

Institute of Hydraulic Engineering and Technical Hydromechanics

Dr.-Ing. Torsten Heyer

Beaver Burrowing Activity in Levees

Characteristics, Countermeasures, Cavity Detection

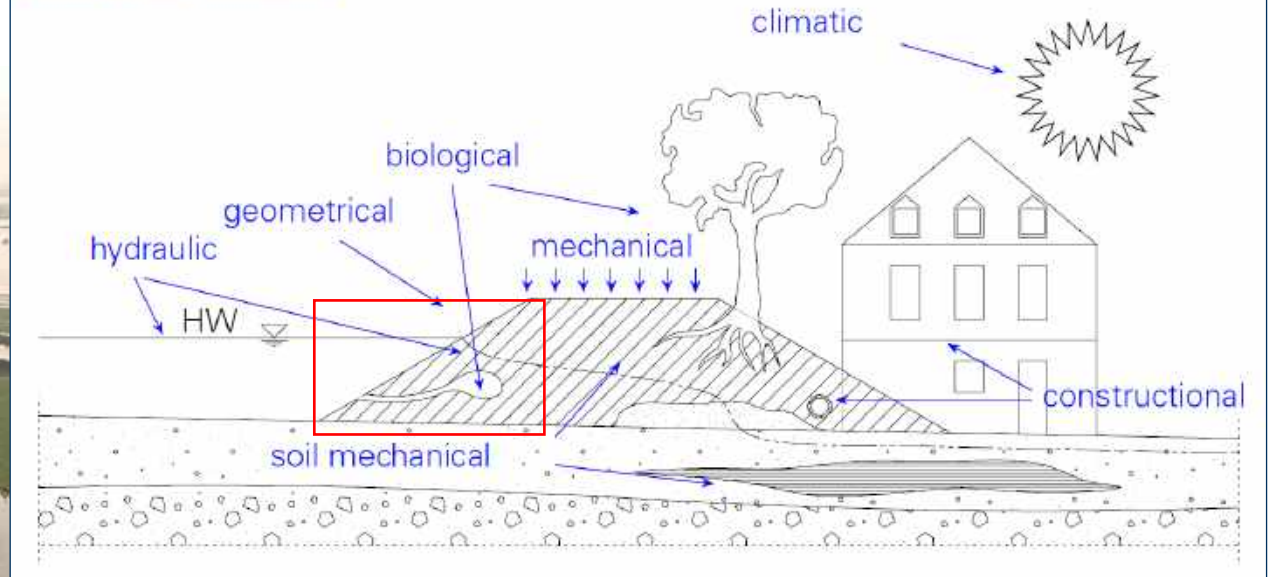
International Beaver Burrowing in Infrastructure Symposium (IBBI)

Wageningen (NL), February 3rd, 2025

What's the problem?

