1. Contestant profile

▪ Contestant name:	**Ruderal LLC: Sarah Cowles Benjamin Hackenberger**
▪ Contestant occupation:	Landscape Architect
▪ University / Organisation	With students from Free University School of Architecture
▪ Number of people in your team:	**12**

2. Project overview

Title:	Optimizing Excavated areas in Floodplains to Increase Biodiversity Using 3D Modeling Software
Contest: (Research/Community)	Community
Quarry name:	Lezhbadini

Abstract (max 0.5 page)

The Lezhbadini Quarry includes alluvial floodplain areas and upland conditions. The current condition of the quarry includes excavated areas and spoils stockpiles. Excavated areas retain water and can potentially provide habitat for a diversity of species and improve water quality. Our project will test an economical method to rehabilitate riverbed mining sites using 3D modeling software to increase biodiversity and improve water quality. This process will be refined and optimized to meet the requirements of Heidelberg's on-site equipment. Using "off the shelf" 3D terrain and parametric modeling software: Rhino (https://www.rhino3d.com/) and Grasshopper (https://bit.ly/3G4PMHT) we will analyze and optimize the existing, inactive excavations. The operations include "relaxing" the vertical profile of pits, increasing the irregularity of the water-land borders to increase surface area, and redistributing excavation spoils. With both drone imagery and fieldwork, we will monitor the evolution of the modified excavations over time and publish the results. The project will be led by landscape architects (Ruderal LLC) involved in Georgian ecological rehabilitation projects and will include a team of students in architecture and environmental science.

Special acknowledgements to Free University Students Ani Sadunishvili, Baka Mamuchishvili, and Zaza Chighladze.

And extra to the studio team, especially Anna Tsao, Marie Schega, Zizi Adamia, Tilly Rigby, Giorgi Nishniadidze, Ana Petriashvili, Luka Tavzarashvili, and Iveta Chxikvadze.

Final report (max 9 pages)

1. Bringing the Ballast

At the end of February, the Ruderal team visited the Lezhbadini Quarry to get familiar with the context and the scale of the operation. Heidelberg operates along a reach of the Khrami river near Khanji-Gazlo, near the Georgia-Azerbaijani border. Quarry Manager Zviad introduced us to the different elements of the quarry landscape: the river, floodplain, riparian forest zones, and wetlands. He explained the mechanics of the gravel extraction process, which includes using excavators to create gravel bars to prevent flooding of extraction areas. Using our drone, we gathered aerial images of the finer details excavation and hydrological patterns.

Next, our team will create diagrams of the quarry operations, and draw a series of cross-sections of the river to understand the spatial and temporal actions on the landscape. We will return in late March to record the different types of emergent vegetation present in the floodplain and riparian forest.

2. Damba Dynamics

After our initial visit in late winter, students working with the Ruderal design team compiled satellite imagery, reviewed drone footage, and composed diagrams describing the mining process.

Comparing the satellite imagery with drone footage reveals a river in constant flux, coming to life each spring as a new layer of vegetation spreads over the bed of silt and rocks freshly deposited by winter flooding. Birds, mammals, and amphibians move in to establish a new, temporary ecosystem. Ballast mining disturbs the riverbed on a timeline of weeks to months, but this impact can be superseded by spring floods that occur on a much larger scale.

Excavators grapple with this shifting landscape by creating dambas, (roughly translated as “dam”). According to the on-site excavators, dambas can be built to protect machinery, but they can also be removed to allow larger floods to replenish excavated material.

This quarry is an active mine, which complicates traditional notions of ecological restoration. Our project proposes that the damba building process canincrease the geomorphological diversity of the mining site. Processes of excavation, damba building, and flooding have the potential to create a wide range of microhabitats that support increased species biodiversity.

In the next steps of our project, we will observe sites with distinct morphological conditions to document how spring and summer bring these remarkable microhabitats to life.

3. Landscape Interpretation: Geomorphology and Succession on the Lezhbadini Site

After our latest site visit, the Ruderal team interpreted imagery collected through smartphones, drones, and satellites to draw connections between varying landscape types and the underlying geological diversity. After identifying these connections, we can design with a better understanding of how geomorphological diversity can support biodiversity in this dynamic site.

In the riparian zone, floodwaters create a diverse field of geomorphological conditions and habitat patches, ranging from late-successional (well established) bosques to dry gravel floodplains deposited by recent floods. These diverse habitats are created by the geomorphological dynamics of the river, but also by human disturbances such as excavation of mining material and the accumulation of mining byproducts, called *spoil heaps*.

This type of diversity is *geomorphological*, and is driven by a collection of factors including elevation, slope, solar aspect (the orientation of a slope to the sun), rock/soil composition, exposure to the river's main channel flow, and the influence of form at various points of the river's flow cycle. Our proposal will use digital modeling tools to replicate these geomorphological factors and generate a landscape with increased *geomorphological diversity*.

