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Innovation for mountain agriculture: Evidence from Switzerland

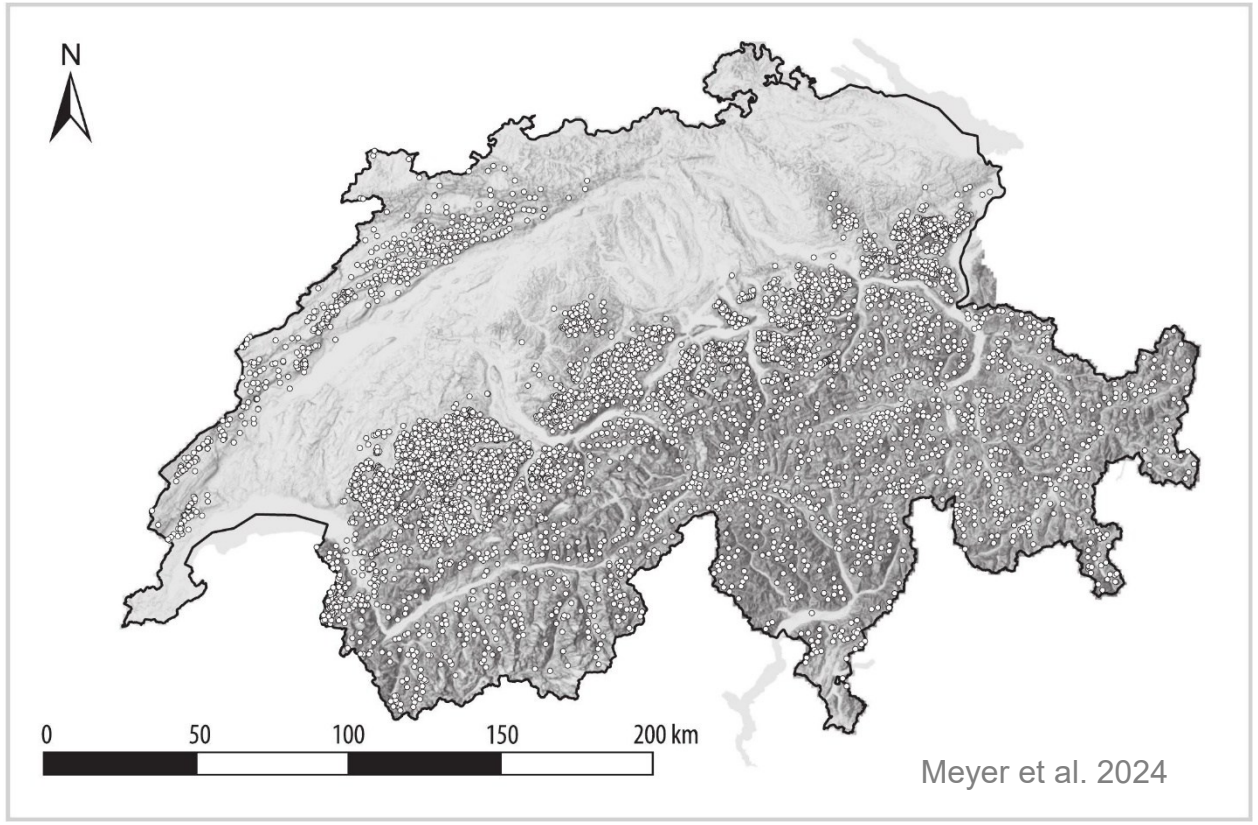
Workshop "Innovative Mountain Agriculture and Forestry“
Alpenkonvention

