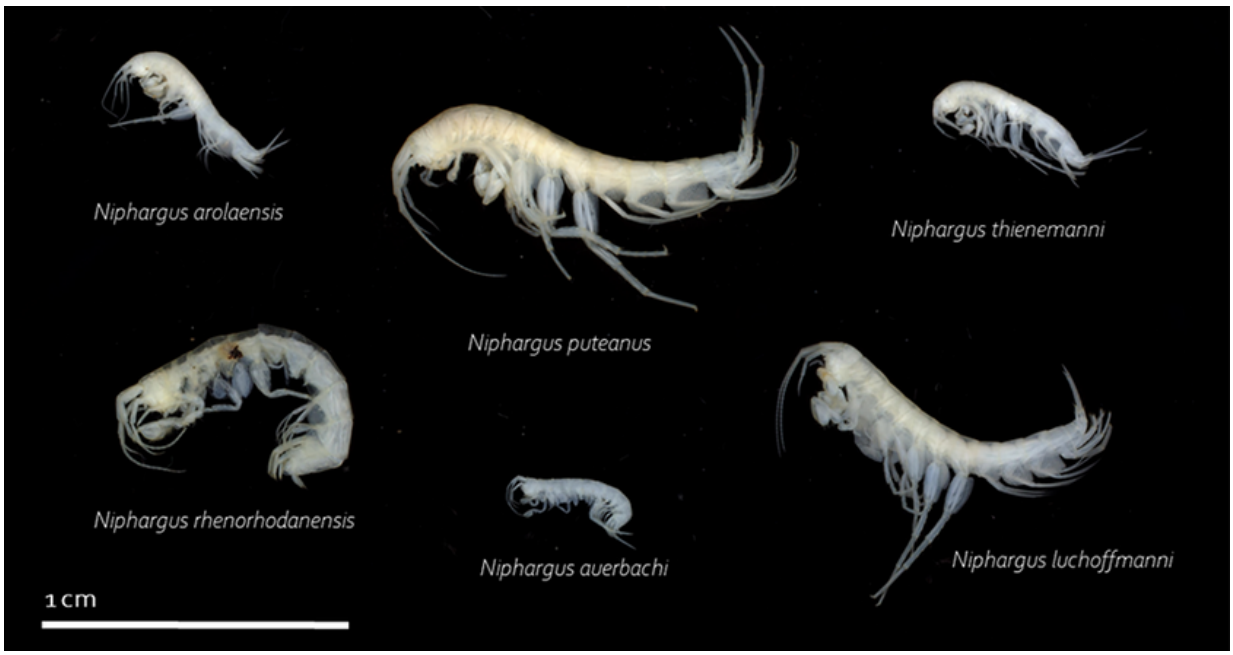
Land use influences organisms living underground

October 22, 2024 | Ori Schipper
Topics: Drinking Water | Biodiversity | Ecosystems | Pollutants

Researchers at Eawag have complied and analysed a globally unique data set on the occurrence of various amphipods in groundwater. They were able to show that land use within a radius of up to one kilometre from the groundwater extraction site has an impact on these sensitive creatures. This could indicate that the current groundwater protection zones are not large enough.

Four fifths of Switzerland's drinking water comes from hidden underground aquifers. Numerous groundwater extraction sites tap into these reserves. Drinking water supplies are under increasing pressure. "In order to fulfil the quality criteria, some extraction sites have to be taken off the grid or water from impacted sites has to be mixed with less impaired water," says aquatic ecologist Mara Knüsel, who is currently completing her doctorate in Professor Florian Altermatt's research group at the aquatic research institute Eawag and the University of Zurich.

In recent years, Knüsel and her colleagues have been working intensively on researching small creatures that are at home in dark and cold water: groundwater amphipods. They resemble tiny shrimps, but unlike the differently pigmented freshwater amphipods on the surface, they are white and blind. They play an important role in the function of groundwater ecosystems.



Some of the groundwater amphipods found. They are all adapted to life in the dark and are therefore unpigmented and without eyes. They are among the largest organisms in groundwater (Photo: Eawag).

