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# Land occupation and land transformation in life cycle inventories

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# Challenges

- New findings in land use impact assessment, but no consensus reached yet for a method
- Different approaches for inventory modelling
- Harmonisation and actualisation of Swiss LCI database (ecoinvent 2000) started two years ago



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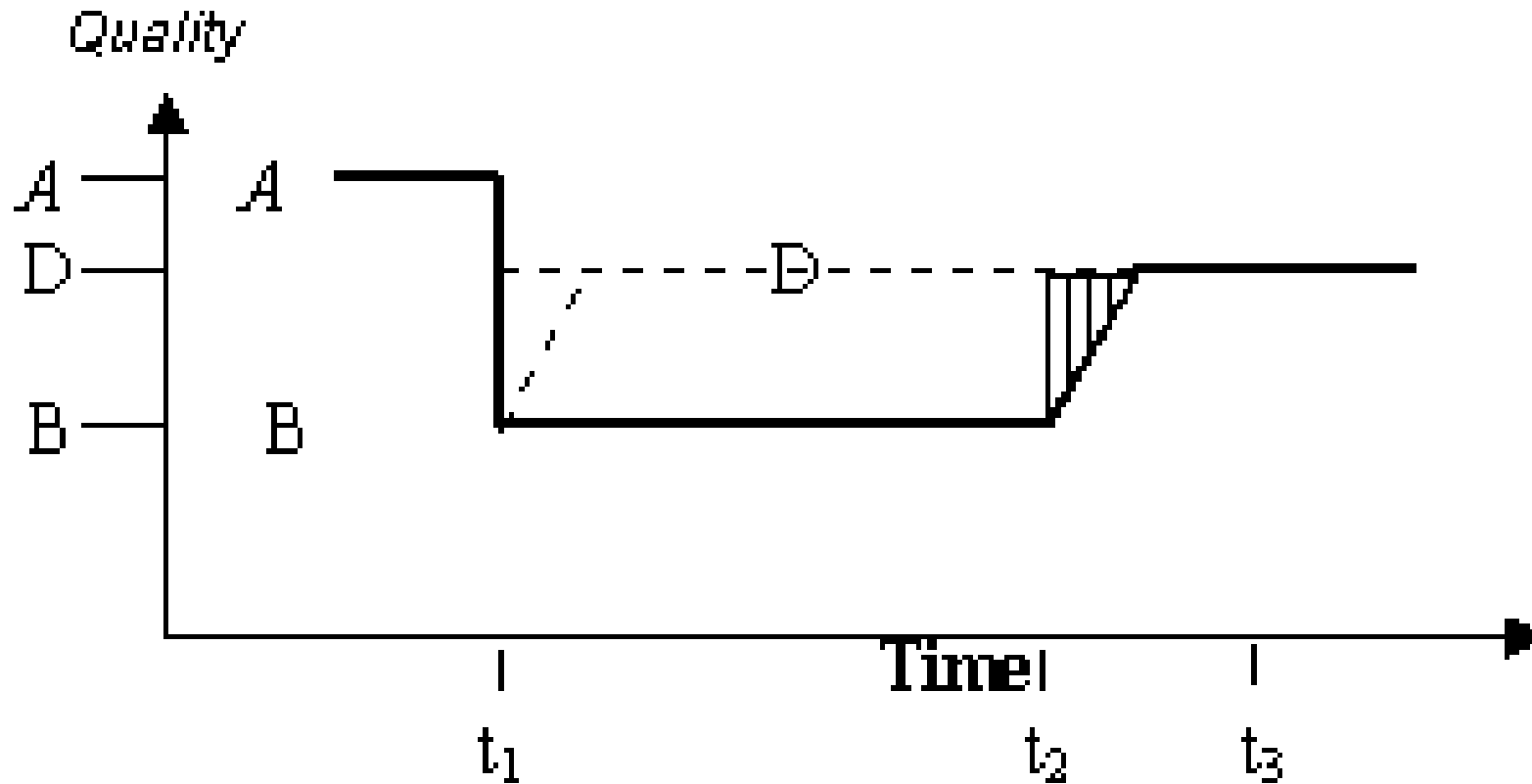
The logo for FAL (Forschungsinstitut für Luft- und Schallforschung), featuring a white cross inside a grey square, with the letters "FAL" and a small circular icon below it.

