Landscape Ecological Decision & Evaluation Support System 
LEDESS 

Users Guide 

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Alterra- Report 447 

Alterra, Green World Research, Wageningen, 2002
ABSTRACT


Keywords:

ISSN 1566-7197
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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).
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 projects1.

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);
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.
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.

![Diagram showing the process of LEDESS context](image)

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 thereof 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 buffer zones, maps with roads and cities, bad environmental qualities, rewetting, flooding and biogeographical maps.

![Image showing map selection in LEDESS](image)

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).

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**Figure 6 Mechanism of LEDESS knowledge tables**

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### Example knowledge table `modifyphys.lkt` (modifying physiotopes by measures)

<table>
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<th>hor</th>
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<th>content</th>
<th>codes</th>
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<td>0</td>
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</tr>
<tr>
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<td>0</td>
<td>0</td>
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</table>

### Example knowledge table `target_to_endvegetation.lkt` (from nature targets to vegetation structures)

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</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

### Example knowledge table `roedeer.lkt` (suitable ecotopes for roedeer)

<table>
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<th>codes</th>
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**Figure 7** Example working with knowledge tables in planning with LEDESS
LEDESS consists of three modules connected by knowledge tables and characterisations (Figure 7). They are described separately in the following paragraphs.
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

![Diagram](Diagram.png)
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

1. Create physiotope map

2. Generate map of lay-out measures
   - (adapted) Landscape plans
   - Measure Knowledge table
   - (modified) present physiotope-map

3. Modify by measures
   - Present vegetation-structure-map
   - Modify-vegetation knowledge table
   - Modify-physiotope knowledge table

Overlaying and reclassification based on selection statements and transformation matrices

User

Modified physiotopes map
Modified vegetation-structure map
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.

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.

![Modify physiotopes by measures toolbox in LEDESS.](image)
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.

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

![Vegetation development diagram](image1)

![Vegetation development toolbox in LEDESS](image2)
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.

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

![Habitat suitability tool in LEDESS](image)

**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 through 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.

**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](image)
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](image-url)
REFERENCES


Wolfert, H.P. & J. Rademakers, 1996. Rijkswateren Ecotopen Stelsel; uitgangspunten en plan van aanpak. RIZA.

APPENDIX 1. A QUICK START: MENU FOR BASIC 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.

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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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 through 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 (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 calculate 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

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3 In LEDESS the skipdistance 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

1. majority forest
2. forest & farmland

Generate measures

- Shallow digging
- Deep digging
- Cultivate / plough
Modify by measures & vegetation development

1. Physiotope & measures
   - Present physical situation file: c:\data\measure_physiotope.lkt
   - Knowledge table: c:\data\measure_physiotope.lkt
   - New situation (output)
     - Only modify both phytopes and vegetation
     - Show in view
     - Save to disk
   - File path: c:\data\modified_phys
   - File path: c:\data\vegstruct_by_measure

2. New physiotope & nature target plan
   - File path: c:\data\vegetation_knowl.lkt
   - File path: c:\data\end_vegetation

Vegetation development

1. Nature target
   - Landscape plan
   - File path: c:\data\landscape_plan
   - Knowledge table: c:\data\vegetation_knowl.lkt
   - End vegetation (output)
     - Show in view
     - Save to disk
   - File path: c:\data\end_vegetation
Economical effects

Habitat Suitability & Size

Present situation

Nature target plan
2.2 Example 2:

LEDRESS IN NATURE DEVELOPMENT 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