Landscape Ecological Decision & Evaluation Support System LEDESS

Users Guide

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ABSTRACT

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Alterra is the amalgamation of the Institute for Forestry and Nature Research (IBN) and the Winand Staring Centre for Integrated Land, Soil and Water Research (SC). The merger took place on 1 January 2000.

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1 INTRODUCTION

1.1 CONCEPTS IN STRATEGIES OF NATURE DEVELOPMENT

To understand the basic strategies in nature development, it is necessary to examine existing plans and schemes in order to reveal and clarify underlying concepts. Two questions are crucial here: what is the ecological objective, and what is the spatial strategy?

The first question is related to the level of the ecosystem. With different types of nature management, different ecosystems can develop at the same site. Nature policy decides which system is to be developed. The second question is related to the landscape as a whole, the spatial pattern of ecosystems. It is taken into account that other activities, such as farming, recreation, water supply and quarrying, also require space. Nature development cannot be considered independently from those activities. Therefore, a spatial strategy is required to combine all land use functions. To find an optimal balance between the two questions, different nature development scenarios are developed.

The next step in these scenarios: are the alternatives realistic, feasible and what are the ecological benefits of each plan? This means a validation at the most basic level of knowledge, i.e. the individual species. Since the stages are not completed consecutively but may alternate cyclically, the results of an evaluation can be used as input for a new planning cycle where the scenarios are adapted and re-evaluated. Ultimately, a more comprehensive plan will be the result.

1.2 DECISION SUPPORT SYSTEMS AND LEDESS

The environment surrounding us is subject to a continuous evolution in development plans. This may be planning at the expense of nature or in favour of nature development. Planners wonder what are the consequences of their scenarios for nature or what kind of nature might develop. Interesting is to know which of the different scenarios made is the most favourable one for nature. Evaluating these scenarios on a qualitative level is common. However, a more spatial presentation is very time consuming. A good comparison has to be done in the same consequent way. Models made to do this are the so-called Decision Support Systems (DSS). They help planners and policy makers to make choices in the spatial arrangement.

The use of a DSS also facilitates the evaluation of certain measures and enables experimenting with slightly different measures and/or targets. This is the so-called cyclic planning. Furthermore, the DSS is applicable on different scales, varying from the larger policy-making level (e.g. 1:100.000) to the small design level (e.g. 1:10.000).

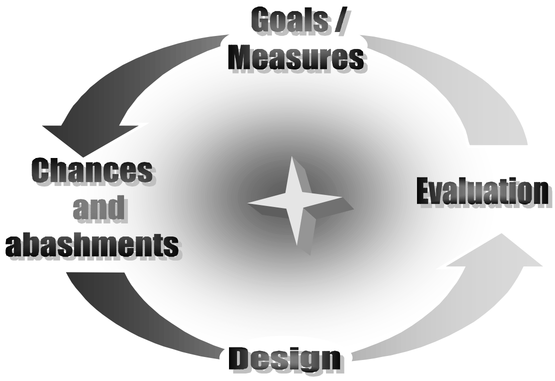

Figure 2 Cyclic planning procedure: the base for a DSS

In the past several different models (COR, Gelderse Poort-model, SCN; Harms et al., 1991, 1994, 1995) have been developed to simulate and evaluate nature. In 1996 the former DLO-Staring Centre (now: DLO-Alterra) developed LEDESS (Landscape Ecological Decision & Evaluation Support System) which was used in several projects[1].

LEDESS is an example of a GIS based expert system. It is a computer model used to assess and evaluate the effects of land use changes on nature. LEDESS works by confronting GIS maps of the existing landscapes with proposed measures and ecological know-how. The results are GIS maps and tables of the expected vegetation and fauna distribution patterns. The LEDESS system consists of three modules, evaluating abiotic site conditions, vegetation development and fauna habitat suitability (see chapter 2).

Recently LEDESS is being incorporated in the more extensive DSS Large Rivers (Projectgroep Rivieren en Zoetwaterbeheer, 1999). This DSS aims at describing effects of measures on the functions of the river. The project consists of three parts, the initiative flow, the policy flow and the design flow. LEDESS is part of the design flow for the evaluation of the landscape and landscape-ecological part.

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1 - 'Natuur-modellenkoppeling voor nationale milieu-en natuurverkenningen, co-financed by the Rijksinstituut voor Volksgezondheid en Milieuhygiene (RIVM);
- Sub-projects of the future explorations 'Verstedelijking & Infrastructuur', 'Landbouw' en 'Ecologische Hoofdstructuur van Natuurverkenningen 1997' (Farjon et al, 1997; Ypma et al, 1997; Bal & Reijen, 1997).

  The Natuurverkenningen 1997 are performed by IKC-Natuurbeheer, RIVM, DLO-Institute for Forest- and Nature Research and DLO-Staring Centre in assignment of the Ministry of Agriculture, Nature Management and Fisheries.

2 MODEL STRUCTURE

2.1 STRUCTURE OF LEDESS

LEDESS evaluates scenarios to see if they are possible from an ecological viewpoint and determines their consequences for nature and/or their economic effects. This way, choices can be made on what kind of nature type is desired and the suitability of the location as well as the economic profitability. The landscape-ecological modelling in LEDESS is based on a simplified view of ecosystems. Four components are considered, namely landscape, physiotope, vegetation and fauna, furthermore their interactions are taken into account. The relations are topological (vertical) and chorological (horizontal). Processes are present as a derivation from the different ecosystems, in other words they are not explicitly present.

Within LEDESS for three of the four components separate modules are designed:

- **SITE**
  The SITE module checks the ecological consistency of a nature target plan by comparing the needed abiotic site conditions with the present abiotic site conditions. For areas which are not suitable, measures can be applied by the user to modify the present situation into suitable site conditions (e.g. by excavation or raising the groundwater level).

- **VEGETATION**
  The VEGETATION development can be simulated. Based on abiotic conditions and management, the user defines the number of years that the vegetation is allowed to develop and which nature target plan is used. A second, simpler option is the snapshot development: a nature target plan is directly translated into an end-vegetation structure.

- **HABITAT**
  Suitable habitats are calculated, based on vegetation and physiotopes (abiotic conditions). Additionally, disturbance buffers may be placed around e.g. roads and cities. Finally, the size of the habitat clusters can be calculated to show how many animals can live in a cluster.

Every module results in a map and generates data for the next module. With the results a (nature development) plan can be adjusted or a choice can be made between different scenarios.

A system of knowledge tables and typologies connects these modules.

The accuracy of the output of the model LEDESS is dependent on the accuracy of the data provided by the user. For every module specific information is necessary (Chapter 3). The modules are explained stepwise in Chapter 4. Chapter 5 is a quick menu to work with LEDESS.

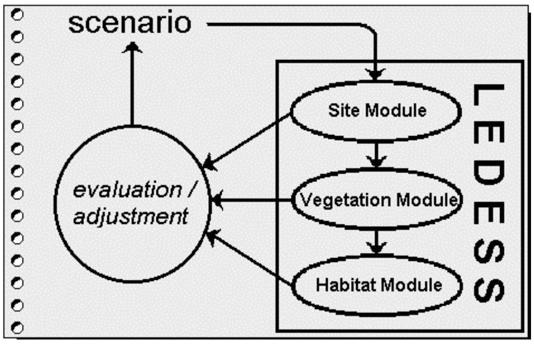

Figure 3 The role of LEDESS in cyclic planning

2.2 SOME DEFINITIONS

Clear definitions are necessary when trying to put nature into a model. What are its characteristics? The main parts of nature are the flora and fauna present in certain abiotic circumstances (site). Together these are defined as a *biotope*.

The spatial element defined as homogene concerning the abiotic circumstances, relevant for vegetation development, is called *physiotope*. Differentiating characteristics are the abiotic processes, ground water levels and substrates.
For the vegetation a difference is made between *vegetation structures, ecotopes* and *vegetation types*. *Vegetation structures* are areas, at a specific scale, with a homogene vertical and horizontal vegetation structure and intensity of management. Floristically and abiotically, they can be heterogene. *Ecotopes* are unique combinations of vegetation structures and physiotopes at the used scale. Within LEDESS the 'Rivier Ecotopen Stelsel' (Wolfert et al, 1996) is used. *Vegetation types* are the sociological translation of one or more ecotopes.

Habitat is a species-specific spatial unity within which all demands of the animal species are met with. In LEDESS, it is defined as a spatial collection of ecotopes fulfilling the minimal surface-demands of a species. The suitability of ecotopes for the fauna is expressed in carrying capacity per ecotope, or if possible, in density of occurrence. Areas with a suitable habitat are called *living areas* if no division can be made in functional areas. The most important *functional areas* are *breeding, foraging* and *resting areas*. The surface of connected living or functional areas can be expressed in suitability for (the amount of) animals and the carrying capacity, possibly divided into amount-classes.

Within LEDESS, two measures are defined: *arrangement measures* (in short measures) and *targets* (e.g. nature- or agricultural targets). These measures and targets are defined in qualitative variables/types.

3 INPUT DATA

LEDESS itself does not contain any information. All the maps and knowledge tables have to be provided by the user.

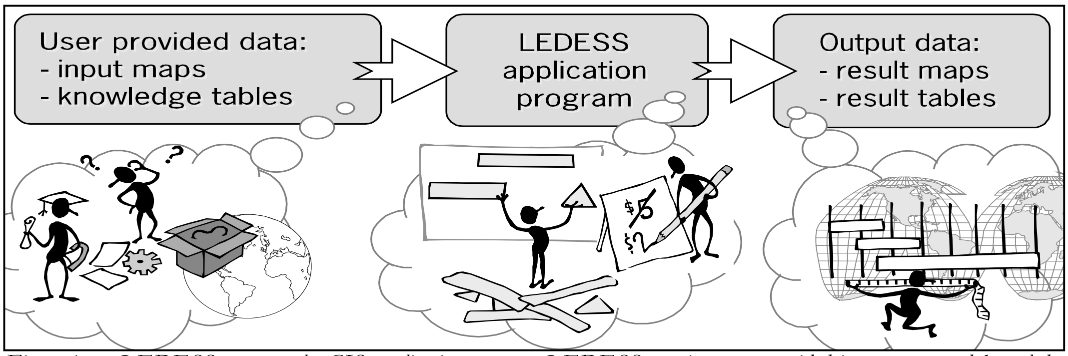

Figure 4. LEDESS context: the GIS-application program LEDESS requires user-provided input maps and knowledge tables to produce result maps and tables

3.1 MAPS

The vegetation structure, physiotopes and measures/targets (nature targets) need to have a location and therefor have to be provided as a separate maps.
A physiotope map can be made by combining several separate abiotic factors, e.g. groundwater discharge intensity, groundwater quality classes, surface water dynamics and parent material (soils).
The scale depends on the questions to be answered. Specific management questions like: "What happens to the vegetation when there is more flooding due to the removal of a dyke?"; need more accurate answers than policy question like: "If we want to store more water in the floodplain flats of the river Rhine, which areas are suitable and will certain vegetation structures disappear/appear?".
Next to these three maps which are obligatory, supplementary maps can be used to overlay with the habitat. Factors influencing the habitat suitability can be weighed. Examples are: maps with bufferzones, maps with roads and cities, bad environmental qualities, rewetting, flooding and biogeographical maps.

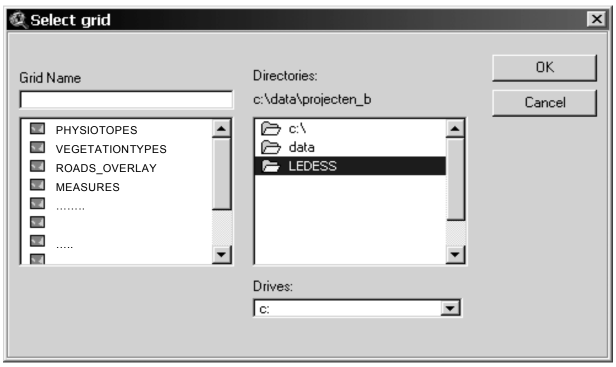

Figure 5 Selection of maps in LEDESS

3.2 CLASSIFICATION

The main input data (vegetation structure, physiotope, measures/targets) in reality are not classified. They show a continuous range of characteristics. However, to be able to use them in LEDESS they need to be classified. The material present, and what you want to investigate defines what these classes look like.

Definitions incorporated in the classes for vegetation structure can be:
- its composition, constitution
- implicitly its management (intensive, extensive or natural)
- heterogeneity of the landscape (e.g. mosaic pattern or larger areas)
- age
- height

For physiotopes, the abiotic environment is more defined in its classification:
- Substrate (sand, clay, silt, etc.)
- Water quantity (ground water levels)
- Water quality (sweet, brackish, salt)
- Dynamics of the water (flooded or not, streaming or stagnant water)
- Water depth

The arrangement measures and targets are classified differently. Targets are more visible than measures. The latter ones usually are underground.
Within LEDESS, measures have to comply with two conditions:
1. They influence the defined physiotopes
2. They clearly have to lead to a different physiotope

Examples of measures are: digging of a deep summer riverbed, digging a shallow water without dynamics, digging a secondary channel, making a water less shallow with dynamics, attaching to the river, lowering the surface, removing the summer dyke, removing vegetation, etc...

Targets are expressed as future land-use and kind and intensity of management. Three levels of targets can be distinguished:
1. Intensity of land use
2. Kind of land use
3. Structure/physiognomy of land use

Examples of targets are: spontaneous vegetation development (with implicitly no management), nature landscapes with grazing, nature development aimed at certain vegetation structures (e.g. grassland, swamp, forest, etc.), extensive agriculture, exploitation of land/forestry, built-up area, etc.

3.3 PARAMETERS

The use of parameters is restricted to the habitat module. Skip-distance defines the maximum distance between two habitat areas at which they can be considered as one suitable habitat. When the functional area has been split into breeding and foraging area a separate skip distance has to be defined. The radius is the critical distance between two breeding or two foraging areas. Furthermore, a threshold value and top-value is given for the habitat quality.

