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Assessment and restoration of artificial ponds in the Palatinate Forest

Bewertung und Entwicklung künstlicher Stehgewässer im Biosphärenreservat Pfälzerwald

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Abstract

The survival of the approximately 1,000 artificial ponds in the Pfälzerwald (Palatinate Forest) biosphere reserve is endangered as they continue to be abandoned, but a large number of them have conservation and historical value. An overall management concept is needed as the high costs for restoration and the requirements of the EU Water Framework Directive regarding river continuity will make it impossible to maintain all of the ponds. Most of the ponds are migration barriers for fish and aquatic invertebrates. The assessment methods presented here are based on readily available data for the evaluation of the ecological and cultural-historical importance of the ponds, their implications within the landscape, and their (often negative) impact on stream ecology. The assessment of the condition of the ponds' manmade structures leads to conclusions about the urgency for action. The assessment classes are linked with recommendations for action. In the synopsis of all assessments, management concepts emerge for the individual ponds, and priority lists of ponds can be generated that point out where actions are preferential.

Keywords: *artificial ponds, eco-morphological assessment, migration barrier, historical structures, landscape and recreation, management concept*

Zusammenfassung

Aufgrund zunehmender Nutzungsaufgabe an den etwa 1.000 künstlichen Stehgewässern im Biosphärenreservat Pfälzerwald und ihrer gleichzeitig oft hohen naturschutzfachlichen bzw. kulturhistorischen Bedeutung ist ein Managementkonzept notwendig geworden. Dem Erhalt der Anlagen stehen hohe Sanierungskosten sowie die Anforderungen der EU-Wasserrahmenrichtlinie, für eine biologische Durchgängigkeit der Fließgewässer zu sorgen, entgegen. Die meisten Anlagen stellen nämlich unüberwindliche Wanderbarrieren dar. Die vorgestellten Bewertungsverfahren, basierend auf einfach zu erhebenden Merkmalen, beurteilen die ökologische und die kulturhistorische Bedeutung der Anlagen, die Bedeutung für das Landschaftsbild sowie ihre (negativen) Auswirkungen auf das Fließgewässersystem. Die Bewertung des baulichen Zustands ergibt Aussagen über die Dringlichkeit des Handelns. Die einzelnen Bewertungsklassen sind mit Handlungsempfehlungen verknüpft. In der Zusammenschau der einzelnen Empfehlungen leiten sich Maßnahmen für die einzelnen Gewässer ab sowie Priorisierungen von Teichen, an denen vorrangig Handlungen erfolgen sollen.

Schlüsselwörter: Teiche, Weiher, ökomorphologische Bewertung, Wanderhindernis, historische Bauwerke, Landschaftsbild, Erholung, Managementkonzept

1 Introduction

In the Palatinate Forest there are practically no natural bodies of standing water, but there are more than 1,000 artificial ponds (Koehler & Gramberg 2004). The ponds were originally built for fish or for hydropower, but are increasing being abandoned. Only a few are currently used for fish breeding, recreation, and water sports. In some cases, the related secondary biotopes have developed high ecological value, as shown in Figure 1.

Mainly because of the effects of pollution, the forest administration has chosen not to renew the land leases of a high percentage of ponds (Hahn & Friedrich 2000), leading to abandonment, and the responsibility for the ponds thereby reverts to the forest administration or the municipality. These public owners don't have the resources to maintain all of the bodies of water, and some of these biotopes have been or will be lost. Many of the remaining ponds are in danger of disappearing within the next years.

On the other hand, these unused ponds can still have a negative influence on the associated watercourse, particularly on the movement of animals. No management concept exists for these barrier structures, particularly in terms of the requirements of the EG Water Framework Directive (EU 2000).

Roweck et al. (1988) conducted a very detailed investigation of 19 ponds in the Palatinate Forest with a special focus on vegetation and offered proposals for management and maintenance. Beyond this work, only monographs about individual ponds within this landscape exist. Recommendations for the management of standing bodies of water in the low mountain regions of Germany are very general (e. g., Rahmann et al. 1988) or deal only with specific impacts such as periodic draining of ponds (e. g., Zeitz & Poschlod 1996).

