# Avoid – mitigate – compensate: Halting the loss of biodiversity in landscapes "under pressure" - Landscape Planning and Eco Account examples from the Stuttgart region, Germany

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## Introduction and Literature Review

Within the European Union, Germany has the largest population (ca. 80 million) and the fourth highest population density (about 230 inhabitants per km²). In addition, the population's need for living space is among the highest within Europe: in 2012, the rate of living space per resident was around 40 m² per person and far above Europe's average for many other indicators, like percentage of urbanized land, population density, and motorization (table 1).

With its long history of urbanisation and industrialization after World War II and its geographical position in the centre of Europe, Germany faces strong challenges to balance the demands of people's welfare and the country's natural resources like biodiversity and water quality. The current situation with a high number of people immigrating temporarily or permanently from abroad strengthens the need for finding smart solutions for long-term spatial planning and for a sustainable land use in general. Due to a low birth rate and negative migration rate, Germany's population decreased from 82.5 million in 2002 to 80.5 million in 2012), but a strong increase of immigration within the recent years (300,000 to 600,000 per year) resulted in a number of 81.2 million residents in 2014 (Statistisches Bundesamt, 2013). In addition, the number of automobiles per 1.000 residents is situated in the top third within the EU (Statista, 2016). Through the last decades, an ongoing process of fragmentation of the land by roads and of degradation of the land by spatial development has taken place (Jaeger et al. 2012).

**Table 1. selected indicators (Bundeszentrale für politische Bildung, 2013a,b)**

| | Urbanized land [%] | Pop. density [Inhab./km] | Living space [m² / inhabitant] | Automobiles / 1,000inhabitants |
|---|---|---|---|---|
| France | 8.5 | 101 | 38 | 499 |
| Germany | 16 | 248 | 40 | 573 |
| Italy | 9 | 198 | 36 | 605 |
| Spain | 6 | 98 | 31 | 515 |
| Poland | 6 | 110 | 22 | 318 |

## Goals and objectives

All in all, the high population density combined with high demands of living space per person and a high level of motorization result in a strong pressure upon the environment and landscape. How can we deal with these challenges and threats? Within the last decade, several means and methods have been developed to determine impacts like the destruction of important biotopes or the sealing of soils with asphalt caused by strong urbanization to reduce its environmental and ecological consequences. The eco-account method and examples of this approach are presented and discussed in this paper.

The Stuttgart Region with its automotive industry and other strong engineering potentials is one of Germany's core regions of economic development, facing the challenges far more than the nation's average. The paper intends to illustrate the complexity of the problem and the chosen example presents a reconnection of habitats e.g. by "green corridors", the renaturation of a creek and a management system for sustainable water retention in the landscape.

## Methods and instruments being developed to halt the loss of biodiversity by multifunctional measures

To halt the decrease of open, non-urbanized landscapes by urbanization and fragmentation is a very strong aim in Germany's nature conservation policy. Considering the threats discussed above, it is a big challenge to achieve these ambitious aims. Therefore, the means having been developed recently, mainly consider the multiple ecological functions in planning processes when creating new urbanisation in previous undeveloped landscapes. Strict regional planning to avoid severe impacts, and a generally accepted evaluation system are needed to implement these demands and to enable spatial and landscape planners as well as structural and hydraulic engineers to sustainably restructure the landscape with natural elements.

An efficient and in particular congenial cooperation of spatial and landscape planners and structural and hydraulic engineers is needed for example to maintain biodiversity, landscape water regimes, and visual qualities of cultural landscapes, just as efficiency and cooperation is needed to restructure the landscape with natural elements. Improving biodiversity is based technically on an evaluation system for ecological functions and ethically on the "Polluter Pays Principle". All spatial plans are to follow the determinations of the Regional Plan. For example, this plan defines zones where spatial developments in addition to other protected areas are not permitted. The ecological quality (of biotopes, watersheds, soils, climate and so on) of the non-urbanized land is defined by standard methods and forms the basis for development "inside" or "outside" prohibited zones.