The geomorphologically diverse zones identified during our second site visit are also biologically diverse. The migration and dispersion of mammals, amphibians, reptiles and birds (and at a slower rate, plants) takes place at the quarry site and the adjacent landscape. Unique living conditions favourable to different species are created due to varying material configurations and compositions, exposure to climatic elements and processes like erosion, and other factors of disturbance within each habitat zone.

4. Combining Early and Late Succession in Geomorphologically Diverse Habitats

Our site visit with Klára Řehounková opened up new insights into the role of geodiversity and geomorphological diversity in early successional habitats and to the overall biodiversity of the site. We were able to take a much closer look at the biodiversity already developing on the site, and saw more clearly the connections between early and late successional habitats. Rather than focusing on developing large patches of late-succession bosques, we propose a mosaic of habitats in different stages of succession.

The geomorphological heterogeneity of the zones generates more opportunities for biodiversity to develop across the quarry site. This diversity is further enhanced by constant changes and interactions between major zones of disturbance or stasis, as well as between the species inhabiting those sites.

Geomorphological and biological diversity are interlinked. These diagrams show how large-scale dynamics of the site, such as flooding and mining, impact the spatial development of early and late stage habitat zones.

Special thanks to Klára Řehounková, whose guidance on site, book "Near-natural restoration vs. technical reclamation of mining sites in the Czech Republic", and numerous other articles have helped us draw connections between the concept of geodiversity and geomorphological approaches driven by digital modeling.

5. Early Succession on the Site

After speaking with Dr. Řehounková, the role of early successional sites became more important to our project. This blog post investigates the biodiversity of early-successional sites, which can be bolstered by guiding the disturbance caused by mining and flooding on the site. Sub-zones of the overall site that are mined or flooded every two or three years can contribute to the geodiversity and biodiversity of the site significantly.

Even the aggregate of seemingly static spoil heaps changes significantly in a relatively short amount of time due to erosion and accumulation from flood, rain, wind, and anthropogenic disturbances.

Fauna on the site have a greater, more deliberate radius of movement between bordering microhabitats. Amphibians, for example, favour complex mosaics of habitats to complete the various stages of their life cycles. As the diagrams depict, dry elevations like berms, spoil heaps and ridges are found in close proximity to wet habitats like shallow gravel and vernal pools, all of which provide feeding and breeding grounds for frogs and toads among other amphibians.

For reptiles, grassy areas provide hunting grounds while the various South- and North-facing aspects of spoil heaps allow reptiles like snakes and lizards to thermoregulate in both sunny and shady spots. Birds nesting in the intact bosque at the river edge also visit the quarry, indirectly yet significantly shaping the landscapes through their movement of food and nest building materials. Where conditions are suitable, droppings of seeds grow into saplings, then shrub and trees, gradually contributing to the accumulation of organic material and altering the topographic composition of the floodplains.

6. Developing a "Geomorphological Toolkit"

We analyzed the landscape patterns of spoil pile fields and began to build digital modeling tools to rapidly visualize possible berm configurations. The tool simultaneously estimates the quantity of resources necessary to construct the design.

Parametric tools allow designers to set formal parameters or logics for design objects (in this case berms and spoils piles) and rapidly compute many iterations at once. In this project, we use the parameters of damba construction and spoils piling to create a tool to model and visualize dambas and spoils piles in various configurations.

In this project, the boundaries of the proposed berm system are the edges of the intact forest and the main channel of the river at the start of the project. These edges are subdivided into start and end points for the berm and distances between all possible start and end points are calculated. Each of these possible berms is then recalculated as a set of bi-arcs, or curves composed of two simple arcs. Because these arcs face opposite directions with respect to the path of the sun, each face of the berm creates a different gradient of exposure to the sun.

These models are overlaid on drone imagery to create quick and rigorously measured collages. While more complicated landscape qualities such as textures and objects (e.g. a pool of water or an escarpment) remain loose, the digital model remains rigorous.

7. Designed Landscapes as Frameworks for Interpretation

The project approaches the design of landscape through two lenses: geomorphological diversity and interpretation of biodiversity by visitors to the site. The protocol for iterating public landscape that this project proposes creates a landscape experience in which geomorphological diversity is organized and perceived along every pedestrian path. Landscape architects use compositional rules of landscape photography and painting to give meaning and order to this perceived landscape.

While digital modeling tools allow us to understand the metrics and ecological performance of damba configurations, pictorial landscapes allow us to interpret that landscape from a human perspective. Designing the damba landscape from both a metrics-based and pictorial perspective allows us to create a landscape imbued with interpretation. We can use these digital tools to set up different ecological conditions along pedestrian paths and viewpoints, creating key moments where differing ecological conditions occur together.