In 2004 the Department of Hydraulic Engineering and Water Management at the University of Kaiserslautern proposed a 'concept for the ecological assessment and development of ponds in the Palatinate Forest' (Hauptlorenz et al. 2007). The Deutsche Bundesstiftung Umwelt (DBU) decided to support this project financially from 2007 to 2010.

There are three main goals of the project:

- Development of an assessment system taking into account the cultural-historical value, the function for recreation, the scenic landscape value, the ecological quality, and the influence of the ponds on the river system.

- Creation of a management concept and a decision-support system based on the assessment.
- Planning and realization of first measures on chosen examples.

2 Data collection

A base data collection protocol was developed to guide the on-site survey. Its parameters are shown in Table 1. In the years 2007 and 2008, 235 ponds were documented using the protocol.

In addition to the parameters in Table 1, vegetation, dragonflies, und benthic invertebrates were documented. Vegetation and dragonflies were chosen as indicators for the ecological quality of a pond in support of the development of the eco-morphological assessment system. Benthic invertebrates collected in the watercourse up- and downstream of the ponds were used to get information about the effects of the ponds on life conditions of the streams. The number of ponds in which each aspect of data collection was undertaken is shown in Table 2.

The ecological quality of the streams and the real and potential watercourse interconnectedness were determined according to existing morphological assessments. A literature search was made to determine the cultural and historical importance of the ponds.

All of the base information was merged and prepared for a database to be used for the subsequent analysis and assessments.

3 Morphological and hydrochemical description

The surface areas of the ponds range from a few square metres up to 12 ha. The dimensions reflect their uses and are presented in Table 3. The height of the dam walls mostly ranges from 2 to 4 m and the maximum water depths are 1–2 m. The most common outlet structure is shown in Figure 2. Some of the outlets were designed to support hydropower, mill, or "drift" usage and consist of an overfall or a tube (Tab. 4). Drift refers to the practice of rafting small pieces of timber. To do this, the watercourses were built into channels with bricked walls during the 19th century, and ponds were built along them to drive the floating system.

More than 80 % of the ponds are centered in the watercourse, and therefore are of high relevance for the stream systems (Tab. 5). Considering this in combination with the structure of the most common outlet (Fig. 2), it is clear that the ponds have a strong influence on the interconnectedness of the streams.

Almost all of the watercourses of the Palatinate Forest are located on sandstone (bunter). Only a thin strip in the east shows the influence of calcium carbonate. The variegated sandstone is lacking in bases and nutrients. The pH values range mostly from 5 to 7, and the conductivity is about 100 µS.

The ponds with low pH and low conductivity are mostly dystrophic and are located in forests. Ponds in meadows have higher pH and conductivity values and are rarely dystrophic. The intensity of fish breeding is connected with even higher pH and conductivity values. The highest values are found in ponds that contain saline runoff from roads and in ponds that are located in the calcium carbonate area where viticulture is practiced.

4 Assessment of the ponds

Existing assessment systems for standing water bodies are focused on nature protection aspects. In most cases there are only general proposals for an assessment (e. g., Schoknecht et al. 2004), and the assessment systems are restricted to natural lakes (e. g., LAWA 1998). Assessment approaches for small artificial bodies of water can be found in Mayer et al. (2003) for an area in the state of Brandenburg but not for the low mountain regions of Germany.

Fig. 1: Secondary biotope with high ecological value at an abandoned pond.

Abb. 1: *Ökologisch hochwertiges Sekundärbiotop an einem aufgegebenem Weiher.*

Tab. 1: Parameters of the data collection protocol.