**Results: the method and its application in Landscape Planning**

As a result of these planning processes, impacts are restricted spatially to locations outside areas of strong ecological vulnerability and without ecological protection like Natura 2000 or other protection categories. To cope with impacts in non-protected areas, most of the federal German states have been establishing “eco-accounts” by introducing laws for offsetting impacts. In the state Baden-Württemberg, where the Stuttgart region is located, the so called “Ökokontoverordnung” (ÖKVO, decree for offsetting impacts - Land Baden-Württemberg, 2011) was implemented by the state government in 2011 for all (!) public or private impacts outside municipal land-use planning (for the latter the regulations are slightly different but the principles and methods for implementation are almost the same). One of the authors of this paper was involved in the development of the method which has become the most important means to internalize the “ecological cost” caused by new urbanizations: the one who causes the impacts has to pay for its mitigation and compensation. The instrument is very helpful especially under restricted (public) financial resources. The method runs through an ongoing development process and will be used for further restructuring measures in landscapes to re-establish natural and cultural elements in 2016.

How can we determine the severity of impacts and the quality and quantity of compensatory measures? The main principles of the eco account method are:

1. to determine how to avoid the impact or its negative effects
2. to mitigate inevitable impacts; figure out what measures are needed to minimize the negative effects of the impact
3. if negative effects of the inevitable impact remain: to determine the ecological status of the site to be impacted by scales or a range of points (from A = low quality to Z = high quality, or other scales). This should be done for biotopes and also for soils, water, climate, and landscape character (example with a scape from 1 to 64 points from ÖKVO for biotopes see Table 2)
4. to predict the ecological status of the site after being impacted, do this by the same scales or a range of points as under 1.; include interdependencies and side effects like biotope fragmentation into assessment
5. to compare 3 and 4 and calculate the difference between *status ante* and *status post*, multiply by the area [ha or m²] impacted respectively (quantitative ecological deficit, “qed”, unit: Eco Point(s), EP)
6. to find areas where it is possible to increase the ecological quality by measures and run through the same process again (this time quality of

*status ante* is lower than the one of *status post*, because of ecological improvements)

7. to define and implement measures in areas as described under 6. (quantitative ecological surplus, "qes")
8. to allocate the adequate number of the compensation's surplus eco points (qes) to the deficit in eco points (qed) caused by the impact. As soon as the "eco account" is balanced, the impact is compensated.

Note: it is not sufficient just to equalize eco point deficits. Any measure being done for compensation purposes must originate from an ecological or landscape concept

Table 2 shows excerpts of the eco-account evaluation system. After mapping, the biotopes are to be evaluated by the eco-account system. The scale ranges from 1 EP (for asphalt or concrete areas) to 64 EP (natural, undisturbed, highly endangered biotopes being very rich in species). Columns 3 and 4 (for existing and planned biotopes respectively) contain a triple of numbers; the second number (bold) is the common value for typical biotopes without an outstanding biodiversity on one hand and strong disturbances on the other.

**Table 2. Evaluation system of existing and planned biotopes in Ökokontoverordnung (ÖKVO; = decree for offsetting impacts, excerpt); unit: Eco Point (EP)**

| ID number for type of biotope | Type of biotope (name) | Existing biotopes | Planned biotopes |
|---|---|---|---|
| 33.10 | wet meadow | 14 / **26** / 39 | 14 / **26** / 34 |
| 33.41 | typical meadow on fertile soils | 8 / **13** / 19 | 8 / **13** / – |
| 36.70 | xeric grassland | 22 / **37** / 50 | 22 / **31** / 37 |
| 37.11 | field in intensive use | 4 / **8** / - | **4** |
| 41.21 | typical hedge on dry soils | 14 / **23** / 35 | 14 / **18** / 23 |
| 53.10 | oak forest on dry soils | 22 / **43** / 57 | 22 / **28** / - |
| 60.10 | asphalt, concrete | **1** | **1** |
| | Additional or reduced number of EP depending on<br>+ number of endangered species living in biotope above average<br>+ rich in structures, ecotones etc.<br>+ …<br>- number of endangered species living in biotope below average<br>- eutrophicated sand/or disturbed site,<br>- … | | |

Hence, if the assessment for example yields an extraordinary number of endangered species living in the biotope and / or many ecotones occur, additional values can be given. The "typical hedge on dry soils" equals 23 eco points (EP). Up to 12 extra EP can yield for very rich forms of this biotope (maximum: 35 EP, last number of the triple); if the biotope is of very low quality, EP might be reduced down to 14 (1st number of triple). The ecological value of planned or newly planted biotopes (column 4) ranges below the values of existing biotopes due to their delay in growth and habitat characteristics.