➤ Flexible inventory items required

# Land use impact

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Lindeijer et al. (2001)



# Environmental impacts

- Increase of land competition

## Impacts on

- **Biodiversity**
- Life support function
- Man-made environment



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➤ Focus in ecoinvent are impacts on biodiversity

# Land cover nomenclature



Approach based on CORINE land cover classes:

121: industrial area

131: mineral extraction site

132: dump site

21: arable

22: permanent crop

31: forest

etc.

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# Transformation - occupation



Distinction for two types of intervention:

- Land transformation  
e.g., conversion of agricultural land to built up land
- Land occupation  
e.g., covering with buildings and thus influence of the occupation on the biodiversity of the used land

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# Land occupation

- Surface area
- Duration of occupation
- Amount of products / services manufactured / delivered
- Land quality during occupation  
e.g., road, industrial area, arable land, etc.

Land occupation recorded as

$\text{m}^2$  times year per unit output

Example:

0.3  $\text{m}^2\text{a}$  occupation, mineral extraction site (CORINE 131) per kg gravel



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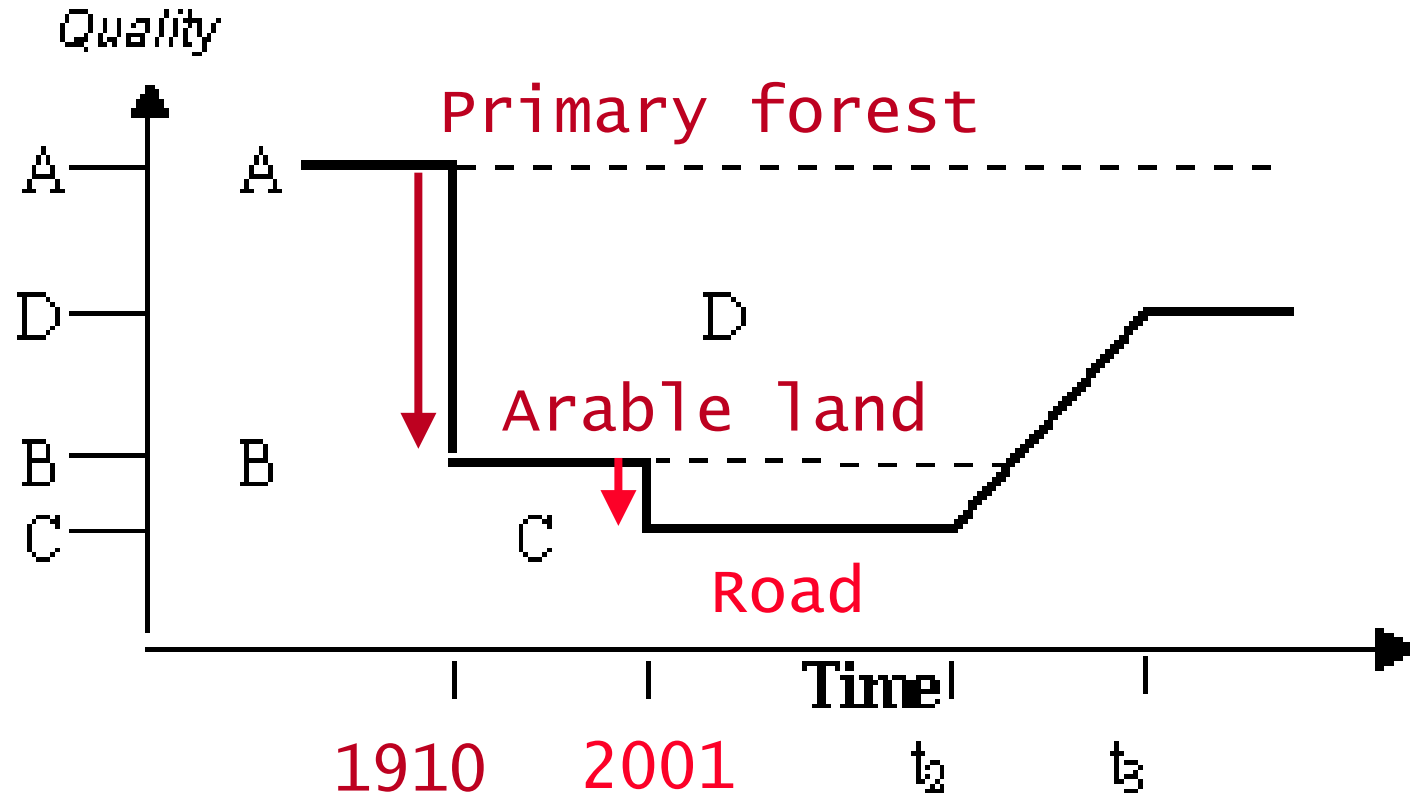
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# Land transformation