Tab. 1: *Parameter des Erhebungsbogens.*

Main parameters	Sub-parameters
Pond morphology	Dimension, location, supply, water body, banks
Man-made structures	Inlet, outlet, dam wall, floodwater overfall
Use	Kind and intensity, infrastructure
History	Historical use, age, historical construction
Description of the biotope	Aggradation, shading, vegetation, special structures
Surroundings	Type of forest, land use, settlements, adjacent biotopes, riparian zone
Stream biotope	Stream morphology, passability, adjacent migration barriers
Hydrological chemistry	pH, O_2 concentration, temperature, conductance, trophic condition

Tab. 2: Number of ponds in which data were gathered.

Tab. 2: *Anzahl der Erhebungen.*

Investigations	Investigated ponds
Base data collection	235 of about 1000 ponds
Vegetation	200 of the 235 base data collection ponds
Dragonflies	32 of the 235 base data collection ponds
Macrozoobenthos	11 test points upstream and downstream of 5 different ponds or pond groups

Tab. 3: Typical uses of ponds of different dimensions.

Tab. 3: *Ausdehnung der Wasserflächen und typische Nutzungen.*

Size	Use	Percentage
> 1 ha	Old fish ponds, waterpower ponds, recreation	3 %
0.1 to 1 ha	Old fish ponds, mill ponds	38 %
< 0.1 ha	Drift ponds, new fish breeding ponds	59 %

Tab. 4: Outlet structures.

Tab. 4: *Auslauf-Bauwerke.*

Structure type	Typical use	Percentage
As in Fig. 2, additionally other structures possible	All fish ponds	74 %
Only overfall or tube	Hydropower, mill, and drift ponds	25 %
None remaining or designed with no outlet		1 %

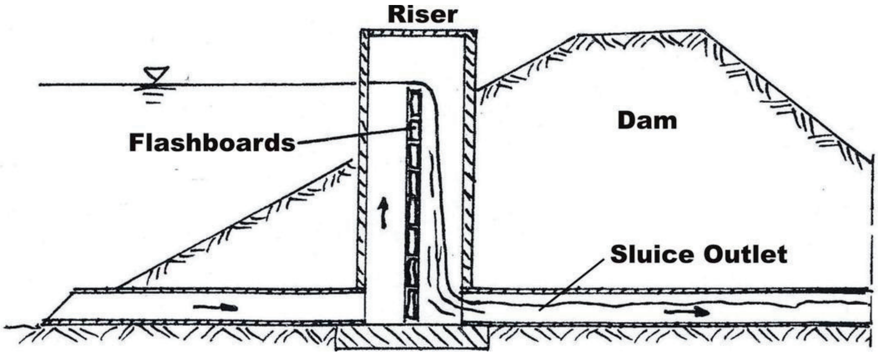

Fig. 2: Principle of the most common outlet construction.

Abb. 2: *Prinzip des häufigsten Auslauf-Bauwerk-Typs ("Mönch").*

Tab. 5: Position of the ponds in relation to the watercourse.

Tab. 5: *Lage der Weiher im Gewässersystem.*

Type	Description	Percentage
Centred	Centred in the watercourse, holding back all of the water, the watercourse is interrupted	82 %
Bypass	Pond and watercourse are located in a parallel connection, holding back some of the water, the watercourse is continuous (bypass channel)	13 %
Spring supply	Pond is located next to the watercourse, supply is only from backed-up or piped springs; the natural spring biotopes have been disturbed or destroyed	5 %

Rahmann et al. (1988) recognized the necessity of considering the following aspects in a management concept for small bodies of standing water: the historical facts and scenic landscape conditions as well as concerns regarding nature protection, agriculture, recreational and professional fishing, and tourism. Additionally the effects of the ponds on the ecological state of the stream according to the Water Framework Directive must be taken into account. Based on this, five assessment systems were created:

1. Condition of the structures
2. Eco-morphological assessment
3. Influence on the watercourse
4. Cultural and historical assessment
5. Scenic landscape und recreation impacts

Each assessment uses the data collection protocol as the main database supplemented with additional data such as historical facts. All five assessment systems are independent from each other, and in all but the first, the ponds are rated on a five-point scale from very high to very low.

