevertheless, the discussion in the Advisory Group showed that in the area of simulation models, great complexity is often in demand. This stands in agreement with Bishop (1998), who, however, criticizes all too high expectations regarding the complexity of planning tools and points out that there are different tools each having a specific purpose. This holds for the direction of the content of models (for example, economy versus ecology) just as much as for the functions of the instruments within the planning process (for example, visualization versus simulation).

Transparency and trust

The transparency of models and trust in models play an important role in the acceptance of models in planning practice. This is also confirmed by the Advisory Group, in agreement with Vonk et al. (2005) and Cockerill et al. (2004). Transparency in the sense of detailed and comprehensive documentation is important first and foremost for users that are dealing with the model in detail, who need to be able to assess the method of proceeding and have to appraise the plausibility of the results. These users can be teams or also individual persons in government and in consulting companies.

For users that do not themselves examine the model in detail, such as for example political office holders as the potential commissioners of a study, it is not the transparency of the model that is crucial but instead trust in the model, its developers and its users. This means that active trust-building in the run-up can be a decisive factor in the acceptance of a model in the planning process (Cockerill et al., 2004).

Interactive instruments

In accordance with Vonk et al. (2005), for the Advisory Group also an interactive instrument is a goal worth striving after in the long term. With high interactivity and fast computing times it becomes possible to «play around» with the model. Professional users could in this way quickly assess the plausibility of a model and its limitations. The models could then also be used directly at meetings and public events.

Data availability and data quality

Although in international comparison the data situation in Switzerland is very good, data availability and data quality in practice represent a great challenge, and the effort and expense required for data preparation is often not desired. In the Advisory Group this is seen as a purely technical challenge and less problematic in the long term, even though obtaining data at present still represents a great obstacle.

3.2 Problems and possible solution approaches for establishing the use of models in planning practice

3.2.1 Data availability and data quality

The technical problems that make the use of computer-based tools very expensive in terms of money and time include, among other things, the availability and preparation of data sets (Advisory Group, see Appendix; Vonk et al., 2005). In contrast to research, in the world of practice it is often not possible to gather data only just before a model or planning tool is implemented. The data sets that are utilized in spatial and landscape planning are multilayered and differ in content as well as in spatial area and spatial and temporal resolution. Although there are extensive data available, the data do not yet cover many of the needs of spatial and landscape planning sufficiently.

Full-coverage data sets

For Switzerland there are several data sets available that cover the whole country. The advantage of these data sets is that they are obtainable for all of the regions of Switzerland, they are not subject to any restrictions due to data protection law and they are well-documented. They are collected and maintained mostly by the Federal Statistical Office (FSO/BFS) and by swisstopo (Federal Office of Topography), and they include, for example, the GEOSTAT (BFS, 2001) and Vector25 (swisstopo, 2006) databases.

The GEOSTAT data sets cover a broad range of topics. The database contains, for example, census records but also pedological and climate information (BFS, 2001). Another advantage of these data is that precise time series exist, such as for Swiss land use statistics (1979/85, 1992/97 and soon 2004/09) and for national censuses (1990 and 2000) (BFS, 2001). However, the spatial resolution of the GEOSTAT data is only partly sufficient for conducting regional and local studies (Figure 3-1).

Vector25 also covers Switzerland as a whole. The spatial resolution of this database is much better, as the Vector25 database is based on a 1:25,000 scale map of Switzerland, which is mostly sufficient for regional and local studies. However, it contains exclusively information that is required for the maps of Switzerland (swisstopo, 2006). Ecological and sociological data are not in-cluded, and time series are not (yet) available due to the young age of the data base.

Form and content of other data sets available to the public

In addition to these full-coverage data sets in the federal offices, there are other data sets available to the public at the government offices of the cantons and municipalities. As the data of the cantons and municipalities are often of a higher spatial resolution, they are a useful complement to the full-coverage data sets of the federal government. Figure 3-1 shows an example in the area of land use. Whereas the map on the left is based on the land use statistics with a resolution of 100 x 100 m (BFS, 2001), the illustration on the right shows additional data gathered by the municipal surveyor's office of Landschaft Davos. For the utilization of virtual instruments in particular it would be very helpful to record and make public the availability, features and contents of such data. Making these data sets consistent in form and content from one municipality to the next would be a further step helping to simplify the transferability of models from region to region.

Combination of already existing data sets available to the public

When preparing data for spatial and landscape planning, combining already existing data sets that are available to the public would be a great improvement. For example, it would be very helpful to combine traffic data with the road network of Vector25 or to combine the data on number of stories per building with the building database of Vector25. The information is available at the government offices in the form of reports and plans that cover practically the whole country, but they are not available in digital form, or there are legal restrictions prohibiting access to the data.

Aggregation of data according to spatial units

Not all information that is of interest for spatial and landscape planning is spatially explicit. Important socioeconomic data are registered at the level of administrative units, such as, for example, important figures on the regional economy and the structure of agriculture. The aggregation at the level of the municipality is often sufficient for spatial and landscape planning. But it is problematic if data are collected at higher administrative levels only, such as is the case, for example, for financial flows between branches of the economy. That kind of data, as needed for input/output tables, is gathered only at the national level, even though the data vary greatly by region. Regionalization of data sets of that kind is laborious, but the information gain for the regions would be great, as the input/output tables in the ALPSCAPE project show (Wegmann and Kytzia, 2005).

Gaps in data coverage

Despite the overall very good data situation in Switzerland, there are still some holes in the data coverage. As a result of these gaps, spatial and landscape planning have to again and again rely on rough estimates in important areas and on relatively badly documented surveys. For instance, one of these gaps is the distribution and utilisation rates of second homes. Especially in the Alpine regions, this information is very important for spatial and landscape planning. Great hopes are being placed in the current undertaking to harmonize the registers. This requires detailed information on utilisation rates of first and second homes in all of Switzerland, and in the long term it is planned to replace the traditional national census.

Just as difficult is the collection of data on the streams of day tourists and their spatial and temporal preferences.

Figure 3-1

Comparison of land use statistics to the data set of the municipal surveyor's office

Depending on the spatial resolution, different contents can be represented and information statements made.

Map Scale: 1:100,000

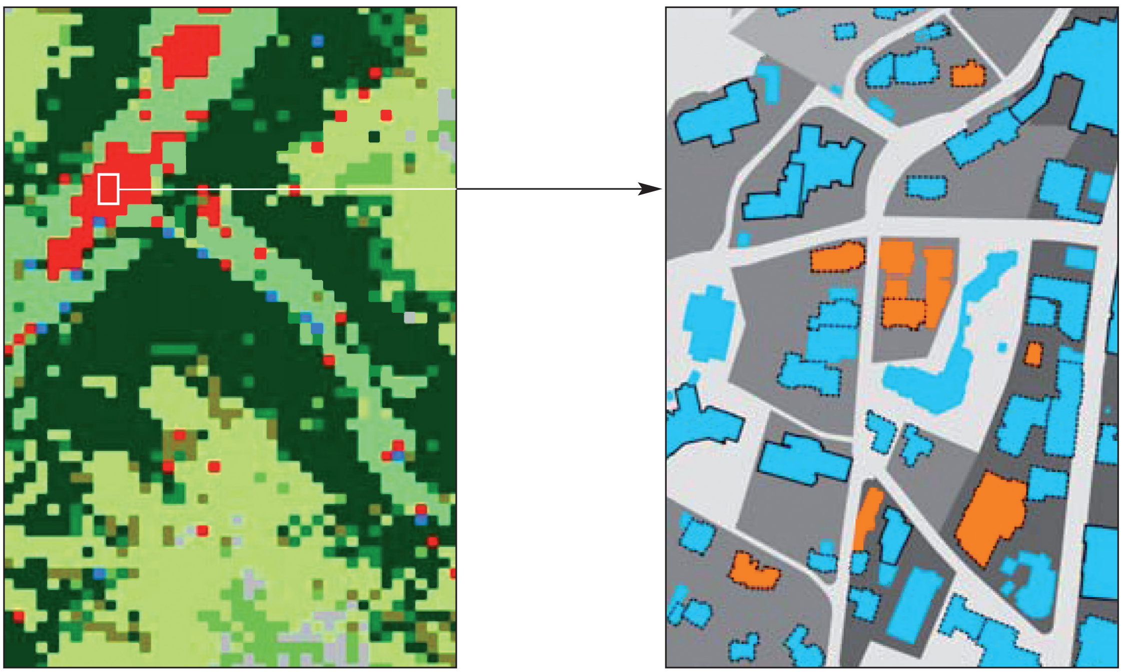
Spatial resolution/accuracy: 100 m

Focus: Interacting changes in settlement, agriculture and forest

Map Scale: 1:5,000

Spatial resolution/accuracy: ~ 0.25 m

Focus: Usage of built-up and settlement structures



Land use classes

- Closed forest
- Open forest
- Overgrown area
- Intensive agriculture
- Extensive agriculture
- Unproductive grassland
- Bare land
- Housing and infrastructure
- Water surfaces

Usage

- Residential
- Tourist accomodation: hotel

Tenure

- Single owner
- Multiple owner

Planning

Construction capacity factor (CCF)

- CCF = 0 m^2 GEA/m^2 base area
- CCF ≤ 0.5 m^2 GEA/m^2 base area
- CCF ≤ 1.0 m^2 GEA/m^2 base area
- CCF ≤ 1.5 m^2 GEA/m^2 base area

Source: Adapted from Walz, 2006.

Day tourists do not have to pay hotel taxes and do not have to register. Gathering of this important information for spatial and landscape planning in the Swiss Alps is dependent upon the cooperation of the mountain railways. How well this cooperation works depends mostly on personal contacts, even though the data would be of public interest.

Certainly, not all of the gaps in the data can or must be closed, but still, it would make planning processes considerably easier in the future if certain gaps that recur again and again could be identified and resolved. In many cases, and also in the examples mentioned, that would not only be helpful for the use of models and planning tools but would also make available considerably improved bases for discussion and decision-making from the outset.

Modelling as an analysis tool

Up to now we have focused on model-based planning instruments, that is, on the development and use of a tool. But modelling can also be a method of analysis, and one which is not very well established in planning practice yet.

In planning practice laborious surveys are conducted regularly (such as traffic censuses). Modelling on the basis of this data collected specifically on a question would often make sense as a complement to the standard analyses conducted today. For instance, instead of the scenarios that are carried out mostly purely mentally, well-documented scenario analyses and computer simulations could be carried out.

3.2.2 Interfaces between different tools

For establishing the use of simulation models in the world of practice, improvement of the interfaces between different tools is considered essential. Because these interfaces between different software packages, such as between Geographic Information Systems (GIS) and simulation models, are poorly worked out or non-existent, a great deal of time has to be spent on preparing and exchanging the data between software packages (Bishop, 1998). These technical problems make it very awkward to utilize computer-based aids and models.

Recent developments, however, show how rapidly technical advances can lead to new standards. An example of this is the use of GIS. Use of GIS is now standard in planning processes. Another example is the virtual globe programme Google Earth, which with its sheer amount of data, computing speed, and interactivity would not have been considered possible just a few years ago. The existing technical problems are now viewed as solvable and as important fields for future research and development.

Two of the NRP 48 research projects focus precisely on these problems. In the IPODLAS project a concept for technical optimization of the connection between GIS, visualization software and dynamic, time-critical models was worked out (Isenegger et al., 2005). The focus was on the conception of a software architecture that allowed direct data flows between the three tools and development of proof of concept on the basis of three use cases. GISALP, on the other hand, focused on the development of a data model allowing the combined use of various, already existing models in the area of natural hazards. Here, the solution of conversion problems stood in the foreground, so that the combined use of the models was greatly simplified (Rothenbühler, 2006).

3.2.3 Required multiple layers and complexity

In planning practice it is of great importance that tools and methods are appropriate for the planning problem at hand. But more complex models are characterized by many layered results and larger amounts of required input data. However, approaches that are relatively simple in technical aspects and in method often meet the goal.

If the various features of models in spatial and landscape planning are carried over to a building, models can be found that simply show the exterior of the building. More complex models show the building from multiple angles and perhaps also in its environs. Even more complex models also show the interior of the building and allow the observer to take a walk through the inside. Finally, there are models that, in addition to the building, also depict its use, the people that go in and out and the material flows connected with the construction and operation of the object.

Illustration and visualization

It is not easy for experts or the public to visualize interventions in the landscape, especially if the changes are gradual, creeping changes. The visualization of landscape changes is therefore assessed as being an important aid, and it is already and frequently being used in spatial and landscape planning effectively.

A computer-based visualization of a planned object shown in its surroundings is often already very informative and instructive (see, for example, Figure 3-2). For the visualization, digital photo editing software is used to change photographs in order to depict the intervention under discussion, or 3D visualization is used, which embeds the planning object (in the form of a digital data set) virtually in its environs (digital terrain model and land cover map). For the 3D visualization of a planning object, data on the measurements of the planned object, the surroundings in which it is to be built, and a standard software programme, in which both can be shown from various perspectives, are required. Suitable software packages are available as direct visualization tools, and there are also suitable products available from the field of computer-aided design (CAD) and GIS.

Whereas the editing of photographs is a largely familiar technique that was used long before computer use became established, the use of 3D visualization is a technique that has gradually become established in recent decades, with corresponding software and increasingly available data.

Even if the images today look in part somewhat unnatural, 3D visualization has some advantages over the editing of photographs. Because the images are based on data that has become available for many areas and planning objects, it is relatively easily transferable. The detail sharpness of the visualizations can be adapted in almost any way – as long as the data to do so is available – and with additional computing effort to fit the requirements of the planning process. In addition, computer-based visualization allows the object to be depicted from different perspectives. As Figure 3-2 shows, this can be a great advantage over physical architectural models when it comes to evaluating the visual effect of proposed construction. Finally – and of particular interest in connection with virtual worlds – visualization can also be used to translate the results of simulations of landscape development into an easy-to-understand picture. This makes it easier to grasp the meaning of abstract simulation results, which can be very important for people's understanding of gradual, creeping changes.

Computer-based visualization was used successfully in the case of the new national park centre (depicted below) in Zernez, GR, for instance. The location of the already approved construction project was put up for discussion again, after a true-to-scale visualization showed that the building in Schlossgarten would block the view of the castle and castle grounds and would thus have a very detrimental effect on the look of the site, which is listed as worth protecting in the ISOS «Inventar der schützenswerten Ortsbilder der Schweiz» (Inventory of Swiss Sites Worth Protecting), which bases on the «Natur- und Heimatschutzgesetz» (Protection of Nature and Cultural Heritage Law) (see Figure 3-2). Set in motion by this visualization, the decision to change the location of the building was made. What was not studied was the extent to which the black colour of the new construction in the visualization influenced the discussion on the location of the new national park centre.

Causal connections and model building

A higher degree of complexity is reached when depicting causal connections. Methods for establishing these connections were developed in the area of systems analysis and systems dynamics (for example, Forrester, 1972;

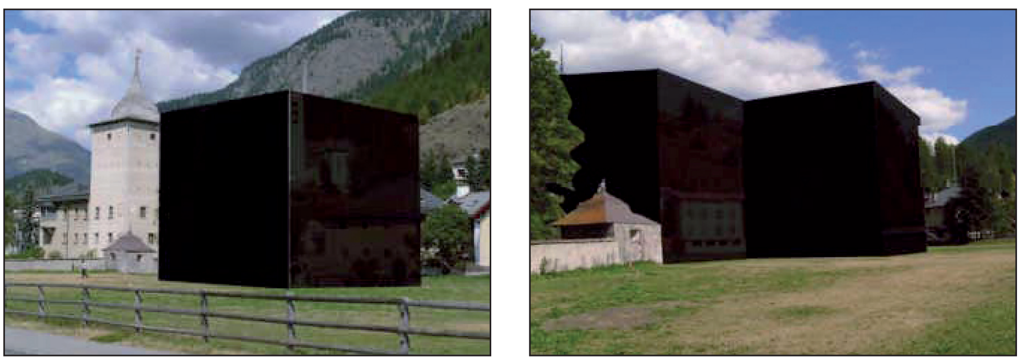
Figure 3-2

Computer-based visualizations in comparison to (analogue) 3D architectural models

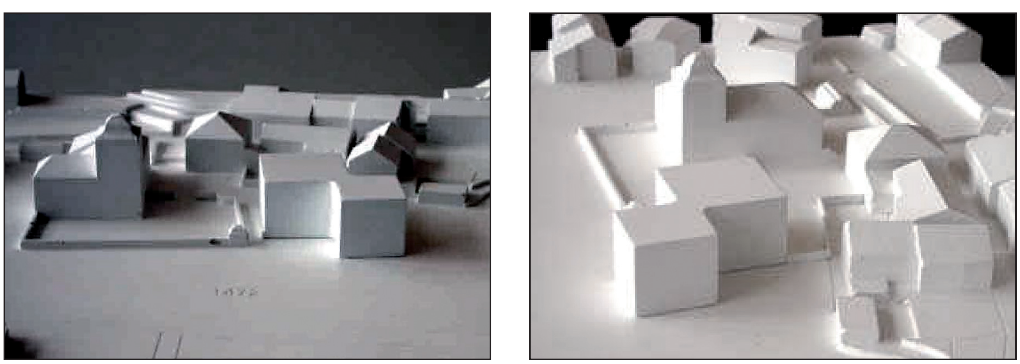
The example shows the planned national park centre in Schlossgarten in Zernez, GR.