The quantities can easily be determined by the system shown above. For example: a typical hedge of 1,000 m² is to be destroyed for development purposes. The compensation by a new hedge of the same type has to be done by planning a larger hedge (1000 m² x 23/18 = 1.278, roughly 1.300 m²). In some cases it's not possible to create a new hedge but a new piece of forest instead. If for example it makes sense to plant oaks on a suitable site, only 820 m² are needed (1000 x 23/28). The higher the value of the planned biotope, the lower is the area needed for compensation. This is an important issue in landscapes "under pressure", e.g. where strong demands for development occur and space for measures is rare. The numeric approach is valid for finding the quantity of a compensatory measure, but not for it's type. So planning without a concept on how and when to implement a measure are not accepted by the authorities! Therefore, every plan is bound to a professional survey and expertise, based on deep knowledge on landscape ecology and biology.

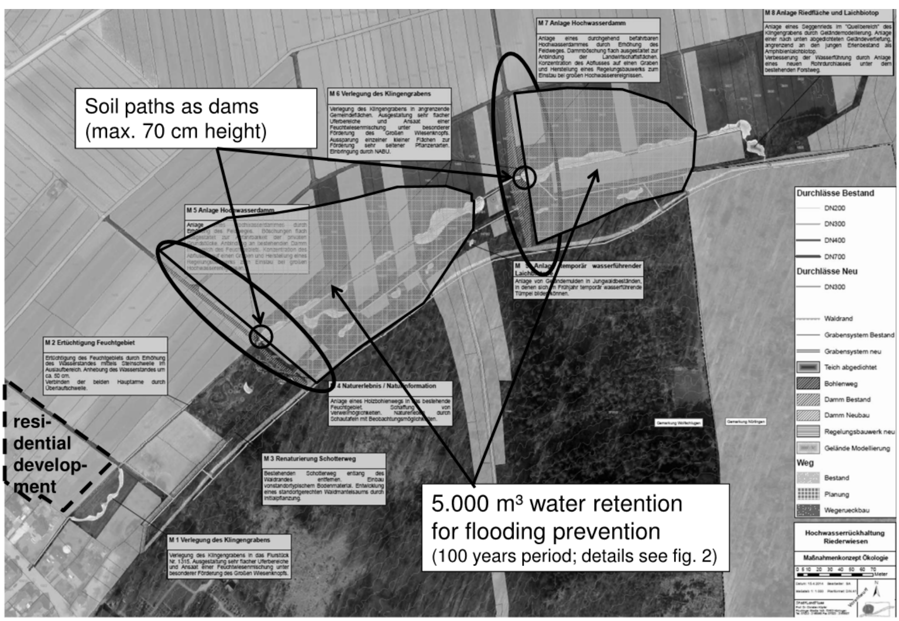


**Figure 1. Overview on the package of multifunctional measures (Stuttgart region project)**

Figures 1 (overview) and 2 (detail) present a multifunctional measure planning ("Riederwiesen") in an "everyday landscape" in the Stuttgart Region where space for measures is rare (Küpfer, 2008 and Küpfer & Arnold, 2015). Fig. 1 points out the main objectives such as water retention to prevent flooding (centre of fig. 1) due to a new residential development (left side). The retention is linked to several measures where biotopes are to be newly created or optimized in their quality. Furthermore, the area will be (partly) accessible for the public and information on the project on panels are given.