4.1 Condition of the structures

The dam walls and the outlets of the ponds exist in different conditions. The current condition of the structures was assessed as intact, damaged, or ruined (Fig. 3). Damaged dam walls endanger the whole pond and the area below. Damaged outlets degrade the pond.

4.2 Eco-morphological assessment

A crucial difficulty in developing an ecological assessment is that there is no natural model for the ponds due to their artificial origin. Therefore we used habitat limiting structures, the diversity of natural structures, and the naturalness of banks and surroundings as assessment parameters as shown in Figure 4.

The assessment scheme was evaluated with the help of biological investigations, primarily the comprehensive vegetation surveys. Correlations between the individual parameters of the data protocol and parameters of ecological quality generated from the biological investigations (such as number of Red List species, Red List vegetation communities, total number of dragonfly species) have been tested. No correlati-

exhaust constructions \ dam wall	intact	damaged	ruinous	not specified
several constructions all intact	39	3		
one construction intact	104	9		2
several constructions two intact	2			
several constructions one intact	18	3		
no intact construction	31	18	1	1
not specified	1	1	1	1

- A no restoration required
- B restoration of an exhaust construction
- C restoration of the dam wall
- D restorations strongly required

Fig. 3: Condition of the structures in the 235 observed ponds and conclusions for their restoration.

Abb. 3: *Zustand der Bauwerke der 235 untersuchten Weiher und Folgerungen für deren Sanierung.*

on, for example, was found between the grade of aggradation and any of the biological parameters, so this parameter was not used for the eco-morphological assessment. Also the "impression of the surveyor" regarding the ecological quality on site was used as guidance for emphasizing relevant parameters for this assessment.

The detailed assessment scheme can not be presented here as it is very complicated. Some parameters, such as oxygen and pH, are only relevant when they exceed critical values. Others are assessed in combination with each other (if-then relation). Some of the degradation parameters are assessed pessimistically, only the worst are included in the overall assessment.

Corresponding to the Water Framework Directive assessment, the eco-morphological value is classified into five levels: very high, high, moderate, low, and very low. The results of the eco-morphological assessment are shown in Figure 5. Most of the investigated ponds have a moderate or low ecological value.

4.3. *Influence on the watercourse*

As mentioned above, ponds centred in the watercourse act as migration barriers. The water quality can also be disturbed under certain conditions. In addition, investigations showed that even slightly eutrophic ponds degrade invertebrate communities in streams. Another influence that must be taken into account is the loss of the stream biotope caused by backwater. Thus, the passability of the man-made structures, the interconnectedness of the stream system with and without the pond, the trophic state, and the morphological quality of the stream are used as parameters to assess the influence of the pond on the watercourse. All parameters can be determined from the observed attributes in the data collection protocol.

The execution of the developed assessment method at the 235 investigated ponds led to a fairly homogeneous distribution among five quality classes with a plurality rated as moderate (Fig. 6). To better understand this, it is necessary to look at the individual assessment components to understand what aspect led to the rating and how significant it is what is also essential for deriving measures. In 87 % of all cases, there was an impassable structure, but mostly this was not a crucial aspect for the stream system. Due to the upstream