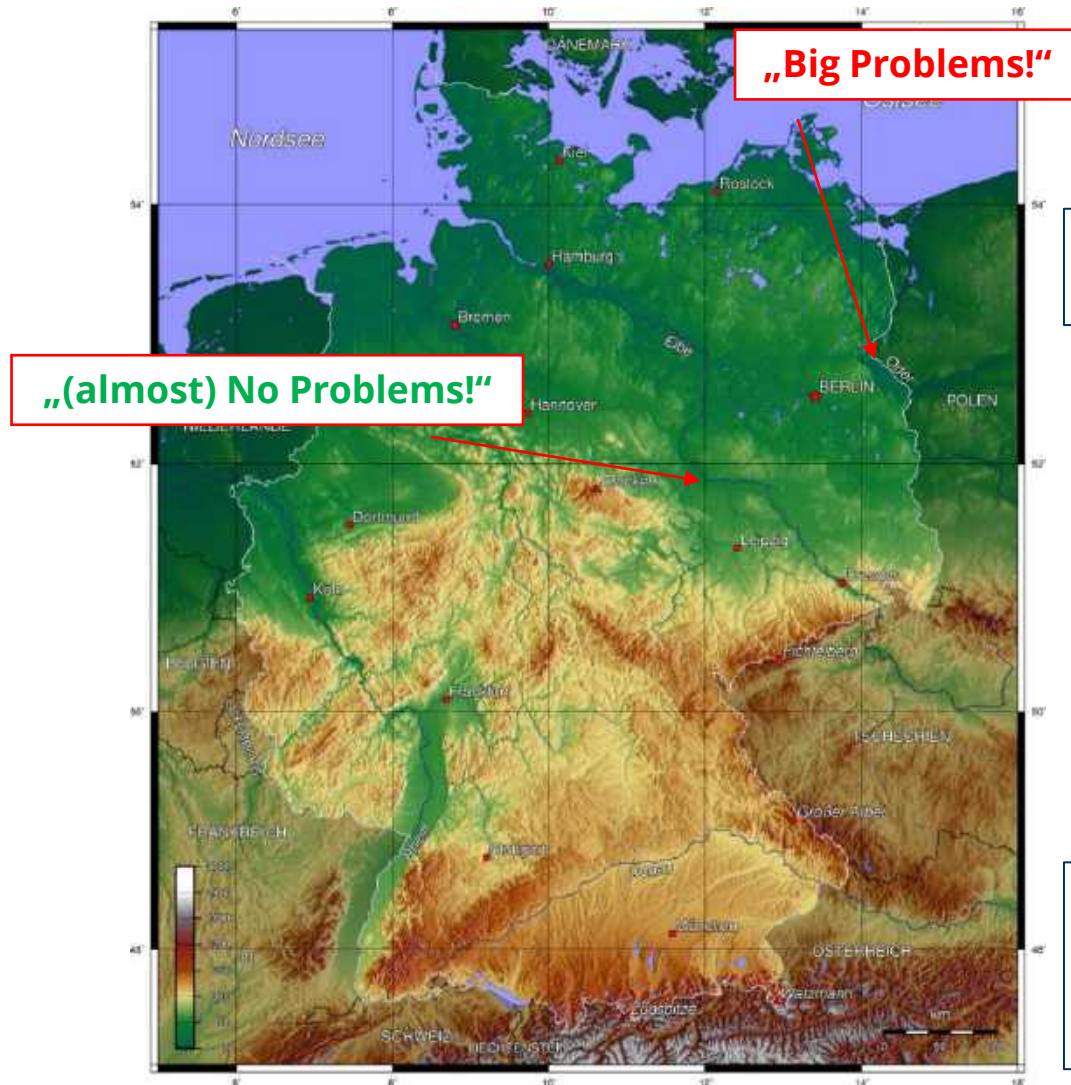


Relevant factors



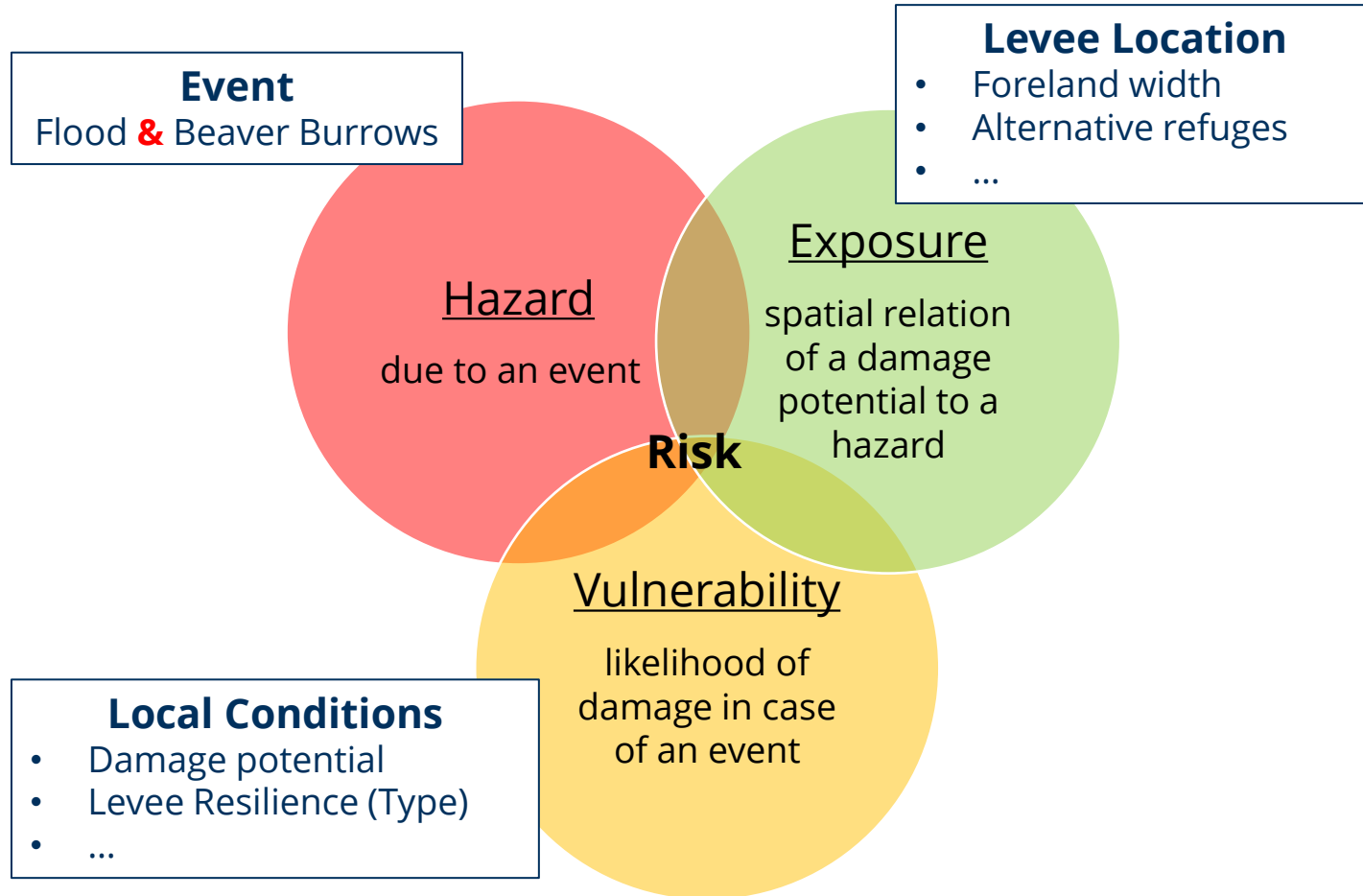
Failed Levee at the Elbe River, Flood 2002 (Photo: LHW Saxony Anhalt)

Levees at (Beaver) Risk?



$$\text{Risk}_{\text{Event}} = \text{Probability}_{\text{Event}} * \text{Damage}_{\text{Event}}$$

[EUR] = 0,0...1,0 * [EUR]



What's the problem?

- Cavities (tunnels, tunnel systems, dens) and surface damages at
 - River banks → erosion and sediment input (small water courses)
 - Foreland → danger to river maintenance works
 - Levees (on water- and landside) → reduced reliability → risk increase
- Flood at Oder River in 2010: 550 Damages incl. 150 larger tunnel systems in levees (10-20 m into levee)
- most damages in levees, if distance to main river bed is < 20 m