The builder's stake-out of the foundation lines of the proposed building

Simulation of the building produced by opponents of the project



3D model constructed by the architect



Source: Pro Chaste da Zernez, 2004.

Vester and Hesler, 1980). These approaches are applied in computer science, in the natural sciences and also in the economic and social sciences. One of the early and very well-known examples is the 1972 report, «The Limits to Growth», a report to the *Club of Rome* (Meadows et al., 1972). At present, systems analysis methods are being used mainly in the context of scenario analysis (for example, Scholz and Tietje, 2002) and in the area of adaptive management (for example, Sendzimir et al., 2007).

The systems analysis approach is initially qualitative and is very well suited for group work. In a first step, the system is defined and its boundaries determined; in a second step, the elements relevant to the question are selected; in a third step, the relationship between the elements is determined; and finally, the characteristics of the whole system and its relations to its environment are viewed. The result of qualitative systems analysis describes the causal relationships within the system, and it is shown in graphic representation in the form of a flow diagram (see Figure 3-3).

Following that, the relationships between the elements can be determined semi-quantitatively or quantitatively. Examples of this are the semi-quantitative assessment of the effect between elements or the quantification of material or energy flows between elements. Using suitable software (such as Stella, Powersim and Vensim, among others) a systems analysis quantified in this way can be further developed relatively easily as a simulation model.

Systems analysis is frequently the first step in the development of numerical, computer-based models. It determines the logic and the structure of the model and can be viewed as one of the actual steps of model building.

Systems analysis is also very well suited to support dialogue and learning processes (for example, van den Beld, 2004; Vennix, 1996). In a stage of the planning process in which the focus is on improving the stakeholders' and decision-makers' understanding of the system and the problem (see also section 1.2.5), systems analysis can for this reason be usefully implemented in a participatory process (for example, Sendzimir et al., 2007). In NRP 48 Synthesis Report III, «Landschaft gemeinsam gestalten» (Shaping landscape together), it is therefore described also in connection with mental models (Simmen and Walter, 2007).

Quantification of causal relationships and calibration

In order to assess the intensity of processes, the result of interacting processes or the exceeding of threshold values, the relationships in a represented system have to be quantified and calibrated. This concerns parameters that are estimated on the basis of empirical observations, such as economic indicators in agriculture (SULAPS), migration cycles of larch bud moths (IPODLAS) or hikers' preferences (ALPSIM).

This quantification makes it possible to use the model under supporting assumptions dynamically for computer simulations. The results of computer simulations are strongly dependent upon calibration of the model. Only with very detailed documentation can potential users estimate whether a given model meets their requirements, whether modifications are needed and whether it reproduces the case at hand sufficiently well.

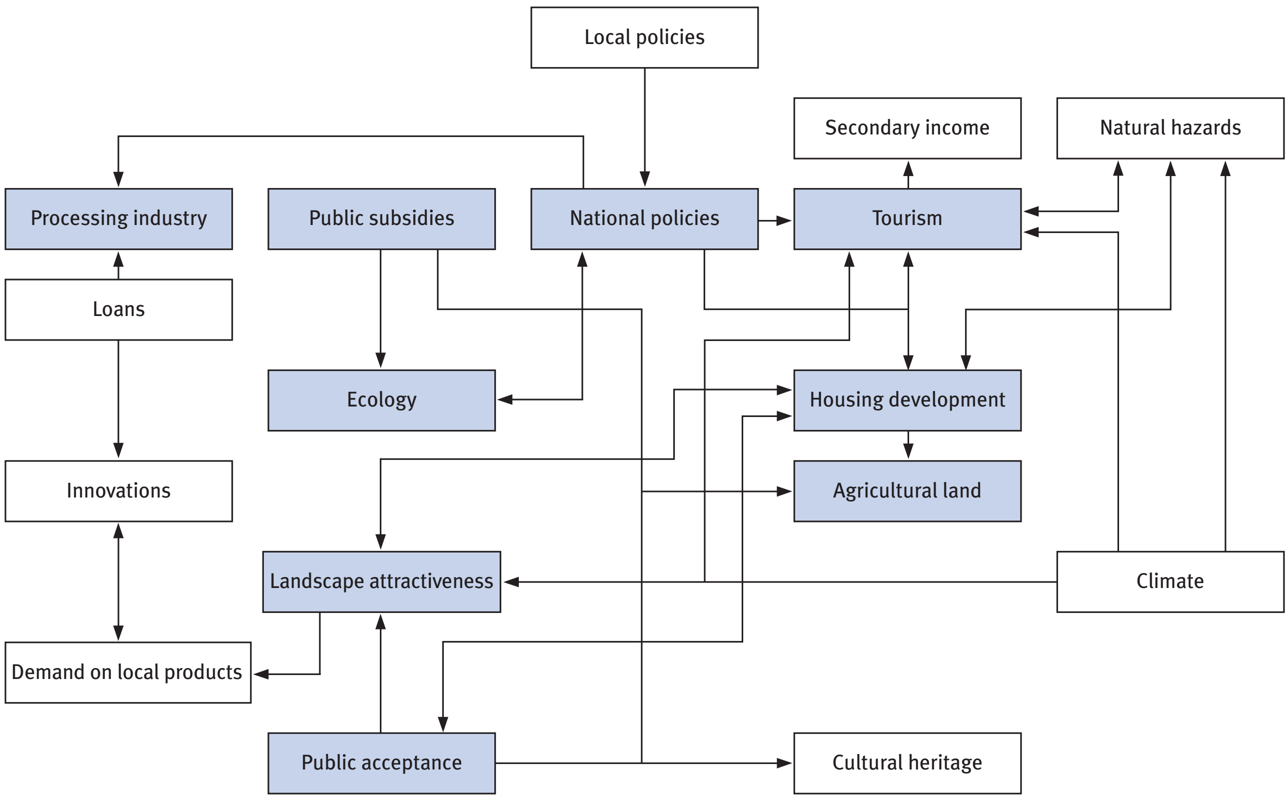
Because the option to recalibrate and adapt a model is of great importance in the spread of its use, the source code is often provided when the model is made available. In individual cases, recalibration and adaptation of a model can be very intensive in terms of labour and data (Stevensa et al., 2007), although some automated methods are becoming available for recalibration (for example, Straatman et al., 2004).

The calibration of models becomes all the more difficult, the less well that relationships can be quantified. In integrated approaches, in which models stemming from different disciplines are combined, this is particularly difficult. In the NRP 48 research projects, ALPSCAPE was a typical example of an integrated model. The different models, calibrated to the local conditions, were not put together

Figure 3-3

Example of qualitative results of systems analysis from the ALPSCAPE project

Here the example of farmers (Satellite Group: Agriculture)



Source: Walz et al., 2007.

through a completely automated mechanism but instead by the developing of scenarios (Walz et al., 2007). For instance, to judge the effects of land use changes on the productivity of local agriculture or on a change in the scenic beauty of a landscape, the individual case required further assumptions that could be best communicated in the framework of scenarios.

At these interfaces – especially between ecological and economic issues – there are research gaps that are of vital importance for the Swiss Alps. Future research must deliver considerable contributions in this area in order to make integrated model approaches attractive for planning practice. Initial contributions are found, for example, in the SULAPS and ECOSYSSERV projects and in NRP 48 Synthesis Report IV «Den Wert der Alpenlandschaften nutzen» (Using the value of Alpine landscapes) (Simmen et al., 2007).

3.2.4 Transferability of models

We see a further problem, and probably the most difficult problem in the long term, in the establishment of the use of computer-based aids in planning practice in the fact that few decision situations are comparable. That is, the tools and models vary with regard to their main content emphases and also with regard to the necessary data sets.

To what extent a simulation model can be applied to another planning situation, how open and flexible a decision tool must be in order to adequately handle different situations, or whether first and foremost the experience and developed models can be taken over in new application situations, is highly dependent upon the complexity of the questions. With regard to the transferability of models, two main directions for the use of models in spatial and landscape planning become evident:

- For one, there are models that are technical aids, or «tools», that due to their relatively simple data requirements can be applied to many individual cases. An example of this is the depiction of structures in their environs from various perspectives using visualization software, CAD or GIS. In this case, the data availability and the technical software requirements are practically standard.
- For another, there are models used for the purpose of deepening our understanding of a problem or a system. In this area of use, the learning process of everyone involved stands in the foreground; the models are «learning aids». Important in this implementation of models is that the problem is structured through the modelling and the system understanding itself is worked out. For this reason, the process of model development is of central importance. Falling back on existing models can be helpful only partly. An example of this kind of use is the Alpscape project, in which local decision-makers and representatives of the public participated in the process of scenario development (Walz et al., 2007). Further very good examples, in which the learning process stood in the foreground and decision-makers were included in the process of the development of the model itself, can be found, for instance, in van den Beld (2004).

Both of the main uses above show characteristic features regarding transferability of the corresponding models. They can be viewed as the two extreme poles of a range (see Figure 3-4). The simulation models in NRP 48 represent a connecting link between «tool» and «learning aid». As case studies in which cooperation with affected persons and decision-makers took place on the basis of the individual case (Figure 3-4), they lie between the two poles. First, they show technical or methodological solutions in the sense of model development (for example, Ipodlas or Alpsim), which is fundamental to the development of any planning instruments. Second, they represent case studies in which the decision-makers were included, so that they functioned as a «learning aid» for the studied region (for example, Alpscape). And finally, they generated findings that can aid decision-making, also without direct application of the model (for example, Sulaps). Of course, there are differences also among the NRP 48 models. For instance, Alpscape would appear relatively far to the right on the range shown in Figure 3-4 while Schutzwälder would be located towards the left.

3.2.5 Possible functions in the planning process

The use of computer-based aids can not replace planning and decision processes, but it can support them constructively. Here, their functions can vary in different planning processes and in different stages of these processes.

The range of functions comprises: (1) calculation of bases for decisions through complex and predictive analyses such as simulations, (2) communication aspects, (3) assessment using indicators, (4) participatory learning processes, and, finally, (5) analysis and explanation. In connection with the research conducted within NRP 48, these functions were mentioned in part in section 2.2.7 above. Figure 3-5 shows ways in which they can contribute towards decision-making and what the necessary components are.

Figure 3-4
Use of models in spatial and landscape planning as a range between «tool» and «learning aid»

Tool	Case studies with complex simulations	Learning aid
Goal: Tool that can be used in many individual cases	Goal: Drawing up bases for decision-making through simulation	Goal: Structuring of the problem and improved understanding of the system
High transferability: Data for new applications highly available	Medium transferability: Data preparation and possibly collection for new application and adaptations necessary	Only the methods are transferable: Model development as central process
Model development by experts or researchers	Model development with contact with decision-makers at selected points	Model development in cooperation with decision-makers

Source: The authors.

Calculation of bases for decisions (decision support)

Prognoses and predictive analyses can generate arguments and bases for improved individual decisions. Here, in the calculation of bases for decisions, standard methods (such as trend calculations), highly developed techniques of data analysis (such as statistical modelling, data mining, neuronal networks or artificial intelligence) and simulation models, as they were defined in section 1.8 above, gradually merge. Simulation models are used here as a means of predictive analysis in the framework of scenario analyses. The simulation models in the NRP 48 research projects are used for the most part in precisely this area. In the ALPSCAPE, ALPSIM, GISALP, IPODLAS and SULAPS projects, for instance, the focus is on future development.

Here, one of the main emphases is to show alternative paths of development and not to make prognoses or predictions in the narrower sense. For example, in the area of agent-based modelling, SULAPS, with an approach for simulating landscape change on the basis of laboriously collected data on farms, contributes to an improved understanding of the mechanisms of plot abandonment in the Swiss Alpine region. And in the area of «integrated models», the research within NRP 48, and in particular the ALPSCAPE project, contribute towards the integration of various disciplinary models on the basis of scenario analyses.

Communication through visualization

While the calculation of complex decision bases is the main task, visualization is viewed as a cross-functional task (Figure 3-5). A useful realistic visualization does not have to be coupled with a simulation model but instead, depending on what is needed, can be composed of manipulated images or 3D visualizations of a proposed plan (see also section 1.2.3). But in contrast to the often very abstract output of simulation models in the form of indicator values or maps, useful mainly to experts, realistic visualizations can speak also to people that have little experience in spatial and landscape planning. Besides the public, these may also be important decision-makers in government.

With the IPODLAS project, NRP 48 research produced a concept for the integration of tools for the management of (spatial) data, simulation models and visualization instruments. This integration makes it possible to render the complicated transfer between the different instruments easier and, with this, to visualize simulation results immediately (Isenegger et al., 2005). The result of a dynamic simulation can be viewed and presented directly as a film. The ALPSIM project goes a step further. For one, the attempt is to achieve a photorealistic visualization of the landscape, and beyond that, the agents in the model «see» visual stimuli in this virtual landscape and react to them with their behaviour (Cavens and Lange, 2004; Gloor et al., 2004).

Evaluation on the basis of indicators

There is often controversy regarding evaluation approaches, and this was also the case in the Advisory Group. Although the automated, objective assessment of landscape interventions and development options sounds very promising to many, it is not considered to be the central task of computer-based aids. Even supporters view it more as an additional option of a simulation model («nice-to-have»), see Figure 3-5.

Although this shows rather mixed feelings on the part of the Advisory Group, it should be considered that assessment of a landscape change is not always trivial, and an automated evaluation by an expert can be useful in some cases (for example, Mortberg et al., 2007).

The NRP 48 research makes a contribution towards the development of instruments for the evaluation of landscape interventions with the ECOSYSSERV and ALPRO projects. In ALPRO, methods were developed on the basis of surveys for systematic and multilayered assessment of landscape development projects (Baumgart et al., 2005). The project captures preferences, but it does not refer to an automated evaluation of simulation results. In the ECOSYSSERV project, the focus is on various methods of monetarization of landscape changes (for example, Grêt-Regamey et al., 2007). This includes also approaches that could be of greatest importance for automated evaluation of simulation results, such as, for example, the direct «translation» of selected questionnaire findings to the land-cover map or the improved comparability of the valuation for various ecosystem services (Grêt-Regamey et al., in press).

Participatory learning processes

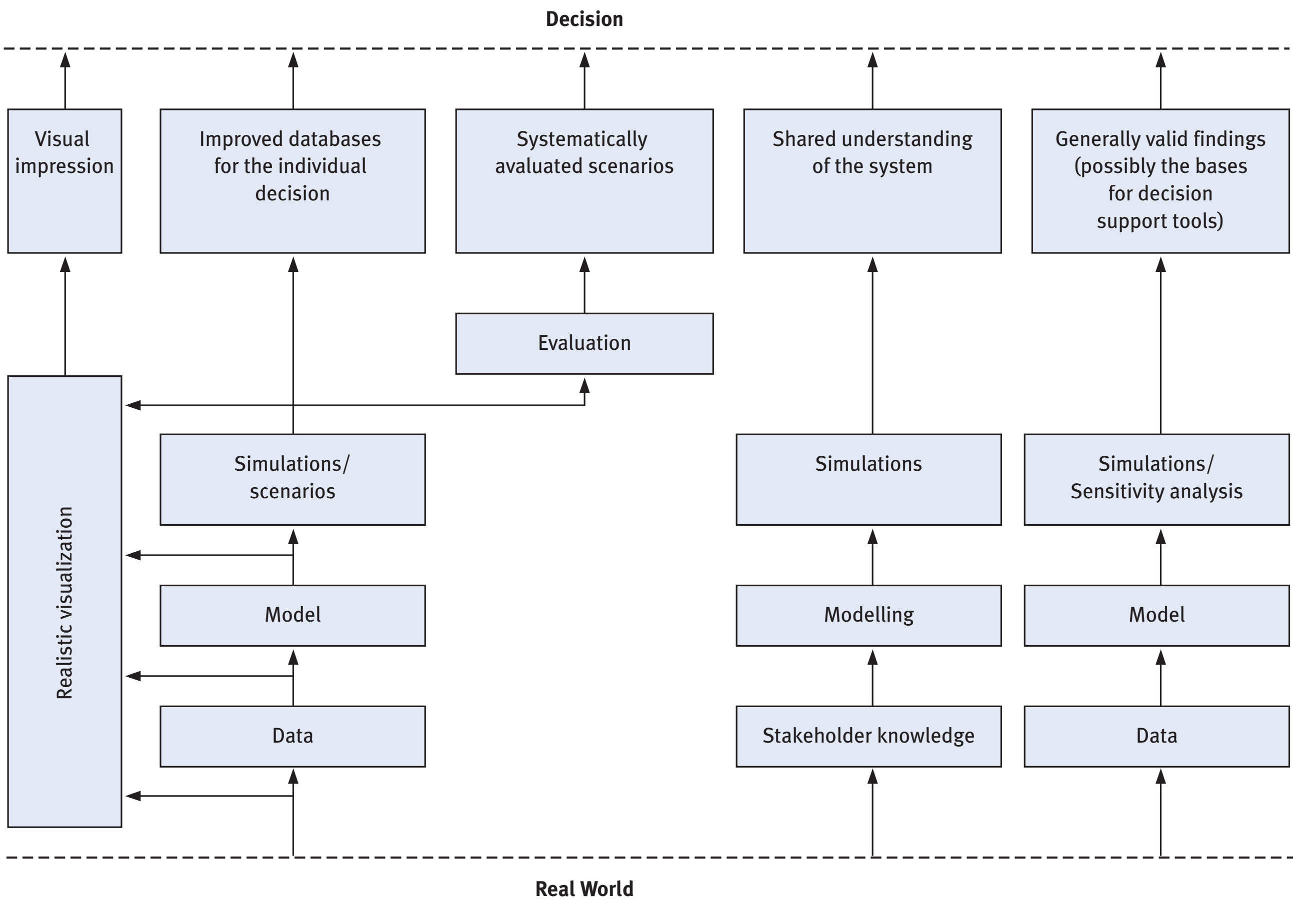
When speaking of the potential of models in spatial and landscape planning, the potential of modelling as a method should also be addressed. In participatory processes, joint modelling can be surprising and revealing and can greatly facilitate the finding of mutual solutions. The NRP 48 Synthesis Report III, «Landschaft gemeinsam gestalten» (Shaping landscape together), also points out the use of modelling in the context of participatory processes.

