



MANAGEMENT OF LAKE DUROWSKIE

Wągrowiec – Poznań July 2015

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I. Introduction

The town of Wągrowiec, located at the southern edge of Lake Durowskie, relies heavily on the lake both as a recreational space and as a source of revenue from tourism. As a popular destination for both locals and tourists, the lake and its banks offer space for many activities, including boating, fishing, swimming and mountain biking. These activities bring locals from Wągrowiec, as well as tourists from Poznań. But if they are not managed carefully, the activities risk damaging the lake and its surroundings, reducing its capacity for recreation and tourism.

Developing sustainable and effective management strategies for Lake Durowskie involves considering both the ecological status of the lake as well as social and economic factors. It is important to ask questions such as: How is the lake used? Does this use negatively impact the health of the lake? Do negative impacts reduce the recreation or tourism value of the lake? Understanding the various impacts of lake use help inform a management strategy that minimizes negative impacts to the lake, thereby increasing the lake's recreational value and generating more local revenue from tourism.

1.1 Current status of Lake Dubrowskie

Lake Durowskie is a eutrophic lake. To improve the trophic index, restoration in Lake Durowskie was implemented in 2009, incorporating physical, chemical, and biological measures (Gołdyn et al., 2013). Lake quality is impacted both by inflow from upstream from Lake Kobyleckie via Struga Gołaniecka River, as well as from rainwater run-off from Wągrowiec.

The aerators in the north and south ends of the lake, installed during 2009, physically re-oxygenate water at the bottom of the lake, preventing anoxic conditions from developing.

Iron sulfate is sprinkled across the surface of the lake, causing phosphorus to precipitate out of the water where it becomes unavailable for cyanoblooms. This iron fertilization normally occurs 2-3 times annually based on phosphorus concentration in the lake, although in 2015 it has already been applied three times, in April, May, and June, due to a strong load of nutrients from Lake Kobyleckie (interview with Ryszard Gołdyn, 8 July 2015).

Finally, pike have been introduced, which feed on smaller "white" fish; this reduces predation by white fish on zooplankton (especially daphnia), which allows the zooplankton to more

effectively control algal blooms. Normally fish stocking occurs once per year, with varying success, possibly due to the low number of fish that are introduced. However, stocking was not done in 2014. During the last re-stocking, 4000 pike were introduced for the whole lake. It is possible that intensified efforts could yield higher success rates (interview with Ryszard Gołdyn, 8 July 2015).

It is important to continue the existing restoration measures which address water quality in the lake. For effective long-term management of the lake, however, it is necessary to also develop manage how people use the lake, to ensure the area is being used in non-destructive ways. To understand how the area is being used, it is important identify the lake's stakeholders.

1.2 Stakeholders

The stakeholders for Lake Durowskie – i.e., those that use the lake and benefit from its healthy state – include all those that use the lake or benefit from it in some way. This includes recreational visitors to the lake such as fishermen, swimmers, beach-goers, boaters and mountain bikers. These can be divided into two groups: locals from Wągrowiec, and tourists from Poznań or other cities. Businesses along the lakeside, such as hotels, food vendors, and recreational spaces such as the Aquapark, are also stakeholders in the lake because they benefit from tourists and recreational visitors. Furthermore, the town government is a stakeholder because of the potential revenue that the lake generates for the city through tourism.

Each of these stakeholders receives benefits from the lake, either by appreciating it as a beautiful space where they can access nature, enjoying it as a recreational space, or benefiting from income generated by visitors. As such, they also rely on the health of the lake to continue to receive the same benefits; when the health of the lake is reduced, its attractiveness is reduced, meaning that the ability to use and enjoy the lake to the same degree is no longer possible.