3.4 KNOWLEDGE TABLES

The LEDESS-input consists of geographical data and knowledge tables. The present situation (vegetation structures, physiotopes etc.) and plans (nature targets) are stored as geographical data. By combining different geographical data layers new (geographical) data can be calculated from relevant knowledge matrices. The link between the maps and classifications is made with knowledge tables. A knowledge table consist of a matrix of the two factors on the X- and Y-axis. Every combination of those two results in a third factor. So, a knowledge matrix represents a set of rules-of-thumb describing a new condition resulting from two existing conditions (expert knowledge)

Six tables have to be made linking (new) physiotopes, targets, measures, vegetation structure, habitat suitability and habitat quality. The physiotopes are always put on the X-axis.
The following knowledge tables need to be made:

- Physiotopes versus targets resulting in measures
- Physiotopes versus measures resulting in new physiotopes
- New physiotopes versus targets resulting in vegetation structures after a certain amount of years
- Physiotopes versus vegetation structure resulting in habitat suitability (functional areas)
- Physiotopes versus vegetation structure resulting in habitat suitability (expressed as a value between 0 and 100)
- Physiotopes versus vegetation structure resulting in a value expressing the economic effect

E.g., if we have two geographical datasets representing conditions A and B, all classes from A are defined as columns in the knowledge matrix, and all classes from B as rows. A new dataset representing condition C can then be derived by looking up the existing combinations of A and B in the matrix (Figure 5 & 6).

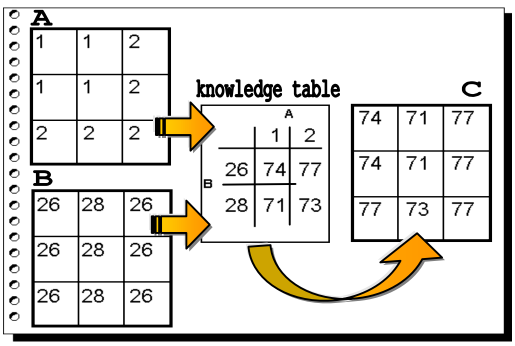

Figure 6 Mechanism of LEDESS knowlegde tables

Example knowledge table modifyphys.lkt (modifying physiotopes by measures)
hor : physiotope codes
vert : measure codes
content: codes changed physiotopes (no change : code = 0)

0	***11***	***14***	***15***	***16***	***17***	***18***	***20***		***22***	***23***	***101***	***102***	***103***	***104***	***201***	***995***	***999***	***-1***
1	0	995	0	0	995	995	995		995	995	995	995	995	0	995	995	0	0
2	0	0	0	0	16	17	17		17	17	17	17	17	0	17	0	0	0
									0	22	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	101	101	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Example knowledge table target _to_endvegetation.lkt (from nature targets to vegetation structures)
hor : physiotope codes
vert : nature target codes
content: vegetation structure codes

0	***11***	***14***	***15***	***16***	***17***	***18***		***21***	***22***	***23***	***101***	***102***	***103***	***104***	***201***	***995***	***999***	***-1***
21	1	0	0	0	0	0		22	0	22	0	22	22	22	0	0	22	0
22	1	22	0	0	22	22		0	22	0	22	0	0	0	22	0	22	0
23	1	0	0	0	0	0		21	21	21	21	21	21	21	21	20	21	0
24	1	21	0	0	21	21		0	21	0	0	0	0	0	0	0	21	0
31	1	0	0	0	0	17		17	0	17	0	0	0	0	0	0	0	0
								16	0	18	0	0	0	0	0	0	0	0
33	1	17	0	0	17	0	17	0	17	0	0	0	0	0	0	0	0	0
34	1	18	0	0	18	0	18	0	18	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	8	8	8	8	8	0	0	0
36	0	0	0	0	0	0	0	0	0	0	7	7	7	7	7	0	0	0
37	0	0	0	0	0	0	0	0	0	0	4	0	0	0	4	0	0	0
38	0	0	0	0	0	0	0	0	0	0	14	14	14	14	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	16	16	16	16	16	16	0	0

Example knowledge table roedeer.lkt (suitable ecotopes for roedeer)
hor : physiotope codes
vert : vegetation- structure codes
content : suitability codes: 1 optimale habitat
2 marginale habitat

0	***11***	***14***	***15***	***16***	***17***	***18***		***21***	***22***	***23***	***101***	***102***	***103***	***104***	***201***	***995***	***999***	***-1***
1	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
4	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	0
5	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
7	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	0
8	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	0
9	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	0
10	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
11	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	0
12	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
14	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	0
15	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	0
								2	2	2	2	2	2	2	2	2	2	0
17	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0

Figure 7 *Exampleworking with knowledge tables in planning with LEDESS*

4 MODULES

LEDESS consists of three modules connected by knowledge tables and characterisations (Figure 7). They are described separately in the following paragraphs.

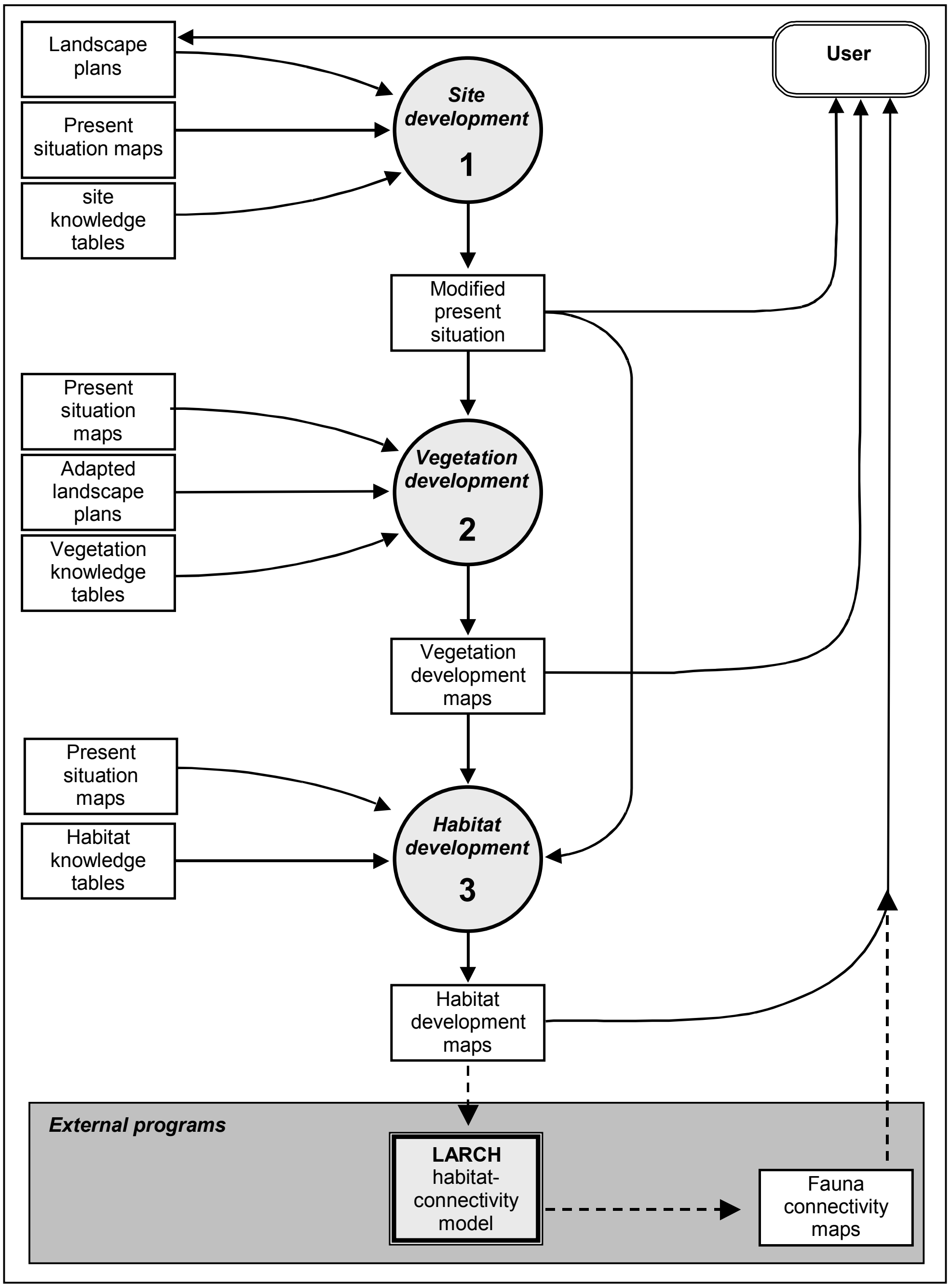

Figure 8 Schematic display of the LEDESS model

The modules all stand on their own. Their results can be evaluated after each run and might trigger the user to adapt (improve) his plan and/or to add an extra evaluation step. This is called cyclic planning (Figure 1).
The SITE development module checks and advises on the ecological consistency of a target plan by comparing abiotic site conditions required by the plan to those existing in the actual situation. The VEGETATION development module simulates the vegetation development. The HABITAT module determines suitable habitats for fauna populations and predicts the maximum number of individuals per habitat patch.

4.1 SITE MODULE

The site 'development' module is summarised in the site development diagram (figure 8). This module checks the ecological consistency of a landscape plan by comparing the plan targets with the abiotic site conditions (the physiotopes). For the areas that are not suitable, measures can be applied to modify the present situation into suitable site conditions. The module must generally be applied at least once for each landscape plan.

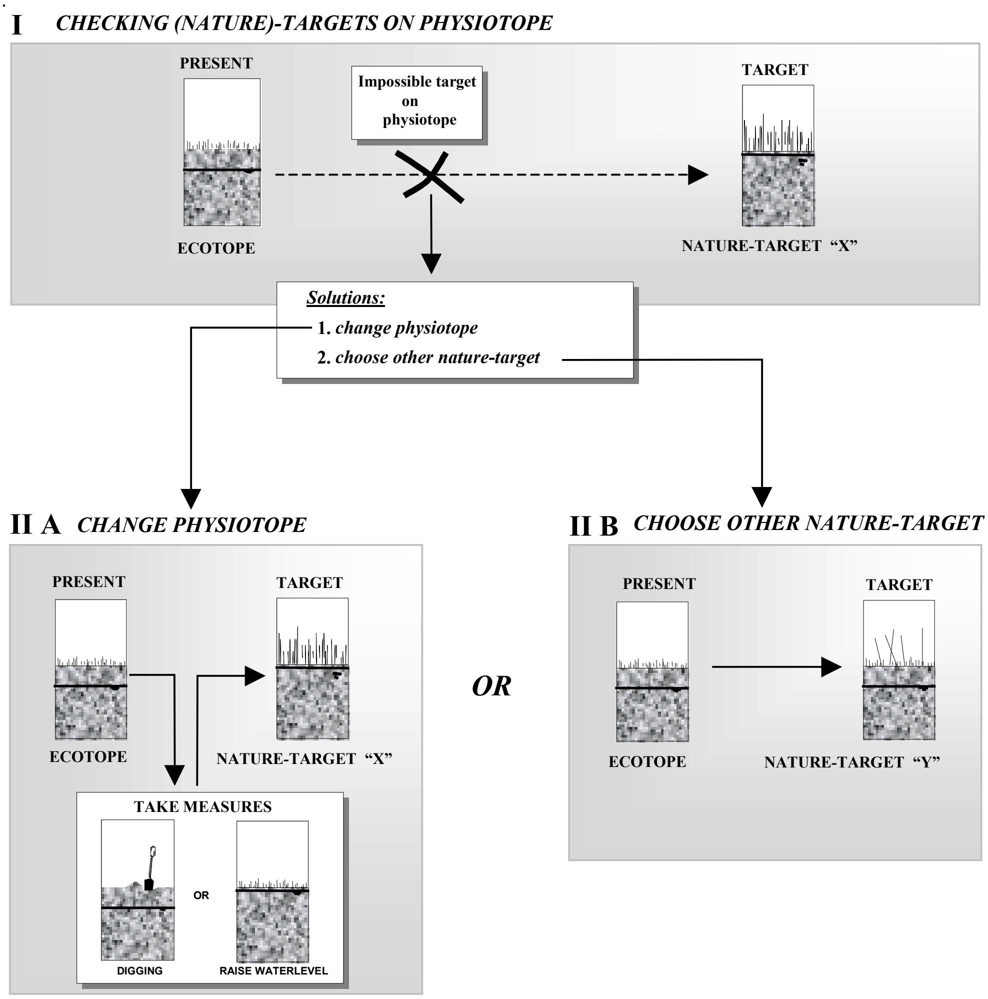

Figure 9. Concept of the SITE-module in LEDESS

The site module might be skipped, if no measures are to be applied. In this case, planned nature targets will not be reached on locations where the abiotic site conditions are not suitable.

The module performs the following operations:
1. creating a physiotope map
2. generating a map of lay-out measures
3. modifying the present situation by applying these measures

4.1.1 CREATING A PHYSIOTOPE MAP

Input:

- map of groundwater discharge intensity
- map of drainage (depth) classes
- map of groundwater quality classes
- map of land inundated by surface water
- map of surface water dynamics
- map of parent material (soils)
- map with additional information

Operation:

A physiotope map is created by overlaying and reclassification based on selection statements and transformation matrices. Default selection values and transformation matrices can be changed by the user.

Output:

- Physiotope map of present situation

This procedure offers the possibility to change the present physiotope map by other measures than provided by the function "generate measures". For instance it is possible to change the groundwater discharge map for the output of hydrological models that evaluate the possibilities of regional measures to increase groundwater discharge. Most of the input maps allow this kind of manipulation.
For an elaborate description of the "create physiotopes"-function see Buit & Farjon (1997).