Modelling in the context of participatory processes, after having reached an initial highpoint in the 1970s, has once again become increasingly important in recent years (Antunes et al., 2006; Förster and Kytzia, 2004; Hare et al., 2003; van den Beld, 2004). It is being used with success particularly in complex and unclear decision situations («messy problems»; Vennix, 1999). In contrast to the use of models for complex analyses and predictive analyses, it is not the model that stands in the foreground here but rather the modelling process itself (van den Beld, 2004).

Through participatory modelling, a group comes to acquire a shared understanding of the problem, the boundaries of the system in question are determined and the effects between individual elements of the system are defined. Using the resulting model, the reactions of the system to external changes can be simulated. Here, the model can be purely qualitative, but it can also be semi-qualitative or quantitative (see also section 3.1.3). In addition to the simulation results, it is especially the jointly acquired understanding of the system that is viewed as the product of the modelling process, and it can contribute towards solutions of decisions that are complex and not clear-cut. This kind of application of models would appear to the far right, under «learning aid», in Figure 3-4.

Figure 3-5

Various functions of models and their contributions to the decision process



Source: Adapted and extended from Bishop, 1998.

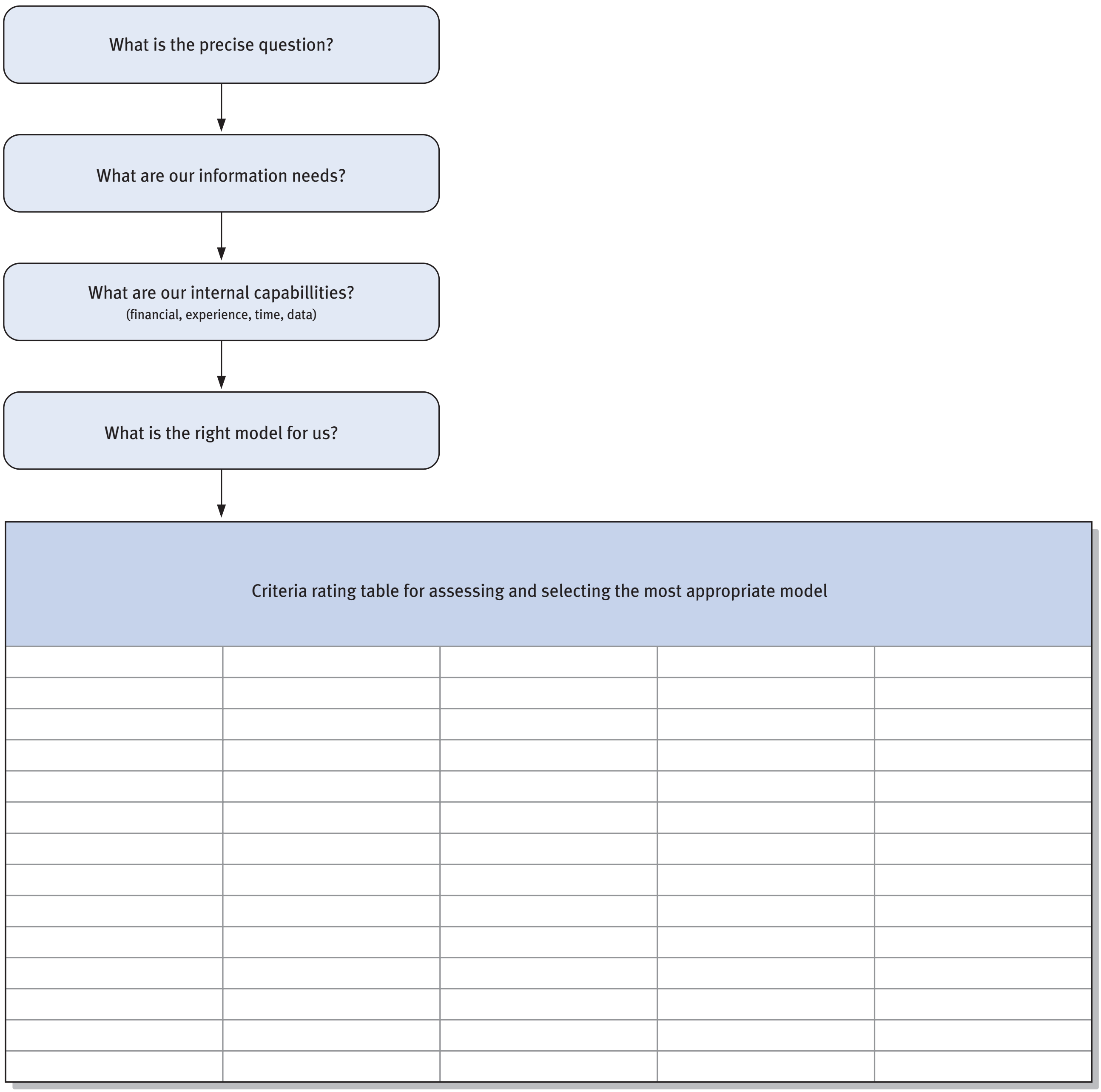
Explanatory analysis

Analytical/explanatory approaches are used primarily in research. The objective is to generate generally valid knowledge (Figure 3-5). Still, these approaches, too, can be relevant for planning. For one, knowledge is generated that can be meaningful for planning practice. For another, planning practice could benefit if in future it implemented modelling also as a method of analysis (see also section 3.2.6).

An example from the NRP 48 research is the SCHUTZWÄLDER project. First, a model was developed for research purposes (Stoffel et al., 2006; Wehrli et al., 2005, 2007). And in second step, the results of this research were used for development of a tool for use in practice (Brang et al., 2004; Brang, 2002).

Figure 3-6

The most important preliminary considerations in selecting an appropriate model in the individual use case



Source: Adapted from USEPA, 2000.

Table 3-1
Criteria rating table for selection of a useful model in a given use case

Criteria	Weight[1] W	Rating Score[2] RS					
		Alternatives					
		Model #1		Model #2		Model #3	
		RS	RS x W	RS	RS x W	RS	RS x W
Content direction/relevancy							
Function of model in decision process							
Temporal and spatial resolution							
Accuracy							
Interactivity							
Form of output/visualization							
Linkage potential							
Transferability							
Data requirements							
Technical experience							
Resources							
Model support							
Experience of other users							
Total Score							

[1] low weight = 1 to 5 = high weight
[2] low match = 0 to 10 = high match

Source: Adapted from USEPA, 2000, which was adapted from Chang and Kelly, 1995.

3.2.6 Establishing models in the planning culture

The lack of experience in working with models and the fact that they are used so infrequently in planning practice points to a considerable need for communication between developers and potential users. Potential users must be familiar with the possibilities of the tools developed, if they are to consider using them.

To establish models in the planning culture, Vonk et al. (2005) suggest the need for professional marketing, which was used with widespread success in the area of GIS applications in the 1990s, for example. We find this suggestion only partly helpful, for with models, there is such a great variety of functions and content directions. We do see, however, great potential in direct know-how transfer through improved cooperation between developers and (potential) users of models.

In the context of planning projects in progress, this cooperation could be facilitated via Master's thesis and doctoral dissertation projects. As a result, qualified experts with experience in working with models would then be available in the labour market to be included in planning practice.

The other way around, the research can also speak to users and decision-makers, in that it includes them directly in comparatively smaller, often less urgent projects. This is in accordance with the approach that NRP 48 followed, with its requirement for and promotion of transdisciplinarity. The potential users of the instruments were to be included in the research projects early on, in the best case already in the planning stage. How successful this strategy turned out to be varies greatly from project to project. The ALPSCAPE project, for example, shows that although the model was not used further in the region, its results in part informed the formulation of an overall concept for Landschaft Davos (Thalmann, 2006).

3.3 Guidelines for assessing the application areas of the models

In order to give interested practitioners a better overview of computer-based methods and modelling techniques in spatial and landscape planning, their potentials and their limitations, the development of guidelines would be a great help in the medium term.

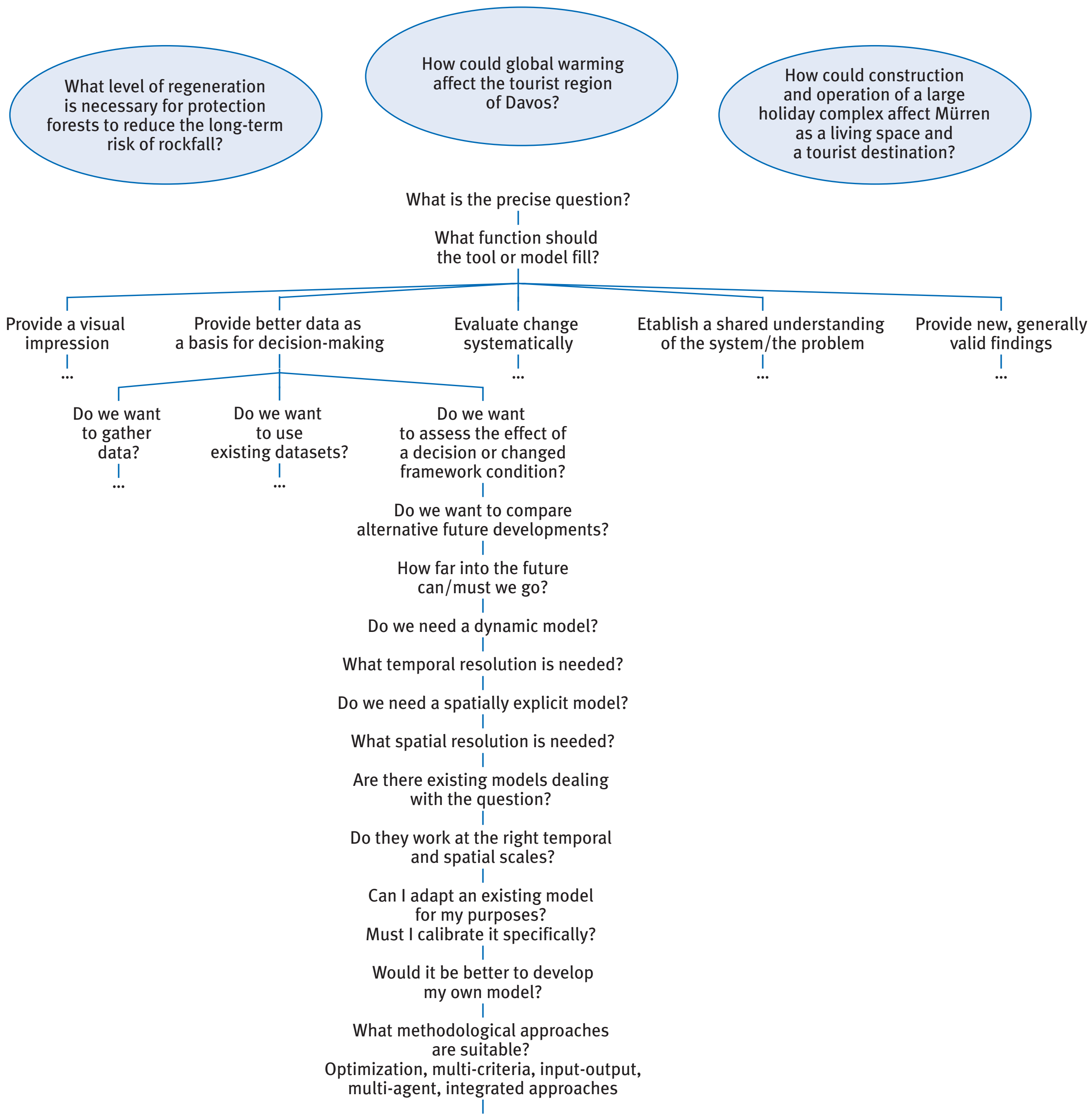
The most important steps in selecting a model of that kind can be summarized here. Before actually selecting a model or tool, the user must become clear on some questions (Figure 3-6). First the problem at hand must be completely understood and the actual question formulated. From that, it must be determined as to what types of information are needed and that will be calculated using the model. These two steps concern the content and functional direction of the model. With this, the number of possibly suitable models can be clearly reduced. The U.S. Environmental Protection Agency (USEPA, 2000), for instance, provides summary information on 22 existing and available land-use simulation models and assessment instruments. The summary distinguishes four main types of planning models – land use, transportation, economic and environmental impact models (USEPA, 2000), with this noting the four most important emphases in content. This distinction is, however, by far not sufficient for selecting a model in a given case, as within these broad groups the individual models differ in methodologies, technical specifications and foci, which makes them suitable only for quite specific tasks.

For this reason, a well-formulated question is of prime importance for beginning with the selection of a model. Potential users must assess what internal resources can be accessed to acquire and use the model. In addition to financial resources, decisive points are the available technical experience in using models, the time budget, and the availability and preparation of data.

In a further step, the selection of the best model is made. Criteria and a criteria rating table (adapted from

Figure 3-7

Draft of a decision tree for assessing models and aids in spatial and landscape planning



Source: The authors.

USEPA, 2000) for selecting the right model in a given case are shown in Table 3-1. This list of selection criteria is the result of cooperative effort in the Advisory Group (especially Workshop 2, see Appendix) and the relevant literature on this topic (such as Brail and Klosterman, 2001; Geertman and Stillwell, 2004; USEPA, 2000).

The publications mentioned above provide a good overview of the features and selection criteria for already existing simulation models and assessment tools (Brail and Klosterman, 2001; Geertman and Stillwell, 2004; USEPA, 2000). But they do not provide a summary of the possibilities of modelling approaches and computer-based tools, which do not necessarily have to be tied to simulation models. They do not consider, for instance, that computer-based visualization tools can make an important contribution to the decision process or that participatory modelling approaches can structure decision processes.

We propose comprehensive guidelines that not only describe existing models but that also serve as a guide to methods that include the range of planning instruments and methods described in section 3.1 above. A possible way to work out the guidelines is to develop a decision tree. In the decision tree, decision criteria for various techniques and models in spatial and landscape planning are arranged hierarchically and thus in a way that is relatively easily accessible to the layperson. The decision tree would provide practitioners with an aid that would allow them, in advance, to form a good assessment of both the expense/effort and the gain resulting from the use of certain methods and models. Figure 3-7 is an initial draft of a decision tree of this kind.

4 Virtual Representation – From «Pretty Pictures» to Helpful Planning Instruments

4 Virtual Representation – From «Pretty Pictures» to Helpful Planning Instruments

It makes a pretty picture – that honeycomb tower on Schatzalp! But is realization of the tower project possible? What will it mean for the natural scenery; how will it affect development of the regional economy and tourism? These are the questions that structural engineers, construction experts, tourism experts, financial and economic experts, planners, and, finally, developers have to answer. But before they do, they often rely upon the power of pictures, using both static and animated images.

While construction projects and large interventions in the landscape are planned accurate to the millimeter in 2D plans, most observers – most decision-makers, namely – can envision the projects only when 3D models or 3D animations become available. Figure 4-1 (showing the tower planned for Schatzalp) represents a static version. The picture combines a terrestrial photograph with a computer-generated representation of the Schatzalp tower and the other required construction changes to the existing building fabric. The angle of vision selected here makes the tower seem «tangible», as the viewer looks down at the tower, so to speak, or sees it at eye level. This makes the tower lose something of its monumental character, which can irritate the viewer looking up at the tower «from below». The photographic basis for Figure 4-1 is an aerial photograph. Figure 4-1 is thus a skilful allusion to architectural scale models built of card stock, which although they are able to give a 3D impression are not able to render the 1:1 situation.