Maximilian Meyer, Dr. agr.
Research Group Managerial Economics in Agriculture

04.05.2026

Swiss transhumant mountain farms

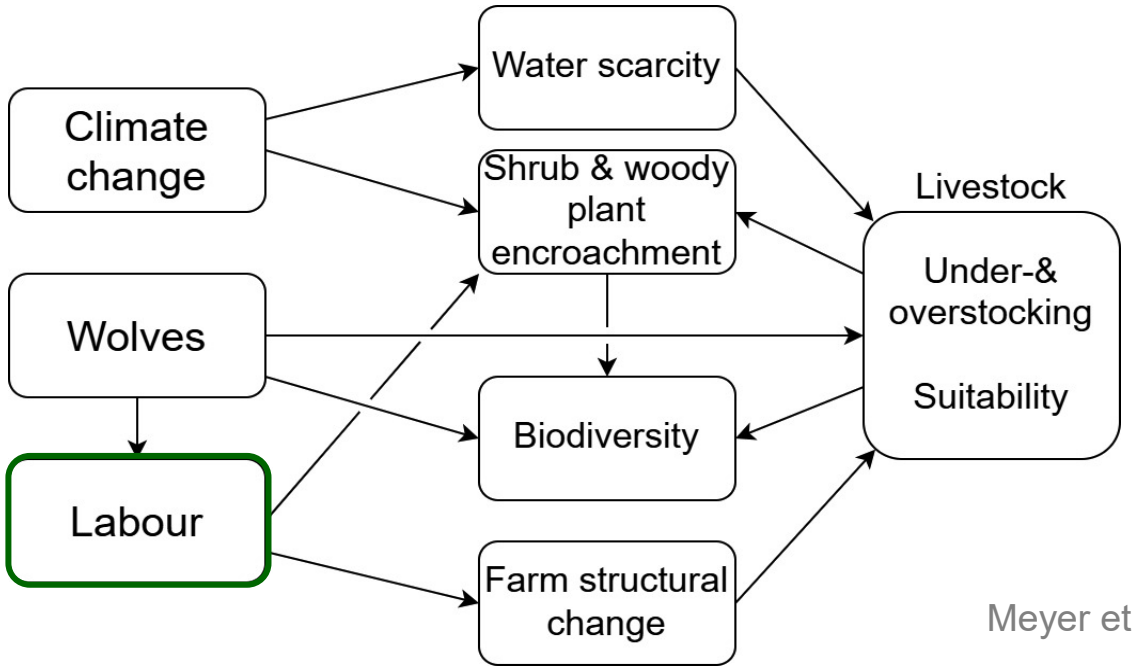
- Swiss farms in Switzerland are of societal importance (Lauber et al. 2013)
  - Food production, cultural heritage & ecosystem services (Pauler et al. 2025)
- ‘Swiss Alpine Season’ as a UNESCO Intangible Cultural Heritage



Meyer et al. 2024

Lauber et al. (2013). Zukunft der Schweizer Alpwirtschaft. Fakten, Analysen und Denkanstösse aus dem Forschungsprogramm AlpFUTUR. Eidgenössische Forschungsanstalt für Wald, Schnee und Landschaft WSL, Birmensdorf.
Meyer, M et al. (2024). Understanding the Heterogeneity of Swiss Alpine Summer Farms for Tailored Agricultural Policies: A Typology. *Mountain Research and Development*, *44 (1)*, R10-R18.
Pauler et al. (2025). Ecosystem services in mountain pastures: A complex network of site conditions, climate and management. *Agriculture, Ecosystems & Environment, 377*, 109272.

Challenges for mountain farming in Switzerland



Meyer et al. 2025a

Only 50% of farm workers return to their job

The main reasons: living and working conditions

Meyer, M., Contzen, S., Feller, M., Pauler, C. M., Probo, M., Röösli, A., Schmidt, R. & Schneider, M. K. (2025a). Resilience of Swiss summer farms: An interdisciplinary analysis of key challenges and adaptations. *Agricultural Systems*, *227*, 104365.

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Can technology help?