Source: F. Krüger



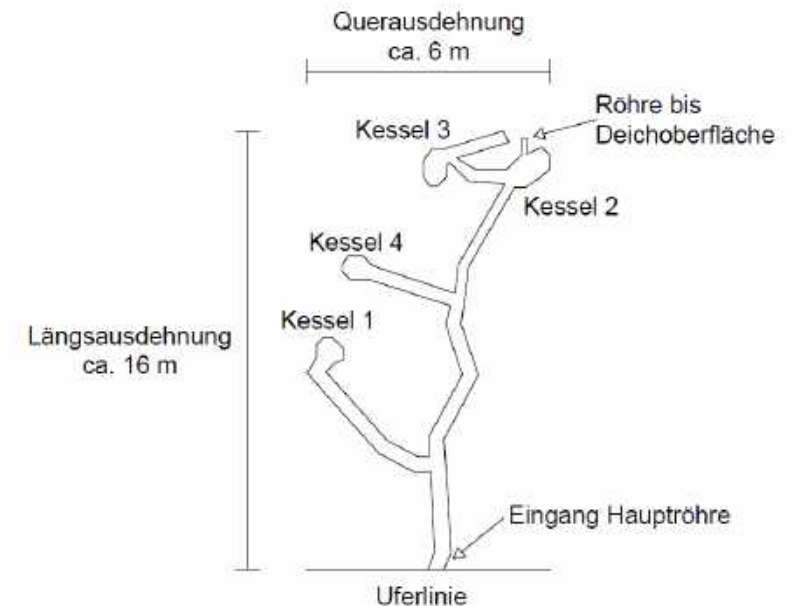
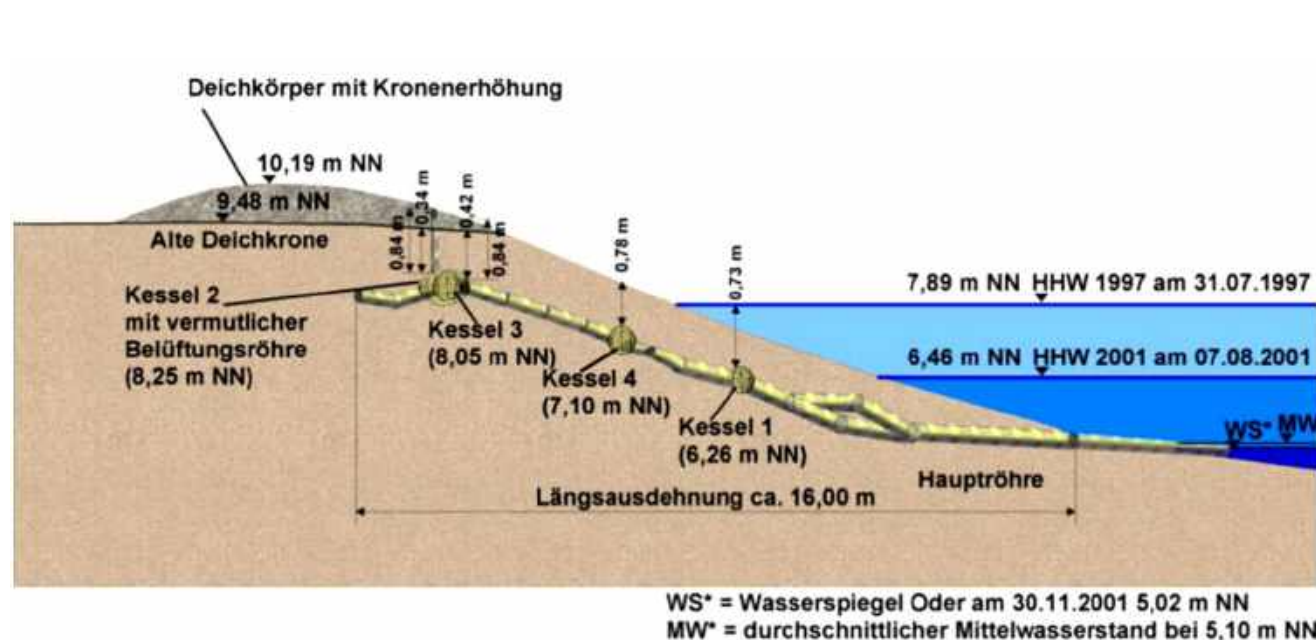
Source: F. Krüger



Source: rbb 24

What's the problem?

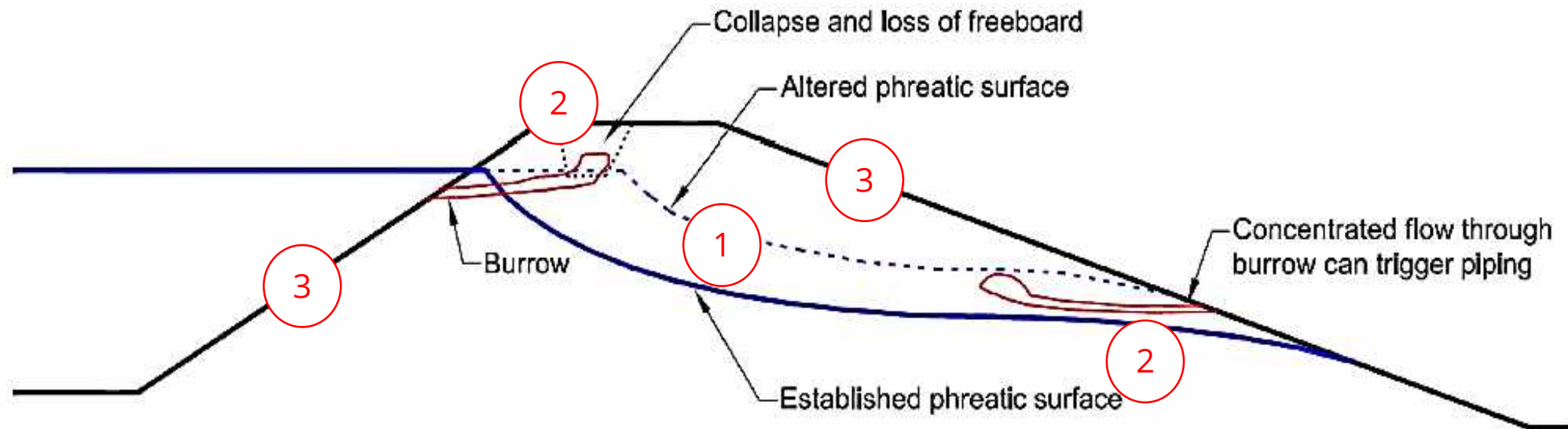
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Source: Hahmann (2004)