Whether we like it or not, representations of this kind influence our decisions, whether as possible buyers of a piece of real estate like this or as voters being asked to vote on a local zone planning revision. Very few people will see the Schatzalp tower in reality as it is depicted in Figure 4-1, as most people in Davos have their feet on the ground. But still, the almost «intimate» view generated by this depiction from above permits a kind of identification with the tower, while the worm's-eye view would produce more of a feeling of awe or constriction.

But this quasi familiarity can be foiled by suggestive and simple means, as the example of the new building of the national park information centre in Zernez shows (see section 3.1.3 above, Figure 3-2). A simple, striking depiction of the new building, which blocks the view of the Planta-Wildenberg Castle, a building that is under cultural heritage protection, was effective enough to challenge the construction project approval and to finally force a relocation of the building site. Constructors, planners and software developers are well advised to anticipate reactions like this and to grant the «customer» of their products the depiction of all perspectives and possibilities. Only with this does the fruitful dialogue, the fruitful study of variants become possible. Virtual, computer-based visualization techniques then fulfil their purpose and become valuable instruments or tools for planning practice.

The aim of Chapter 4 is to deliver insight into what is at the bottom of computer-based planning instruments and landscape analysis instruments, and how they can be developed and exploited by users as well as developers. As many modelling projects were carried out in NRP 48, this can be demonstrated easily using those analyzed examples.

The great difficulty for this synthesis report is that the analyzed NRP 48 modelling-type projects vary in topic and also spatially. The reason is in part due to (original) data availability, which was often determined by the personal contacts of the project leaders but that was also understandably due to an attempt to generate results with a wider geographic range. For the synthesis, however, it would be a lot easier if all of the computer applications referred to the same geographic region. Differences in the necessary data, in the spatial and temporal resolution, in the effort required of the developer or user would then be more obvious – aspects such as generally arising problems and gaps in the topics and missing models, too.

Figure 4-1
The planned tower on Schatzalp

Source: © Herzog & de Meuron, from: Wettbewerbsfähige Strukturen und Aufgabenteilung im Bündner Tourismus, AWT Graubünden, Chur, 2006.

As the prerequisite of homogeneity is not fulfilled, Synthesis Report V introduces a technique that compensates for this at least in part and at the same time is illustrative with regard to constructive dialogue between developers and users of computer applications. It is called the use case technique (see, for example, Cockburn, 2001; Isenegger et al., 2005).

A use case is an informal description of how users will typically use a computer application. Use cases offer an opportunity to break down complex facts and circumstances in the situation and the model into a sequence of individual steps, and from this to capture the software requirements. In targeted software development it is generally advantageous to both developer and user if several use cases are discussed and documented before and during development. Use cases can serve as preliminary stages of the exact programme specifications, and they are also useful in many cases as pragmatic substitutes for those specifications, not least in the sense that the jointly developed use cases are better than never written specifications.

On the basis of an illustrative use case and examples taken from the NRP 48 projects, we would like to introduce this technique in Chapter 4 and at the same time also put something into the hands of planning practice, which places great hopes in the use of virtual planning instruments. A virtual reservoir or a virtual street can be changed or deleted with a mouse click – but once something is built, it can no longer be «edited out» so easily.

An accompanying CD-ROM has been prepared for this chapter that contains several different examples. Detailed documentation on the CD-ROM can be found in the Appendix.

4.1 How can case-specific, individually modified software solutions be developed?

4.1.1 The use case – or, from «the little story» to the functionality list

We understand use cases as follows:

> «A use case provides a description of the behaviour of a specific software system in a typical use as experienced from the perspective of the main actors/users. The description is made either in form of a story (procedural, yet informal) or more formally (e.g. decision table, state transition diagram).» (Quoted from the original proposal on which this Synthesis Report V is based.)

In our opinion it is very important to also apply the methods developed to «real» scenarios. The research projects on which this synthesis report is based were very ambitious and broadly diversified. Use cases can help to break down complexity: They serve as a sandbox so to speak, located between theory and reality, through the aid of which a bridge can be built between software developers and users. The use case makes dialogue between users and the authors or software developers possible, in that it formulates the requirements and wishes of the users and at the same time delivers information that developers need and will then have to translate into software functionalities.

4.1.2 From idea to realization – Who plays what role?

In the ideal case, clients (users) and contractors (developers) sit down together. Clients are usually decision-makers or stakeholder groups, or their representatives; the contractors are the planners and/or modellers – and in the most fortunate case, also the software developers.

If both sides follow the rules agreed upon for developing the use cases, there is nothing to get in the way of a successful use case development process.

4.2 An illustrative example – Laying out hiking trails around the Schatzalp tower

What should the software do? Most users possess no specific software development knowledge, and it is also not necessary for them to have it. It is enough, if the user interface is so good that users can easily «click their way through» the software to the desired functionality, using their intuition and associative, passive knowledge. So that developers can find out what users need, it is useful for users to write a prose description of what they wish to do with the software. This «story» is then broken down into a sequence of actions that amounts to a semi-formal description and that aids identification of the desired functionalities. In the case of virtual planning and landscape analysis instruments, the main thing is to find out what (spatial) GIS functionalities, what temporal and what 2D and/or 3D visual representation functionalities are desired.

The following is a fictitious example that deals with the planned Schatzalp tower in Davos. It is meant to be illustrative and does not at all intend to reinvent the tower. The example is intended only to show how software requirements specifications can be created.

The «little story» in this example goes as follows:

> «The mayor of Davos sits at his desk in the town hall and considers what effect the Schatzalp tower will have on the township of Davos. For one, the township expects that the tower will bring financially strong second-home owners, who will encourage their circles of acquaintances to come to Davos. For another, Davos could offer tourists guided «architecture hikes» to the Schatzalp tower and in this way promote the fame of Davos. It is worth striving for here to present the Schatzalp tower in the best and most interesting light. To achieve that, a specialist hiking guide will test routes to find the best routes of access and also undisturbed sites for the guides' narrations. The result should be an animation (a film) that shows a possible and particularly beautiful hike to the Schatzalp tower and that can be featured on the Tourism Davos Website.»

From this rather simple-sounding story to software requirements specifications, a number of steps are required. At first glance it can not be seen clearly what thread of the story targets what functionality. Is the objective here to calculate a value-added chain, or to simply calculate the visibility of the tower, seen from a network of hiking trails? Or both?

It is the task of a good software developer to filter out the purposes and to define a sequence of actions (sequenced action list), or individual steps. The more clearly that the individual steps in this nested use case can be differentiated, the easier it is to identify the functionalities and to formulate the specifications.

Required GIS functionalities

- Options for loading vector and raster data
- Options for selecting various feature classes (lines, points, areas, grid cells/pixels, aggregations of grid cells/pixels, etc.)
- Calculation of hiking times on individual trail segments in dependency upon ascent gradient and hiking speeds
- Calculation of visibility areas from certain observation points in dependency upon angle of vision and direction of sight
- Overlay functions for various feature classes
- Export and import functions (interfaces) to other required software programmes

Required simulation functionalities

- Simulation of a hiker on a particular stretch of trail
- Simulation of interactions among several hikers on a certain stretch of trail
- Required visualization functionalities:
  - Computation of the 3D image that a hiker sees from every point of the stretch of trail walked

Table 4-1a

Action list – Overview 1

A	Mayor estimates sales possibilities and added value of the tower
B	Hiking specialist must calculate optimum access and viewing sites
C	Hiking specialist simulates possible hike and saves it as an animation

These main parts in turn can be broken down further into individual steps (Table 4-1b):

Table 4-1b

Action list – Overview 2

A1	Mayor requires sales prices of condominiums in the tower
A2	Mayor calculates value-creation potential of the individual condominiums
B1	Hiking specialist calculates hiking times for hiking trails
B2	Hiking specialist carries out visibility analyses
B3	Hiking specialist determines optimum viewing sites
C1	Hiking specialist simulates possible hikes
C2	Hiking specialist saves the hike as an animation

In our example, we will focus on steps B1, B2 and B3 as well as C1 and C2. These fall into the area of landscape analysis. The handling of steps A1 and A2 would require models from economics and business. So that B1 to B5 can be carried out, the sequenced action list has to be broken down further (see Table 4-1c). Based on the (incomplete!) sequenced action list, the required functions and the software environments can now be derived and included in the implementation of the customized software solution. Analysis is conducted to find out what functions are standard functions and what functions may have to be newly implemented.

Table 4-1c
Detailed sequenced action list for identifying the required software functionalities and requirements specifications

B1.1	Hiking specialist starts GIS
B1.2	Hiking specialist loads the trail network into the GIS
B1.3	Hiking specialist selects desired hiking route
B1.4	Hiking specialist selects starting and end points of the hike
B1.5	Hiking specialist loads the according digital terrain model into the GIS
B1.6	Hiking specialist starts calculation of hiking time for the way there
B1.7	Hiking specialist saves the calculated hiking time for the way there
B1.8	Hiking specialist starts calculation of hiking time for the way back
B1.9	Hiking specialist saves the calculated hiking time for the way back
B2.1	Hiking specialist determines observer position and target point for visibility analysis
B2.2	Hiking specialist selects tower site for first approximation of what is visible
B3.1	Hiking specialist overlays the visibility area of the tower with the trail network
B3.2	Hiking specialist selects new observation points in the visibility area
B3.3	Hiking specialist selects tower as observation target point
B3.4	Hiking specialist calculates new visibility areas from observer positions
B3.5	Hiking specialist saves new visibility areas and corresponding observer positions (optimal viewing points)
C1.1	Hiking specialist selects a possible route having an optimal viewing point
C1.2	Hiking specialist calculates hiker simulation(s) on this route
C1.3	Hiking specialist calculates possible interactions among the hikers
C2.1	Hiking specialist creates a 3D surface model with texture from land use and trail network: the surface is created from the digital terrain model
C2.2	Hiking specialist creates further 3D models for the foreground representation and adds them, singly (for example, houses) or in multiples (for example, trees)
C2.3	Hiking specialist uses ray tracing at each point at which a hiker ever stood in the simulation in order to create a picture
C2.4	Hiking specialist puts the pictures together and saves them as an animation

– Putting together the computed images into a sequence of pictures
– Storage of the sequence in an animation (a film)

The majority of the required GIS functionalities are standard functionalities in most of the commonly used GIS systems and essentially cover the steps B1.1 to B3.5 in Table 4-1c. However, the problem of the «best viewing sites» in the present example is not possible only with a sequence of queries in a GIS, even though the positions from which the tower is visible can be calculated in a GIS. For the best viewing points, computation is needed of how hikers influence each other and possibly get in each others' way on the trails and at the viewing sites, which would spoil some of the enjoyment of the hike.

For the simulation requirements (steps C1.1 to C1.3) it is more difficult to find standard solutions. But it is obvious that here the multi-agent technology offers the most promising approach. For the visualization (steps C2.1 to C2.4), rendering techniques are needed, which are very time-consuming. The following shows for the present example the time required for implementation.

4.2.1 Time required for production of the desired Schatzalp animation

Time required for GIS analyses

A person with average experience in using GIS carries out the required GIS standard computations in about two days' time, provided that the necessary data are available and are also in a GIS-compatible format. In the present example, data from Swisstopo, Switzerland's federal geoinformation centre, can be used: Vector25 and DHM25 (© swisstopo), so that in this case, no time-consuming data collection or data preparation is necessary. The effort required for the individual steps is shown in the following:

Accessing and preparing the data for analysis (DHM25, Vector25: trail network, settlements, individual objects)	0.5 days
Calculation of hiking times	0.5 days
Calculation of visibility and overlays	0.5 days
Final work and documentation	0.5 days
Total time required for GIS analyses	**2.0 days**

Implementation time required for the hiker simulation

The implementation time required should be distinguished from the simulation run-time. Implementation time is time needed if the region changes (for example, from Gstaad – ALPSIM project – to Davos), or if the type of simulation changes fundamentally (for example, from a hiker simulation to a traffic simulation). The run-time of the simulation is required for each new utilization. In addition, there is the visualization, which is based on the output data of the simulation.

The agent-based simulation system was already developed in the ALPSIM project and is thus available for the Schatzalp tower simulations. Assuming that nothing has to be changed in the simulation system, and that the user is already familiar with its use, it takes only a short time to install and test it. At most, evaluation may be also necessary, in the case where there is a choice of several systems.

Simulation set-up	1.0 day

The terrain model and network of trails and roads draped on it form the basis for the representation in the hiker simulation and subsequent visualization. But even if these data are available, adaptation is not straightforward in every case. Mountains in particular place higher demands on the terrain model; it has to be sufficiently fine-meshed for the animation to be plausible. For this reason, the following effort is also required:

Digital terrain model in the correct format	5.0 days
Trail network in the correct format	5.0 days

Once these bases are completed, the simulation system can be added. Depending on the system, separate parts of the programme are used for different computations (modular system). Typical modules are: a) computation of the physical world, computation of collisions between hikers and surroundings, but also between hikers, b) calculation of routes, c) visibility analyses, and d) management of the data learned by the hikers (the «brain»).

Set-up, add and test system	2.0 days
Total time required for simulation	**13.0 days**

Time required for the 3D visualization and creating the film

There are programmes available for 3D visualizations from great distances, such as Google Earth. They look as though they would also be suitable for representing user-defined data. However, as soon as views near to the ground are required, the quality of the representation decreases greatly and no longer suffices.

To make the Schatzalp film that is on the CD-ROM accompanying this report, we created our own 3D surface model with texture consisting of information on land use and trail network, which was then rendered into pictures using an existing ray tracer. The surface model contains 3D information on trees and buildings, which were also included in the film calculations. The time required for the parts of the job was as follows:

Select, cut to size, and test elevation model, possibly convert to raster format	2.0 days
Convert into mesh (triangles)	3.0 days
Primary land use categories: grass lands, scree, etc.	2.0 days
3D models of typical local objects (trees, simple plants)	5.0 days
Positioning of trees and plants (randomized)	5.0 days
3D models of buildings: depending on precision	5.0 days
Total time required for film	**22.0 days**

A 3D model of this kind with texture has to be produced once per region. In principle, one single model for Switzerland or even for Europe would be ideal, but the amount of data would be so great that it would then have to be cut, or subdivided. Depending on the scenario, specific buildings or other objects would be to be created additionally.

After setting up the scenario, the simulation is started. For simple scenarios little computation time is needed (a few minutes). The output of the simulation forms the basis for the subsequent visualization. More time is needed for the visualization, however:

For the following computation, a 3D model with 200,000 objects was utilized (mainly trees and land cover elements such as plants and grass). The size of the visualization in memory (RAM) of the ray tracer is just less than 500 megabytes (MB).

The times given below were the times using a computer with a 2 GHz processor and 1 gigabyte (GB) of RAM. Ray tracing is suited mainly for scenes with reflections and transparent objects, which occur seldom in nature. It is therefore possible to use computation methods that are significantly faster. In order to produce a realistic landscape, however, very many individual objects are needed, such as trees and buildings. Importing this data takes about the same amount of time as the computation and displaying of the scene.

For a picture with a resolution of 640 x 480 pixels, the following times in minutes and seconds are required:

Import and display internally	1 m 58 s
Compute and display	1 m 45 s
Total	3 m 43 s

Computation of individual frames, per frame approx.	4 m

At least 5 frames are needed per second of film – 30 frames per second would be ideal. For one minute of film in the present case, 300 frames are needed:

1 minute of film à 5 frames/s	**20 hours**

Total time required for producing the Schatzalp animation

Adding up the total time required (see Table 4-2), nearly two months' work time is required for the production of a one-minute film, which itself would require another 20 hours of computer computing time. That seems horrendous! But the balance sheet looks different when one considers that this includes implementation and work on the various aspects (model adaptations), the partial adaptation of the programme code and the modelling of the new 3D objects. And also, the work required would decrease with each new application for a different study region. The required effort would never become negligible, however, because each new region studied would require adaptations as to the research question, data availability and simulation.

Table 4-2
Total time required to produce the Schatzalp animation (film)

Total time for GIS analyses	2.0 days
Total time for simulation	13.0 days
Total time for the film	22.0 days
Total time	**37.0 days**

4.2.2 Types of visualization used

Computation of the following visualization examples (Figures 4-2 bis 4-7) was based spatially on Vector25 and DHM25 (© swisstopo) topographical data. All of the 3D objects – trees, flowers, grasses and the Schatzalp tower – were produced either in the ALPSIM (Figures 4-3 and 4-4) or in the framework of this synthesis report (Figures 4-6 and 4-7).

Real-time visualization

Real-time visualization extracts data directly from a simulation in progress and displays it. Here the focus is on the positions of the hikers; the information (in addition to position, also speed, destination, information on hunger, thirst, energy and interest) refer often to individual hikers and are not aggregated further.