- Precision farming technologies are increasingly being used across all areas of agricultural production
  - Drones, virtual fences, GPS, remote sensing, variable rate technology
- Technologies can reduce the workload, thereby increasing the efficiency of resource use (Martin et al. 2022)
- Potentially far-reaching consequences for rural development & labor recruitment

→ **Focus on drones, virtual fences and digital livestock monitoring**

Martin, T., P. Gasselin, N. Hostiou, G. Feron, L. Laurens, F. Purseigle, and G. Ollivier. (2022). Robots and transformations of work in farm: a systematic review of the literature and a research agenda. *Agronomy for Sustainable Development* 42:66

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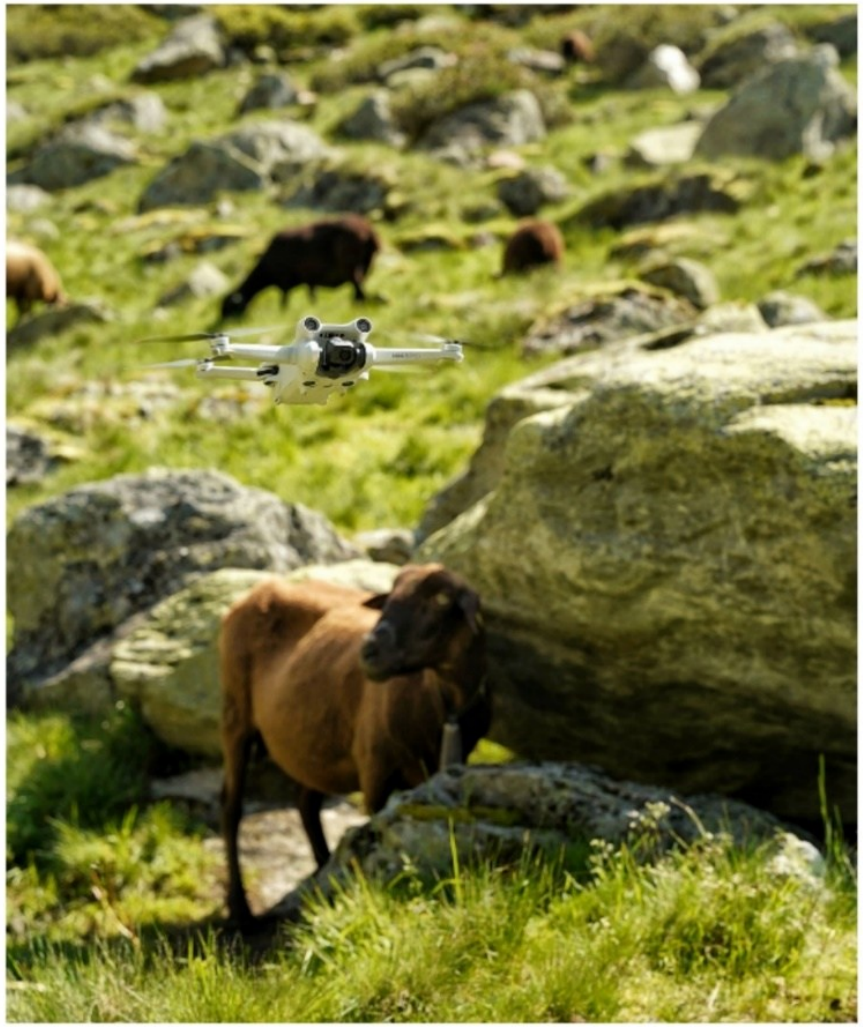
Pioneers use drones



“The youngster started doing it, then we gave it a go. It really isn’t difficult.”
Farmer, Bernese Oberland

(Meyer et al. 2025b)

Meyer, M., Reissig, L. & Heitkämper, K. (2025b). «Akku rein und losfliegen»: Drohnennutzung in der Alpwirtschaft, *Agroscope Science* 207, 1 - 20