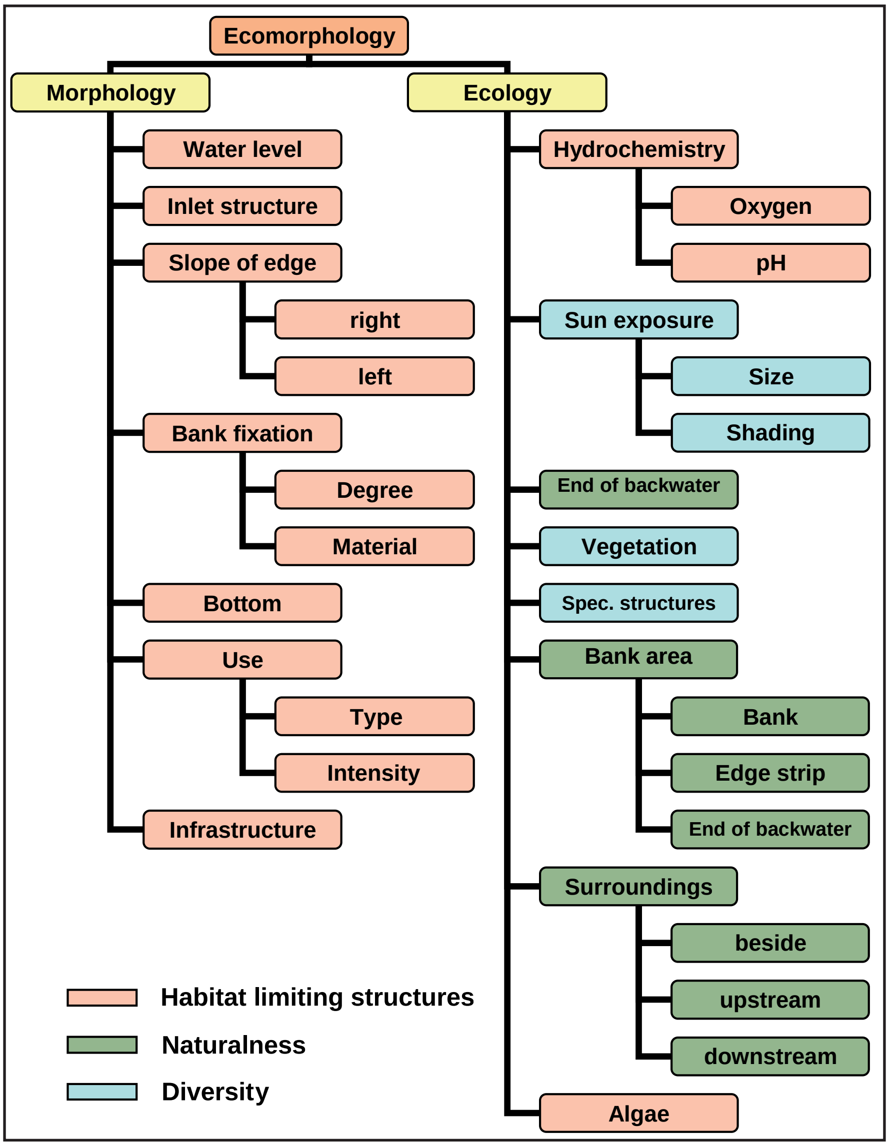

Fig. 4: Eco-morphological assessment structure.

Abb. 4: *Zusammensetzung der ökomorphologischen Bewertung.*

location of the ponds and the presence of other existing barriers, the interconnectedness wouldn't improve significantly in three-quarters of cases if the pond was removed.

4.4. Cultural and historical assessment

The history of the development and use of the ponds is diverse. Four main groups can be differentiated (Tab. 6).

The assessment system uses the age of the pond and the existence of significant cultural-historical structures as parameters. A third parameter is the history of the pond and asks if an individual pond has its "own story" (historical events, regional legends, outstanding use, or change of use), a "common story" of a special group of ponds such as drift ponds, or no special history.

Most of the observed ponds have only a low or very low cultural-historical value. Considering this, there is a growing need to preserve the few ponds with high or very high historical importance (Fig. 7).

4.5 Scenic landscape value and recreation

The landscape assessment takes into account that the most important usage for the ponds in the future will be passive recreation. The Palatinate Forest is famous for its hiking. The assessment considers the spatial diversity, the spatial perception, and the accessibility, estimated from observed attributes such as expanse of the water body, shading, vegetation, hiking trail proximity, special structures, and pond arrangement.

Most of the ponds show a high or moderate importance in scenic landscape terms (Fig. 8).