8. Further Research: Restoration in Dynamic Contexts

[In ecological restoration,] "the rules of the game are familiar, the final positions only approximately predictable." (Lucia Grosse-Bächle, Strategies between Intervening and Leaving Room, p. 238)

The dynamic qualities of riparian systems challenge traditional conceptions of restoration. Because the baseline condition of our site is constant change, restoration is a process of amplifying geomorphological diversity rather than attempting to return the river to a specific state. Our design intent is to guide disturbance from flooding and mining interventions to increase the diversity of habitat zones within the extraction zone. The next steps of our research beyond this project will integrate tools of analysis to test the performance of various berm iterations.

When designing to increase biodiversity in a disturbed riparian system, it is important to recognize the limits of a deterministic or predictive approach to ecosystem restoration. By beginning with the familiar “rules of the game”, we are able to push a certain ecosystem toward increased geodiversity without the need to determine precise outcomes. As Grosse-Bächle notes, designers would do better to approach restoration as a dialectic relationship between humans and nature. Rehabilitation is understood as a “third nature” co-created by natural processes and calculated, specific human interventions (Grosse-Bächle p. 232)

At the quarry site, which has been unintentionally homogenized by monotonous patterns of extraction, we encounter the possibility of a dialogue, or interaction between the sites altered by different levels of disturbance andintervention. Introducing a geomorphologically diverse set of post-extraction sites can produce a greater range of interactions between emerging habitats and thus increase the overall biodiversity of the quarry site.

Which dialogues are found at the quarry?

- **River** - disturbance, re-channelling by humans, but also annual flooding by river (water still originates from river, not humans)
- **Bosque and floodplains** - **birds** disperse seeds, transport materials from intact bosque and places further away that build up early successional bosque along the floodplains of the quarry - here human action would be to
    - Leave new trees/shrubs undisturbed to grow into intact bosque
    - Maintain the the growth (redirect, stop, redirect, stop)
    - Intervene drastically ex. Cutting down tree shrub for other species to develop more easily (without having to work against strong competition of tree shrubs etc)
- **Spoil heaps** - existing material is directly moved by humans and creates new habitats, here also different possible dynamics
    - Undisturbed: vegetation increases and covers spoil heaps over time, weight and gravity “flatten” elevation of heaps
    - semi-disturbed by ex. Partly moving material to another place - success disturbed/stopped, re-configured/directed, but vegetation/animals present adapt and adjust to this change
    - fully disturbed ex. If spoil heap completely moved, entire composition reconfigured, succession stopped

Conclusion

The conceptual framework of geomorphological diversity presents interesting opportunities for collaborations between ecologists, designers, and industry. As designers we are responsible for turning scientific data and principles into formal spaces that perform ecologically, socially, and educationally.

While the results of this project are preliminary, they present bright multiple promising paths forward for increased accuracy, precision, and flexibility as we continue to develop these modeling tools and design processes. Significant research lies ahead in articulating the spatial, material, and energetic parameters of geomorphological diversity. The project also revealed the need for greater accuracy and integration of spatial metrics and the parameters of other projects, including the textures and compositional logics of landscape images.

THE QUARRY LIFE AWARD

HEIDELBERGCEMENT

To be kept and filled in at the end of your report

Project tags (select all appropriate):

This will be use to classify your project in the project archive (that is also available online)

Project focus:

- X Beyond quarry borders
- ☐Biodiversity management
- ☐Cooperation programmes
- ☐Connecting with local communities
- ☐Education and Raising awareness
- ☐Invasive species
- X Landscape management
- ☐Pollination
- X Rehabilitation & habitat research
- ☐Scientific research
- X Soil management
- ☐Species research
- ☐Student class project
- ☐Urban ecology
- ☐Water management

Flora:

- X Trees & shrubs
- ☐Ferns
- ☐Flowering plants
- ☐Fungi
- ☐Mosses and liverworts

Fauna:

- X Amphibians
- X Birds
- X Insects
- X Fish
- X Mammals
- X Reptiles
- ☐Other invertebrates
- ☐Other insects
- ☐Other species

Habitat:

- ☐Artificial / cultivated land
- ☐Cave
- ☐Coastal
- ☐Grassland
- ☐Human settlement
- X Open areas of rocky grounds
- ☐Recreational areas
- X Sandy and rocky habitat
- ☐Screes
- X Shrub & groves
- ☐Soil
- X Wander biotopes
- X Water bodies (flowing, standing)
- X Wetland
- X Woodland

Stakeholders:

- X Authorities
- X Local community
- X NGOs
- X Schools
- X Universities