Impact on Levee Stability

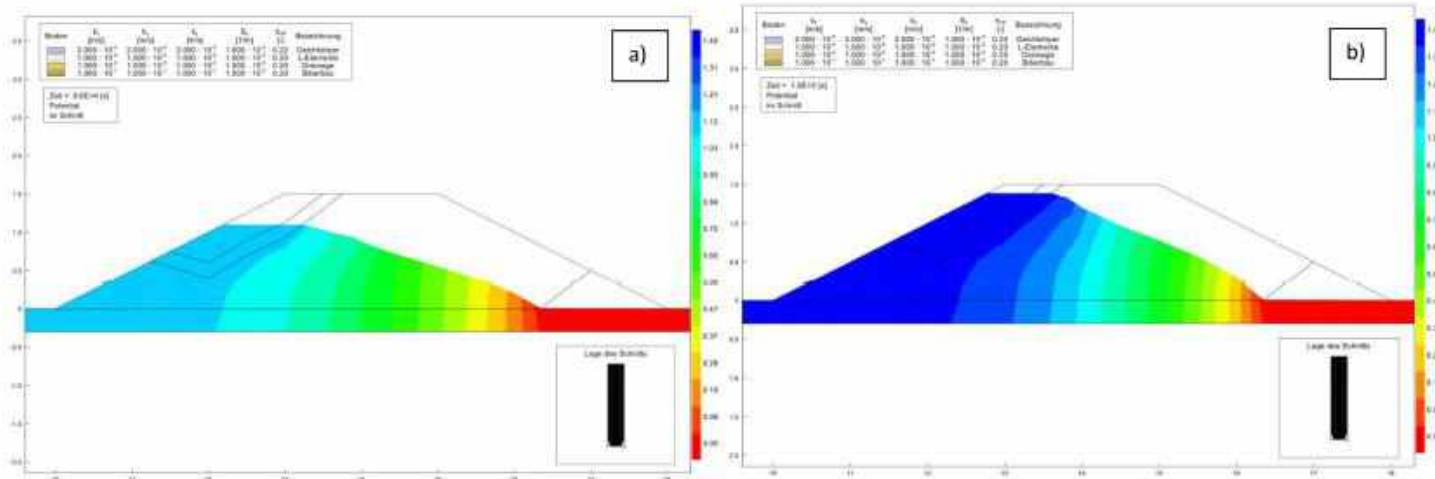
- 1) Altered seepage behavior
- 2) Structural instability
- 3) Decreased erosion resistance → less important with regard to beaver activity
 - Indirect hazards (tree felling, blocking of culverts, etc.)



Source: Cobos Roa (2015), modified

Impact on Levee Stability

○ Altered seepage behaviour

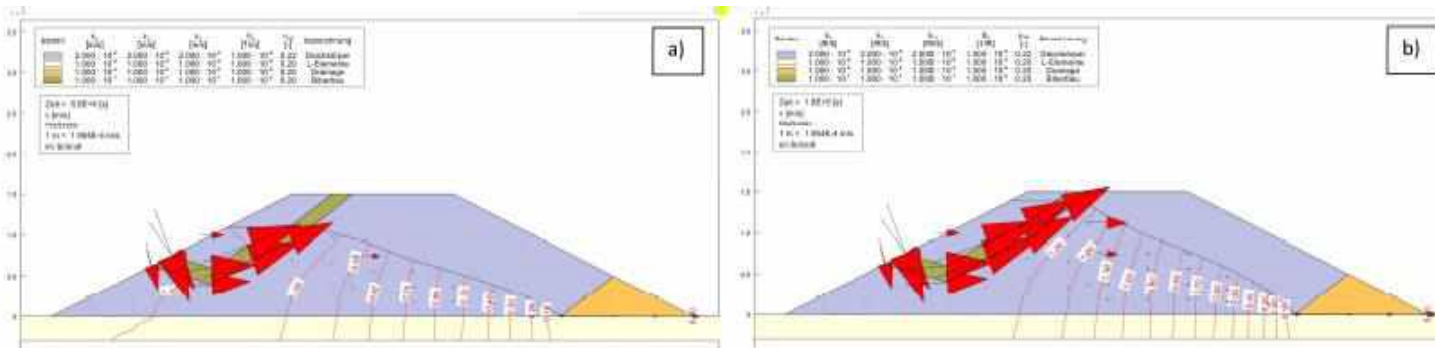


Length of seepage path decreases:

- Hydraulic gradient increases
- Seepage velocity increases, which favours piping
- Phreatic surface on higher level, leading to decreased stability of landside slope

Investigations van Bonn (2022):

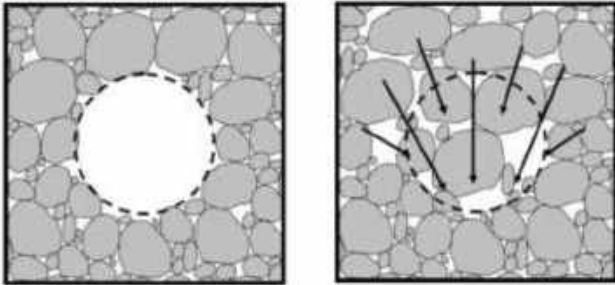
- if tunnel length exceeds about 60% of levee width, failure is likely



Source: van Bonn (2022)