Less nitrate at groundwater extraction sites surrounded by forests

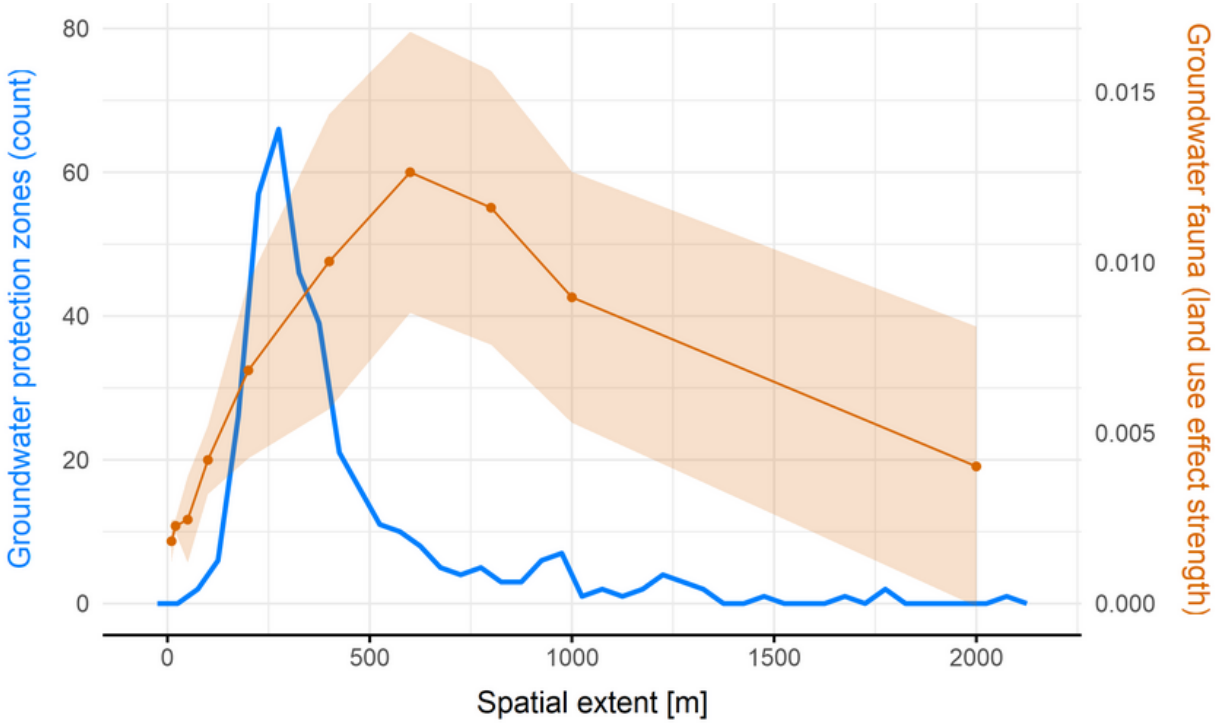
In their latest article, which has just been published in the journal Ecological Applications, the researchers link the occurrence of amphipods to the type of land use on the Swiss Central Plateau. The researchers often found amphipods at groundwater extraction sites in the middle of a forest, whereas they encountered amphipods much less frequently at groundwater extraction sites near farmland. The groundwater at the extraction sites close to crops also tended to be more contaminated with nitrate than at the sites surrounded by forest, which indicates poorer drinking water quality.

However, Knüsel's colleague Roman Alther points out that it would be premature to conclude that the water quality is poor because amphipods are absent. "Hydrogeology also plays a role," he explains. "Factors such as the structure of the local groundwater aquifer, including pore size and water chemistry, can also influence whether or not amphipods are present." The researchers therefore regard the presence or absence of the small organisms more as a supplementary indicator. "As an indication that the biology at a particular location may be impaired," says Alther.

The amphipods are collected from the groundwater (Photo: Eawag).

Influence of farmland still found within a distance of up to a kilometre

The researchers also show that the type of land use has an impact on the occurrence of amphipods in a larger radius. In the data set, farmland located 600 to 1,000 metres away from the groundwater extraction site also leaves a negative signal in the groundwater. In Switzerland, the Water Protection Act stipulates that protection zones must be created around groundwater extraction sites in order to protect valuable drinking water from contamination and other harmful influences. On the Swiss Central Plateau, however, these protection zones cover an area that extends on average only 300 to 400 metres around the extraction site. “We conclude that the currently established protection zones may not be large enough to prevent possible negative effects of land use on groundwater communities,” the researchers state in their article.



The effect of land use on the groundwater fauna (green line) changes with the distance from the groundwater extraction site (x-axis). This also applies at a distance where there is practically no groundwater protection zones (blue line). (Chart: modified according to Knüsel et al. / http://doi.org/10.1002/eap.3040)

A unique habitat

Just like lions in the savannah, amphipods in groundwater are at the top of the food chain. As a result, they also influence all other living organisms at lower trophic levels. “The great diversity of life forms in groundwater is still largely unexplored,” says Knüsel. The researchers have therefore only just laid the foundations with their data set on amphipods: their findings could be an argument in favour of a possible extension of the groundwater protection zones. Beyond this, they are keen to “raise awareness among the general public that groundwater is not only a precious drinking water reserve,” says Alther, “but also a unique habitat that needs to be preserved.”

New findings about amphipods

The Eawag researchers worked closely with water supply managers who are responsible for over 900 different groundwater extraction sites throughout Switzerland and “without whose help this work would not have been possible,” as Mara Knüsel emphasises. The collaboration resulted in a systematic collection of amphipods, in which the researchers also discovered several previously unknown species with the help of genetic analyses. The researchers also traced how the last ice age around 20,000 years ago affected the spread and the present occurrence of groundwater amphipods. “We find some species only in places that were not

glaciated," says Knüsel.