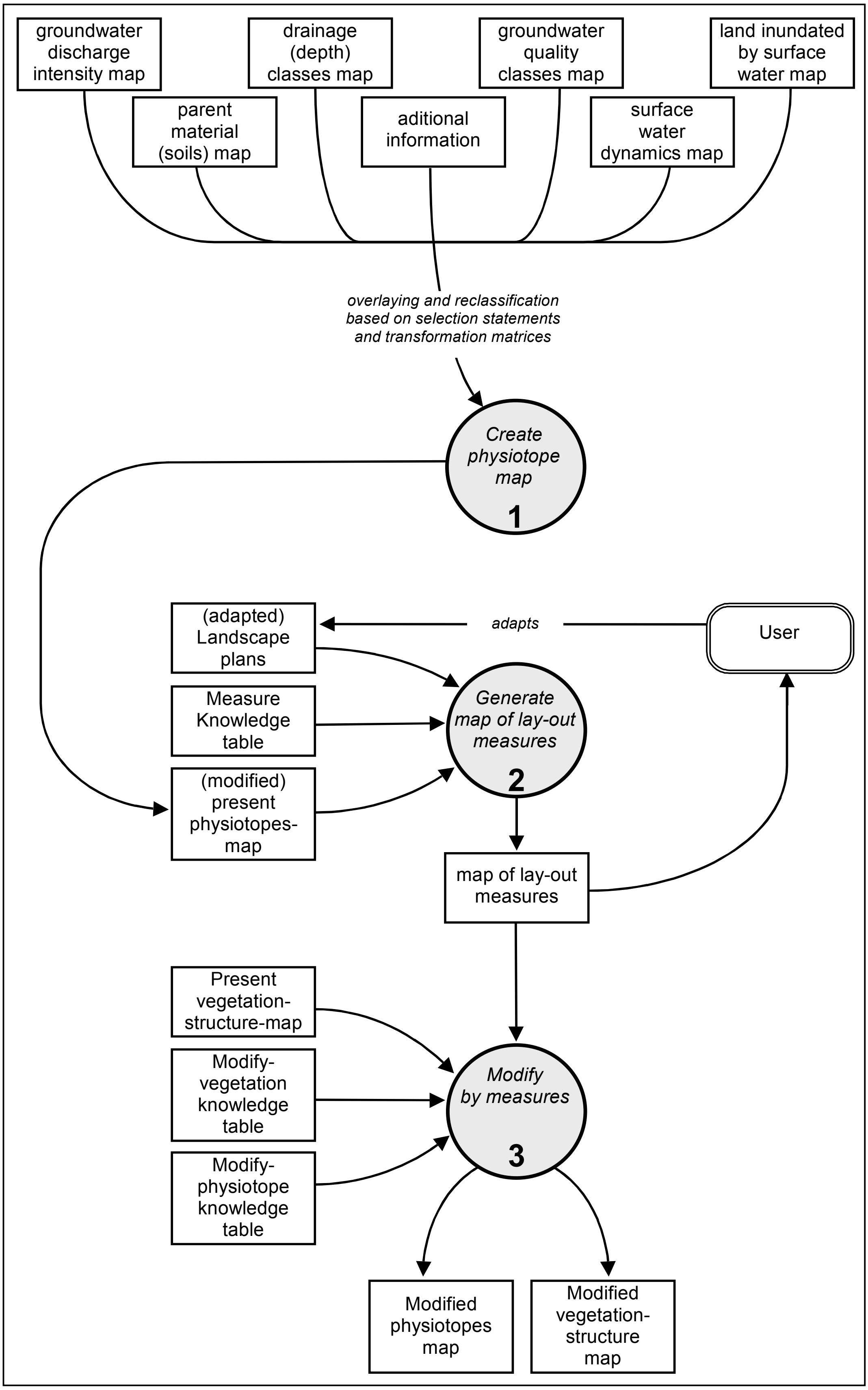

Figure 10. Site development diagram

4.1.2 GENERATING A MAP OF LAY-OUT MEASURES

Input for this operation:

- Map of the present abiotic site situation, the physiotope map
- Map of a landscape plan
- Measures knowledge table, with which necessary measures are identified. This table indicates, for each incompatible combination of nature target and physiotope, if a measure is possible and if so, which measure should be taken to make the abiotic site conditions suitable for that nature target.

Operation:

By comparing this table with the physiotope map and the nature target map, a measures map is generated, indicating where which measure must be applied and where no measures are possible.

Output (for each landscape plan):

- Map of the necessary lay-out measures, input for the next operation.

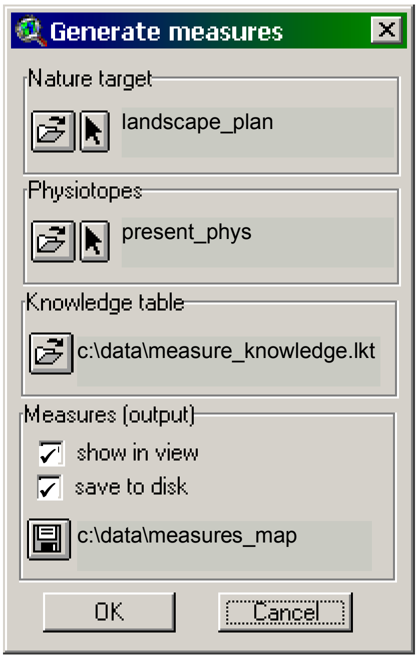

Figure 10 generate-measures-toolbox in LEDESS

If no measures are possible the user will have to adapt the landscape plan. The user might also decide to adapt his target plan to mitigate the amount of necessary measures (modification of the plan can be done by using the standard ArcView toolboxes which are continuously present in LEDESS). After modification of the plan, the same operation can be run again to check whether these have been successful. By repeating this procedure, the plan might be optimised until no (unacceptable) measures are necessary.

4.1.3 MODIFYING THE PRESENT SITUATION BY APPLYING MEASURES

Input:

- Map of lay-out measures (output of previous operation)
- Map of the present physiotopes
- Map of the present vegetation structure
- Modify-physiotopes knowledge table, which gives for each combination of physiotope and measure, the resulting physiotope (when a measure is applied).
- Modify-vegetation knowledge table, which gives for each combination of vegetation structure and measure, the resulting vegetation structure (when a measure is applied).

Operation:

The first table is compared with the present physiotopes map and the measures map, generating a modified physiotopes map (e.g. on locations where "raising the groundwater level" is applied, will result in a more wet physiotope on those locations). The second table is compared with the present vegetation structure map and the measures map, generating a modified vegetation structure map (e.g. on locations where "excavation" is applied. The present vegetation will be removed; on those locations the vegetation structure will change into bare land or pioneer vegetation).

Output (for each landscape plan):

– Map of the modified physiotopes, input for the other modules
– Map of the modified vegetation structure, input for the other modules.

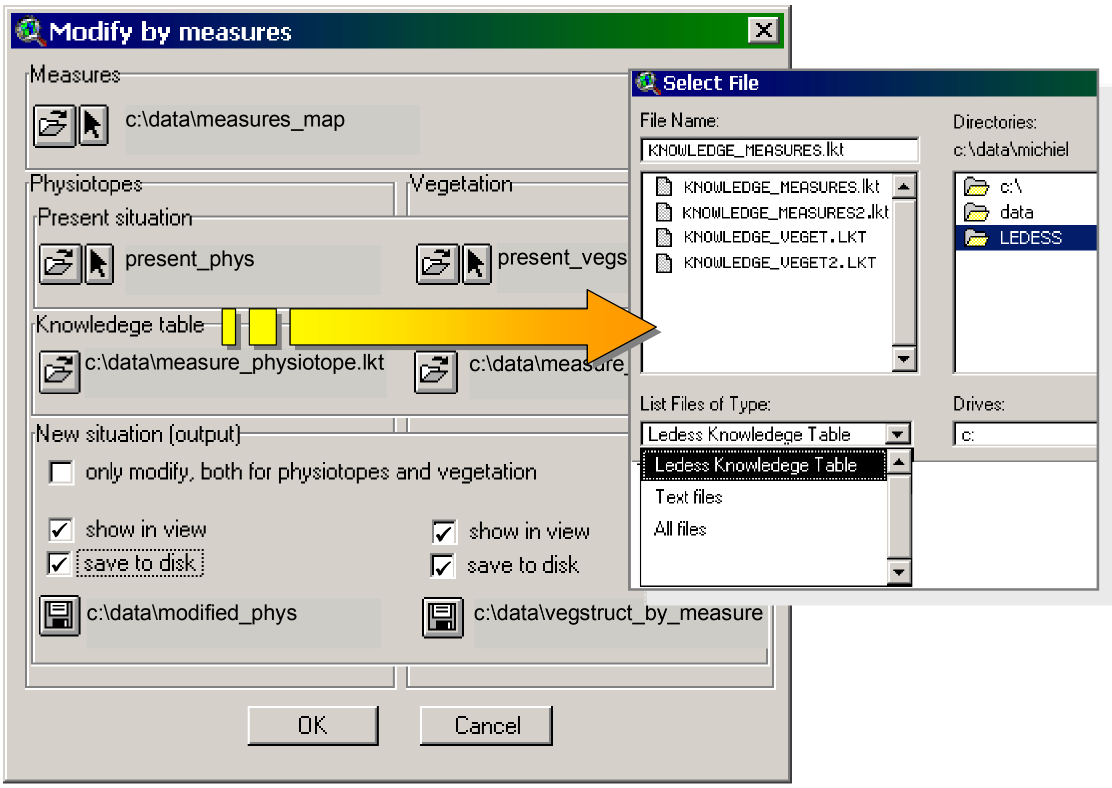

Figure 11 Modify-physiotopes-by-measures-toolbox in LEDESS.

4.2 VEGETATION MODULE

Based on abiotic conditions and management, in this case, the user defines the number of years that the vegetation structure is allowed to develop and which nature target plan is used. A second, more simple, option is the snap-shot development: a nature target plan is directly translated into an end-vegetation structure

Input:

- Map of the modified physiotopes (output of the site development module)
- Map of the modified, or present, vegetation structure (IN NATURE TARGET)
- Map with the targets
- Knowledge table: new physiotopes versus targets resulting in vegetation structures after a certain amount of years

Operation:

The vegetation module simulates for different measures and/or targets the vegetation development. By comparing the knowledge table with the physiotope map and the target map, a vegetation structure map of the end situation is generated. The areas that have no target remain unchanged (present vegetation structure).

Output:

- Map of the end vegetation structure. This map is the input for the habitat development module.

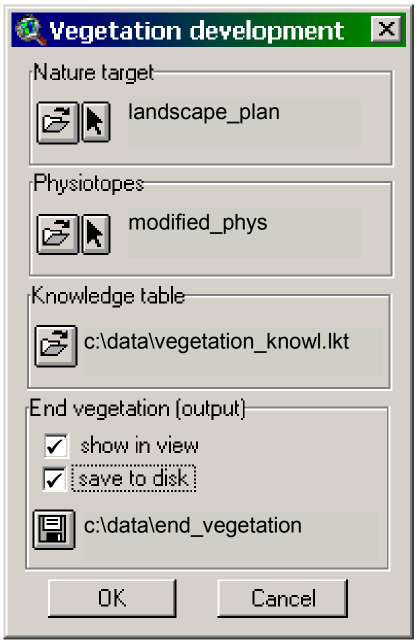

Figure 12 Vegetation-develomment--toolbox in LEDESS

This procedure (Figure 13) can be repeated several times, to compare the effect of different targets on the end vegetation structure.

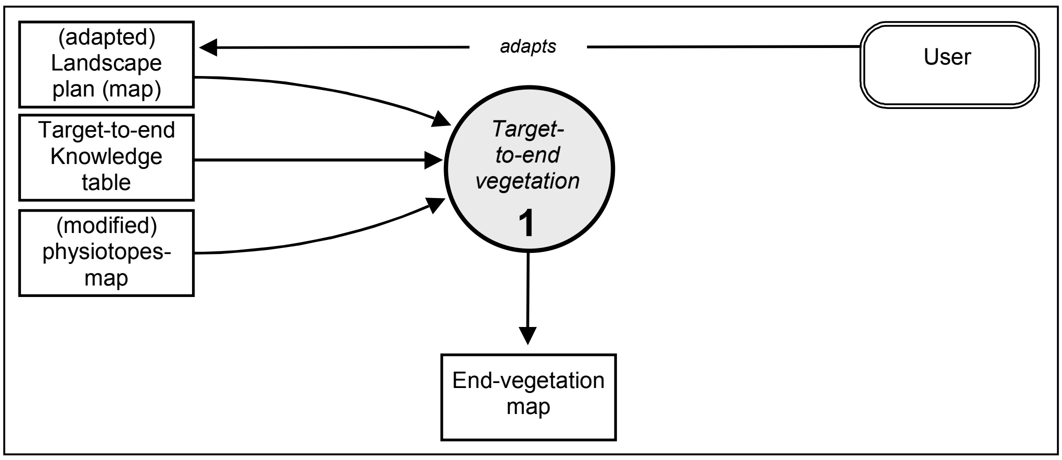

Figure 13 Vegetation development diagram.

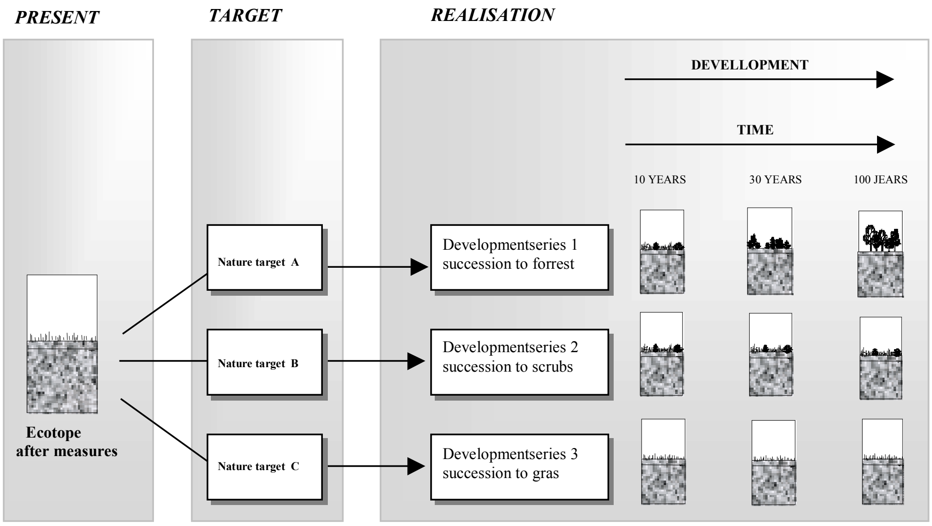

Figure 14 Concept of the vegetation-module in LEDESS

4.3 HABITAT DEVELOPMENT MODULE

This module determines the suitable habitats and potential fauna populations (indicator species), based on vegetation structure, spatial requirements and additional land use. The module must be applied for each target, for as many animal groups and time periods (vegetation development steps) as required, producing as many maps.