Impact on Levee Stability

○ Structural instability

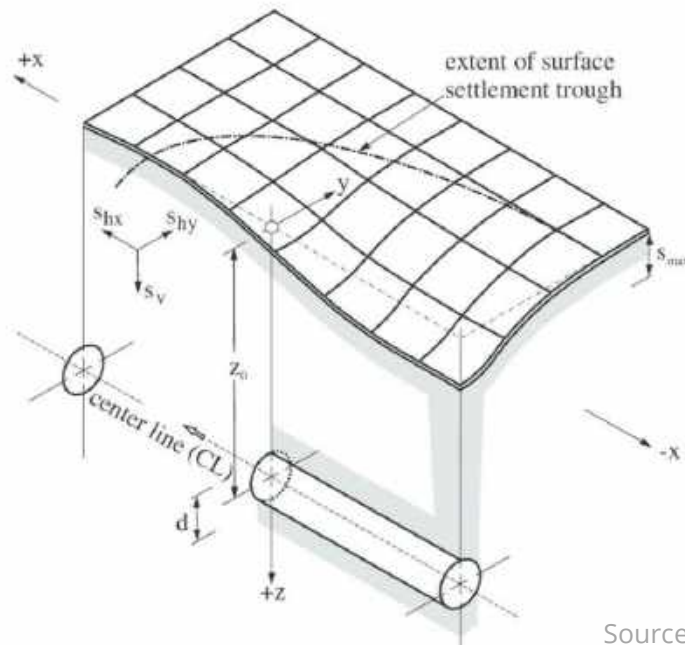


Collapse of Tunnel System

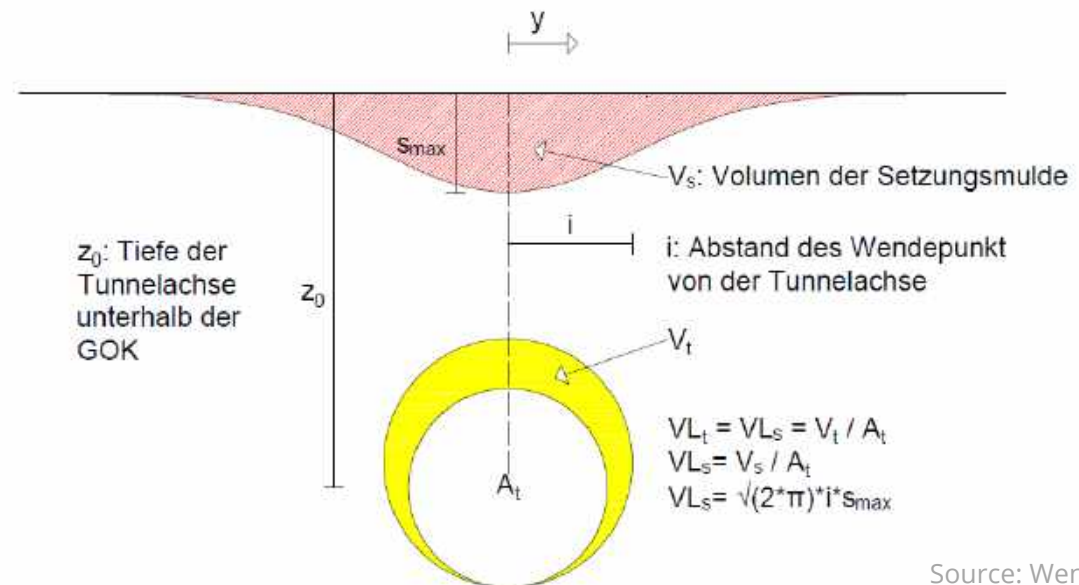
- Loss of Freeboard
- Overtopping
- Breaching

Investigations Wendler (2021):

- Deformation of cavities and earth surface can be predicted by analytical and numerical models (Analogy: Tunnel engineering)
- Goal: “satellite based detection” (e.g. InSAR) could not be achieved



Source: Attewell (1986)



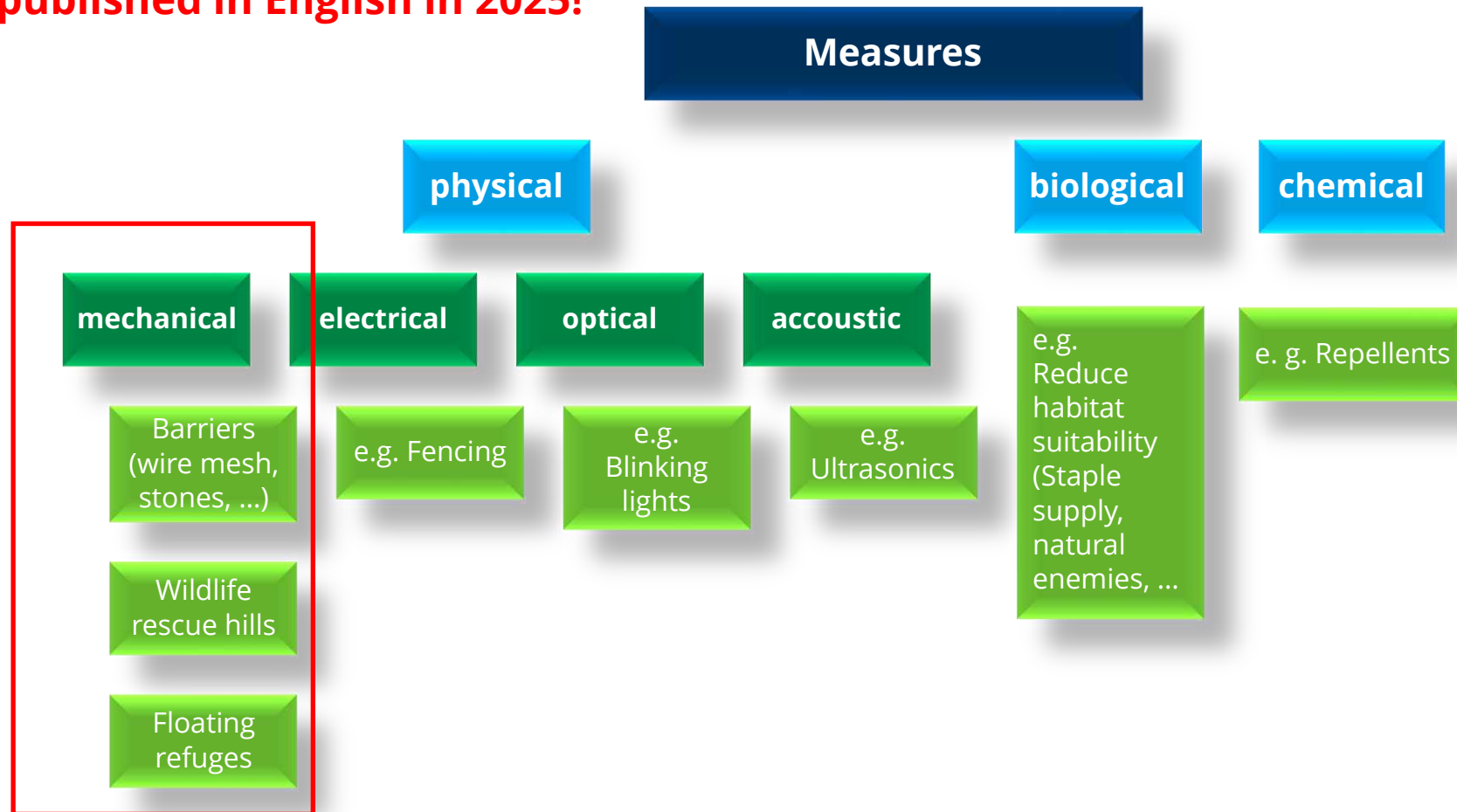
Source: Wendler (2021)

Countermeasures

→ DWA-Guidelines M 608-2:

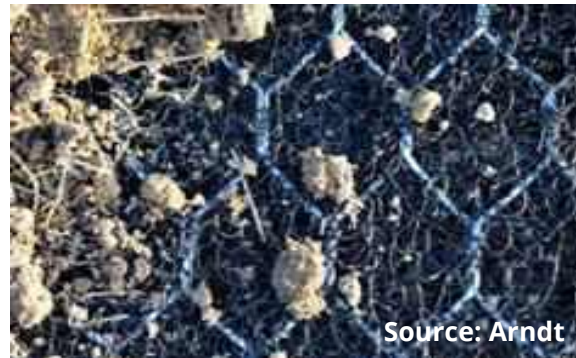
„Muskrat, Beaver, Nutria – Technical design and protection of river banks, dikes and dams“

- to be published in English in 2025!