Conflicts of interest

However, the different uses of the lake can generate conflict. When the lake is used in ways that take space away from some stakeholders or are destructive to the lake's health, the lake's capacity to provide recreation, enjoyment, and revenue is reduced for all stakeholders. For example, a motorboater may be enjoying the lake for its recreational value, but is also creating

noise pollution and taking space that might otherwise be used by swimmers or kayakers, thereby reducing their ability to enjoy the lake. In addition, the motorboat's engine generate waves that accelerate bank erosion, which requires financial spending by the local council to implement erosion control measures, using tax money of all locals. Another scenario is when visitors leave behind garbage, introducing harmful pollutants to the lake and decreasing the aesthetic value of the area. This costs the local council money to clean up and reduces recreational value, as no one wants to visit a beach that is covered in garbage.

Misuse of the lake may occur when stakeholders do not feel a sense of responsibility toward the lake. As outlined in 'The Tragedy of the Commons' (Hardin, 1968), when a common resource is used and no one takes responsibility, the resource can be degraded to a point where it is no longer usable. It is therefore important that each user of the lake is conscious that they are an owner of the lake, and have shared responsibility for its care.

1.3 Aim of the Study

This report seeks to determine potential sources of damage or deterioration, and propose possible management strategies to address current problems.

II. Methods and Data Collection

To obtain information about sources of damage to the lake, the Lake Management group explored the lake by kayak, and investigated its trails by foot (Figure 1). By visiting different parts of the lake by kayak, the Lake Management group looked for evidence of erosion along the coast, including gaps in macrophyte belts, eroded shoreline, and use of erosion control techniques. Lake usage was also observed, including swimming, fishing, motorboat usage, kayaking, and other water activities.

Erosion risk was investigated along the trails next to the lake. Footpaths accessing the lake were considered highly erosive, and were marked using a handheld GPS device. The distance between each footpath and the nearest staircase was measured to determine the distance that visitors would need to walk to use a non-erosive alternative. These routes were mapped using Google Earth.



Figure 1: Data collection including measurement of eroded pathways (left) and investigation of the lake by kayak (right).

Finally, information was obtained from the other working groups, including data on macrophytes, algae and macro-invertebrates, as well as physico-chemical data. These data provided further information about the current state of the lake, and areas of higher or lower health.

III. Identified Issues

Access to the lake is possible from multiple areas and in different ways, one road allows drivers to go down to one area where they can put boats in to the water, it is possible to find multiple paths that people use to access by foot to the lake, some of those paths are used too as trails for cycling.

3.1 Slope Erosion

Erosion is predominantly caused by the use of footpaths rather than stairs on the hill leading down to the lake, and by the use of trails for mountain biking. The Lake Management group from 2014 estimated that the amount of sediments entering the lake by erosion was 640 m³ generated just by paths. They also said that 1m³ of sandy soil contains 700 gr of Phosphorus, due to this process the amount of this element in the water can increase leading to problems with the quality of water because some microorganisms will benefit for this situation affecting the equilibrium of the system e.g. cyanobacteria blooms leads to loss in the quality of water,

can produce dead of fish in the area that at the same time can be easily observed and reduce the recreational value of the area.

3.1.1 Footpaths



Near to the city some stairs allow people to go down to the lake. Unfortunately it is possible to observe a trend where more unofficial paths or shortcuts appear farther from the city (Figure 2). The movement of sediments due to erosion occurs quickly in these places due to the slope of the area and lack of vegetation that can reduce movement of sediments into the lake.