The visualization can be 2 or 3-dimensional. For the visualization to be carried out in real-time, elaborate detail must be dispensed with. This type of visualization will look more or less abstract depending on the available computing power.

Real-time visualizations are helpful to users of the simulation, for they can observe immediately what is going on in the virtual world. This is also a way to demonstrate how the simulation system works.

Offline visualization

If a visualization is produced using the acquired data after the end of the simulation, there is a lot more computer time and computing power available, and more effort can be put towards making the visualization look realistic. It is possible to compute photorealistic 3D visualizations. Figures 4-4, 4-6 and 4-7 were created in that way.

The estimate of the time required given in section 4.2.1 is based on computation of visualizations such as those represented in Figures 4-6 and 4-7.

Visualizations of this kind show the output of a simulation and are therefore particularly suitable for demonstrations that are not meant to show the technology but rather the results of a particular simulation.

Figure 4-2

2-dimensional view of the simulated region

Shown here are the agents with their assigned numbers (orange) and the events affecting the agents (green and red Xs).

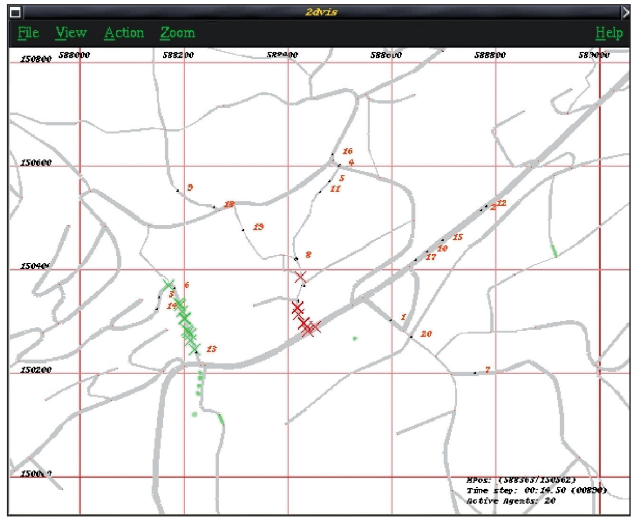
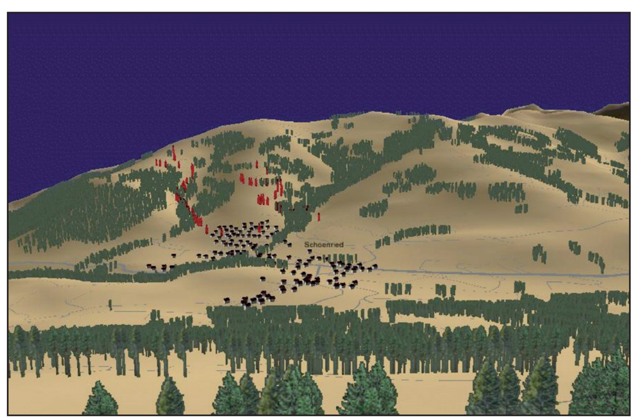


Figure 4-3

3-dimensional view of the simulated region

The same (spatial) view is shown as in Figure 4-2: The agents (red rectangles) are shown greatly enlarged to make them visible at this distance.



Source of the two figures: Gstaad Scenario, Alpsim project.

Figure 4-4

Virtual 3D view, generated offline – same excerpt as in Figure 4-2

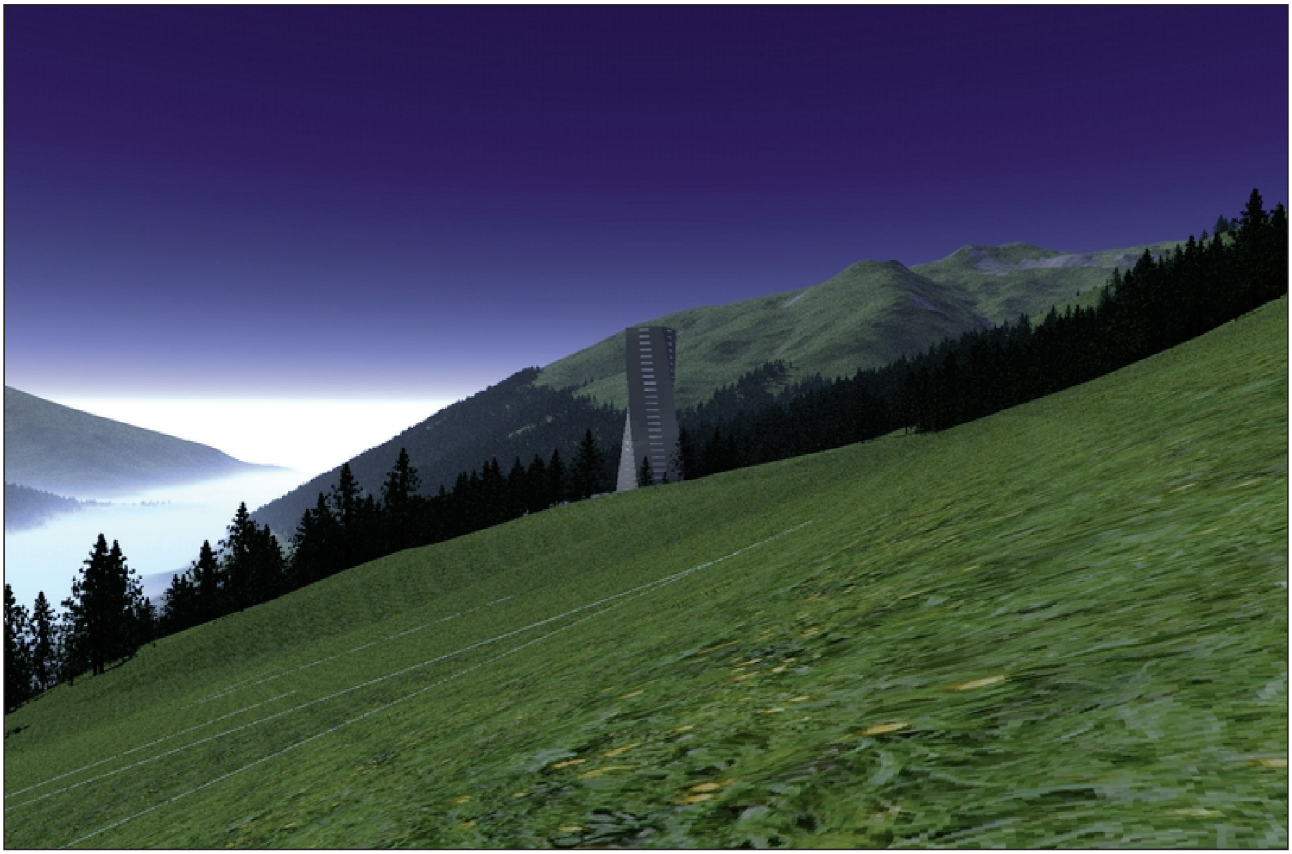
Figure 4-5

Natural photographic view – same excerpt as in Figure 4-2

Source: Gstaad scenario, ALPSIM project.

Figure 4-6

Schatzalp tower scenario in Davos: Cut-out from the animation of the virtual hike to the Schatzalp tower



Source: The authors; generated for the use case example in Synthesis V (Schatzalp scenario).

Figure 4-7

Schatzalp tower scenario in Davos: Calculated view from the meadow above the Schatzalp tower on Büelenberg and Jakobshorn

Notice the detailed structure of the foreground.

Source: The authors; generated for the use case example in Synthesis V (Schatzalp scenario).

4.3 Examples from NRP 48

In the following, illustrative use case situations are taken from the ALPSCAPE and IPODLAS projects and analyzed in brief following the approach described above, without estimation of the work time required, however. The projects were conducted for dissertations, for which the work load is naturally very high and which can not be compared with common work times and approaches in the world of practice.

4.3.1 Use case from ALPSCAPE

This project dealt with modelling the development of townships in Alpine tourism regions. The story of an ALPSCAPE use case could be the following:

> «The representatives of the district council discuss the new building law and the new zoning planning that are being developed for an Alpine tourism township. There is disagreement over what the zoning regulations should be. There are divergent interests, because a) the aim is to allow tourism to unfold freely, b) new housing is needed also for the native residents, and c) new settlement of the landscape is to be restricted. The representatives want to have maps that show where, within the different building zones, there is settlement space, that is, where there is gross floor area still available.»

Action list for the ALPSCAPE use case

The use case as described for ALPSCAPE requires at the minimum the following action list (Table 4-3). Some of the steps could be subdivided, namely, the steps listed for output, or visualization (V). But the following list would be sufficient to allow fruitful discussion with software developers.

Necessary data for the ALPSCAPE use case

- Areas and number of floors per building for estimation of gross floor area
- Current zone planning for estimation of the existing construction capacity
- Data on the ownership structure of existing buildings: If several owners own a piece of real estate jointly (joint ownership), this lessens the probability that a piece of real estate will be torn down and replaced by a building having an increased utilization rate.
- Data on use: hotel, vacation rental, second home, first home per unit of accommodations
- Numbers of overnight stays with high temporal resolution, for several years and according to various categories of tourist accommodations
- Number of beds, differentiated according to use
- Utilization of tourist beds according to category and year
- Maximal utilization of tourist beds according to category
- m^2 gross floor space per m^2 floor space of the property (= utilization, or construction capacity factor)
- Number of beds per property according to category of tourist accommodations

Possible visualization of the ALPSCAPE use case

Figure 4-8 shows where there are settlement reserves within the building zones, or where there is remaining buildable gross floor area. Maps like these can now be compared with the effective building situation and used as decision support.

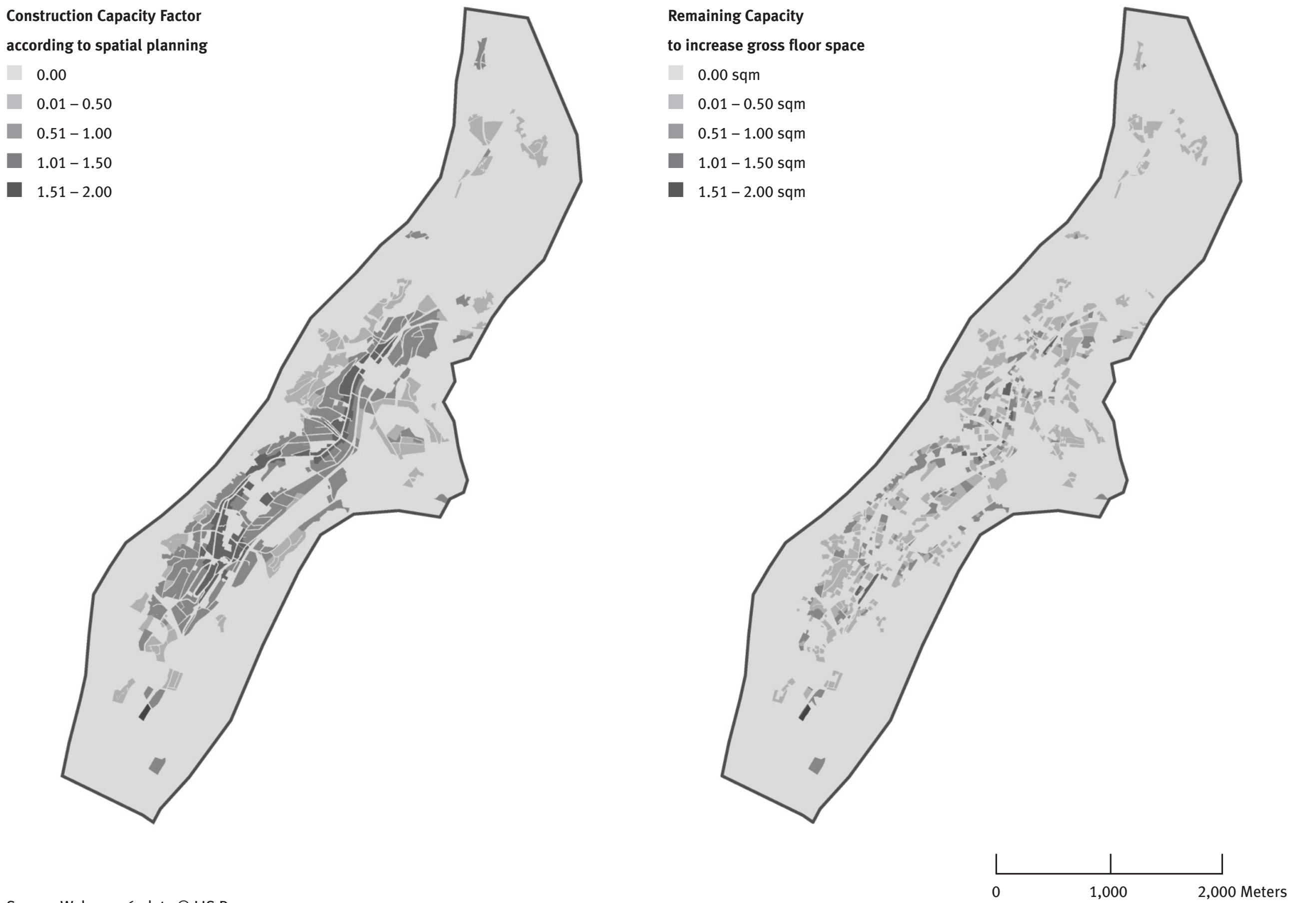
Table 4-3
Action list for the ALPSCAPE use case

Input functions (I)	
I1	Input of zone planning (+ scenarios) in common GIS and CAD formats
I2	Input of overnight stays during the year for different tourism categories
I3	Scenarios in DBF format
I4	Number of beds for various categories of tourist accommodations with possible settlement expansion
Computational functions (C)	
C1	Estimate gross floor area
C2	Computation of actual potential for housing expansion
C3	Computation of potentials in scenarios A and B
C4	Computation of possible overnight stays (for each alternative tourist strategy)
C5	Computation of number of beds per property for different tourism categories
C6	Computation of the required settlement expansion, in m², in the case of an increase of xx beds for certain categories of tourist accommodations, if number of beds per property remains constant
Visualization (V) – Output functions on the monitor and in the form of data files that can be used elsewhere	
V1	Maps with beds per building
V2	Maps with overnight stays per building, including the seasonal course of overnight stays (today, and according to scenarios)
V3	Map with potential m² gross external floor area per building (today and in scenarios)
V4	Number of theoretically needed m² gross external floor area and settlement expansion (according to scenarios)
V5	Map – gross floor area per bed and building
V6	Map – gross floor area per property (utilization today and in scenarios) in common GIS and CAD formats and as JPG
V7	Map – potential to expand gross floor area – Each map should be exportable as a vector data set in common GIS and CAD formats and as JPG and TIFF in various resolutions – Each map should have a legend – Legends should be editable (colour choice + labelling font) – In the output on the monitor, zooming in should be possible – In an output of 1:5000 street names should appear on the monitor, in images and also on print-outs – Printing should be possible direct from model

Source: Isenegger, 2006.

Figure 4-8

Construction capacity factor at present and remaining capacity for expanding gross floor space, exact to the building



Source: Walz, 2006, data © LIS Davos.

4.3.2 Use case from Ipodlas

In the Ipodlas project, the aim was to design a software environment capable of combining spatial and temporal modelling systems and to visualize the modelling processes in the most attractive manner possible. A task as complex as that can be handled only with the help of use cases. To be able to satisfy the demand for real application, case studies and data from already existing research regions were chosen. This prevented the choosing of intuitively simple examples that could then be implemented in textbook fashion. The utilization of existing data, models and software environments placed very high demands on the developers of a system, as all of components had to be integrated. However, the successful proof of concept is then much more valuable.

The following use case from the Ipodlas project describes how an English-speaking PhD candidate from Australia, working within NRP 48, handles the research task assigned to her for the Alpine region, namely, modelling of larch bud moth population dynamics in the Alps as a whole and specifically in the Upper Engadine valley. In addition, the larch bud moth modelling is coupled with wildland fire modelling. This makes sense not only from the perspective of the software developer – who wants to test «hardship cases» – but also in terms of content. Forests stands defoliated due to insect infestation are especially vulnerable for further disturbances such as fires.