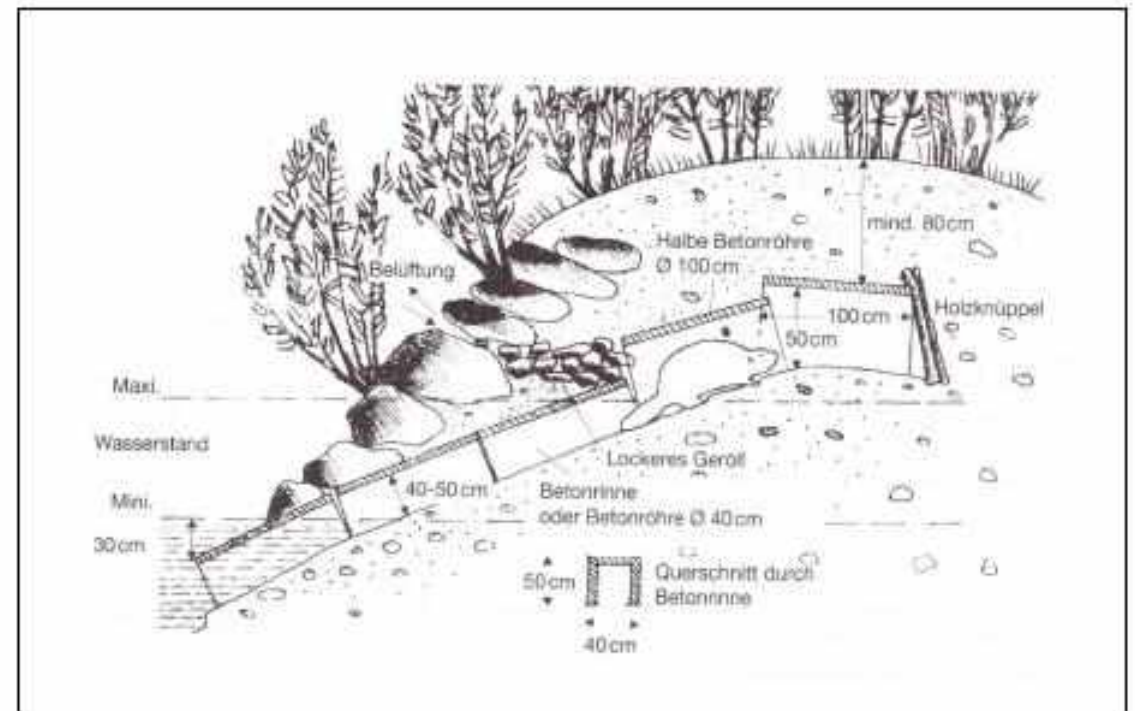
Mechanical Barriers

- **Technical solutions:** Coated wire mesh (corrosion!?), natural & artificial stones, sheet pile walls, ...
- **Appropriate placement** (location, extent) **and construction crucial** for effectiveness
- **Durability** und **sustainability** must be considered (**maintenance** and **environmental issues!**)



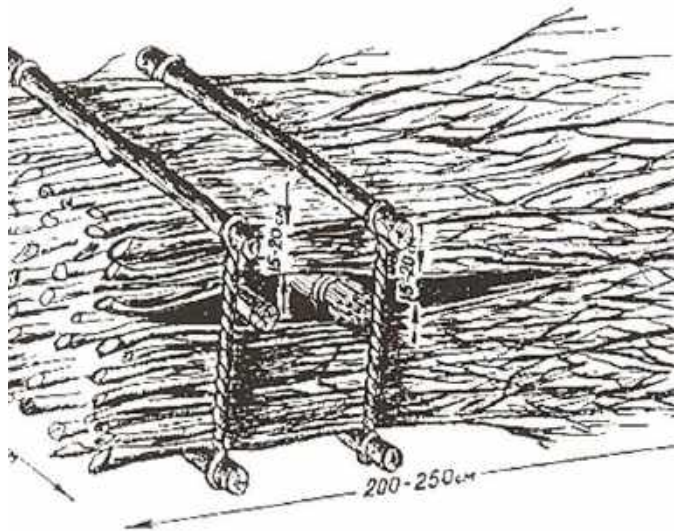
Wildlife Rescue Hills

- Only in locations, where hills are **not critical from a hydraulic point** of view, e.g. wide flood plains
- **Not applicable in narrow river sections** due to backwater effect