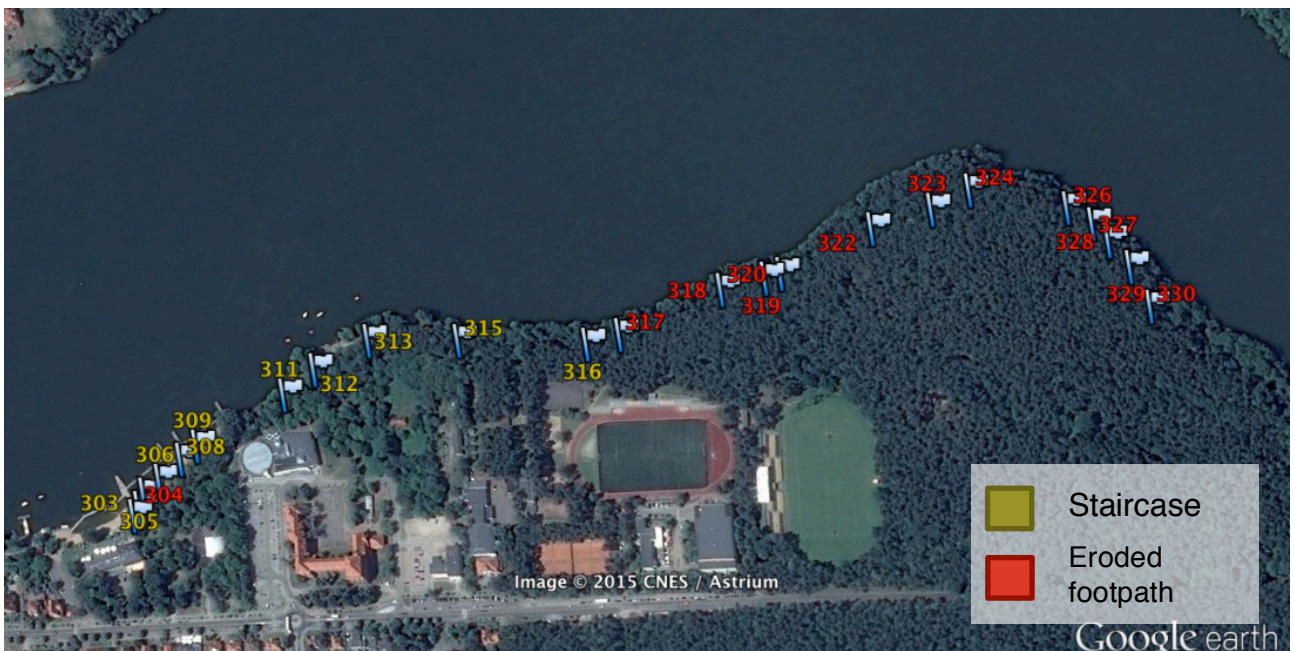


Figure 2 : Staircase (yellow) and Eroded footpath (red) it is possible to observe the change in the pattern were more eroded footpaths appear in the part that is more far from the city.

Additionally official paths are not indicated, promoting the use of unofficial paths. One specific case brings this issue to our attention, there is an unofficial path (flag 317) located just 28m before one of the stairways (flag 316), but this stair is only visible from about 9m before. If

people were aware of the existence of the stairs they would probably use them and not the eroded path.

3.1.2 Mountain Biking



Mountain biking occurs on the western side of the lake farther from the town, and is associated with heavy erosion (Figure 3). The mountain biking circuit is made up of special paths and obstacles that are made of packed dirt, so the impact of mountain bike tires and rain can easily erode material directly into the lake. There are no sediment traps to prevent sediment entering the lake.



Figure 3: on the left one path created for mountain biking, on the right location of the picture.

3.2 Destructive Boat Use



Boat use on the lake is frequent, but some types of boats are more destructive than others. Motorboats, for instance, have a very large negative impact both on the lake's ecological state and on its ability to provide recreational services to other lake users.

The propeller of motor boats mixes the upper layer of the lake, because of that nutrients from deeper layers are brought to upper layers. Additionally, the noise that the propeller makes can disturb fish and other animals and the waves that are generated for the boats have a direct impact on the erosion of the shore. This effect is even stronger if there are no macrophytes in the area. Erosion accelerates the transport of nutrients, especially Phosphorous, into the lake, which increases eutrophication risk.

Although some of the boats stay on the place all the time, some people bring their own boats to the lake. In those cases they have to go through one road that ends in one of the facilities where they can put boats directly into the water. They do not need any permission to use this road, and usually they leave the cars near the lake. By leaving their cars next to the lake, and by using motorboats close to swimming areas, motorboat users reduce the recreational value for other lake users. This pushes out families and others who are using the lake in less disruptive ways. If motorboat use is encouraged, it risks reducing the attractiveness of the area for other types of recreation that is less damaging to the lake.