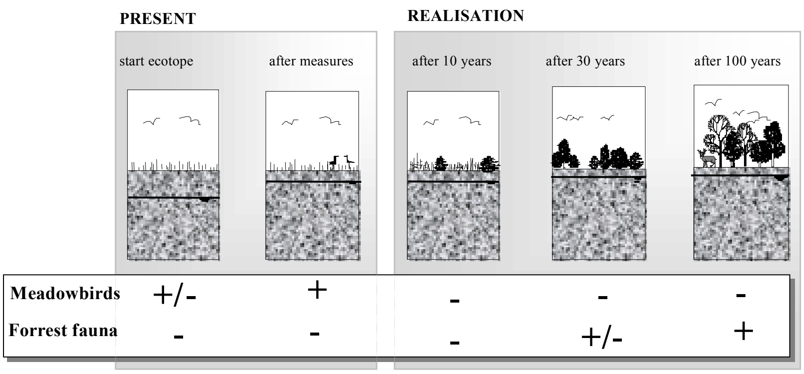

Figure 15 Concept of the Habitat-module

The module can perform the following operations:

- it generates habitat suitability and quality per grid cell from vegetation structure and physiotope
- it may perform an overlay or buffering to restrict the suitable habitats to (fauna group specific) accessible areas, or to expand the computed habitats if correction is needed; this operation is optional and can be skipped
- it increases or decreases the habitat quality, depending on additional habitat factors
- it defines the potential habitat size and carrying capacity by clustering suitable grid cells depending on distance between suitable grids and/or function (foraging or breeding)

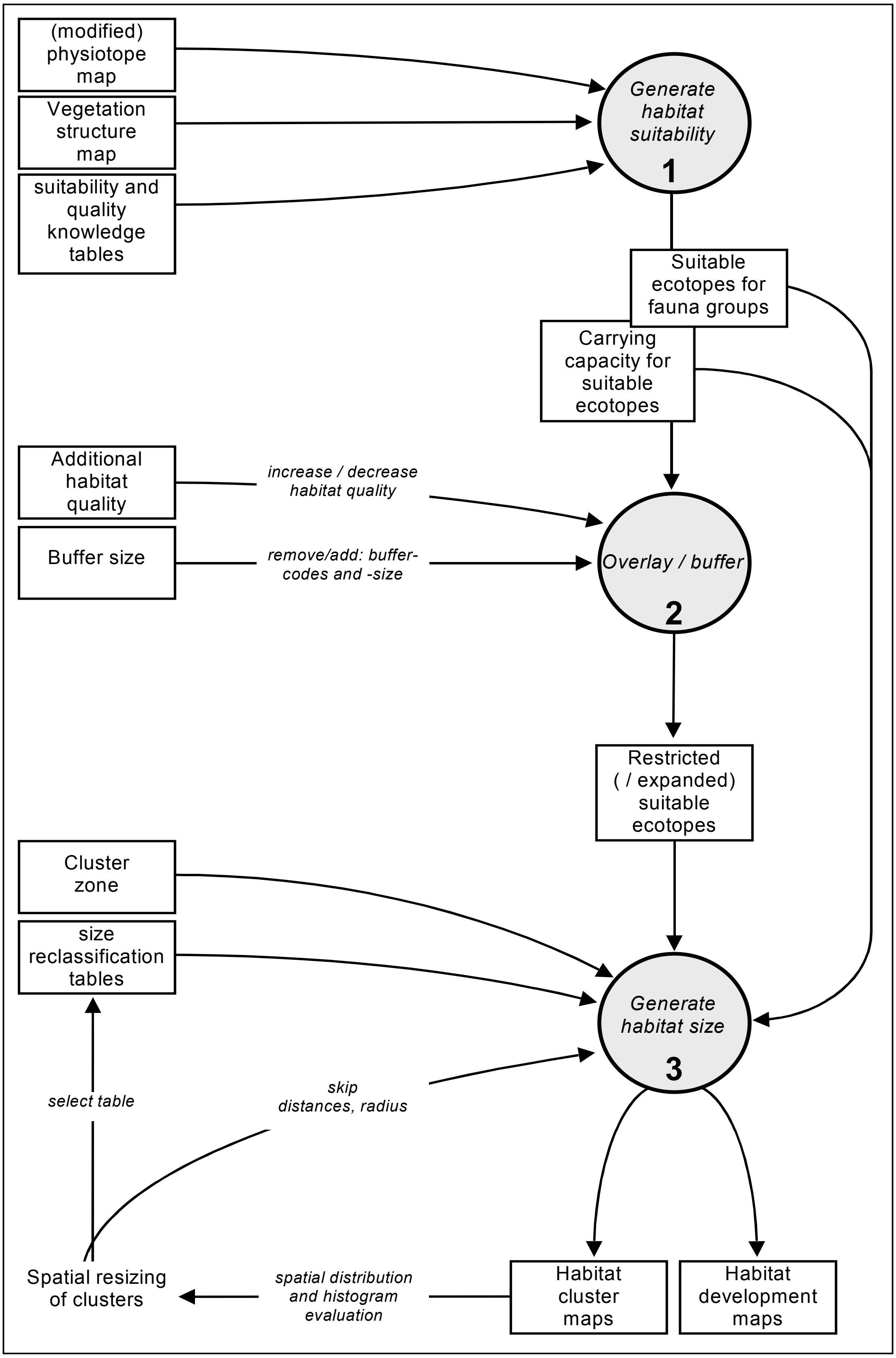

Figure 16 Habitat suitability diagram

4.3.1 Generate habitat suitability

Input:

- Map of (modified) present physiotopes
- Map of (modified) present or expected vegetation structure (after x years)
- Suitability knowledge-table for an indicator species, which gives for each combination of physiotope and vegetation structure the suitability for that indicator species. If required, the suitability as a breeding area and as a foraging area or as a rest area can be distinguished. A second knowledge table is used with the habitat quality for each suitable combination. The quality is expressed in an number between 0 and 100

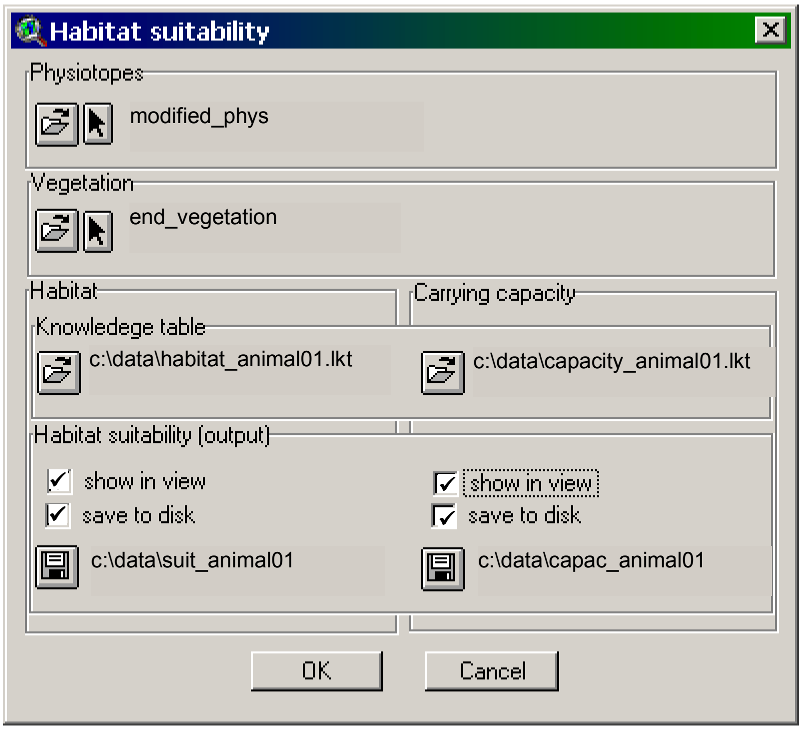

Figure 17 Habitat-suitability-toolbox in LEDESS

Operation:

By comparing the suitability knowledge table with the physiotope and vegetation structure map, a new map is generated indicating where ecotopes with suitable habitat (breeding/foraging/resting) can be expected, given the vegetation structure of the input map. The same operation is done with the quality knowledge table that fits with the suitability table.

Output:

Map of suitable ecotopes (for breeding/foraging/resting) for an indicator species group with their habitat quality. This is a map containing areas that are qualitatively suitable as habitat, but without a check on spatial habitat requirements. A second map is generated with the quality of each habitat.

By going trough this menu for different vegetation structure maps (e.g. present vegetation structure, vegetation structure after measures and end-vegetation-structure), it is possible to compare the habitat suitability and therefore the impact of the nature target plan.

4.3.2 APPLY OVERLAY/BUFFER (OPTIONAL)

Input:

– Map of suitable ecotopes (output of previous operation)
– Additional habitat quality map (to restrict or expand the habitat areas)

Kind of operation:
menu input by the user: remove, add or buffer (buffercode(s) and buffersize)

Operation:

– Remove: by this operation, parts of the suitability map are erased by the overlay map, resulting in a restriction of the suitable ecotopes. This option can be used to indicate which additional, specific areas are inaccessible for the fauna group at hand.
– Add: by this operation areas indicated on the overlay map are joined to the suitable ecotopes; in this way the user can make corrections to the areas that must be considered suitable.
– Buffer: by this operation, buffers are computed with the indicated size (nr. of cells) around the areas with the indicated buffercode on the overlay map (e.g. buffers around built-up areas). Depending on the add/remove choice, buffers are removed or added to the ecotopes map.

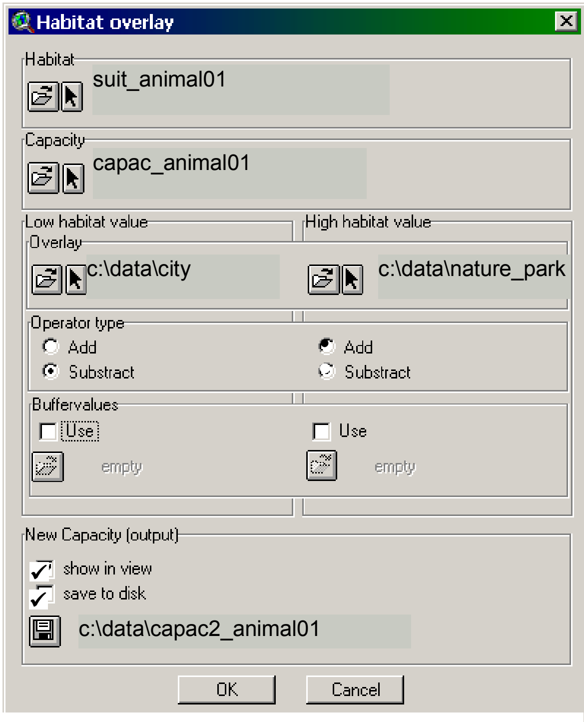

Figure 17 Habitat-overlay-toolbox in Ledess

Output:

– Map of restricted (or expanded) suitable ecotopes for an indicator species.

4.3.3 DEFINE HABITAT SIZE

Input:

– Map of (restricted or expanded) suitable ecotopes (output of previous operations)
– A map of cluster zones (optional): user-defined zones (e.g. areas enclosed by barriers such as rivers) where in suitable habitat grids must be clustered into larger habitat areas, of which the size will then be calculated.

– Skip distance: within this distance, suitable gridcells will be clustered into one habitat area (menu input by the user); this is a buffer distance, which depends on behaviour characteristics such as home range of the animal(s) concerned.
– Radius: the maximum distance between breeding/resting area and foraging area that can be reached by the animal(s) concerned; foraging areas outside this radius get a special code, so they may be treated as "too far away".
– Size reclass table: containing the habitat sizes that must be distinguished, specifying the legend of the output map (one for each fauna group). For species with different function areas different classification tables must be used (and created) for breeding and foraging habitats.
– Breeding area as forage area: this option must be chosen for species that use their breeding areas also as foraging areas.

Operation:

– First all the clusters are generated and cluster sizes are calculated, creating a habitat cluster map with number and size of the cluster and a histogram of the size distribution. By evaluating these results, the user can create a classification table (with a text editor) in which the size of clusters must be grouped into cluster classes, according to the home range of the species. Cluster classes can be seen as potential populations. Next, the program can classify the habitat areas in different size classes, according to this table.

Output:

– Map of habitat clusters
– Histogram with size distribution
– Final map of suitable habitats, classified by size (habitat development maps)

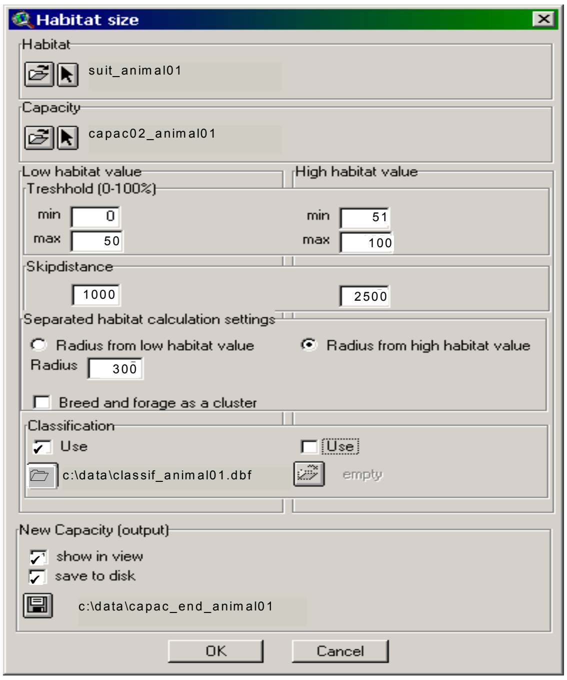

Figure 18 Habitat-size-toolbox in LEDESS

4.4 LEDESS LARGE RIVERS

When using LEDESS Large Rivers a new menu is placed in de ArcView Menu Bar.
The same LEDESS algorithms are used to calculated the scenarios. The knowledge tables and definitions are stored inside a database. LEDESS Large Rivers has been developed for use in a Decision Support System in which measures are taken also on behalf of water management.
If you are using the **LedessLargeRivers** extension in the ArcView extension menu (file, extensions). the **LEDESS 3** extension will be automatically activated. See also §4.4 and Appendix 1: §1.4.

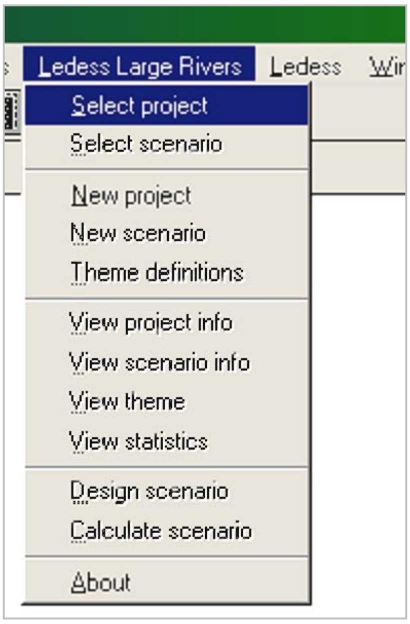

Figure 19 LEDESS Large Rivers Toolbox

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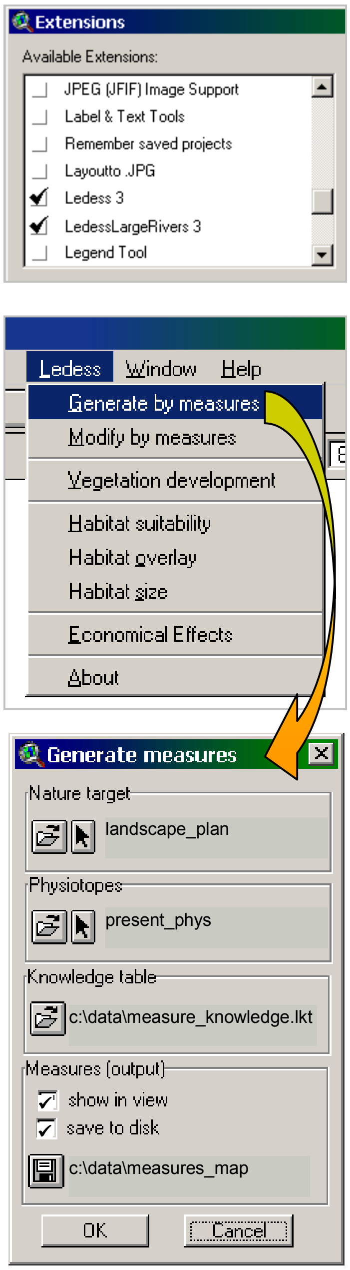
APPENDIX 1. A QUICK START: MENU FORBASIC LEDESS ACTIONS

In this appendix the action described in chapter 5 are placed in a simple menu. It can be used to work with LEDESS or for better understanding the LEDESS model. Some functions will be explained in a simple manner to contain a good overview over the system.