➤ Main difficulty: Definition of reference state, quite often unknown

# Land transformation



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occurs

- **Before** an artificial process  
(road, power plant construction, agriculture, forestry, etc.)
- **During** an artificial process  
(lignite open cast mining)
- **After** an artificial process  
(conversion to another industrial use, **active restoration**,  
natural succession)

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The logo for EMPA (Empfehlungen für die Praxis), featuring the letters "EMPA" in a bold, black font on a red rectangular background.

The logo for EAWAG (Eidgenössisches Anwaltsamt für Wasserrecht), featuring the letters "EAWAG" in a bold, black font on a blue and white background.

The logo for FAL (Forschungsinstitut für Landwirtschaft), featuring the letters "FAL" in a bold, black font on a white background with a small red cross in the top right corner.

➤ If change or restoration is not foreseeable (e.g., roads, hydroelectric power plants): No land transformation at the end of its initial use

# Land transformation inventory



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Two directions are recorded:

- Land transformation from state A
- Land transformation to state B

Information required:

- Amount of surface & land cover types
- Amount of products / services manufactured / delivered

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# Depreciation period for transformation



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- Time period for which land transformation is made  
=> defines amount of products / services  
=> standard “lifetimes” for ecoinvent if duration is not known

- Examples:
  - Industrial areas: 50a
  - roads, railways: 100a
  - agriculture (arable crops): 1a
  - agriculture (permanent crops): 20-30a
  - forestry: 80a

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# Example: Gravel extraction

- total surface: 10'000m<sup>2</sup>
- site lifetime: 20 year
- gravel extracted : 1'000 tons per year
- duration active restoration: 2 years
- Diesel consumption:
  - extraction: 200'000 MJ/year
  - restoration: 40'000 MJ



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# Example: Gravel extraction

|                     |  |                  | unit process raw data               |   | LCI result                          |
|---------------------|--|------------------|-------------------------------------|---|-------------------------------------|
|                     |  |                  | gravel,<br>crushed, at<br>mine<br>t | restauration,<br>gravel<br>extraction<br>m <sup>2</sup> | gravel,<br>crushed, at<br>mine<br>t |
| resource, land      | occupation, mineral extraction site      | m <sup>2</sup> a | 10                                  |   | 10                                  |
|                     | occupation construction site             | m <sup>2</sup> a |                                     | 2   | 1                                   |
|                     | transformation, from unknown             | m <sup>2</sup>   | 0.5                                 |   | 0.5                                 |
|                     | transformation, to resource extraction   | m <sup>2</sup>   | 0.5                                 |   | 0.5                                 |
|                     | transformation, from resource extraction | m <sup>2</sup>   |                                     | 1   | 0.5                                 |
|                     | transformation, to forest                | m <sup>2</sup>   |                                     | 1   | 0.5                                 |
| resource, in ground | gravel, in ground                        | t                | 1                                   |   | 1                                   |
| Technosphere inputs | restauration, gravel extraction          | m <sup>2</sup>   | 0.5                                 |   | 0.5                                 |
|                     | diesel, burned in building machine       | MJ               | 200                                 | 4   | 202                                 |
|                     | ...                                      | ...              |                                     |   |                                     |
| Reference product   | gravel, crushed at mine                  | kg               | 1                                   |   | 1                                   |
|                     | restauration, gravel extraction          | m <sup>2</sup>   |                                     | 1   |                                     |