3.3 Destruction of Macrophyte Belts due to Fishing



Fishing spots on the shoreline prevent plant growth: the incorrect construction and use of jetties can generate problems with erosion of the shore line and affect the presence of macrophytes. Since macrophyte belts function as physical barriers, lakes without wide macrophyte belts are very sensitive to physical impacts such as wave action. Macrophyte belts not only function as barriers against the impacts from offshore, but also work as a sediment traps against sediments coming from the land. Additionally they provide refuge for zooplankton and for small fish. A lake with macrophytes can lead to a more stable ecosystem.



As a result of the sum of different factors, including the reduction of macrophyte belts, reproduction rate of fish can be affected in a negative way. Additionally, reduced water quality can lead to reduced biodiversity, because only species which tolerate certain conditions can survive.

3.4 Littering



Littering appears to occur frequently along the paths next to the lake. This is a problem for two reasons. First, it reduces the aesthetic value of the area, which decreases the lake's attractiveness for tourists and other lake users. Second, it introduces more pollutants to the environment, which can negatively impact the health of the lake.

IV. Management Options

For effective management, it is important to incorporate strategies that address these problems both in the short- and long-term.

4.1 Short-term management: Infrastructure and Regulation

To address destructive use of the lake in the short-term, infrastructure and regulation can be implemented to change people's usage patterns of the lake

4.1.1 Erosion Control

Stairs and Signage

It is important to build more stairs in strategic locations and indicate them clearly (Figure 4), in order to prevent the generation of non official paths.



Figure 4: Proposed stairways could be built at points A and B, where people access the trail from roads. Signs indicating stairways could be installed every 50m to encourage people to use stairs rather than eroded pathways.

Parking Areas

It is necessary to control the entry of vehicles to the area near the lake. The cars or the trailers where the boats come can not stay near the lake due to the fact that they occupy space that can be used for other purposes, and disturb one of the most important recreational areas. Therefore it is necessary to provide a space for people to park so that they do not leave their cars down by the lake. Cars would pay a one-time or monthly participation fee to access the road down to the lake. However it would not be permitted to leave cars by the lake after unloading their boat into the water. Cars could be left in paid parking areas on the upper level above the lake; parking lots farther from the lake could offer parking for lower prices.



4.1.2 Boat use

We suggest two different things concerning this issue. First, the use of private boats has to be regulated as it is necessary to allow only a certain number of boats inside at the same time. The owner of the boat should pay a certain amount of money to have the right to use it in the

lake, which would vary depending on the type of boat (motorboats including jet ski vs. non-motorboats).



Second, we believe that the lake could be divided into areas where motorboat use is permitted or restricted, which can help maintain or even improve the quality of the lake. The Lake Management group of 2011 proposed restricting motorboats from the northern part of the lake, and only permitting their use in the southern part. We agree with this suggestion and further recommend that motorboats avoid macrophyte belts, staying minimum 60m from the shoreline. We also suggest the implementation of swimming areas in locations where people already swim and where as a result macrophyte belts are not present. These areas should be indicated by a circuit of buoys.

4.1.2 Fishing

As management strategies we consider that the number of jetties has to be reduced. This could be done by providing fishermen with alternatives, which could include:

- ability to rent fishing boats and electric motors at reduced rates or for a participation fee
- access to jetties that can be reserved ahead of time, and are accessible to key-holders (Figure 5)

These fishing boats and jetties could be made available by the town of Wągrowiec, which would lead to a source of revenue for the municipality. Indeed, the town can use boats that it already owns in order to start this collaboration with fishermen. In exchange for receiving access to the boats and to jetties, fishermen would agree to a code of conduct that included using less bait, not damaging macrophyte belts, and leaving the jetty or boat clean after use. The fishermen can then book ahead of time, so rather than paying for a private jetties they can pay for the hours of use that they reserve on the public jetties or boats; the price for the use of

these options would be not expensive. This cooperation would benefit the town by minimizing damage to the lake.