4.6 Collective assessment and decision support

Each of the five assessment systems leads to different classes and different recommendations for action, e. g., the assessment of the condition of structures results in conclusions about the urgency of restoration measures, and the five

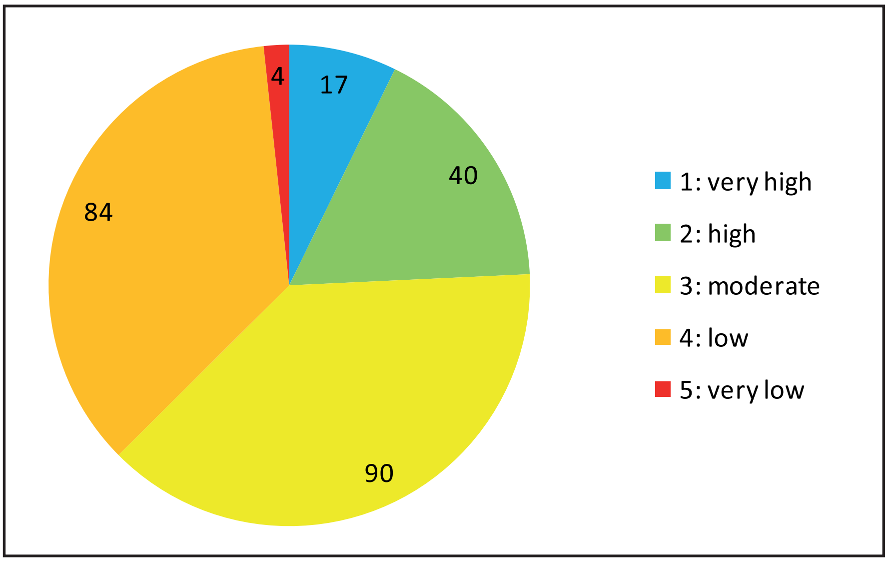

Fig. 5: Distribution of the eco-morphological values of the 235 observed ponds.

Abb. 5: *Verteilung der ökomorphologischen Bewertungsklassen auf die 235 untersuchten Weiher.*

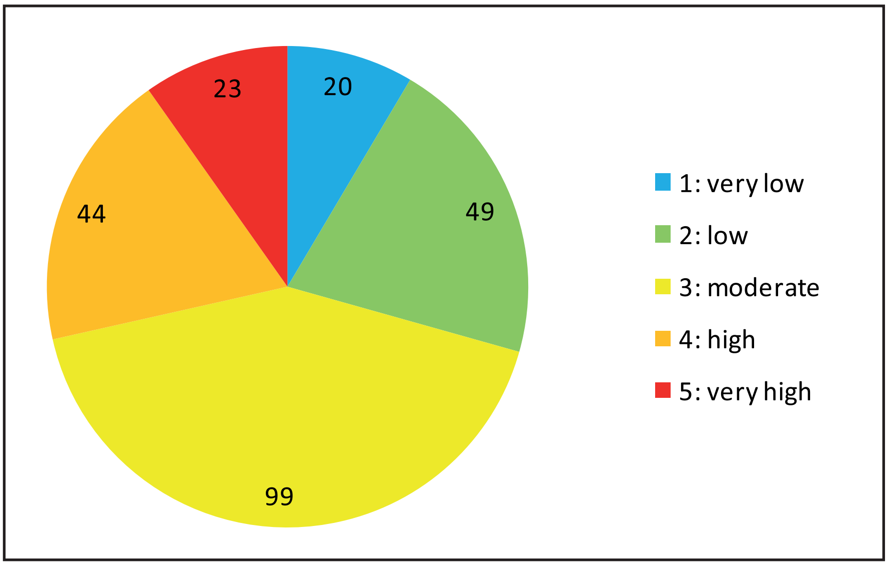

Fig. 6: Distribution of the degree to which the pond influences the watercourse in the 235 observed ponds.

Abb. 6: *Verteilung der Auswirkungen auf das Fließgewässer an den 235 untersuchten Weihern.*

classes of the eco-morphological assessment result in the proposals shown in Table 7.