# Example: Gravel extraction

|                     |   |                      | unit process raw data               |   | LCI result                          |
|---------------------|---|----------------------|-------------------------------------|---|-------------------------------------|
|                     |   |                      | gravel,<br>crushed, at<br>mine<br>t | restauration,<br>gravel<br>extraction<br>m <sup>2</sup> | gravel,<br>crushed, at<br>mine<br>t |
| resource, land      | occupation, mineral extraction site             | m <sup>2</sup> a     | 10                                  |   | 10                                  |
|                     | occupation construction site                    | m <sup>2</sup> a     |                                     | 2   | 1                                   |
|                     | transformation, from unknown                    | m <sup>2</sup>       | 0.5                                 |   | 0.5                                 |
|                     | <b>transformation, to resource extraction</b>   | <b>m<sup>2</sup></b> | <b>0.5</b>                          |   | <b>0.5</b>                          |
|                     | <b>transformation, from resource extraction</b> | <b>m<sup>2</sup></b> |                                     | <b>1</b>  | <b>0.5</b>                          |
|                     | transformation, to forest                       | m <sup>2</sup>       |                                     | 1   | 0.5                                 |
| resource, in ground | gravel, in ground                               | t                    | 1                                   |   | 1                                   |
| Technosphere inputs | restauration, gravel extraction                 | m <sup>2</sup>       | 0.5                                 |   | 0.5                                 |
|                     | diesel, burned in building machine              | MJ                   | 200                                 | 4   | 202                                 |
|                     | ...   | ...                  |                                     |   |                                     |
| Reference product   | gravel, crushed at mine                         | kg                   | 1                                   |   | 1                                   |
|                     | restauration, gravel extraction                 | m <sup>2</sup>       |                                     | 1   |                                     |



# LCI result

## Example , excerpt : Solar and Wood heating



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|  | Unit | heat, at<br>solar+wood<br>heating, flat plate,<br>one-family house,<br>CH<br>MJ<br>0 |
|--|------|--|
| Occupation, forest, intensive, normal        | m2a  | 4.08E-2  |
| Occupation, industrial area                  | m2a  | 1.55E-4  |
| Occupation, traffic area, road embankment    | m2a  | 4.09E-4  |
| Transformation, from arable, non-irrigated   | m2   | 5.03E-5  |
| Transformation, from forest, extensive       | m2   | 3.43E-4  |
| Transformation, from unknown                 | m2   | 1.15E-5  |
| Transformation, to arable, non-irrigated     | m2   | 5.03E-5  |
| Transformation, to forest, intensive, normal | m2   | 3.39E-4  |
| Transformation, to industrial area           | m2   | 7.48E-6  |