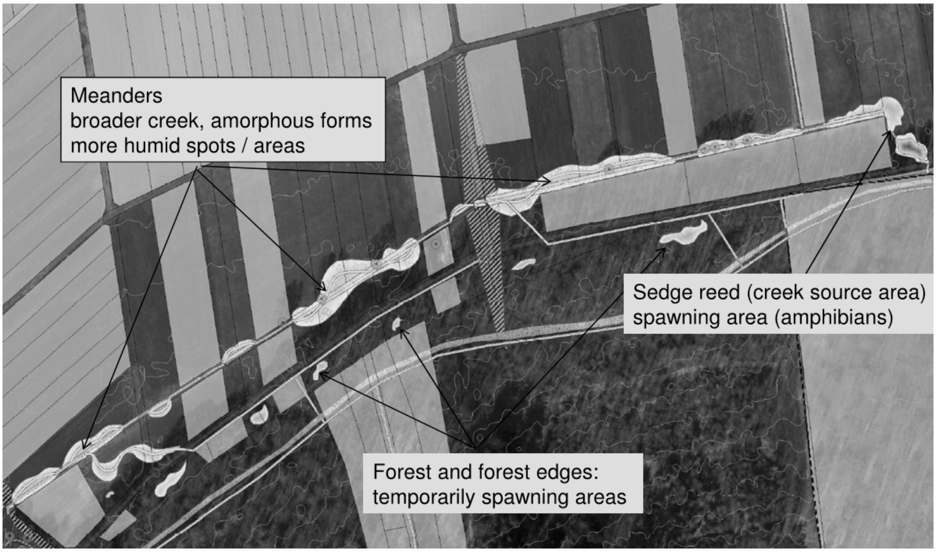


**Figure 2. detail of the measure plan: water retention and biotope connection by measures**

## Discussion

The ecological benefit of the Riederwiesen project was quantified by the eco-account method given in the ÖKVO. Figure 3 shows the quantities of impacts and impact compensations measured in EP. The residential development causes non-avoidable impacts of a value of roughly 220,000 EP. The Riederwiesen project also causes (slight) impacts because soils are to be removed. But it's ecological benefit (green corridor, newly created wetlands and natural structures of a creek) is much higher: the biotope quality will strongly increase caused by regained water retention ("Riederwiesen" meaning reed meadows, saying that in former times the area was very wet and now regains its former retention potential): the Riederwiesen project creates 620,000 EP and therefore covers the total value of the impacts of roughly 240,000 EP. The remaining 380,000 EP will be transferred to the municipal eco-account and can be used to compensate further non-avoidable impacts.

**1. Residential development „Wolfloch“**

ecological deficit (impact on biotopes, soils, …): ⇨ -219.000 EP

**2. Riederwiesen**

impact on soils: ⇨ - 18.000 EP

sum of impacts: ⇨ -237.000 EP

**3. Riederwiesen**

benefit to ecology: ⇨ +620.000 EP

remaining on eco account: 383.000 EP

**Figure 3. Impacts and compensations in the Riederwiesen area measured as eco points**

In general, eco account measures are to be implemented prior to an impact or even independent of foreseen impacts (“early action”). The ÖKVO provides an interest rate of three percent per year to encourage companies or other institutions who cause impacts to implement measures prior to and independently from an impact. The interest is given for implementations up to 10 years prior to the impact. Altogether, this interrelation has increased developer’s ecological awareness and helped to generate measures to improve the ecological quality of the landscape. The interaction between implemented measures and demand of developers is an economical phenomenon: As long as the demand for eco account measures is high, there is no problem. But as the basic idea of eco-accounting is to have a big number of measures (and EP) being implemented, the system regulates itself through laws of the market for eco points.

## Conclusions

Many German landscapes are still rich in naturalness and/or have the potential to provide a high biodiversity. Nevertheless, after World War II an ongoing urbanization has been taking place in the Stuttgart region. Farmland has been transformed into residential and (most of all) commercial land due to strong demands by politics, economics, and population. Transdisciplinary cooperation is strongly needed to achieve the aims of halting the loss of biodiversity, to maintain and to regain the originality of the landscapes where interventions take place.

Although the challenges are strong, there are reasons to be hopeful about finding sustainable solutions: legislation (at the EU, Nation, State levels) gives a framework for the process and – also very important - people's awareness of the problem has risen a lot in recent years. Due to the "Polluter Pays Principle", the eco-account is the key instrument to maintain and regain ecological qualities and biodiversity in landscapes "under pressure".

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