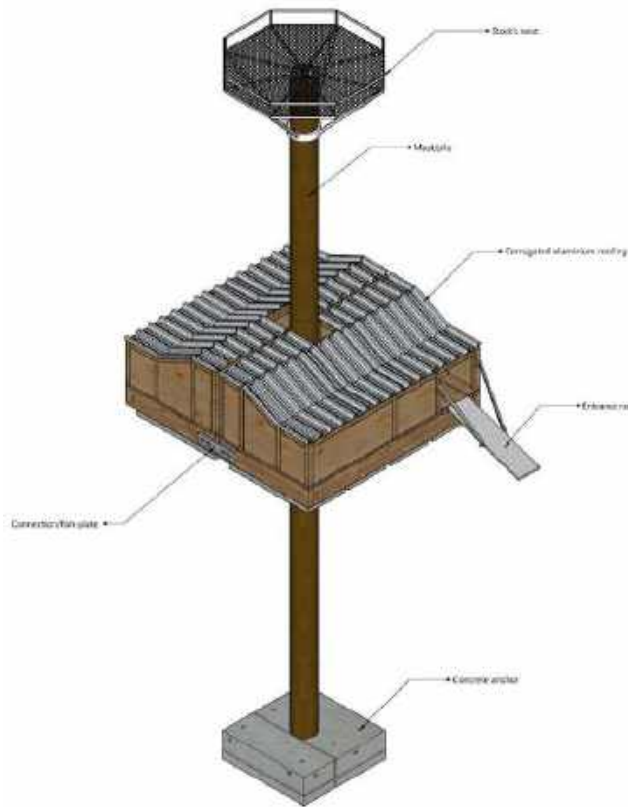


Floating Beaver Refuges

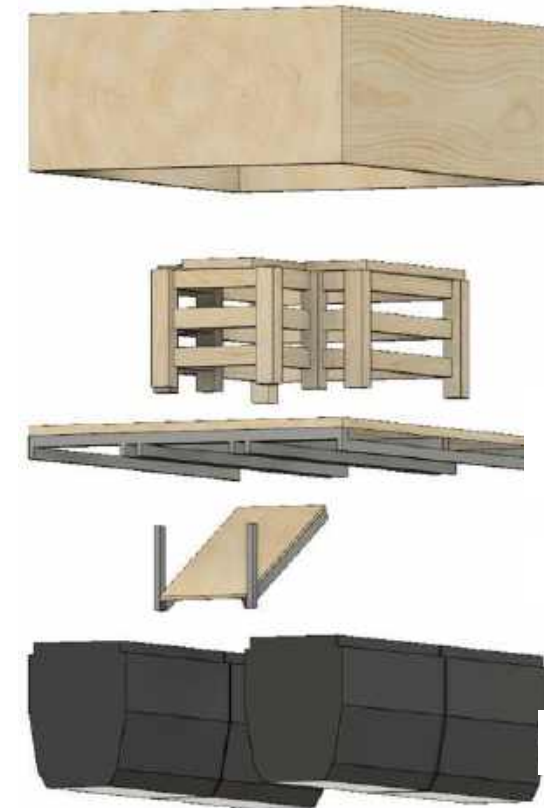
- Idea: provision of **alternative (better?) shelters**
- **Feasible** from technical point of view → **reasonable** from biological point of view?



Source: Safonow (1972)



Source: Gerrits (2022)



Source: Gautier (2024)

Cavity Detection

- **Unsolved problem → Call for joint research!**

Ground penetrating radar (GPR)

Frequency domain electromagnetics (FDEM)

Microwave sensing

Electrical resistivity tomography (ERT)

Geomagnetics

Tracking dog

Multispectral imaging

Thermal imaging

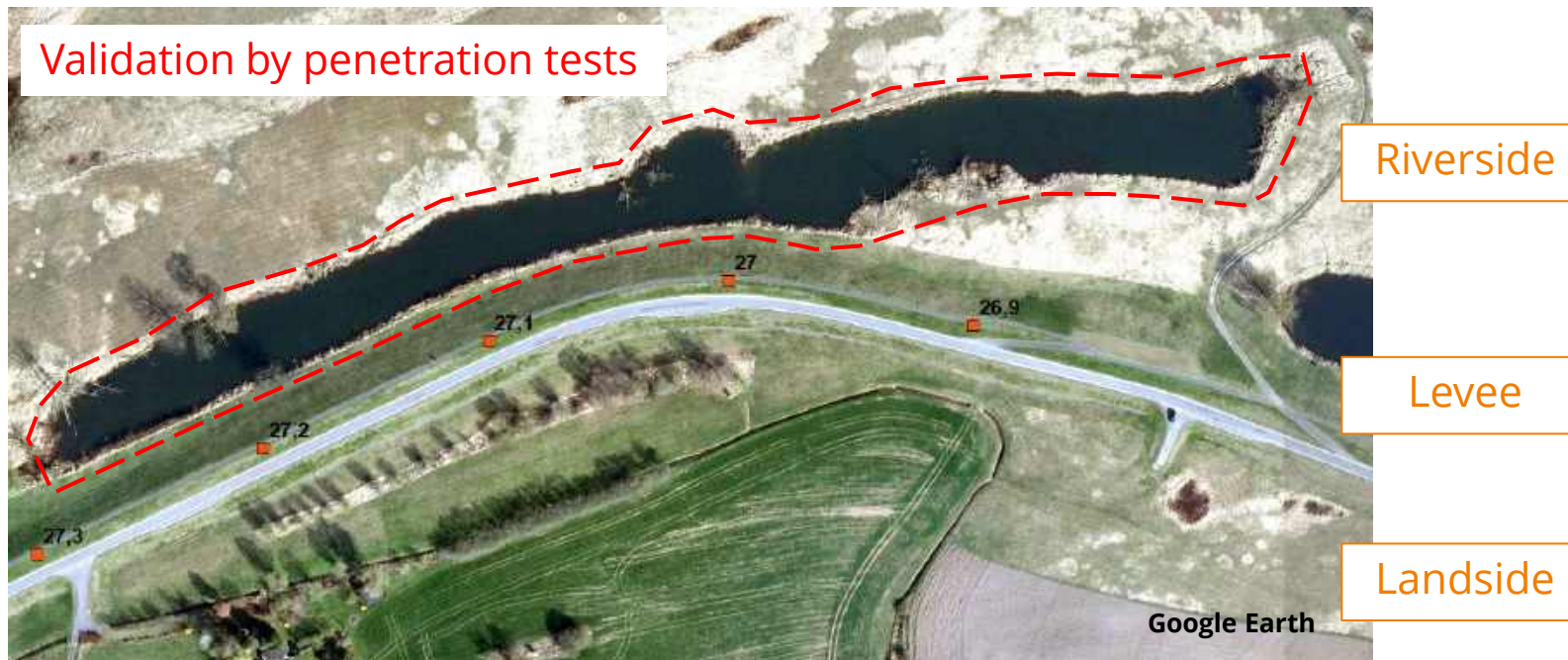
drone
based

Satellite radar interferometry (InSAR)

UW-photogrammetry (UUV, GoPro)

Other:

- Horizontal sonar
- Bees
- Avalanche transmitter
- ...