1.1 THE SITE MODULE

The SITE module checks and advises on the ecological consistency of a target plan by comparing abiotic site conditions required by the plan with those existing in the actual situation. The site module consists of the sub-modules: Generate by Measures and Modify by Measures.



1.1.1 LEDESS 3 EXTENSION

Turn on the **LEDESS3** extension menu (file, extensions). The **LEDESS**-Menu appears in the **Menu Bar**[2].

1.1.2 GENERATE BY MEASURES

Click on the **LEDESS Menu** of the **Menu Bar**

1. Select **Generate by Measures,** this sub-module checks if the physiotopes are suitable for the desired nature development.
2. Select the **Nature Target Theme**. This grid theme contains the nature target plan that needs to be checked.
3. Selection can be done by theme  or by file  .
4. Select the **Physiotope Theme**. This grid theme contains the physiotope map.
5. Select the **Knowledge table** that describes the possibilities for Target Nature development on the different physiotopes. (*.lkt)
6. Press the **OK** button.
7. A new **Measures Theme** will be added to the View, which can be classified in the **Legend** Editor (*.avl)

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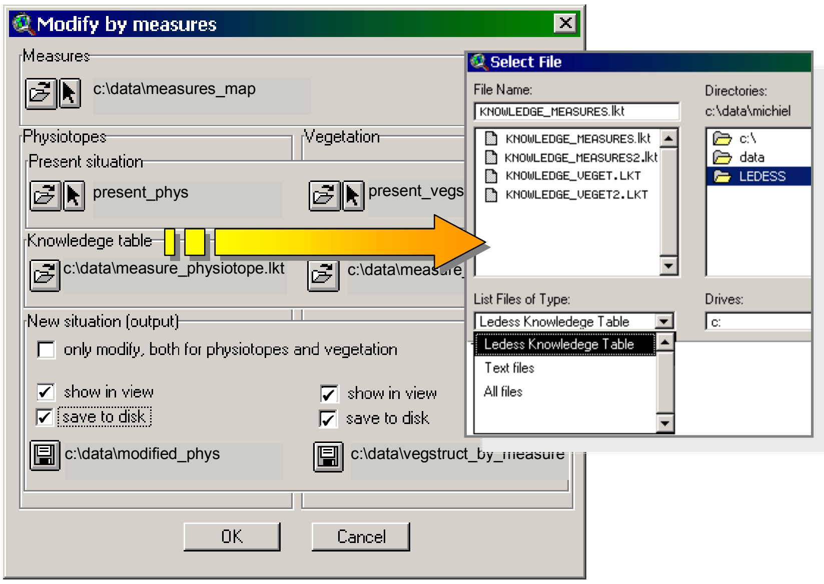
2 If you are using the **LedessLargeRivers** extension in the extension menu (file, extensions). the **LEDESS 3** extension will be automatically activated. See also §4.4 and Appendix 1: §1.4

1.1.3 MODIFY BY MEASURES

1. Click on the **LEDESS Menu** in the **Menu Bar.** Select **Modify by Measures**, this sub-module adapts the physiotopes and vegetation according to the suggested measures for the desired nature development.
2. Select **the Measures Theme**. This grid theme contains suggested measures that need to be implemented to obtain desired nature development.
3. The selection can be done by theme or by file.
4. Select the **Physiotope Theme**. This grid theme contains the physiotope map.
5. Select the **Vegetation Structure Theme**. This grid theme contains the vegetation map.
6. Select the **Knowledge table** that describes the implications of the nature conservation measures for the physiotopes (*.lkt) and vegetation (*.lkt).
7. Press the **OK** button.
8. A **New Physiotope Theme** and a **New Vegetation Structure Theme** will be added to the view, which can be classified in the Legend Editor. (*.avl)



1.2 THE VEGETATION MODULE

The VEGETATION module simulates the expected vegetation development according to the Nature Target Plan and abiotic conditions

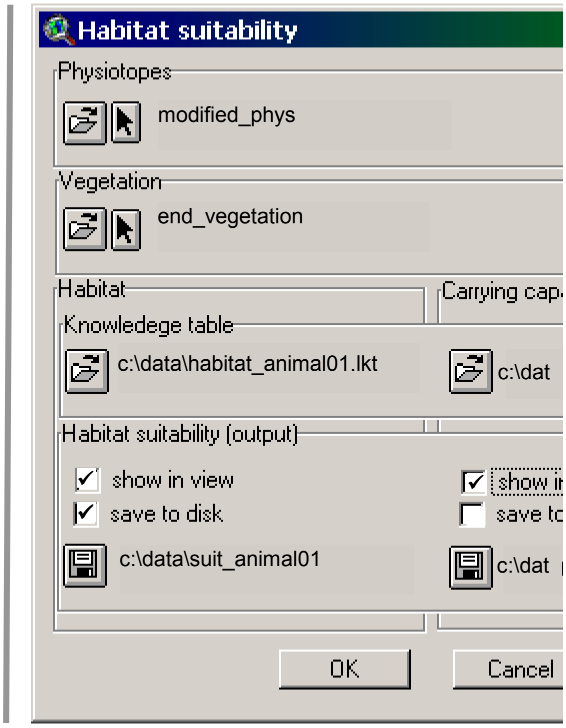
1. Click on the **LEDESS Menu** in the **Menu Bar**
2. Select **Vegetation development,** this option simulates the vegetation development.
3. Select the **Nature Target Theme**. This grid theme contains the nature target plan.
4. Selection can be done by theme or by file.

5. Select the **Physiotope Theme**. This grid theme contains the physiotope map. If measures have been implemented, select the New Physiotope Theme.
6. Select the **Knowledge table** that describes the expected vegetation development. (*.lkt)
7. Press the **OK** button.
8. A new **Vegetation Structure Theme** will be added to the View, which can be classified in the **Legend Editor** (*.avl)

1.3 THE HABITAT MODULE

The HABITAT module determines suitable habitats for fauna populations and predicts the maximum number of individuals per habitat patch. The habitat module consists of three sub-modules: Habitat Suitability, Habitat Overlay and Habitat Size.

1.3.1 HABITAT SUITABILITY

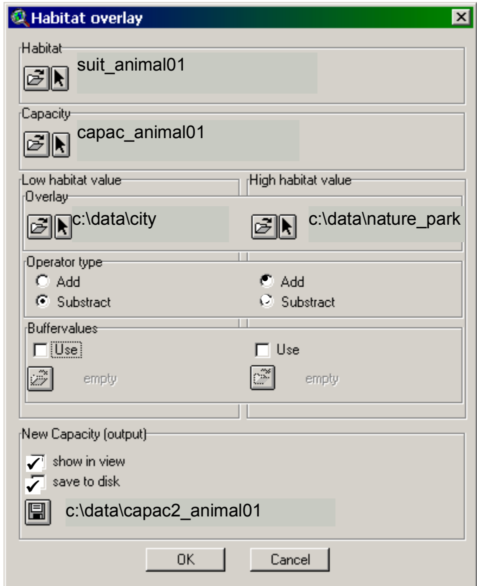


1. Click on the **LEDESS Menu** of the **Menu Bar**
2. Select **Habitat Suitability,** this option creates a the habitat suitability map
3. Select the **Physiotope Theme**. This grid theme contains the physiotope map. If measures have been implemented, select the New Physiotope Theme.
4. Select the **Vegetation Structure Theme**. This grid theme contains present or modified vegetation structure. If measures have been implemented or vegetation development has been calculated select the concerning Vegetation Structure Theme.
5. The selection can be done by theme or by file.
6. Select the **Knowledge table** that describes the expected habitat suitability for combinations of physiotopes and vegetation (*.lkt).
7. Select the **Knowledge table** that describes the expected carrying capacity for combinations of physiotopes and vegetation, %-max car.cap (*.lkt).
8. Press the **OK** button.
9. A new **Habitat Suitability Theme** will be added to the View, which can be classified in the **Legend Editor** (*.avl)
10. A new **Carrying Capacity Theme** (% max capacity of suitable habitat grids) will be added to the View, which can be classified in the **Legend Editor** (*.avl) .

By going trough this menu for different vegetation structure maps (e.g. present-vegetation-structure, vegetation-structure-after-measures and end-vegetation-structure), it is possible to compare the habitat suitability and therefore the impact of the nature target plan.

1.3.2 HABITAT OVERLAY

Capacity grid values are changed by overlaying a grid and a possible buffer distance. The effect of overlay is defined in the Classification List.



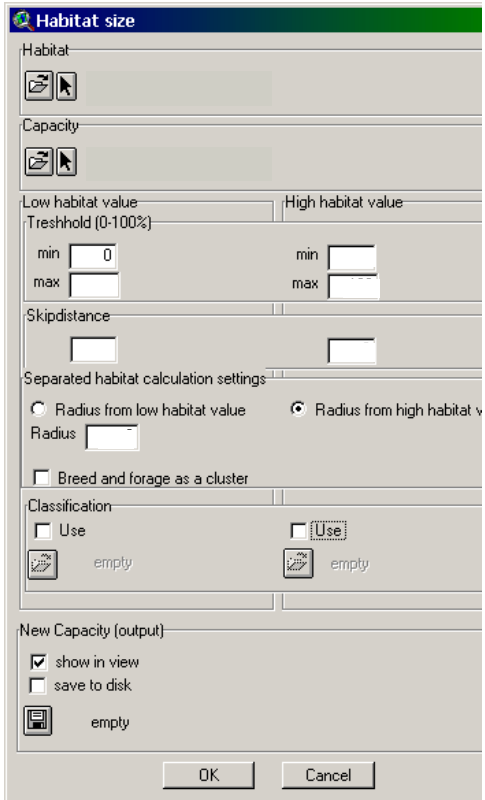
E.G.: Classification List: *0-2 : 70*
3-5 : 50
6-7 : 20

Capacity within 0-2 cell units from the overlay will be decreased by 70%, capacity within 3-5 cell units from overlay will be decreased by 50%, etc.

1. Click on the **LEDESS Menu** in the **Menu Bar**
2. Select **Habitat Overlay,** this option adapts the habitat suitability according to external influences. Choose add or subtract.
3. Select the **Buffer** values. These values are used to reclassifying a grid. It can be of (Avenue) the type ClasList, or VTab. If it's a VTab, the VTab should contain the item names: from, to, new (delimited file *.txt).

1.3.3 HABITAT SIZE

The algorithm looks for suitable habitat grids from a possible successful habitat cluster.
It looks for example at sizes of different clusters/regions, spatial organisation of breed versus forage areas and total capacity of those clusters/regions.



1. Click on the **LEDESS Menu** of the **Menu Bar**
2. Select **Habitat Size,** this option estimates the maximum number of individuals per patch.
3. The threshold is **0 - 100%**.

A cluster can be made up of different patches. The **Skipdistance** determines the buffer-distances[3] (in cellunits) for the patches to belong to one region.

4. Select the **skipdistance** (= buffer distance in cell units m). It is also possible to define a special skipdistance from lower and high habitat values.
5. (optional) Select if **breed** and **forage** habitat should be treated as one cluster

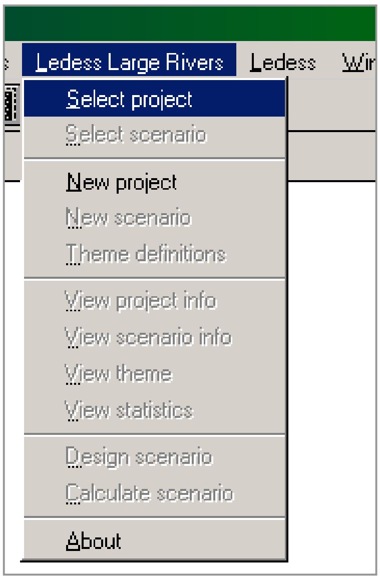
Habitatsize- grid values are changed by a **Classification List**. It divides the Habitatsize-grid in **amount-classes**.

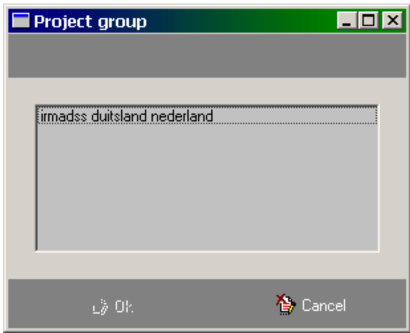
6. (optional) Select the **Classification** values. The effect of classification is defined in a ClassificationList (see Appendix 2. §1.3.2)

1.4 THE LEDESS LARGE RIVERS MENU

When using LEDESS Large Rivers a new menu is placed in de ArcView Menu Bar. The same LEDESS algorithms are used to calculated the scenarios. The knowledge tables and definitions are store inside a database.