By assembling the recommendations resulting from the five assessment systems together, a management concept for each individual pond can be generated. The eco-morphological assessment, the influence on the watercourse, the cultural-historical assessment, and the landscape and recreation assessment lead to decision support regarding the preservation or the removal of the pond and measures for improvement. The assessment of the condition of the structures leads to conclusions about the urgency of action when

Tab. 6: The four main uses of the ponds in the Palatinate Forest.

Tab. 6: *Die vier Hauptgruppen der Teichnutzung im Pfälzerwald.*

Use	Description
Old fish ponds	Their existence can be documented to medieval times in some cases. They are positioned in the centre of the watercourse and can be very large. Most of the ponds belong to this group.
New fish ponds	In most cases, some of the water is diverted from the watercourse to small ponds positioned alongside the stream. Sometimes the supply is only by springs, in particular at the edges of wide valleys. These ponds were mostly built in the 20th century.
Mill ponds	Built for hydropower, these ponds are mostly positioned in the center of the watercourse and the mill has been activated by a delivery channel or tube from the pond.
Drift ponds	Used for floating small pieces of timber, these ponds were built with sandstone at the beginning of the 19th century. They were abandoned at the end of the 19th century.

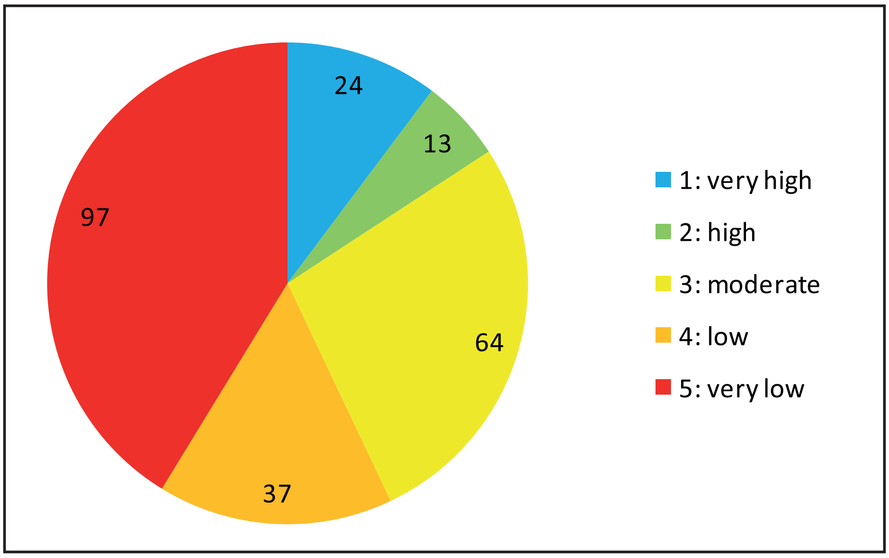

Fig. 7: Distribution of the cultural-historical values of the 235 observed ponds.

Abb. 7: *Verteilung der kulturhistorischen Bewertungsklassen auf die 235 untersuchten Weiher.*