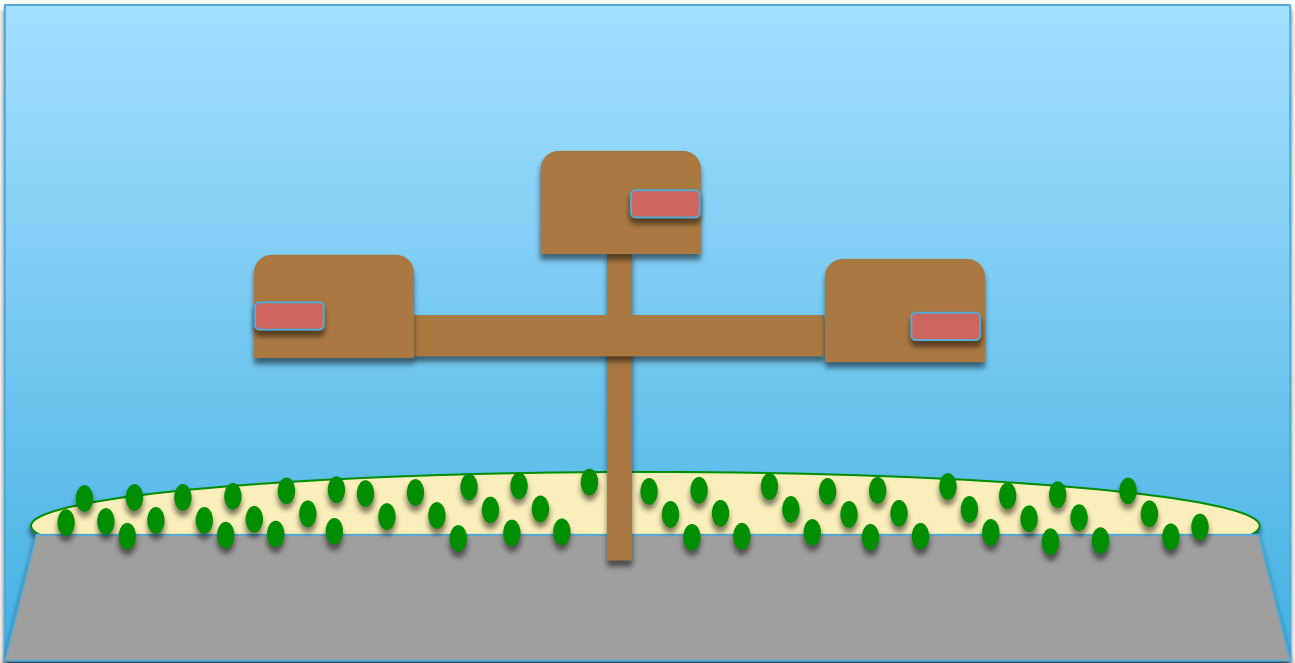


Figure 5: public jetties could be made available to fishermen to encourage them to use non-harmful structures rather than fishing directly on the bank or from private jetties. These structures would have multiple platforms and be placed in front of the macrophyte belt to avoid harm.

4.2 Long-term: Empowering Beneficiaries

To address lake use issues in the long-term, it is important to change attitudes towards the lake by increasing awareness about caring for the lake, and building a sense of ownership and responsibility towards lake in stakeholders. This can be done through education and community outreach, as well as by fostering cross-boundary cooperation with communities upstream from Lake Durowskie.

4.2.1 Education

Educating users of the lake about the impacts of lake use will play a vital role in changing attitudes toward the lake, and in increasing the sense of ownership and responsibility for the lake as a common resource. It also provides an opportunity for communication between scientists, policy makers, and the public.

The Lake Management group has identified two main interest groups to whom education should be aimed, based on their use of the lake: fishermen, and local visitors and tourists.

Fishermen

Fishermen are among the main users of Lake Durowskie. The periodic restocking of pike in the lake is organized by the same private company that issues fishing licenses, which means that the fishing community is actively involved in restoration measures in Lake Durowskie.