1. Click on the **LEDESS Large Rivers Menu** of the **Menu Bar**
2. Select **Select project**, this selection opens a menu to select the project. based on a **Project-group** (definition of knowledge), which first has to be selected
3. In the **Selected Project** could exist one or more **Scenarios** (analogous with nature target plan in LEDESS 3). Select one ore create a new one
4. **Theme definitions** have to be set





5. (optional) **Design** a **Scenario** (analogous with nature target plan in LEDESS 3). When LEDESS Large Rivers is implemented in a Decision Support System a scenario building toolbox could be opened
6. **Calculate** the selected scenario

---

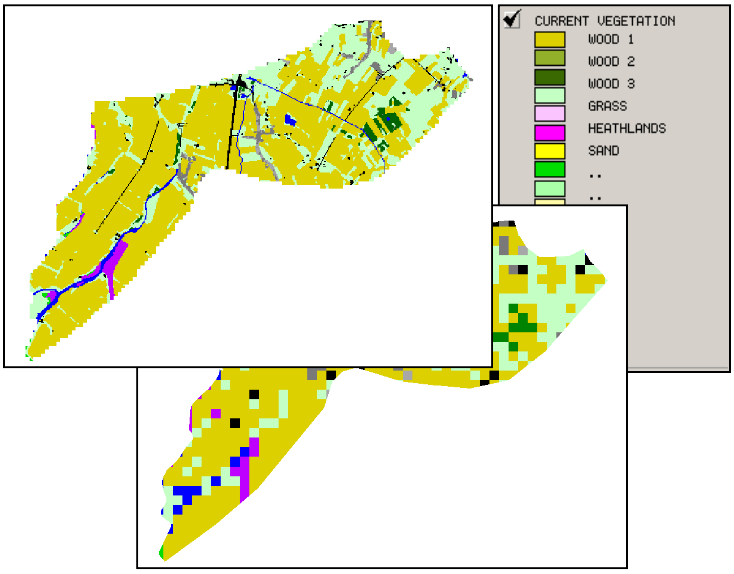
[3] In LEDESS the **skip**distance is treated as a **buffer**-distance = "**0.5 × reachable distance**".

APPENDIX 2. EXAMPLES OF INPUT AND OUTPUT

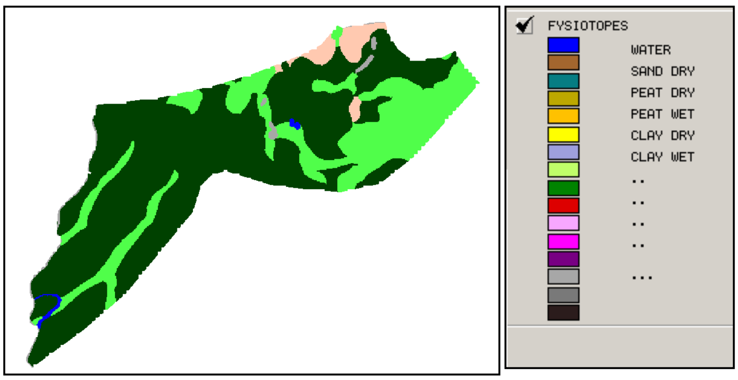
In this appendix, some pictures and examples are presented to explain the functions in chapter 4 in a visual way.

2.1 EXAMPLE 1: MAPS AND FUNCTIONS

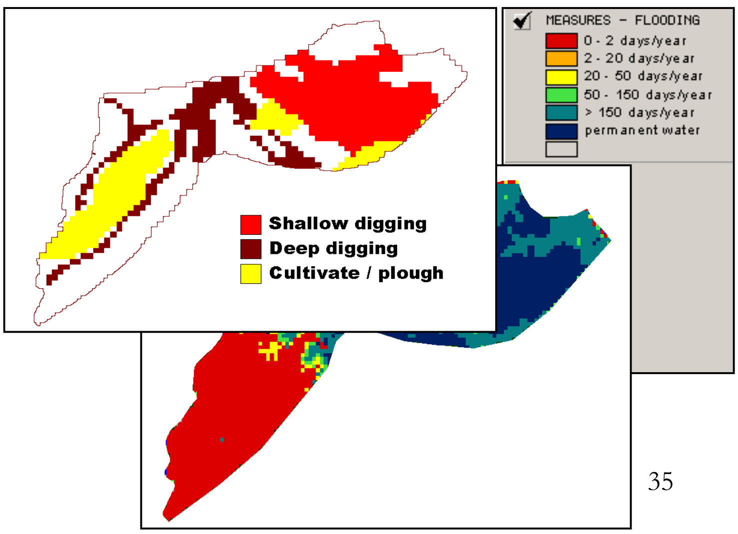
– Present vegetation-structure map (different grid sizes are possible)



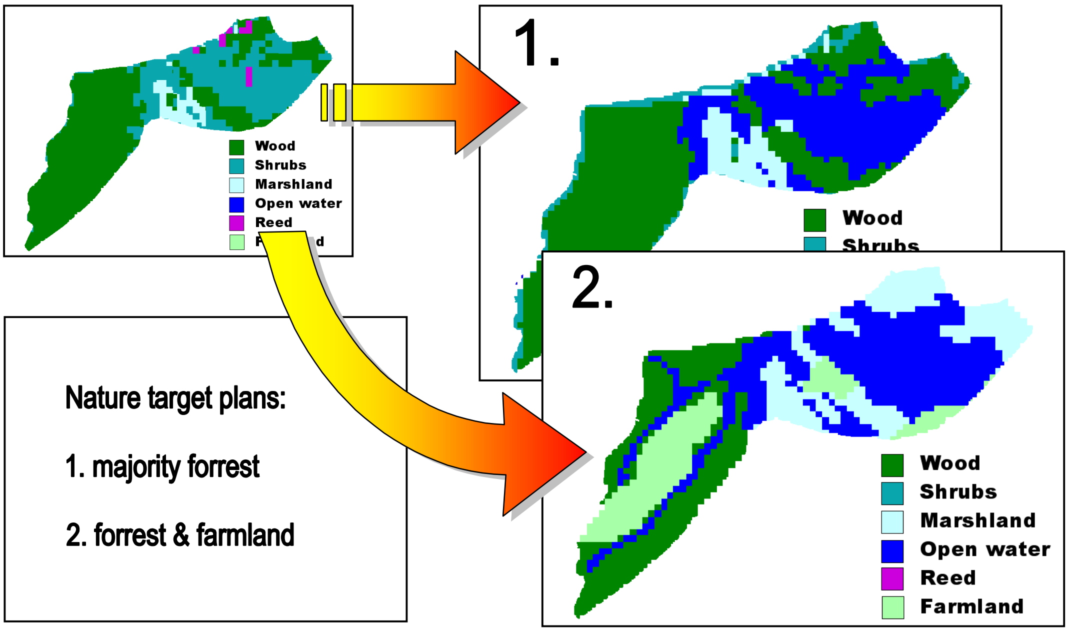
– Present physiotope map



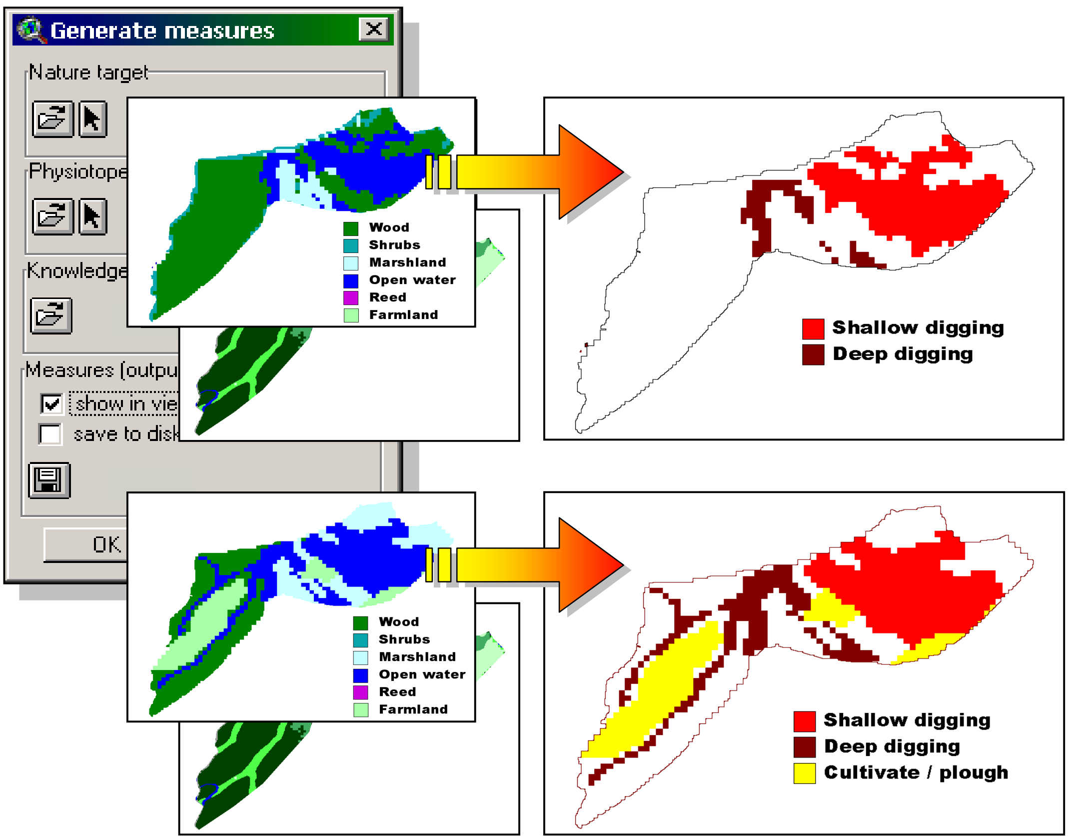
– Measure maps



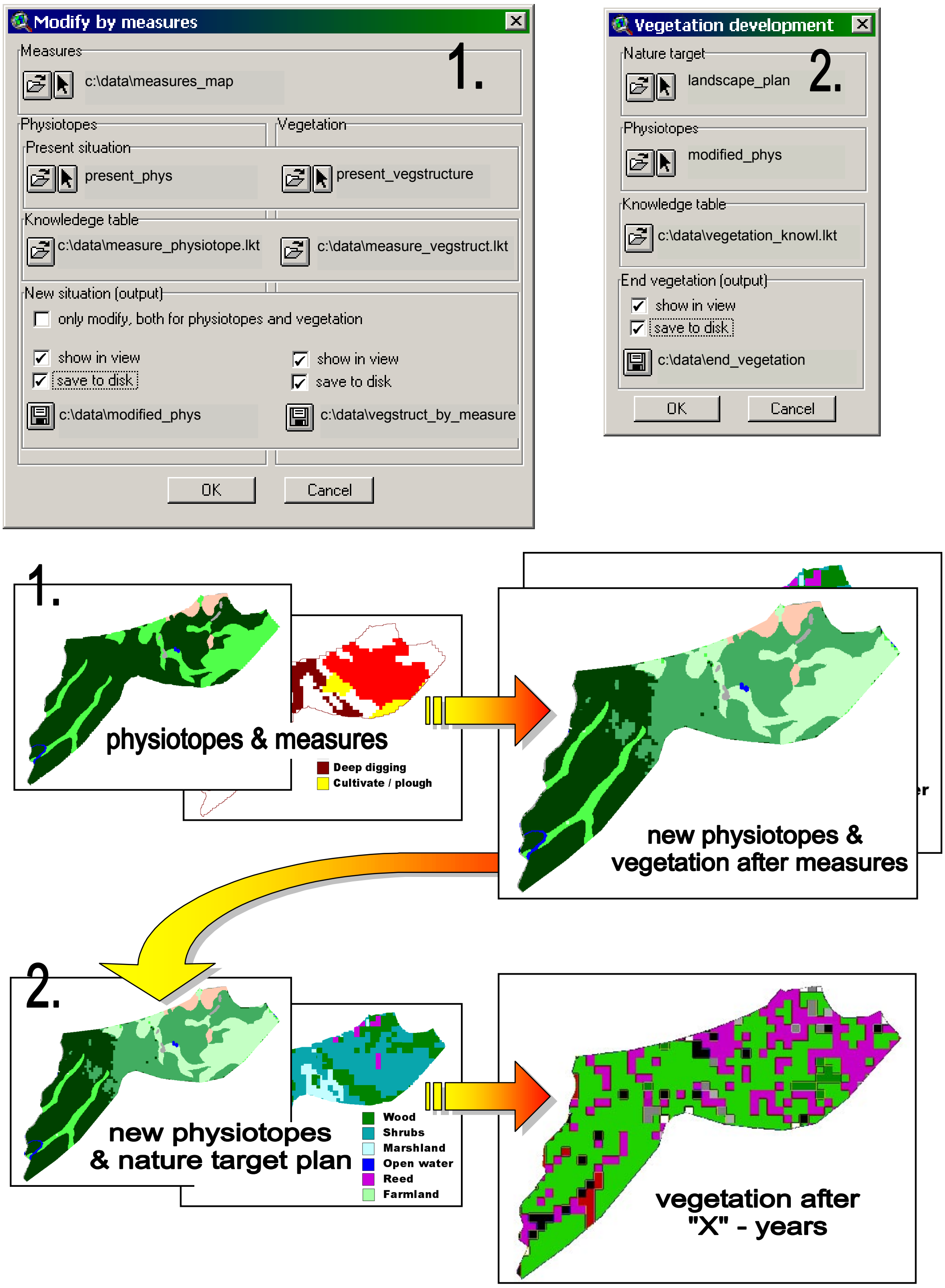
Nature target plans



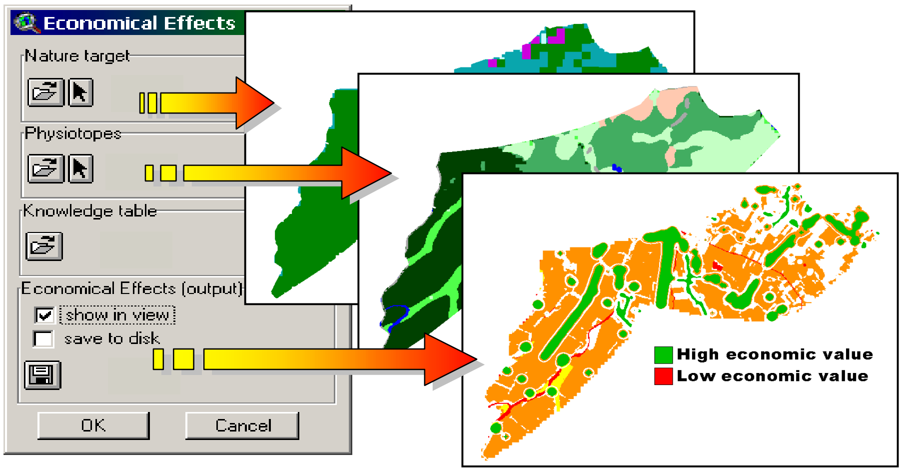
Generate measures



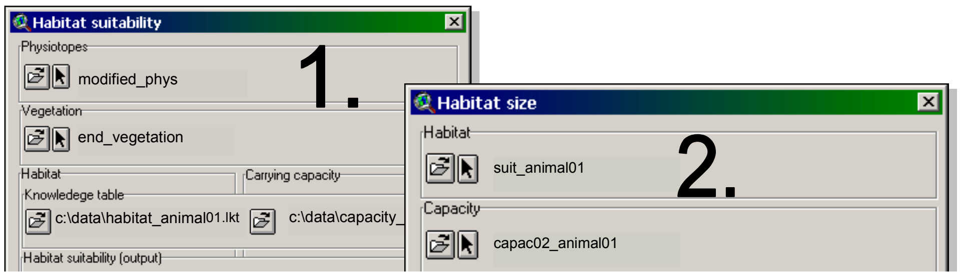
Modify by measures & vegetation development