Groundwater fauna in Switzerland

The aim of the AmphiWell project is to record and document the occurrence of groundwater organisms at extraction sites throughout Switzerland. In order to collect as much data as possible throughout Switzerland, Eawag researchers work together with water supply managers.

Cover picture: Farmland or forest? Researchers found amphipods less frequently at groundwater extraction sites located near farmland than at those in the middle of a forest (Photo: Wikimedia, Adrian Michael).

Original publications

Knüsel M, Alther R, and Altermatt F. Terrestrial land use signals on groundwater fauna beyond current protection buffers. Ecol Appl. (2024). http://doi.org/10.1002/eap.3040

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 Location: Switzerland (41,285 km²), including data from 906 sampling sites.
Taxon: groundwater amphipods, genera Niphargus and Crangonyx (Crustacea, Amphipoda).
Methods: we applied a highly standardized citizen science approach to collect repeated groundwater fauna samples in collaboration with municipal drinking water providers. Using detection–nondetection data of the genetically identified groundwater amphipod species, we assessed the overall species diversity of both rare and comm

on species. The distribution of commonly found species was predicted using m
ultispecies occupancy modelling.
Results: we retrieved 3882 samples fro
m 906 sites, yielding 2350 groundwater amphipod individuals. We identified a
remarkable species diversity, comprising few commonly and many rarely found
species. Considering commonly found species, we identified distinct distrib
ution ranges, low local species richness and a predominance of negative co-o
ccurrences. In contrast, a major portion of species were found rarely (gener
ally at just one or two sites each), distributed uniformly throughout the st
udy area and unrelated to common species' recognized hotspots. Many of these
rarely found species are not yet formally described.
Main conclusions:
Our results give robust emphasis on the rare occurrence and narrow distribu
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subterranean biodiversity patterns along a Late Pleist
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um (LGM); stygofauna' (96 chars) description => protected'Understanding spatial
patterns of biodiversity within the context of long-te
rm climatic shifts is of high importance, particularly in the face of contem
porary climate change. In comparison to aboveground taxa, subterranean organ
isms respond to changing climates with generally much lower dispersal and re
colonization potential, yet possible persistence in refugial groundwater hab
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rge-scale effects of glaciation on contemporary groundwater biodiversity pat
terns is still very limited. Here, we tested how Late Pleistocene glaciation
influenced the diversity and distribution of 36 groundwater amphipod specie
s in Alpine and peri-Alpine regions, characterized by extensive glaciation c
ycles, and how its legacy explains contemporary diversity patterns. We based
our analysis on an unprecedented density of ~ 1000 systematic sampling site
s across Switzerland. Using presence–absence data, we assessed biodiversit
y and species' ranges, and calculated for each site within-catchment distanc
e to the Last Glacial Maximum (LGM) glacier extent. We then applied a slidin
g window approach along the obtained distance gradient from LGM ice-covered
to ice-free sites to compute biodiversity indices reflecting local richness,
regional richness, and differentiation, respectively. We found a strong sig
nal of the LGM ice extent on the present-day distribution of groundwater amp
hipods. Our findings revealed pronounced species turnover and spatial envelo
pes of individual species' occurrences in formerly ice-covered, ice-free, or
transitional zones, respectively. While local richness remained constant an
d low along the LGM distance gradient, groundwater communities in LGM ice-co

vered areas were more similar to each other and had lower gamma diversities and decreased occurrence probabilities per sliding window compared to commun ities in Pleistocene ice-free areas. These results highlight the significant impact of Pleistocene g...' (2137 chars) serialnumber => protected'0906-7590' (9 chars) doi => protected'10.1111/ecog.07321' (18 chars) uid => protected33018 (integer) _localizedUid => protected33018 (integer)modified _languageUid => protectedNULL _versionedUid => protected33018 (integer)modified pid => protected124 (integer) Knüsel, M.; Alther, R.; Locher, N.; Ozgul, A.; Fišer, C.; Altermatt, F. (2024) Systematic and highly resolved modelling of biodiversity in inherently rare groundwater amphipods, *Journal of Biogeography*, 51(11), 2094-2108, doi:10.1111/jbi.14975, Institutional Repository
Knüsel, M.; Alther, R.; Altermatt, F. (2024) Pronounced changes of subterranean biodiversity patterns along a Late Pleistocene glaciation gradient, *Ecography*, 2024(8), e07321 (10 pp.), doi:10.1111/ecog.07321, Institutional Repository

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Related Links

Project Amphiwell

Contact

Mara Knüsel
Tel. +41 58 765 6727
mara.knuesel@eawag.ch

Roman Alther
Senior scientist (he/him)
Tel. +41 58 765 5638
roman.alther@eawag.ch

Florian Altermatt
Tel. +41 58 765 5592
florian.altermatt@eawag.ch

Annette Ryser
Science editor
Tel. +41 58 765 6711
annette.ryser@eawag.ch

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