However, activities by fishermen can also damage the lake. The use of more bait than necessary can introduce high loads of nutrients into the water, contributing to eutrophication (Lake Management Group 2014). Meanwhile, as mentioned previously, fishing along the banks can contribute to the destruction of macrophytes, which reduces the ability of the lake to filter run-off water as it enters, and which contributes to erosion of the banks.

To counteract the potential damage that fishermen can cause to the lake, it is important to engage with them to discuss responsible fishing practices. Information should be provided regarding bait usage, and the importance of protecting macrophyte belts due to their role in preventing bank erosion and trapping sediments. This education can take place in the form of meetings between the town council and fishing associations. Informational pamphlets about bait usage and the protection of macrophyte belts could also be produced and given out to fishermen.

Local Visitors and Tourists

The other main interest group that uses the lake area and to whom education should be aimed are visitors to the lake, both locals and tourists. These groups both use the lake recreationally – beach-going, swimming, boating, etc. – and can be targeted through education and outreach strategies encouraging responsible use of lake areas. To involve both locals and tourists in caring for the lake, it is important to foster a sense of responsibility for the lake, and create awareness about protecting the lake to promote low-impact use of the area.

Generating awareness about protecting the lake can be done both through educational means and through involving the community. Educational approaches can include signage and information points in the lakeshore park and at intervals along the trails.

Informational signs could provide information about the lake and its surroundings, educating readers about topics such as (a) how the aerators function and what they are doing in the lake; (b) the role of macrophyte belts in lake ecosystems; and (c) lake species that they might observe during their visit.

Signs can also encourage responsible behavior and low-impact use of the lake and surroundings. For instance some could direct people to follow paths and use stairways, explaining that taking shortcuts contributes to lakeshore erosion. Signs reminding people that "this is your lake", and to "leave nothing but footprints, take nothing but memories" can also inspire a sense of pride in the area and in keeping it clean (Figure 6). These also work to instill a sense of ownership by reminding visitors to the lake that it is their space, and that they should not leave a trace when they use it.



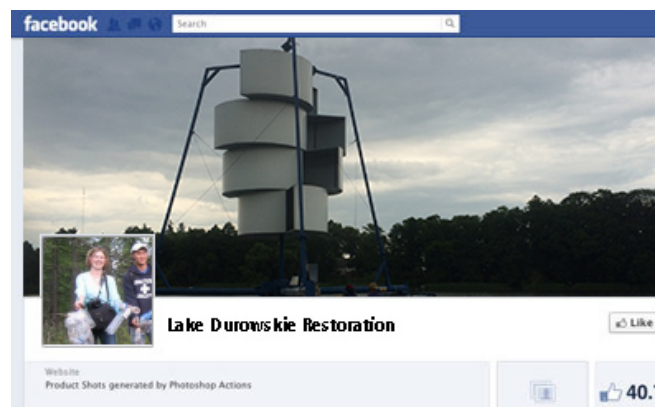
Figure 6: Signs promoting low-impact and responsible use of the lake and its surroundings can help to foster a sense of ownership and responsibility toward the lake.

4.2.2 Involve the Community

In addition to educating stakeholders, involving the community is important in building a sense of responsibility toward the lake. This can be done by involving community members in lake cleanup and in small monitoring projects, by giving children an opportunity to become involved through school or through summer sport camps, and by instituting educational events such as a town "Lake Day".

Social Media

Social media can be a powerful tool to keep people informed about restoration activities, and a useful space to educate people about how to care for the lake. A Facebook page (right) could serve as a useful point for information about



lakeside events that people can participate in, such as nature walks, kayak tours, or trash collection.

Summer Sport Camps and School Science Projects

It is especially important to involve the younger generation, as they are the future stewards of the lake, and have a vital role to play in sustaining the lake's quality and importance for the community. Activities that introduce children to the lake ecosystem, and instill a sense of pride for its care, will create a future generation that has a strong interest in maintaining and improving the lake's health.

Activities could include bird watching, nature walks, camping, kayak tours, and trash collecting along the shores. These could be implemented through the pre-existing summer sport camps that occur in Wągrowiec, which include children both from the town and from surrounding areas.