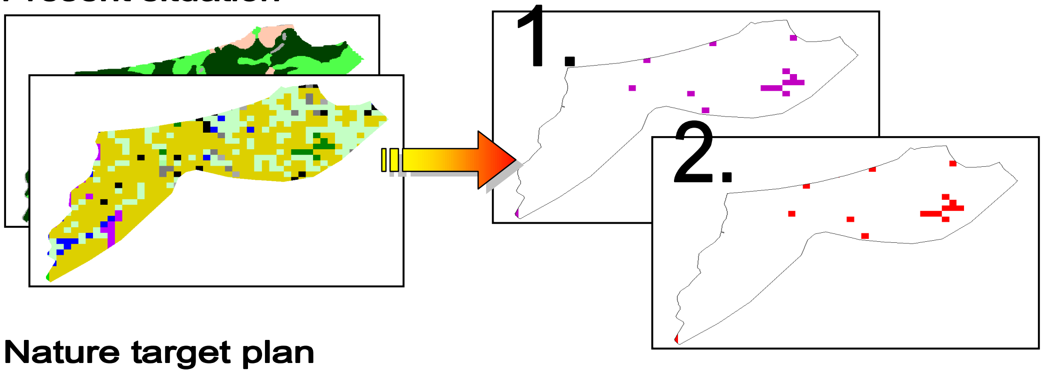
Economical effects



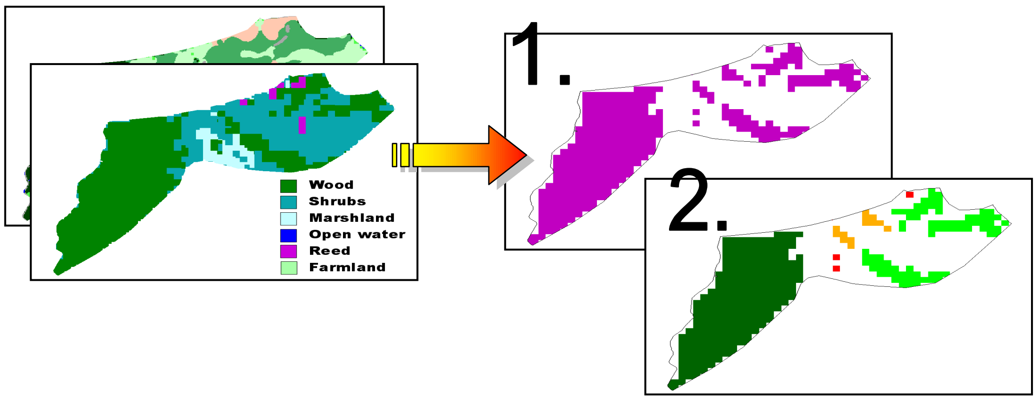
Habitat Suitability & Size



Present situation



Nature target plan



2.2 Example 2:

LEDESS in nature develepment plan "De Gelderse Poort"