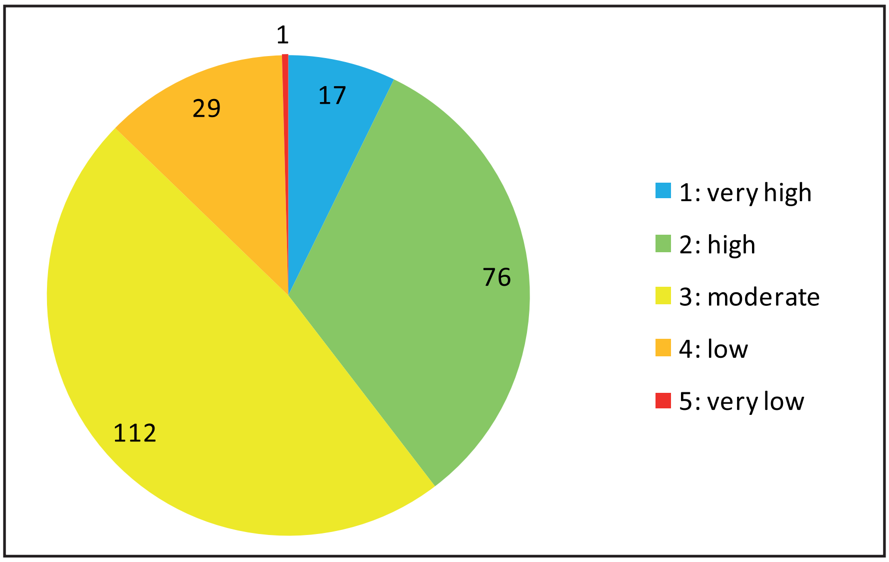

Fig. 8: Distribution of the landscape values of the 235 observed ponds.

Abb. 8: *Verteilung der Landschaftsbild-Bewertung auf die 235 untersuchten Weiher.*

Tab. 7: Decision support derived from the eco-morphological classes.

Tab. 7: *Aus der ökomorphologischen Bewertung resultierende Entscheidungshilfen.*

Class	Management decision support	Measures for upgrading
1 Very high	Conservation of the pond, preservation has highest priority	None necessary
2 High	Conservation of the pond, preservation essential	Ecological support reasonable, but not a priority
3 Moderate	Conservation and preservation desirable	Ecological support measures desirable
4 Low	Not necessary	If preservation is desired for other reasons, ecological support should be provided
5 Very low	Pond can be shut down if there are no other arguments for conservation (decay permitted or removal required depending on other assessments)	If pond preservation is desired (for some other reasons), ecological support measures would likely not be cost-effective

preservation is recommended based on the other assessments.

In addition, a calculated comparison between the eco-morphological value and the influence on the watercourse can be performed. Such an “ecological matrix” compares the ecological values of the pond and of the stream and tries to determine if the backwater is more of a hindrance or more of an enrichment from the ecological point of view. An “anthropogenic matrix” combining the cultural-historical assessment and landscape/recreation value ranks the relevance of the pond for human interests. This may be a further important reason – beyond the ecological argument – for the conservation of the pond.

5 Management Concept

The management concept will be derived from the results of the assessments as explained above and modified based on the existing rights and usages. The main goal is the conservation and maintenance of historically and ecologically valuable ponds. Undesirable uses should be identified and corrected (e. g., intensive fish breeding, retention basin for road drainage), and new options for use can also arise. The ecological value or the value for recreation can be enhanced with mostly low cost measures (e. g., removal of spruce or Douglas fir) whereas in the case of damaged structures, the question of restoration versus decay or removal must be answered.

Possible measures for improvement include the following:

- **Installation** of a **bypass channel** next to the pond (conversion from a centred to a bypass pond)
- **Installation** of a solid **overfall** with rough-textured chute down to the tailwater to improve passage for stream-dwelling organisms
- Medium-term **maintenance and support** of ponds (e. g., conservation of structures, stocking regulation, improvement of the surrounding)
- **Restoration** of damaged structures
- Lowering of water table or **removal** of ponds

Decisions regarding the individual ponds will be made in coordination with local authorities, owners, and users (forestry, municipality, environmental authorities, water management offices, fishing associations, fish farmers, private owners), who can make use of our recommendations for the observed ponds. For the larger number of ponds that have not yet been investigated, the data collection protocol and the assessment systems will enable the stakeholders to reach appropriate decisions.

To realize the first measures based on our management concept, we are currently in negotiation with municipalities and forest administration. One anticipated measure, for example, is the rehabilitation of a damaged dam to maintain a historical drift pond with an existing sandstone outlet (Fig. 9). The planning should include the construction of a fish pass to assure the biological passability of the structure.

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Fig. 9: Drift pond dam from the 19th century with historical outlet structure (right side) and damage requiring restoration (left side).

Abb. 9: *Damm eines Triftweihers aus dem 19. Jahrhundert mit erhaltenem historischen Auslassbauwerk (rechts) und sanierungsbedürftigem Schaden (links).*

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