Additionally, school groups could do science projects related to the lake; their work could be publicized on the website or social media platform, which would give students a sense of pride in their work, and acknowledge them for their participation in restoration efforts. Science fairs, where students present their work, could extend awareness to the students' families and friends.

Lake Day

Social events that celebrate the lake could also be a fun and effective way of involving the community. A town event such as "Lake Day" could occur annually, and be a space to educate people about caring for the lake (Figure 7). This event could include music in the park by the lake, as well as educational stalls that provide leaflets and information about lake health, the importance of macrophyte belts, and suggested low-impact activities that families can enjoy by the lake. Activities by the pier could include kayaking or swimming races, as well as a competition to collect the most trash along the trails. Bike tours could be offered between Wągrowiec and Kobyleckie to the north.



Figure 7: A flyer from Oakland, CA, shows how a Lake Day could be advertised to engage the community.

Lake Day could also provide a good venue for students to present the results of their science fair projects.

4.2.3 Cross-Boundary Cooperation

Management of Lake Durowskie does not need to be limited just to the lake itself; it can also include upstream lakes and communities. Lake Durowskie is downstream from Lakes Kobyleckie, Buchowieckie, Grylewskie, Laskowickie and Smolary. At present the upstream lakes have not undergone the same restoration activities as in Lake Durowskie, and are considered eutrophic. Water from these eutrophic upper lakes is carried downstream via Struga Gołaniecka River, increasing the amount of nutrients flowing into Lake Durowskie and lowering the water quality. Eutrophication can result in algal blooms, fish death, and other impacts that result in reduced aesthetic and recreational value; this makes the area less attractive, which can lead to a loss in economic benefits as fewer people would be willing to use the area as a recreational space.

To effectively address this risk, it is important to implement a long-term management strategy that prevents further inflow of nutrients from upstream. This could be done by fostering cooperation between the community of Wągrowiec and other upstream communities, to provide incentive for upstream communities to restore their lakes. By providing economic support, Wągrowiec can encourage upstream communities to implement restoration measures. In this way, the quality of water flowing into Lake Durowskie would be improved, and upstream communities would see economic benefits as well as improvements in the quality of their own lakes.

This report recommends first and foremost a cooperation between Wągrowiec and the upstream town of Kobyleckie. As the closest lake to Lake Durowskie, Lake Kobyleckie is eutrophic and suffers from input of agricultural run-off, which is carried to Lake Durowskie via Struga Gołaniecka River. A partnership to restore Lake Kobyleckie and bolster the area's local economy would have positive impacts on the health of Lake Durowskie.

Restoration partnership

The first and most important goal of the collaboration between the communities would focus on restoration of both lakes. Through meetings and communication between members of both communities, Wągrowiec could support restoration efforts in Lake Kobyleckie by providing

data and information on its own restoration process, and by recommending restoration techniques and management practices that have been successful on Lake Durowskie.

Implementing restoration measures on the upper lake could also reduce restoration costs for Lake Durowskie, as restoration measures such as iron fertilization would need to be implemented less frequently.

Tourism growth

To support Kobyleckie in its restoration efforts, Wągrowiec can help to bolster the economy in the upstream community by encouraging visitors to also go to Lake Kobyleckie. This can be done by diverting mountain bikers and cyclists to Kobyleckie through improved bike paths and new biking infrastructure, by providing extra signage directing visitors to Lake Kobyleckie, and by creating more parking areas in Kobyleckie.

The installation of a mountain bike circuit within the Kobyleckie district could attract the mountain bikers who currently ride close to the edge of Lake Durowskie. This would accomplish two things: first, it would increase the number of visitors going to the Kobyleckie area, increasing local spending and thereby generating more economic revenue for the area. Second, it would reduce the number of mountain bikers by Lake Durowskie, which in turn would minimize erosion; this would reduce erosion control costs for Lake Durowskie.