In the following, we present the Ipodlas use case «story», action list and list of derived functionalities. This documents how the Ipodlas Prototyp prototype was developed step-by-step and through utilizing use cases that built upon one another. The following bases upon dissertations by Bronwyn Price (2005), Daniel Isenegger (2006) and Yi Wu (2007), which were all completed in the framework of the Ipodlas project. The doctoral project by Isenegger took over the task of software design and development. The dissertation by Price worked out the larch bud moth modelling, and in this way took the role of a user with a complex research question. And finally, the dissertation by Wu focused on 4D visualization of the modelled spatial processes. The story of an Ipodlas use case could be as follows:

> «Bronwyn is an ecologist and expert user of the Ipodlas system. She is a PhD student within the Ipodlas project and wants to use functionalities of the Ipodlas system to help her answer research questions concerning the spatiotemporal dynamics of the Larch Bud Moth (LBM) *Zeiraphera diniana* Gn. *(Lep.,* Torticidae) at differing scales and to investigate the influence of spatial data resolution on modelling LBM dynamics in the Upper Engadine valley.
>
> In particular, Bronwyn wants to see LBM migration within the Upper Engadine valley, in particular a 3-D visualization of the seasonal LBM migration from given sites to other sites and the resultant forest appearance due to defoliation. After a simulation run, Bronwyn changes parameters of the LBM simulation model in the Ipodlas GUI: she wants to simulate warmer winter conditions with higher egg mortality. Afterwards, Bronwyn is interested in the interaction of LBM and wildland fire occurrence (WLF). She wants to explore WLF spread in a LBM peak year exhibiting high defoliation and tree mortality. Bronwyn starts a WLF in a site having a high defoliation rate.» Quoted from Isenegger, 2006.

Action list for the Ipodlas use case

While the action list may seem extremely meticulous, it is a great aid to designing the required software architecture and identifying the necessary software functions, for in this way the specifications for the software developer can be formulated.

Table 4-4
Action list for analysis of the larch bud moth in the Upper Engadine valley
The abbreviation LE3 stands for «larch bud moth expert use case number 3».

Action	Description of action
LE3e-1	Bronwyn starts IPODLAS and selects LBM from the list of topics.
LE3e-2	IPODLAS shows her the Alpine Arc with highlighted areas where LBM data are provided. Bronwyn selects the Upper Engadine valley.
LE3e-3	IPODLAS displays a 2-D map of the Upper Engadine valley. An additional menu shows several options (geographic data, 3-D, simulate, pre-calculated movie). Bronwyn chooses to simulate and see the output in 3-D.
LE3e-4	In the LBM configuration window, Bronwyn chooses a start and stop time (1953, 1954) and otherwise keeps all defaults, then runs the model.
LE3e-5	IPODLAS displays a 3-D visualization of the output showing comparative numbers of LBM migrating (departure and landing points) and the resultant coloring of the forest in the sites symbolizing the defoliation ratio.
LE3e-6	After the end of the simulation, Bronwyn changes the «winter egg mortality» parameter in the LBM configuration window, keeps all the other defaults, and starts the simulation again.
LE3e-7	IPODLAS displays a 3-D visualization of the output showing comparative numbers of LBM migrating (departure and landing points) and the resultant coloring of the forest in the sites symbolizing the defoliation ratio.
LE3e-8	After the simulation ended, Bronwyn selects in the IPODLAS GUI the WLF topic and then the WLF simulation configuration window. In there, Bronwyn chooses that the ignition point can be set in VR and that the «live moisture» parameter of the WLF simulation model is taken from the output of the LBM simulation.
LE3e-9	In the VR interface of IPODLAS the defoliation of the forest in the respective sites is displayed applying different colors. Bronwyn now selects a WLF ignition point in a site exhibiting high defoliation values.
LE3e-10	In the VR interface of IPODLAS the spread of a WLF is shown starting from the user-selected ignition point.

Table 4-5
GIS functionalities and communication of the results to the visualization subsystem

Action	Required GIS functionality	Type of GIS functionality
LE2-2a, LE3e-2a	Receiving request to provide areas with available data	Communication/information exchange between subsystems
LE2-2b, LE3e-2b	Selecting data from storage(s): areas with available data	Connection to storage(s) and retrieving data from storage(s)
LE2-2c, LE3e-2c	Notifying the requesting subsystem about available data via IPODLAS	Communication/information exchange between subsystems
LE2-4a, LE3e-4a	Receiving request concerning forest and in particular larch distribution, calculating slope and aspect, and wind simulation	Communication/information exchange between subsystems

LE2-4b, LE3e-4b	Selecting data from storage(s) if simulation data is not already available: forest data, larch data, temperature data, DTM	Connection to storage(s) and retrieving data from storage(s)
LE2-4c, LE3e-4c	Calculating, if not available in storage: – Larch per hectare, forest area per hectare, temperature distribution – Slope, aspect – Wind speed and direction statistics	– Map algebra, map overlay, clipping – Slope, aspect calculation from DTM – Simulation using the wind model and calculating statistics using Map algebra
LE2-4d, LE3e-4d	Notifying the requesting subsystem about available data via IPODLAS	Communication/information exchange between subsystems
LE2-5a, LE3e-5a	Receiving request to transform tabular simulation output to raster	Communication/information exchange between subsystems
LE2-5b, LE3e-5b	Transform tabular simulation output to raster	Join attribute data with spatial data and generate raster through rasterization
LE2-5c, LE3e-5c	Notifying the requesting subsystem about available data via IPODLAS	Communication/information exchange between subsystems
LE3e-6a	Receiving request concerning LBM data with changed «winter egg mortality»	Communication/information exchange between subsystems
LE3e-6b	Selecting data from storage(s) if simulation data is not already available: forest data, larch data, temperature data, DTM, defoliation	Connection to storage(s) and retrieving data from storage(s)
LE3e-6c	Calculating, if not available in storage: – Larch per hectare, forest area per hectare, temperature distribution – Slope, aspect – Wind speed and direction statistics	– Map algebra, Map overlay, clipping – Slope, aspect calculation from DTM – Querying wind model
LE3e-6d	Notifying the requesting subsystem about available data via IPODLAS	Communication/information exchange between subsystems
LE3e-8a	Receiving request concerning defoliation data in sites	Communication/information exchange between subsystems
LE3e-8b	Selecting defoliation data from storage(s) if data is already available	Connection to storage(s) and retrieving data from storage(s)
LE3e-8c	Notifying the requesting subsystem about available data via IPODLAS	Communication/information exchange between subsystems
LE3e-9a	Receiving request concerning WLF simulation (with ignition point)	Communication/information exchange between subsystems
LE3e-9b	Starting WLF simulation	Accessing and invoking a WLF simulation model to simulate a WLF spread
LE3e-9c	Notifying the requesting subsystem about available data via IPODLAS	Communication/information exchange between subsystems

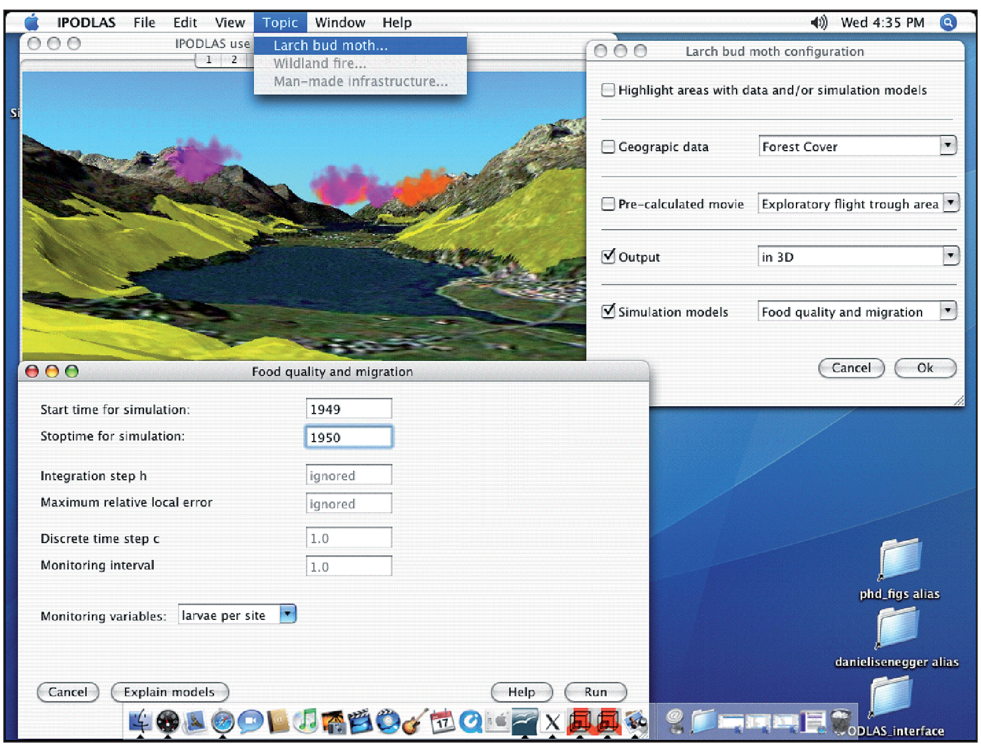
Source of the two tables: Isenegger, 2006.

Possible visualization of the IPODLAS use case

Figures 4-9 and 4-10 represent the larch bud moth populations as coloured clouds. Figure 4-11 shows a possible spread of a wildland fire in the forest stands weakened by defoliation. From the original data on the larch bud moth populations and the larch bud moth models of Upper Engadine, it is known what subpopulation comes from what forest stand. The task for the visualization was then to depict the migration of the subpopulations in such a way that viewers could comprehend what subpopulation flies away from what forest stand to what forest stand. The colour scale of the forest stands (green to yellow/orange) indicates the extent of defoliation.

Figure 4-9

Excerpt from the user interface for computation of the larch bud moth and wildland fire models



Source: Isenegger, 2006.

Figure 4-10

Excerpt from a larch bud moth flight animation

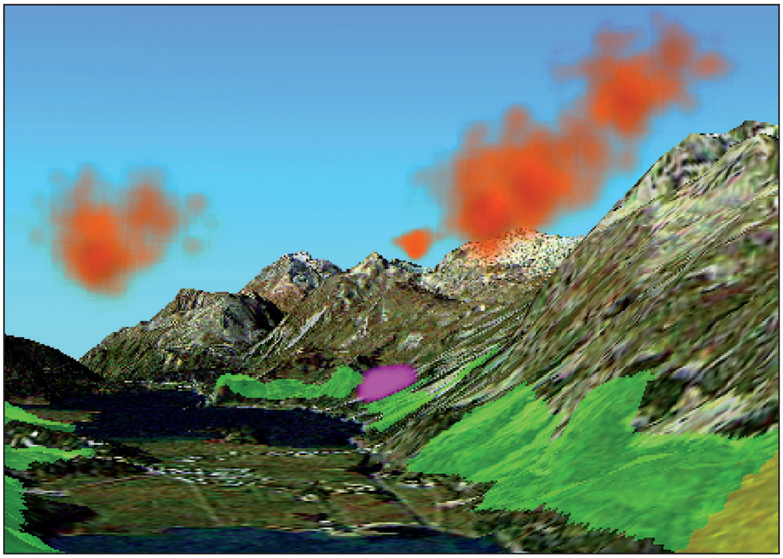
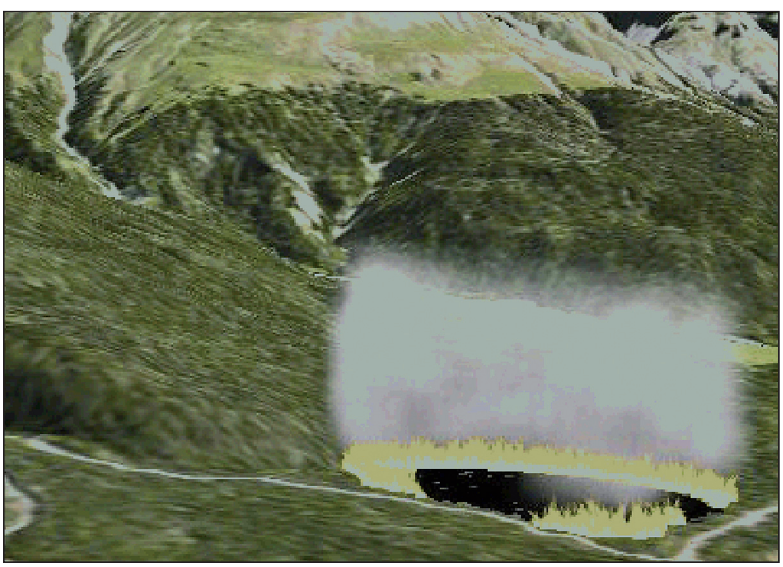


Figure 4-11

Excerpt from the wildland fire modelling



Source of the two figures: Wu, 2007.

4.3.3 Use case on the effects of changing framework conditions for agriculture on landscape and tourism in the Alps

In conclusion and as an outlook, the following outlines what would be possible if some of the models developed in the NRP 48 projects were brought together as a common use case. The use case story for this would be:

> «In the National Council and the Council of States, the opening of agricultural markets and the development of agricultural policy is being discussed. It is assumed that through the extreme cuts in agricultural subsidies, all farming on hillside locations in the Davos region will be discontinued. It is expected that in the succession triggered by this, a large part of the cultivated landscape will be replaced by land cover forest up to the timber line. It is expected that the resulting landscape will be considerably less attractive to summer tourists and that the tourists will go elsewhere.»

This use case is comparatively complex. But it turns out that models that were developed within NRP 48 can handle these questions. Theoretically then, there is the possibility to combine the NRP 48 models as follows:

First, **Sulaps** examines changes in mountain farming as a consequence of changes in agricultural subsidies:

- Change in the size of farms and their main emphases
- Change in plot utilization

Alpscape takes up these results and simulates:

- Direct and secondary effects on the regional economy
- Changes in material and energy flows and in the self-sufficiency rate of the region as a result of the changes in agriculture

Building on that, **Wasalp and Ipodlas** compute the spatial/temporal development of the expansion and structure of the forest stands in the Davos area. The results of this model are:

- Wasalp delivers at high spatial resolution the differentiated plant cover in the Davos area
- Ipodlas computes the changes in the forest structures and composition with the help of the relevant growth functions for certain forest types
- The combined result is a forest stand map that contains both content information (forest species composition, structural parameters) and geometric information (forest expansion), subdivided into desired time periods

Based on that, **Gisalp** generates static pictures of the changed plant cover and computes from that indicators of possible changes to the attractiveness (scenic beauty) of the landscape.

Based on the changed evaluations, **Alpsim** simulates changes in the behaviour of hikers. The results of this model are:

- Changes in the routes chosen by hikers
- Changes in hiker satisfaction (such as dissatisfaction with the fact that to see a nice view, you now always have to hike to above the timber line)
- Changes in the activity structure while vacationing (for example, fewer hikes and more visits to the public swimming pool)
- Changes in the desired length of stay at the vacation destination

Based on changes in satisfaction, the **Erreichbarkeit** model assesses the change in choice of destinations by weekend visitors. Here, it is also examined whether the expected losses could be counterbalanced through faster rail connections.

The practical implementation of this combination of models would present some problems at the outset, however. In a first step, the models would have to be ported from their mostly regional views to another, national geographic level. Further, interfaces between the models would have to be programmed. And even after that, it is likely that certain elements would be found to be lacking and would have to be developed. The models together would also probably not be able to provide all of the answers that the users would like to see in the end result. Still, this use case is workable in principle.

4.4 Conclusions drawn for software development and applications in the area of spatial and landscape analysis

Software development projects do not usually fail because of technical issues but instead because people do not understand each other, can not understand each other. Users and developers may be aiming at the same goal, but their roles and possibilities could not be more different. While users seek an answer (preferably clear and brief!) to a substantive question, software developers as a rule strive after cleverly devised technical solutions. If implementation processes take longer than planned, or if they do not deliver the desired result, understanding difficulties can occur. The more carefully that use cases are developed, the more that difficulties of that kind can be avoided.

The use case examples in Chapter 4 show that complex research questions can be approached using the use case method in an almost playful manner and broken down into understandable single questions, without forgetting the overarching research questions. Of course, it seems obvious that software users and software developers do not speak the same language. But the same can be said for the area of spatial and landscape planning: the various actors also do not always understand each other. At the start of a planning process, modellers, planners, building owners, politicians and technicians certainly speak very different languages.

These «language difficulties» can be analyzed in great detail using the method presented here. The use case method is responsive to people's frequent habit of explaining complicated contents in an intuitive way, as «sequential stories» that have a starting point and a desired result. The use case constructs a bridge, so to speak – an aid that makes mutual understanding possible, without the people involved needing to know much about each other's areas of expertise right away. And users do not have to understand much about programming.

The use case technique is employed frequently in software development. But in the area of spatial and landscape planning it is not yet well established. In the view of this synthesis report, it therefore seems to make sense to propagate this approach, as it is a methodological approach that can be adapted for any area and for any type of data. Beyond that, this way of proceeding – without being obtrusive – can take on the role of a mediator, which for most planning processes can only be beneficial.

5 Conclusion

5 Conclusion

What insights do the NRP 48 research projects deliver in the area of modelling, computer-based simulation, and virtual representation?