# Damage factors, Eco-indicator 99

Damage factors for  
occupation

Positive factors for  
„transformation to  
...“

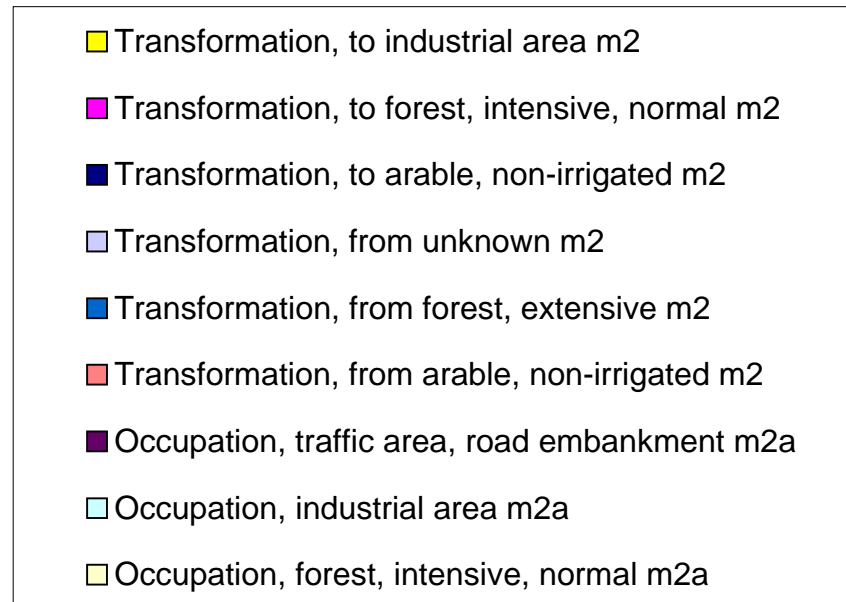
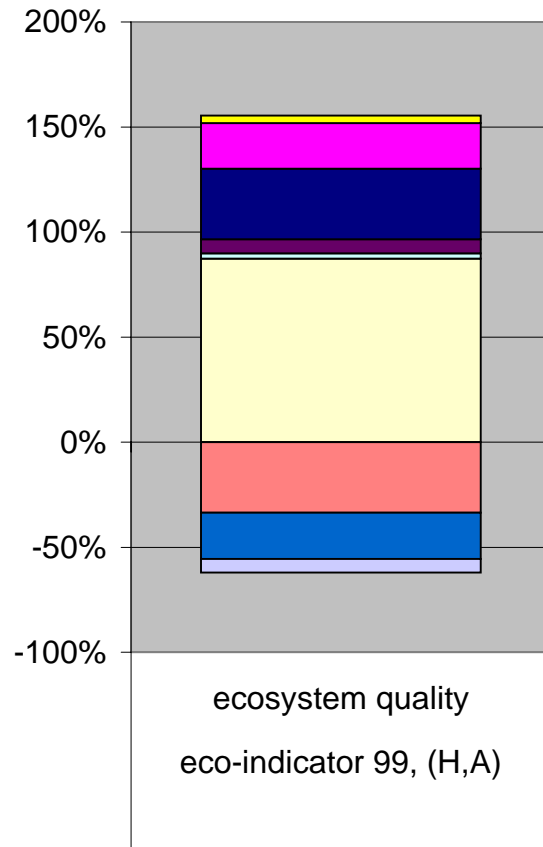
Negative factors for  
„transformation from  
...“

Average factor for  
„unknown“

|  |     | eco-indicator<br>99, (H,A)<br>ecosystem<br>quality<br>land<br>occupation<br>points |
|--|-----|--|
| Occupation, forest, intensive, normal        | m2a | 0.00858  |
| Occupation, industrial area                  | m2a | 0.0655   |
| Occupation, traffic area, road embankment    | m2a | 0.0655   |
| Transformation, from arable, non-irrigated   | m2  | -2.68  |
| Transformation, from forest, extensive       | m2  | -0.257   |
| Transformation, from unknown                 | m2  | -2.24  |
| Transformation, to arable, non-irrigated     | m2  | 2.68   |
| Transformation, to forest, intensive, normal | m2  | 0.257  |
| Transformation, to industrial area           | m2  | 1.96   |

# Results: LCIA (EI'99), land use

## Example: Solar and Wood heating



# Summary



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- Transformation and occupation are separated
- “Transformation, from” and “transformation, to” are separated
- 41 different land use classes (nomenclature based on CORINE land cover classes)
- Methodology open for the use of different impact assessment approaches
- Land use type before occupation is difficult to determine

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