Furthermore, improved bike paths between the two communities could also connect more visitors to the Kobyleckie area. Signage could direct both cyclists and motorists to Kobyleckie, guiding them to available recreational areas.

New parking areas near Kobyleckie Lake would also provide space for overflow summer parking from Lake Durowskie, providing access to alternative recreational spaces for people who can't find parking in Wągrowiec on crowded days.

Expectations and Outcomes

A collaboration between Wągrowiec and Kobyleckie would result in better quality water in both lakes, increased economic benefits for the Kobyleckie community, and reduced erosion stress from mountain biking by Lake Durowskie. It would also be attractive to tourists and lake visitors, because it would expand their recreational options and provide additional parking during peak season.

This collaboration could be expanded to include other upstream communities, implementing restoration and economic collaboration measures that could include lakes as far as Smolary.

V. Conclusion and Recommendations

5.1 Conclusions

Management of Lake Durowskie currently incorporates restoration methods that seek to restore the lake to a mesotrophic state. This has seen some successes, and water quality was observed to improve this year in the southern part of the lake (Physico-Chemical Group, 2015). But to holistically manage Lake Durowskie, it is crucial to also ensure that stakeholders use it in non-destructive ways that maximize its capacity to provide recreational and economic benefits.

Currently, destructive practices include erosion due to unofficial footpaths, use of motorboats, destruction of macrophyte belts due to fishing, and littering. These can be prevented or minimized by implemented both short- and long-term management strategies that ensure best practice usage of the lake and surroundings.

5.2 Recommendations

The final recommendations of the Lake Management group are the following:

- Improve infrastructure that encourages people to use the lake and its surroundings in less destructive ways. This can include the following measures:
 - Better signage and new stairways in strategic spots will reduce hillslope erosion by encouraging people to use stairs, thereby preventing the creation of new footpaths;
 - Fees for motorboat use will reduce the number of motorboats on the water. Revenue generated from fees can be used for erosion control along the lakeshore;
 - Public jetties and boat rental to fisherman will reduce macrophyte destruction and bank erosion by providing alternatives.
- Increase education and involve the community to increase lake users' sense of ownership and responsibility toward Lake Durowskie. This can be done in the following ways:
 - Education targeted toward fishermen, local visitors, and tourists can promote more responsible and low-impact usage of the lake and surroundings;

- Summer Sport Camps can incorporate educational activities related to the lake, which would instill a love of nature and sense of responsibility for the lake in the young people who are future stewards of Lake Durowskie;
- "Lake Day" and other educational events could promote enthusiasm and a sense of community pride in keeping the lake clean.
- Foster cross-boundary cooperation between Wągrowiec and Kobylec to improve the quality of Lake Kobyleckie. This would incorporate the following aspects:
 - Creating a mountain bike circuit near Kobylec would boost their local economy by directing more visitors to their town. This would reduce mountain biking by Lake Durowskie, thereby reducing erosion and minimizing erosion control costs;
 - Boosting the local economy of Kobylec would give them the means to implement restoration measures for Lake Kobyleckie; this would improve the quality of water entering Lake Durowskie, reducing restoration costs;
 - Both Wągrowiec and Kobylec would observe improved water quality and economic benefits.

Through these recommendations, the Lake Management Group hopes to convey that the most effective strategy to manage Lake Durowskie is a combination of short- and long-term measures that influence people's behavior and usage of the lake in the short term, but which also change attitudes in the long term. In this way, the lake's capacity for recreation and tourism is maintained and even enhanced.

VI. Acknowledgements

We would like to thank the collaboration of the professors from and Kiel University who have helped to collect and analyze data during the past two weeks. Especially we would like to thank our group supervisor, Wilhelm Windhorst, for guiding us and prompting us to think holistically in our work. For the professors from the Uniwersytet im. Adama Mickiewicza w Poznaniu, we would like to extend a huge thank you for making us feel so welcome and at home during our stay. Finally, we are grateful to the work and collaboration of our classmates, whose brainstorming helped us with our final report, and whose laughter and good company helped to make these past two weeks memorable.

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