- The NRP 48 models presented demonstrate the great diversity of possibilities in the area of modelling and visualization. They do not by far cover the range of possibilities, and neither do they represent a systematic selection. They do not represent a coherent result but provide a number of examples, illustrating what is possible.
- The NRP 48 models are complementary, complementing one another in content and method. The great potential of these models is thus the coupling of different approaches. A first example of this potential are the contributions of the WASALP, ALPSCAPE and ECOSYSSERV projects, as outlined in section 2.2.1. Another, hypothetical example is described comprehensively in section 4.3.
- The modelling projects in NRP 48 could make important contributions to current international research questions. These contributions cover content, methodological, and also technical challenges in the area of landscape modelling.
- Methodological contributions of international importance were also generated in several of the projects. The ALPSIM project made important advances in the area of agent-based modelling in the handling of «visual» impressions of the landscape. Here the project worked with visual effects in a double way: For one, agents react to visual impressions of an independent virtual landscape, and, for another, these impressions are stored in the form of a film and in this way visualized for the user.

  An important methodological/conceptual contribution in the area of valuation approaches is made by the ECOSYSSERV project, with the multilayered, spatially explicit monetarization of ecosystem services.

  With its integrated modelling approach and strong involvement of the local population, the ALPSCAPE project also is up-to-date in its methodology. But there is still a great need for future research in particular in the area of defining and calibrating the interfaces between the individual disciplinary approaches.

  For future work in landscape modelling, the findings on the speed of landscape changes and on systematization of driving forces in the TRANSFORMATION project will be very important.
- Contributions towards solving technical challenge in the area of landscape modelling were made especially by the GISALP and IPODLAS projects. GISALP developed a unified data model for combining different natural hazards models, and IPODLAS worked out a concept for direct coupling of various software environments.
- The modelling projects were able to produce important results for Alpine research in general. Here the research on changes in the landscape in the WASALP and SULAPS projects and the results on management of protection forests in the SCHUTZWÄLDER project should be mentioned. These findings are important above and beyond the regional case studies. In other projects the relation to the Alps is more local (for example, ALPSCAPE), or the location of the area investigated in the Alpine region was not of direct importance (for example, IPODLAS).

With regard to applicability, what are the most important research areas in the field of computer-based landscape modelling for the future?

- Work with the Advisory Group and the review of the literature showed that there is certainly interest in the use of models within spatial and landscape planning. It can not be the goal of the research in this area to cover all possible themes in all possible fields of application. However, the research can provide important services in the area of the methodological and technical challenges.
- Corresponding to the high complexity of issues in the area of spatial and landscape planning, integrated modelling approaches promise important advances. In par-

ticular, the interfaces between different disciplinary approaches represent a main research emphasis.

- Also integrated models should not be designed or understood as «super models» that can handle many different questions. This is because the selection of the methodological approaches that are utilized in the different parts and the definition of the interfaces have to be optimized in a targeted manner for the specific question under examination.
- Realistic visualization is used as an important instrument in the communication of future scenarios. A great deal of further research is still needed in order to automate the «translation» of abstract information into realistic images and films and also regarding the design and effects of these media.
- Today, data management, data analysis, model building, simulation and visualization are often realized in different software environments, each specialized for the individual task. This separation frequently makes the development and utilization of models unwieldy. Technical solutions for combining the different software environments can hopefully make the use of models easier in the future.

Are modelling, simulation and visualization techniques useful aids for solving existing problems in spatial and landscape planning? If so, in what way do they make a contribution?

- Models, simulations and visualization techniques are judged to be useful tools in spatial and landscape planning both by the Advisory Group and in the international literature.
- Because spatial and landscape planning deals with ever more complex problems, and modelling orders and systematizes this complexity, models are considered to have great future potential.
- Models and visualization techniques can not solve conflicts in spatial and landscape planning. But they can be used as decision support tools – providing additional information, objectifying the decision processes and making them more transparent. For highly emotionally charged issues, models can possibly be used in participatory approaches (in the sense of «mediated modelling», van den Belt, 2004).
- Problematic at present is the effort required in order to use these instruments. This will be greatly reduced in coming years and decades, especially with technical advances and improved data availability. Recommendations on this can be found in section 3.2.1.
- The effort and gain ratio of implementing models has to be sensible. To guarantee that the effort required and the information gain through modelling are appropriate, the utilization and development of models in the planning practice will most likely be restricted to big and elaborate (planning) cases. Smaller projects continue to be suitable for methods development in research.
- As there are complex problems and big projects to be dealt with in the Alpine region, models can be utilized already today as aids to decision-making in spatial and landscape planning. Projects such as the SAWIRIS project in Andermatt, harbour city Flüelen, Gotthard Base Tunnel, Porta Alpina station project and expansion of Grimsel reservoir constitute the typical range of possible applications. Further problems of the Alpine region, where model use is appropriate for problem solution, are, for example, decreasing mountain agriculture, transit traffic over the Alps, establishment of national parks in Switzerland and large investments in winter tourism in the face of the expected climate change.
- It should be noted that here, modelling can also be used as a learning aid and analysis method. Already existing models often cover only partial aspects of the issue at hand, but they still demonstrate the fount of possibilities and methods for application in the specific individual case.
- Visualization as a form of communication plays an important role in decision-making in spatial and landscape planning. Here, for the appropriate ratio of effort and

gain, the selection of a suitable technique is important. Depending on the individual case, the appropriate visualization can be a retouched photograph produced through manipulation by computer of the real photograph, a «superficial» landscape model based on terrain data, land use data and building data, or a complex simulation that includes material, monetary, and traffic flows.

Can we find characteristics of research models that make them suitable also for practical applications?

- In research, the aim of modelling frequently lies in knowledge gain. Models often focus on questions of detail, testing numerous factors and combinations of factors to find answers. Although the findings can be important for the world of practice, the focus of these models is on scientific research questions that are not per se identical with planning problems.
- In research, models are also developed explicitly for applied purposes. But even these models find ultimately little implementation in practice. In addition to transferability of content, other important aspects are user friendliness, provision of documentation and support for the models, if their use in practice is to become established.
- A necessary prerequisite for the establishment of models as tools in practice is that they be based on full-coverage and publicly available data.
- The models have to be well documented. Besides instructions for installation and operation of the model, details on internal data processing and on calibration of the model must be provided. So that the model may be modified for the specific individual case, the source code should be well structured and annotated.
- Models that are suitable for application in the world of practice can be made available via the Internet. For some models, not only documentation is provided but also examples of applications, discussion forums where users can ask questions and contact information. Having this information available and having the option of contacting the developer of the model directly make getting started much easier (for example, www.cluemodel.nl, www.ncgia.ucsb.edu/projects/gig/project_gig.htm or www.whatifinc.biz).
- The questions in individual application cases are seldom similar enough to be able to transfer existing models 1:1. The more complex the question is, the more difficult it is to find a model that does justice to the point of departure and the problem.

What are the prospects of computer-based modelling, simulation and visualization techniques for practice? What are the next steps towards making them easier to use in practice in the future?

- Due to the increasing complexity of decisions and the reduction of technical difficulties, we assume that the importance of models will increase in the future.
- Models can take on various tasks in planning practice. For planning the following three tasks are relevant: (1) simulation models, (2) visualization techniques and (3) participatory modelling approaches. The importance of evaluation approaches is judged to be not (yet) very great.
- The simulation of alternatives is of great significance in planning. Simulation models that depict complex developments and thus can provide decision support are rated to be important future planning instruments.
- These simulation models may have to be designed specifically for the concrete issues. However, the effort this entails can be worthwhile especially for big projects, which already require data collection for their evaluation.
- As it is often difficult to imagine a future development visually and concretely, photorealistic visualizations can be an important means of communication. This is seen as an advantage especially in communication to the public and to decision-makers that possess no in-depth experience in the area of spatial and landscape planning.

- Along with pure information, photorealistic visualizations also always carry an emotional component. On the one hand, this makes them impressive and easy to understand, but on the other hand, there is the possibility of manipulation.
- Participatory modelling approaches can be a helpful means of structuring and solving problems, especially if the boundaries of a problem are not easily delineated. Here the process of modelling stands in the foreground rather than the model as a tool.
- Technical difficulties in the area of the interfaces between software environments and in the area of data preparation make the work with models and visualization techniques unwieldy. Based on current developments in this area, it can be expected that these problems will be solved relatively easily in the future.
- The availability of data in local, cantonal and federal institutions has increased rapidly in recent years. To reduce the effort that is as yet still required, we recommend targeted closing of the gaps in the databases.
- The databases of various institutions and organizations should be managed jointly and made available beyond the individual administrative levels. Even if the data can not be stored in a central location, data contents and characteristics should be regularly updated and made visible in publicly accessible data catalogues (meta-metadata).
- Because research projects typically work on method development using small case examples, involving actors from the world of practice is often difficult. The effort required for the modelling is worth it in planning practice only for large projects. In order to establish modelling as a method in planning practice, there should be cooperation between research and practice mainly on large projects. The methodological know-how can be transported from research to planning practice in these real-world applications.

How can the needs of potential users directly inform the development of a model?

- Users and developers (of models) usually live in very different mental worlds. In addition to establishing participatory processes, the use case methodology described in Chapter 4 seems to be an ideal way for both sides to learn to understand each other and to break down what initially appears to be complex issues into individual questions.
- The use case technique is implemented frequently in the field of software development. In the area of spatial and landscape planning it has not yet become established. In the view of Synthesis Report V, it makes sense to propagate this approach, as it is a way of proceeding that can be adapted for any area and any type of data.

6 Appendix

6 Appendix

6.1 Documentation of the Advisory Group process

To include the opinions and experience of experts, Synthesis V was advised by a group of 14 persons from the field of spatial and landscape planning. The Advisory Group was made up of members of the Steering Committee of NRP 48 and nine further experts from the areas of administration/government, policy, consulting and research. Apart from being experts, these members represented also important stakeholders in the area of landscape and regional development and covered numerous planning authorities at all spatial levels of administration from the local to the national level.

The Advisory Group met twice for workshops during the synthesis project. Prior to the first workshop on August 14, 2006, a questionnaire survey captured the participants' experience and expectations in dealing with computer-based models. At the workshop itself, the Synthesis V project was introduced and a discussion was conducted on similarities in understanding of models and on possibilities and problems of the use of models. Following the workshop, the participants filled out the same questionnaire a second time.

At the second workshop on January 19, 2007, requirements profiles from various perspectives were worked out for possible models supporting decision processes. At the beginning of the workshop, a film on hikers' behaviour simulated by the ALPSIM model was presented as an example of modelling output and visualization product (see also the companion CD-ROM to Synthesis Report V). Then the expectations regarding virtual planning instruments were discussed – first in small groups and then in plenum – from the points of view of policy makers, administration/government, planning practice and tourism. In conclusion, the proposed features of models were rated as to importance in plenum.

6.1.1 Evaluation of the questionnaires

The goal of the questionnaire survey was to capture various experiences with computer-based models and corresponding expectations for various application areas. The number of Advisory Group members that filled out the questionnaire is too small to yield a representative result. However, the questionnaire responses show a range that can be rated as typical when compared to the relevant scientific literature (see, for example, Brail and Klosterman, 2001; Cockerill et al., 2004; Vonk et al., 2005).

The questionnaire administered on August 18, 2006, covered the areas discussed in the following:

Application area

The use of computer-based models in the areas of spatial planning and landscape planning seems helpful to questionnaire respondents both with and without experience in the use of computer-based models. As important application areas the respondents name mainly the context of regional development, the assessment of landscape changes, climate change, tourism development and economic development.

Evaluation of various functions

The experts see the greatest potential use of models in the demonstration of complex connections and portraying complex developments in the form of simulations. If the models thus generate information that is plausible in content and understandable in methodology, they can sensitize the decision-makers for long-term developments and enrich the decision process decisively.

A further function of models rated as very important by the respondents is the corresponding visualization of the information. Visualization in particular was brought up again and again in the discussion, and for the participants that work at the local and cantonal levels especially, this is the most important argument in favour of using computer-based models.

A last argument mentioned in favour of the use of computer-based models, both on the questionnaires and in the discussion, is more about their development than their application: This is the learning that occurs during the modelling process – learning that results in a deeper understanding of the problems examined. The decision process benefits in this way independently of the actual results of the simulation, in that during the course of modelling it is necessary to develop a clear understanding of the problem and to structure all influencing factors.

The possibility to use models to conduct systematic evaluations through indicators was rated by the experts for the most part as «nice but not obligatory».

Users

The use of computer-based models is rated as particularly significant by the experts and committees due to the fact that they deliver bases that can inform the further decision processes. In addition, many of the questionnaire respondents think that it makes sense and is desirable to make «live» use of models at board and committee meetings. As a prerequisite for live use, the models should have a user-friendly design and fast computing times. The experts viewed the use of models by the public, such as via an Internet portal, as less likely.

Time effort

The survey shows that most of the participants would be willing to put only a small amount of time into using a computer-based model. Most of the respondents find it tenable to spend one day to become familiar with the model and its use and a week's time to make any needed modifications to the model; only a few of the respondents would be willing to expend greater effort in time and money.

These responses show why expectations regarding models and what models should accomplish and their actual implementation are so very different. The expectations that models can depict complex systems and show long-term developments and that modelling can be used in order to improve one's understanding of a problem stand in stark contrast to the small amount of time that many users can invest.

Importance at different spatial levels

The questionnaire respondents report very different ratings of the importance of models at different spatial levels. The responses tend to show two directions. The one direction refers to the possibility of spatially limited and detailed visualization of landscape changes, which is important especially for decision-making on individual projects and at the local level. The other is the expectation that through modelling, complex systems can be depicted and better understood, which is interesting especially for issues concerning larger spatial areas. However, the respondents also indicate that models can not usually help when it comes to conflict-laden issues. Only two of the respondents rate the importance of computer-based models as equally high, or equally low, at all levels.

Future importance

Respondents also reported very different assessments of the future importance of computer-based models in spatial and landscape planning.

Most of the responses point to greater importance of computer-based models in the future. The increasingly available input data and increasing familiarity with the technology are the main reasons given for this. But also the observation that the complexity of many decisions is increasing and that more and more extensive data are expected to be used as a basis for decision-making speak for the increasing utilization of models. Finally, the respondents assume that further improved models will be used with success in the world of practice, so that general acceptance of models will increase in the future.

But some respondents also express the opinion that in the future computer-based models will not become more important. The reasons given are, for one, credibility and quality of the models themselves, and, for another, the lacking objectivity and lack of system with which decisions are frequently made in the area of spatial and landscape planning.

From these considerations and also from the group discussion, it emerged that the fundamental prerequisite for successful use of computer-based models is relatively objectively-led discussion in the decision-making bodies. Political tactics and maneuvering interferes with the use of models. A model will also never be able to act as a mediator between different interests, so that decision conflicts can be solved only to a limited extent through the use of models.

6.1.2 Requirements profile for models from the point of view of (potential) users

The goal of the second workshop was to discuss the needs of potential users from the various fields of application and to develop requirements profiles. As an example of a possible use of a model, the Schatzalp tower in Davos, and simulations connected with it, were chosen. The requirements were divided into four groups, each group representing the point of view of policy makers, administration/government, the economy/planning practice and the tourism industry.

Each group spent 15 minutes listing approximately six requirements for a potential model and spent about ten minutes ranking the requirements according to importance. Then discussion in plenum was opened for ten minutes, and the requirements were brought together and discussed and their importance rated in detail.

Each workshop participant was asked to choose a group independently of his or her professional or specialist interest. The group work was insofar a kind of role playing using free argumentation.

Requirements profile from the point of view of policy makers

Transparency – in the sense of understanding the model and trust in the model – was rated the most important by the policy makers' group (see Figure 6-1a), whereby the terms «transparency» and «trust» were used largely interchangeably in the discussion. For decision-making, policy makers do not need precise knowledge of every mathematical detail of a model but instead need most of all to have trust in the results. This does not have to be first and foremost trust in methodological/technical aspects but rather trust in the responsible modelers. This trust arises mainly from the communication between them.

Great importance was also ascribed to visualization and this for two reasons. For one, visualization makes it possible to «sell» sensible solutions convincingly. For another, only with the aid of visualization can both policy makers and the public truly imagine the consequences of a decision, such as the approval of a construction project or a change in the zoning laws. Despite the high value of visualization, however, the topic was a controversial one in the discussion, and no agreement was reached, for example, on whether its evaluation should be conducted by the policy side or directly through the instrument based on previously defined criteria.

In the discussion, the importance of the requirements for computer-based models as decision support was again fundamentally qualified. The ability of the models to provide targeted support to different phases of a decision process by means of different requirements was seen as an overarching necessity.

Requirements profile from the point of view of administration/government

From the point of view of administration/government, two fields of application for models were distinguished from the start (see Figure 6-1b). For one, models are used internally to generate data as a basis for decision-making, and, for another, they are used as a means of communication in participatory processes and in public relations.

With internal use, the depiction of complex connections in order to prepare decision bases stands in the foreground. These connections may be, for example, the possible consequences of a proposed intervention in the landscape. For decisions on the basis of simulated information, the transparency of the model is of key importance. The possibility to compute alternatives is rated as important for both internal and external use of models, but it is not seen as absolutely necessary for the models to be computable in an interactive fashion during a discussion. With the current state of the technology, automated evaluation according to indicators is rated as desirable but as less important.