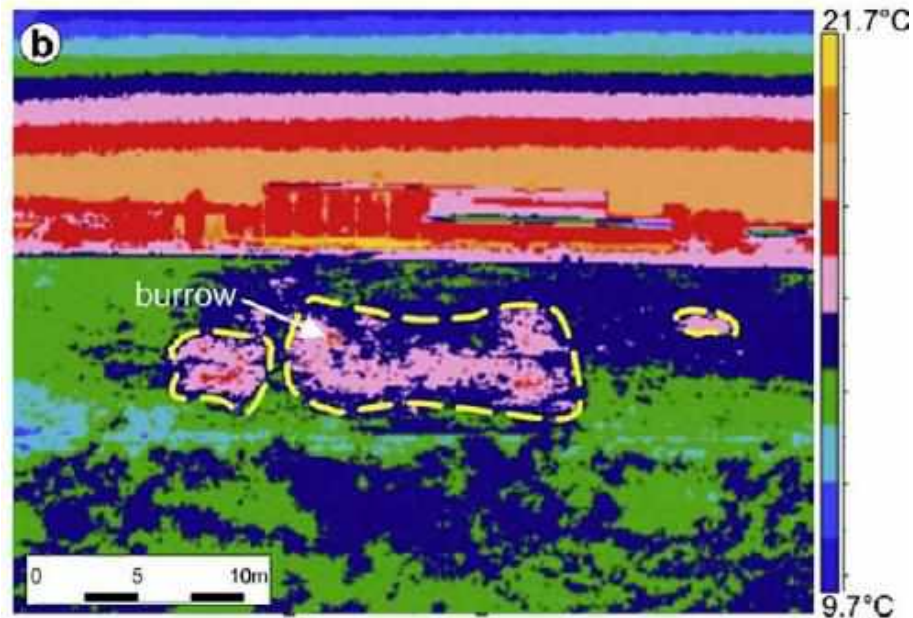
Potential
Methods



Field
Survey

Cavity Detection

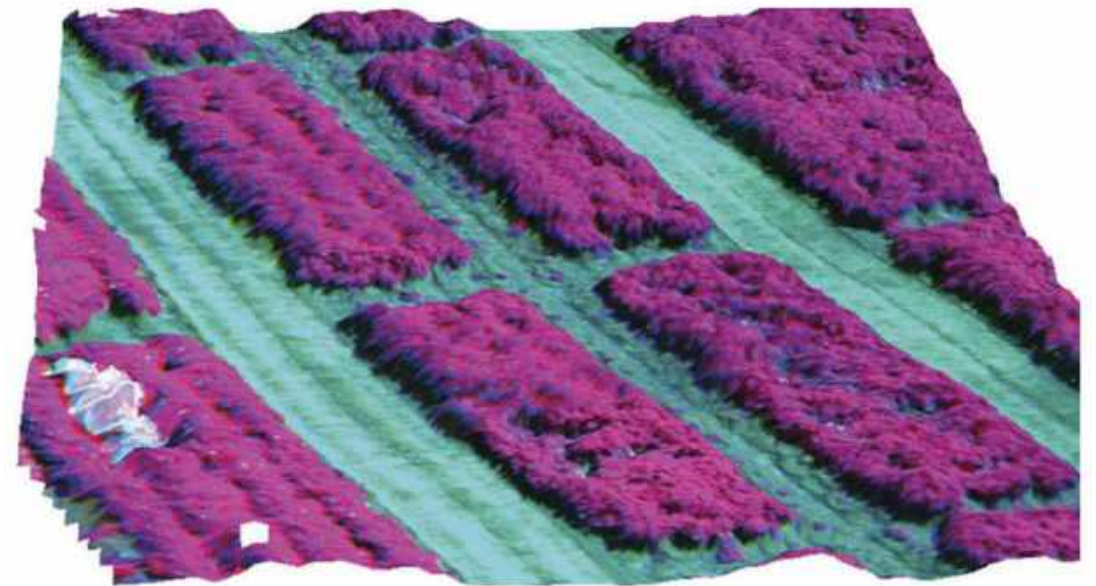
Thermal Imaging



Borgatti (2017)

→ **Surface Temperature**
cooler or warmer?

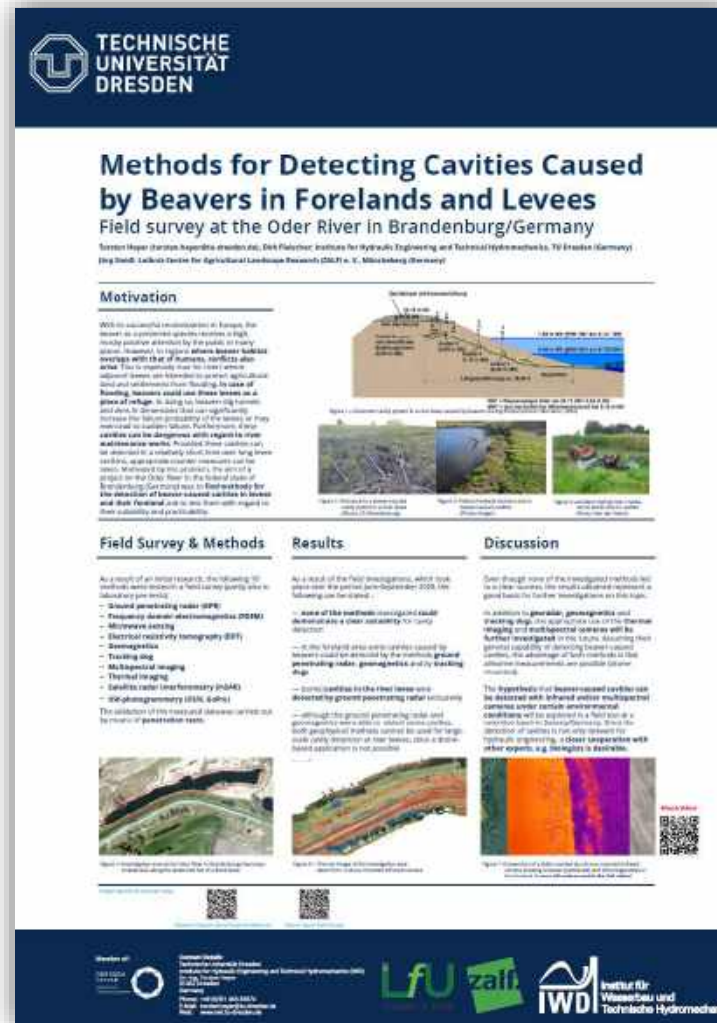
Multispectral Imaging



Hunt (2018)

→ **Plant Stress**
low soil moisture content?

Final Remarks



Thanks for your Attention!

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