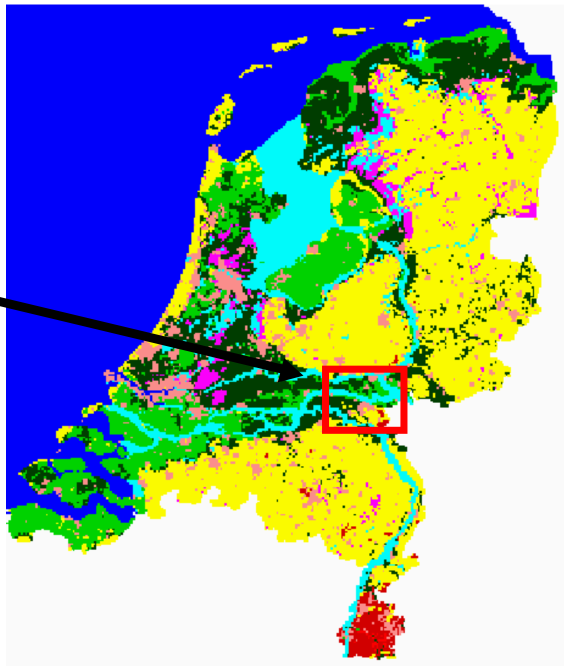
Map of The Netherlands

soil groups and water

types

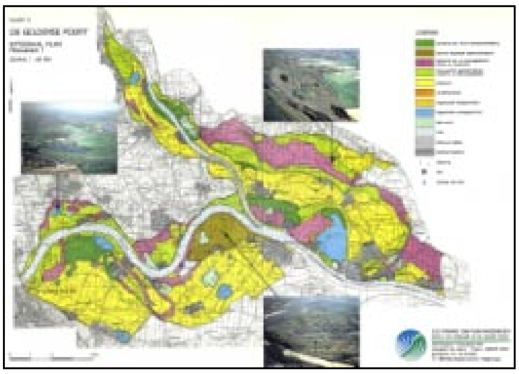
Study area

De Gelderse Poort

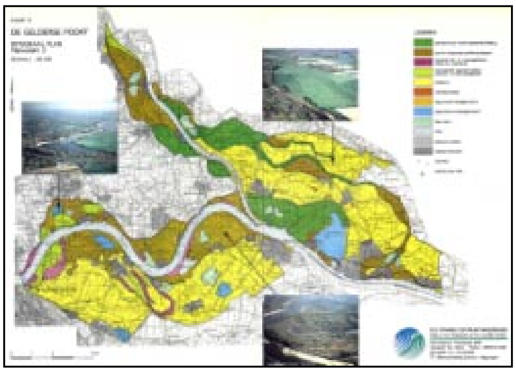


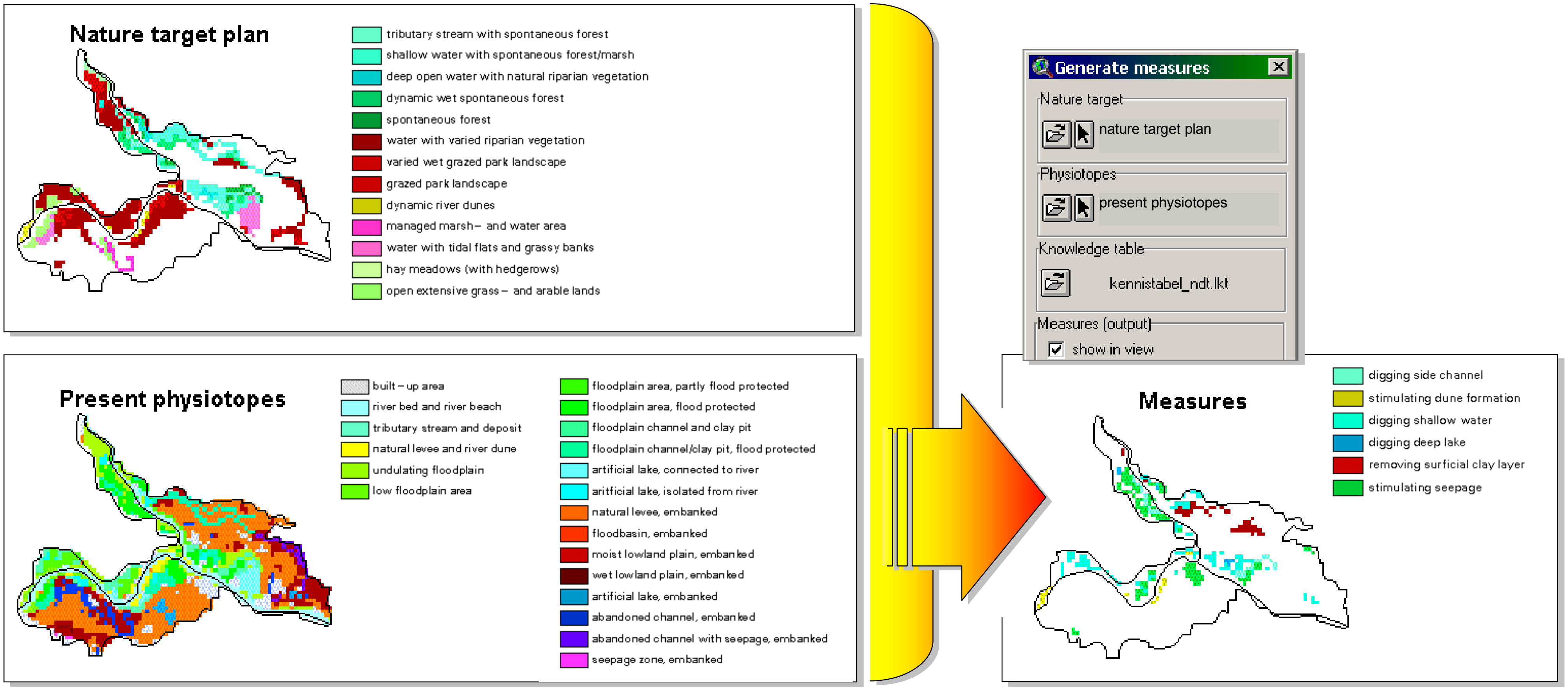
Scenario approach

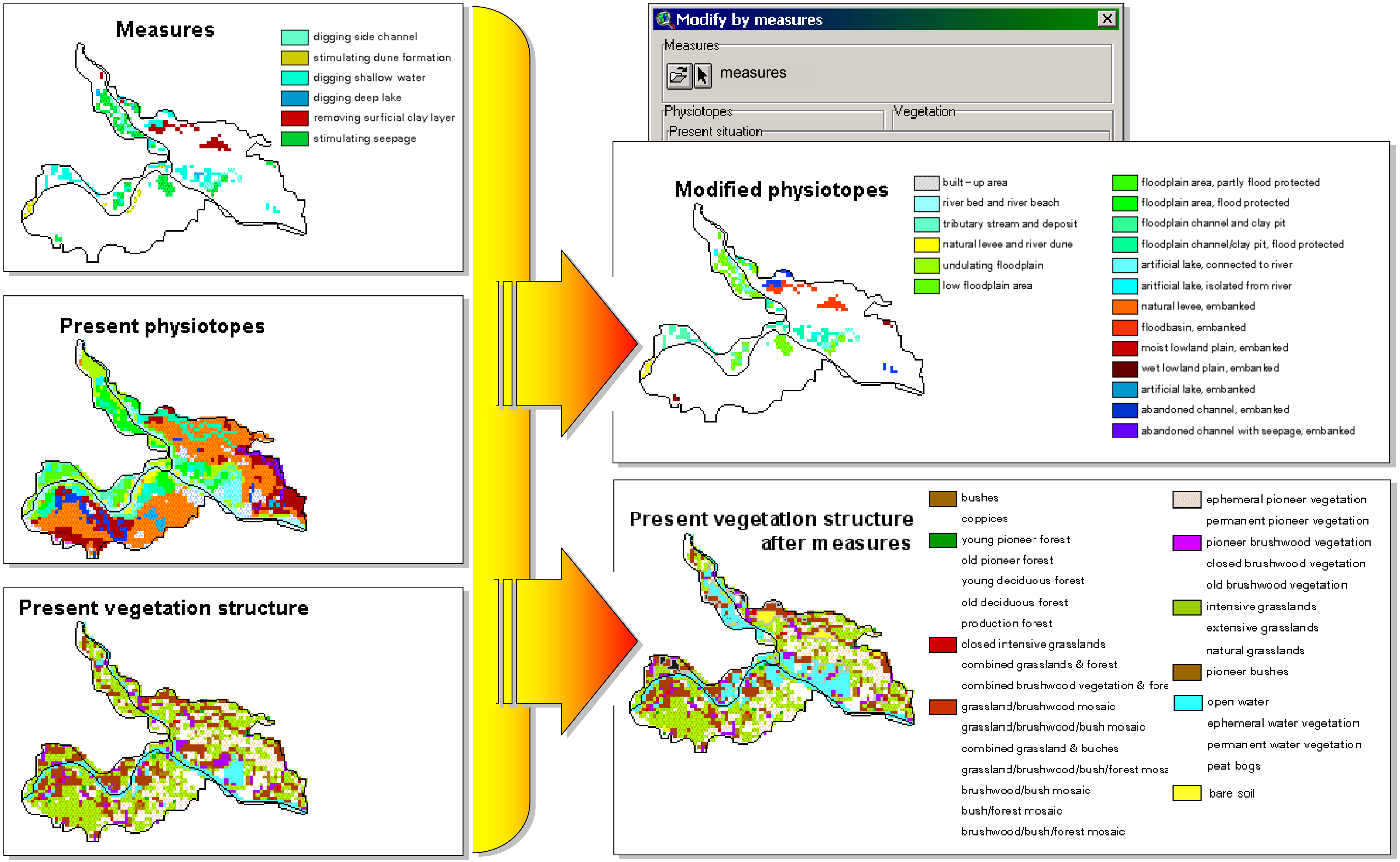
Alternative 1. Macrogradient

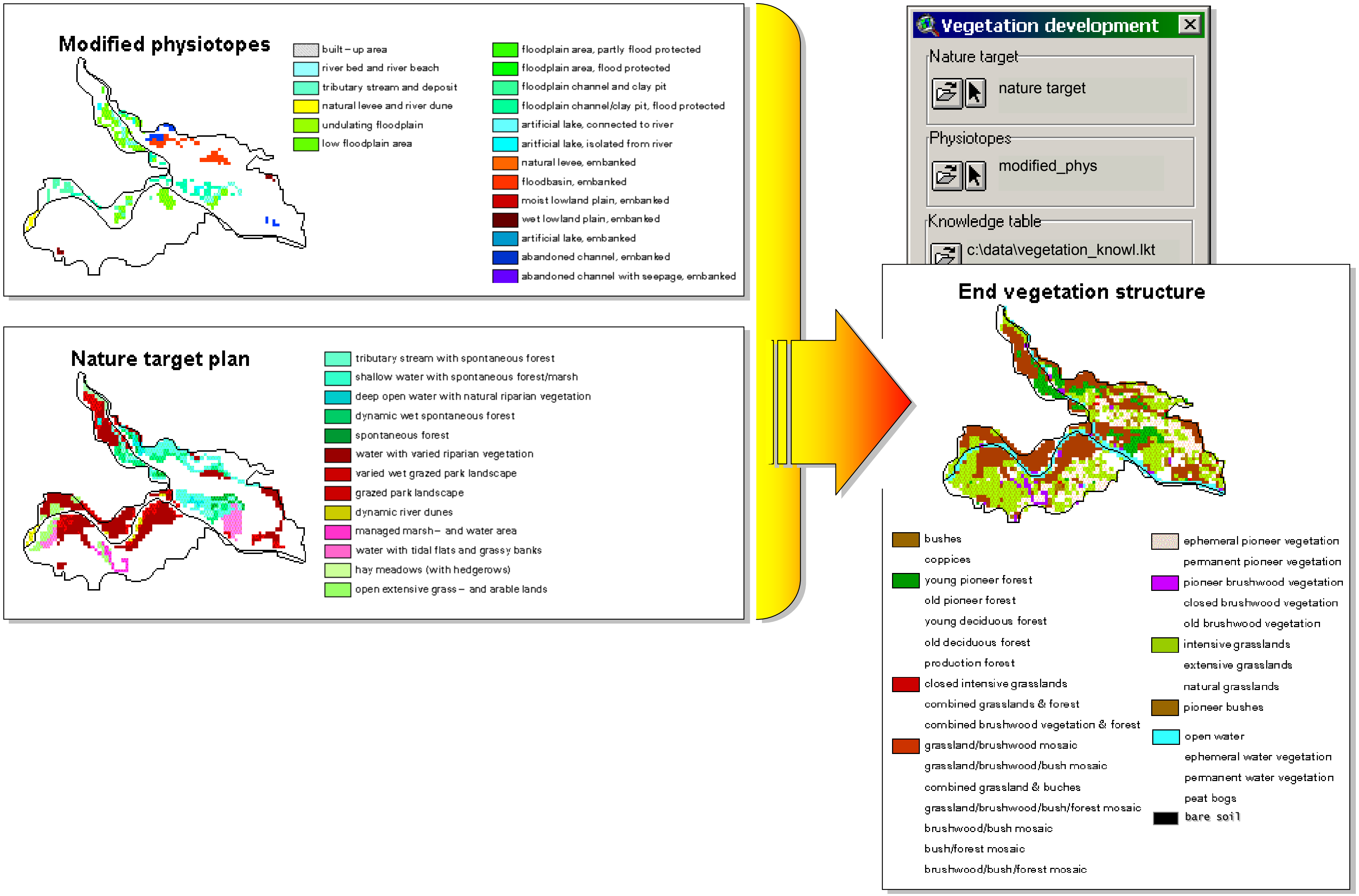


Alternative 2. Riverdynamics




Nature target plan
tributary stream with spontaneous forest
shallow water with spontaneous forest/marsh
deep open water with natural riparian vegetation
dynamic wet spontaneous forest
spontaneous forest
water with varied riparian vegetation
varied wet grazed park landscape
grazed park landscape
dynamic river dunes
managed marsh– and water area
water with tidal flats and grassy banks
hay meadows (with hedgerows)
open extensive grass – and arable lands
Present physiotopes
built – up area
river bed and river beach
tributary stream and deposit
natural levee and river dune
undulating floodplain
low floodplain area
floodplain area, partly flood protected
floodplain area, flood protected
floodplain channel and clay pit
floodplain channel/clay pit, flood protected
artificial lake, connected to river
aritficial lake, isolated from river
natural levee, embanked
floodbasin, embanked
moist lowland plain, embanked
wet lowland plain, embanked
artificial lake, embanked
abandoned channel, embanked
abandoned channel with seepage, embanked
seepage zone, embanked
Generate measures
Nature target
nature target plan
Physiotopes
present physiotopes
Knowledge table
kennistabel_ndt.lkt
Measures (output)
show in view
Measures
digging side channel
stimulating dune formation
digging shallow water
digging deep lake
removing surficial clay layer
stimulating seepage


Measures
digging side channel
stimulating dune formation
digging shallow water
digging deep lake
removing surficial clay layer
stimulating seepage
Present physiotopes
Present vegetation structure
Modify by measures
Measures
measures
Physiotopes
Vegetation
Present situation
Modified physiotopes
built – up area
river bed and river beach
tributary stream and deposit
natural levee and river dune
undulating floodplain
low floodplain area
floodplain area, partly flood protected
floodplain area, flood protected
floodplain channel and clay pit
floodplain channel/clay pit, flood protected
artificial lake, connected to river
aritficial lake, isolated from river
natural levee, embanked
floodbasin, embanked
moist lowland plain, embanked
wet lowland plain, embanked
artificial lake, embanked
abandoned channel, embanked
abandoned channel with seepage, embanked
Present vegetation structure
after measures
bushes
coppices
young pioneer forest
old pioneer forest
young deciduous forest
old deciduous forest
production forest
closed intensive grasslands
combined grasslands & forest
combined brushwood vegetation & fore
grassland/brushwood mosaic
grassland/brushwood/bush mosaic
combined grassland & buches
grassland/brushwood/bush/forest mosa
brushwood/bush mosaic
bush/forest mosaic
brushwood/bush/forest mosaic
ephemeral pioneer vegetation
permanent pioneer vegetation
pioneer brushwood vegetation
closed brushwood vegetation
old brushwood vegetation
intensive grasslands
extensive grasslands
natural grasslands
pioneer bushes
open water
ephemeral water vegetation
permanent water vegetation
peat bogs
bare soil


Modified physiotopes
built – up area
river bed and river beach
tributary stream and deposit
natural levee and river dune
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wet lowland plain, embanked
artificial lake, embanked
abandoned channel, embanked
abandoned channel with seepage, embanked
Nature target plan
tributary stream with spontaneous forest
shallow water with spontaneous forest/marsh
deep open water with natural riparian vegetation
dynamic wet spontaneous forest
spontaneous forest
water with varied riparian vegetation
varied wet grazed park landscape
grazed park landscape
dynamic river dunes
managed marsh– and water area
water with tidal flats and grassy banks
hay meadows (with hedgerows)
open extensive grass – and arable lands
Vegetation development
Nature target
nature target
Physiotopes
modified_phys
Knowledge table
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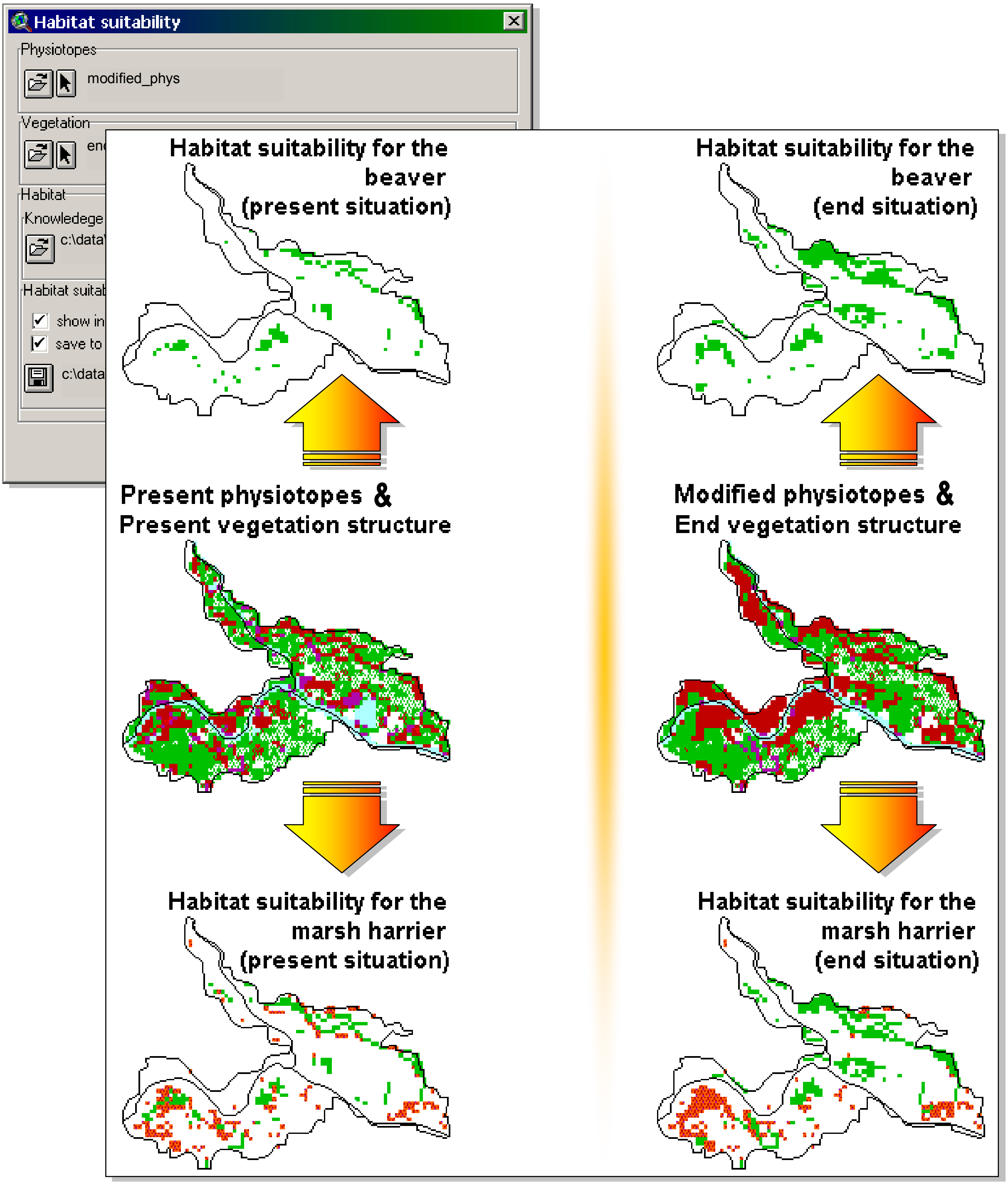
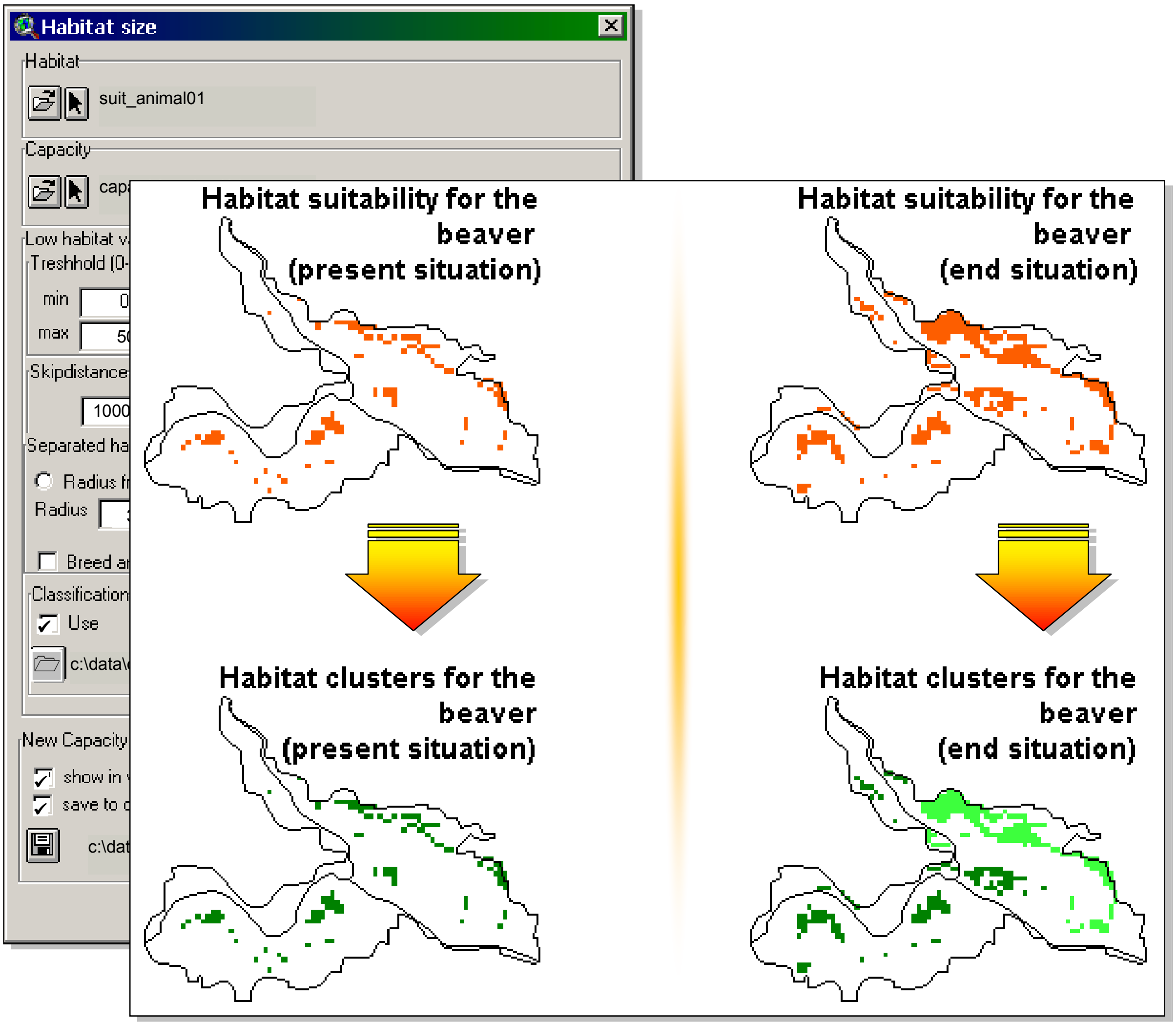
End vegetation structure
bushes
coppices
young pioneer forest
old pioneer forest
young deciduous forest
old deciduous forest
production forest
closed intensive grasslands
combined grasslands & forest
combined brushwood vegetation & forest
grassland/brushwood mosaic
grassland/brushwood/bush mosaic
combined grassland & buches
grassland/brushwood/bush/forest mosaic
brushwood/bush mosaic
bush/forest mosaic
brushwood/bush/forest mosaic
ephemeral pioneer vegetation
permanent pioneer vegetation
pioneer brushwood vegetation
closed brushwood vegetation
old brushwood vegetation
intensive grasslands
extensive grasslands
natural grasslands
pioneer bushes
open water
ephemeral water vegetation
permanent water vegetation
peat bogs
bare soil


Habitat suitability
Physiotopes
modified_phys
Vegetation
Habitat
Knowledege
Habitat suitab
show in
save to
Habitat suitability for the beaver (present situation)
Habitat suitability for the beaver (end situation)
Present physiotopes & Present vegetation structure
Modified physiotopes & End vegetation structure
Habitat suitability for the marsh harrier (present situation)
Habitat suitability for the marsh harrier (end situation)



Habitat size
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Capacity
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Habitat suitability for the beaver (present situation)
Habitat suitability for the beaver (end situation)
Habitat clusters for the beaver (present situation)
Habitat clusters for the beaver (end situation)