All in all, the assumption is that for internal use of models in administration/government, a quite technocratic approach can be followed also without realistic visualization, in contrast to the requirements seen by the policy group and in contrast to the requirements for models for external use.

For external use for public participation and public relations, visualization is rated as highly important. Here computer games have set a high standard regarding realism, a standard that simulation models can not yet meet today. Similar to the policy group, the administration/government group also rates the possibility to simulate and present alternative development scenarios as a discussion basis as extremely important. It was also pointed out in the discussion, however, that public participation and public relations work is not the main task of administration/government and instead belongs in the area of policy setting.

Requirements profile from the point of view of economy/planning practice

The discussion in the economy/planning practice group was strongly shaped by the cost-benefit ratio of the potential use of models. The group's findings can be summarized as two larger thematic constellations (see Figure 6-1c) rather than as a ranking list, as was actually foreseen.

Thematic constellation A, which starts out from the demonstration film of the hiker simulation that was shown, criticizes the excessive expenditure for the creation of a visualization of that kind. As a less expensive alternative to films, the group proposes the use of a series of retouched photographs to serve as communication aids. On the other hand, it becomes clear that the effort required for the demonstration film would have been a lot less had prepared data already been available. For that reason the plenum discussion rejected the group's critical standpoint on visualization, in view of the expected technical advancements.

Thematic complex B starts out from the effort required for modelling and sees great potential in the possibility to represent complex systems and to create bases for decision-making. The expenditure required is estimated to be very high, however, and in the opinion of the group members, individual studies with targeted data acquisition can suffice in most cases.

Based on this demonstration, an urgent need was also expressed for interactivity that would help people to learn to understand and use the models.

In the plenum discussion the economy/planning practice group's critical opinion of visualization met with great surprise. It was thought that investors are the people that should be most interested in visualization, as it can be used effectively in marketing.

Figure 6-1a

Results of group work on listing the requirements for models dealing with the Schatzalp tower, from the point of view of policy makers

Policy makers' group

Transparency

Visualization

Evaluation
for example, according to sustainability criteria

Overarching goal and thematic orientation

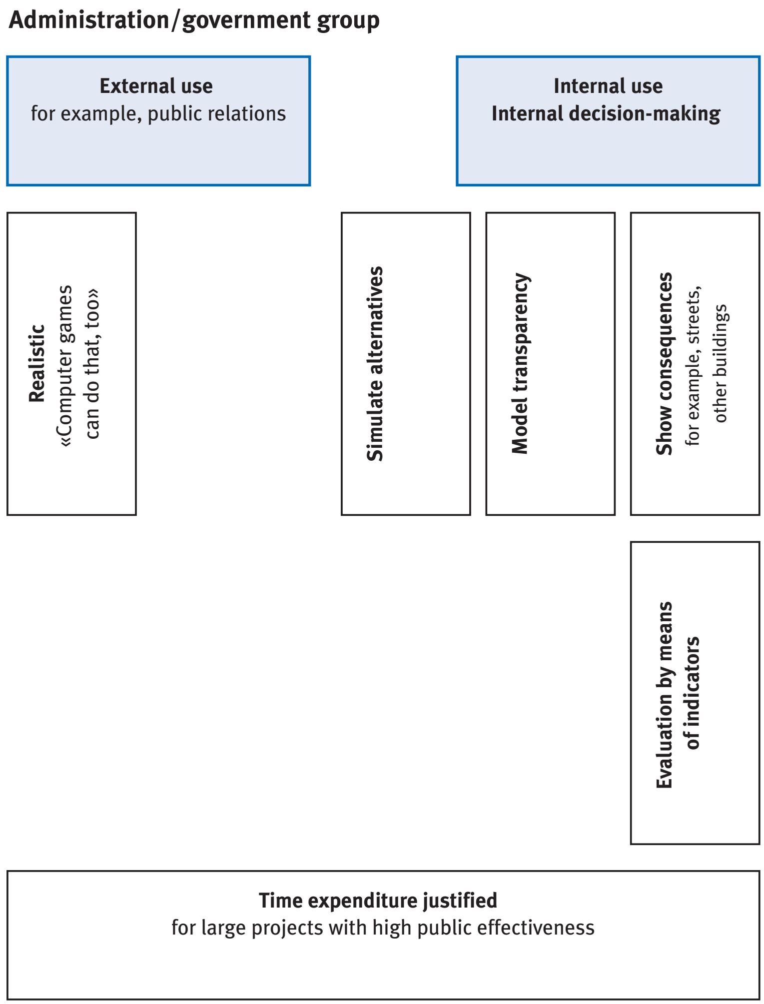
Cost estimation

Interactivity
to test responses and to compute alternatives

Source: The authors.

Figure 6-1b

Results of group work on listing the requirements for models dealing with the Schatzalp tower, from the point of view of administration/government



Source: The authors.

Figure 6-1c

Results of group work on listing the requirements for models dealing with the Schatzalp tower, from the point of view of economy/planning practice

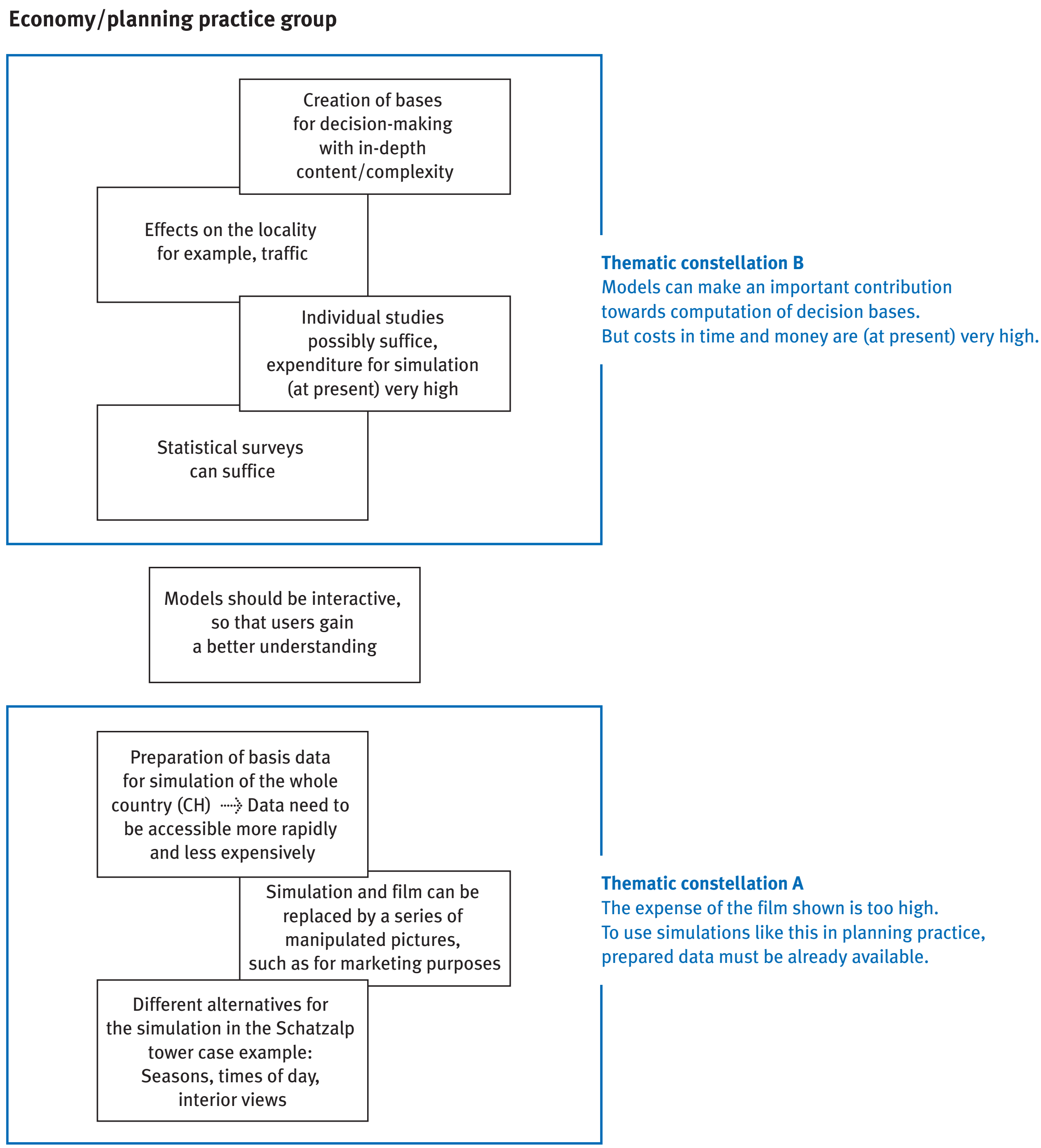
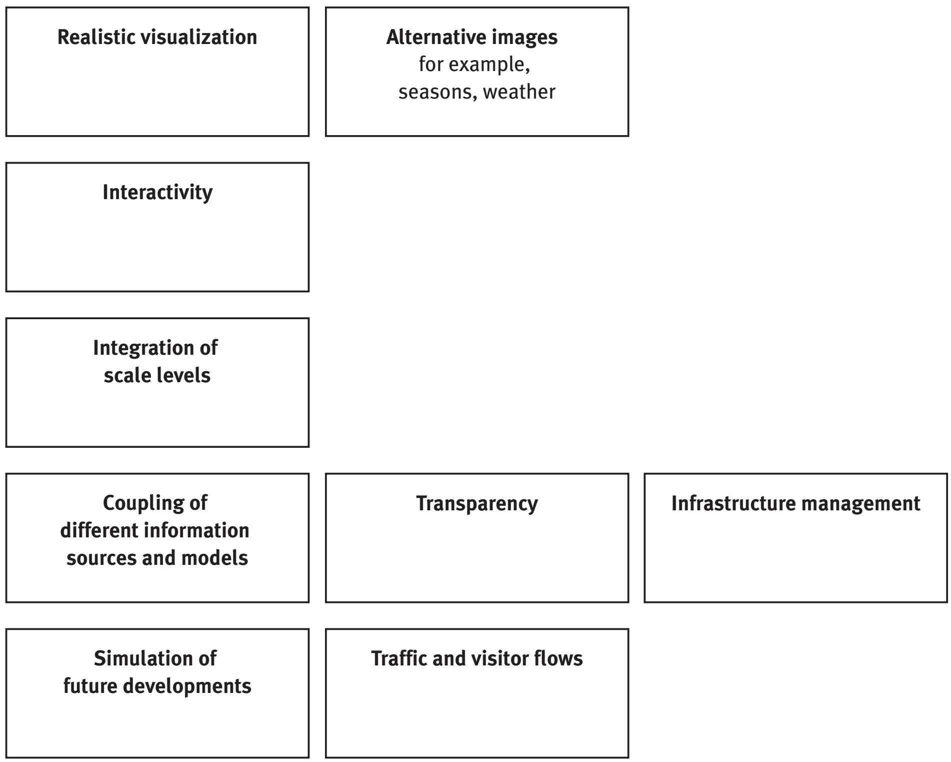


Figure 6-1d

Results of group work on listing the requirements for models dealing with the Schatzalp tower, from the point of view of tourism

Tourism group



Source of the two figures: The authors.

Requirements profile from the point of view of tourism

The tourism group sees great potential in the use of models and computer-based decision support mainly in the area of marketing and finds realistic visualization the most important (see Figure 6-1d); visualization should also include alternative views, showing different seasons and times of day. In addition, there should be a high degree of interactivity, so that the tool can be used directly at meetings and also for marketing purposes via an Internet portal.

Similar to the other groups, the group finds that simulation of future developments should be able to assess the consequences of a discussed intervention in the landscape with regard to tourism. Here the group expresses the explicit requirement that for this, various information sources and models should be coupled in order to do justice to the complexity of the situation.

This group, too, sees transparency of the model as a prerequisite for its use, and similar to the policy group, it uses the term «transparency» largely synonymously with «trust».

Joint rating of features of models

In the subsequent plenum discussion, the features that the groups had named were rated by the plenum. The features and ratings shown in Table 6-1 make no claim to completeness, and the ratings are not differentiated into very great detail. Instead, Table 6-1 reflects very well the course of the plenum discussion and summarizes it to a large part.

As a fundamental distinguishing feature, the table takes up the distinction – a distinction already discussed in the administration/government and economy/planning practice groups – between models whose results are used internally as decision support and models whose results are used mainly for communication to the outside.

The table lists transparency as one of the most important points. In the sense of detailed and complete documentation, transparency is important first and foremost to users seeking to examine individual issues in a very detailed analysis. In the course of the plenum discussion, however, not all of the potential users found the term «transparency» very apt. For in those areas in which individual issues are not examined in extremely great detail, such as in policy, it is not the transparency of the model that is crucial but rather trust in the model, its developers and its users. Results that are communicated to the public should have already been checked for accuracy and trustworthiness. In that way, transparency and trust-building play a more important role in the run-up. Table 6-1 lists, in addition to transparency of the model, also the transparency of the decision-making process. Although the model features play only a small role in this transparency for the public, the decision-makers and practitioners rated this very highly.

Further requirements for possible models that were rated as important were the ability to depict different kinds of consequences of decisions and the ability to simulate alternatives. These two requirements indicate that simulation models of high complexity are certainly desired by users. Estimation of future developments is rated by potential users as a definitely helpful contribution to decision bases. The degree of complexity that a model should cover can vary greatly from one case to another. But the discussion at the workshop showed that in the area of simulation models, high complexity is often desired.

As was already found by the small groups, realistic visualization was ascribed a very high value in the plenum discussion, especially for communication to an external audience that does not have a great deal of experience in planning. That audience could be the public or also policy makers. It should also be mentioned, as a complement to the workshop discussion, that a visualization can convey surprising impressions to experts and decision-makers connected with planning practice, too. For example, it is difficult for experts to picture what consequences a higher capacity of the utilization rate can have on a townscape.

Although the experts of the Advisory Group are definitely aware of the technical problems and additional expen-

Table 6-1
Rating of features of models in plenum; second Advisory Group workshop, January 19, 2007

Features of the model	For internal decision support	For communication to external audiences
Model transparency/trust-building	+++	++
Portray consequences	+++	++
Options to generate alternatives	+++ (up to 30 alternatives, up to 3 days' work time or computing time per scenario acceptable)	+++ (approx. 3 alternatives)
Realistic effect	+	+++
Interactivity	Can to a certain extent be replaced by alternatives. Desired in the long run (=++)	Interactive viewing of the scenarios
Database for model application	++	
Indicator systems	+	
Transparency of the decision-making process		++++

Source: The authors.

diture involved in the implementation of a model, they see interactive instruments as a goal worth striving after in the long term. High interactivity combined with fast computing times would allow people to «play around» with a model. Professional users could assess the plausibility and limits of a model relatively quickly, and models could be used directly at meetings and public events.

The availability and preparation of data is rated not very highly as a purely internal challenge. And also the automated evaluation of simulation results using a predefined system of indicators is viewed as less important at this stage.

Summary of the second Advisory Group workshop

The extensive documentation of the second Advisory Group workshop can be summarized in a few main results. The most important results of the discussion were that:

– The use of simulation models today often entails great expense, and for smaller projects it is not worth all that expense
– The expense reflects the current state of development, and in the near future, very different standards can be expected, especially with regard to data availability and technical problems
– It is important to distinguish between the use of models for computation of data bases for the internal working-up of decisions and the use of visualizations for commu-

nication with external audiences, because they result in different requirements for the virtual planning instruments
- In all of the user groups, the requirements for models and tools from the different points of view were all similar and had only somewhat different weights depending on whether the focus was on internal or external use
- Simulation models that are complex and interdisciplinary in design are still seen as the ideal
- Availability and preparation of data as a purely internal challenge are rated not very highly
- The automated evaluation of simulation results using a predefined system of indicators was rated as not very important.

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For rapid overview all cited NRP 48 publications are assigned to their original projects and listed under the respective project acronym (see Table 2-1).

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Synthesis Report NRP 48

Virtual Worlds – Real Decisions? The Alps in a Modeller's Nutshell

Thematic Synthesis Report and Outlook, Research Focus V «Virtual Representation»

With landscapes there is no room for experimentation. Real changes to the landscape become an indelible part of it – mostly for decades or even centuries. That is why level-headed and foresighted planning is required before final decisions are made. Computer-based models allow the testing and visualization of development options and decision alternatives. For this reason virtual representation of landscape processes is gaining increasing importance in planning.

The Thematic Synthesis Report V of the National Research Programme 48 «Landscapes and Habitats of the Alps» shows the potential of computer-based models and visualizations for spatial and landscape planning and examines the current state of research. The models developed within NRP 48 deal with the most important issues in spatial and landscape planning in the Alps – mechanisms and landscape changes through changing agricultural use patterns, tourism and intensive settlement development, and changes in the natural hazards potential due to global warming. Synthesis Report V throws light on chances and obstacles of models and visualizations in planning practice and demonstrates how the formulation of use cases facilitates the development and improvement of computer-based models and the corresponding software for the world of practice.

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