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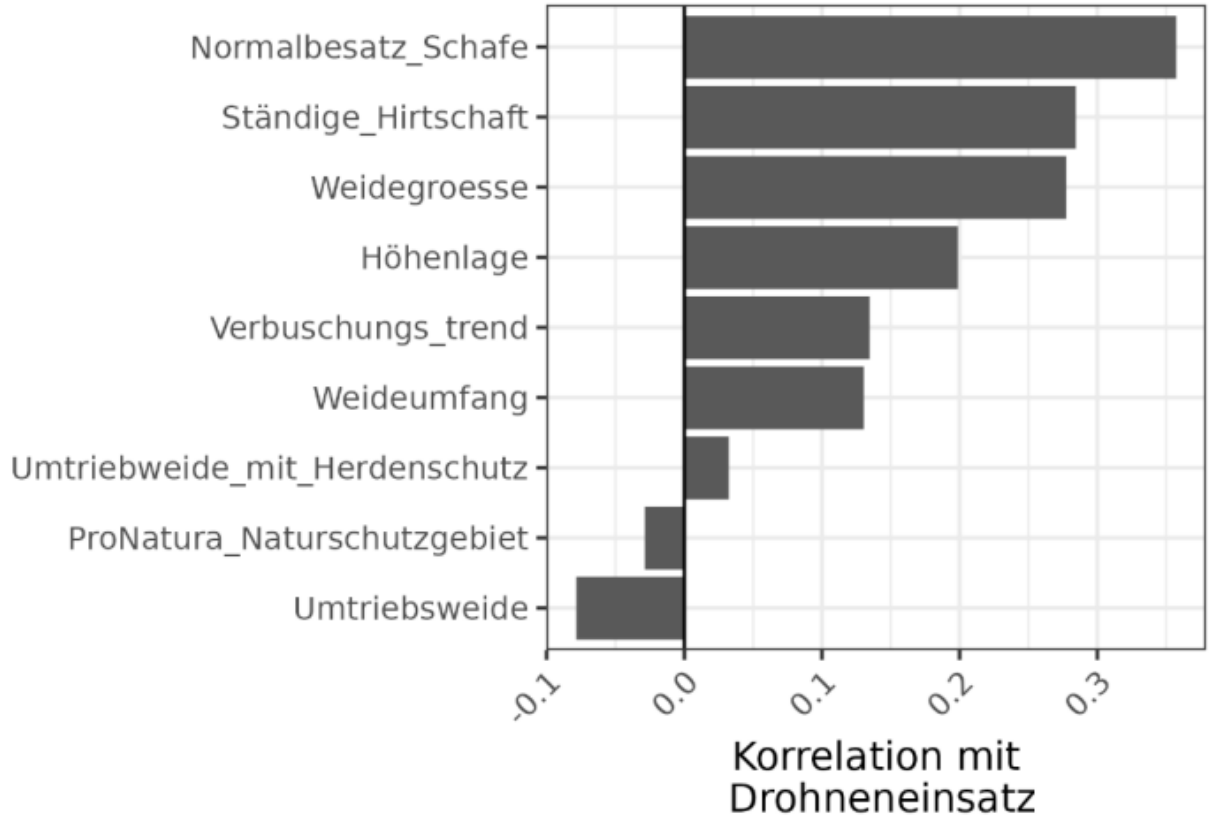
Determinants of drone use in a Swiss canton

Use of drones *more likely*:

- Large farms with shepherds and extensive pastures
- High-altitude & difficult-to-survey terrain (shrub encroachment, size of pasture)

Use of drones *less likely*:

- Rotational grazing
- Conservation restrictions



Meyer et al. 2025b

N = 178

Meyer, M., Reissig, L. & Heitkämper, K. (2025b). «Akku rein und losfliegen»: Drohnennutzung in der Alpwirtschaft, *Agroscope Science* 207, 1 - 20

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Own experience

Tests: Fence inspection, herding, animal and wolf search

Pilot project: ‘Searching for lost livestock in the Alps using drones’

- Collaboration between Swiss Summer Farming Association, Fawn Rescue Switzerland (RKRS) & Agroscope
- RKRS drone pilots are well-equipped and trained
- After the peak season (May & June) for fawn rescue, pilots have additional capacity to assist on the alpine pastures.
- RKRS drone pilots are available in 2025 and 2026 for further research

Foto: Alain Marti, RKRS

Drohnen über der Alp

Wie Hightech 34 verlorene Rinder rettet

In den Schweizer Alpen verschwinden jedes Jahr Dutzende Tiere spurlos. Jetzt wird erstmals mit Hightech gefahndet.

Foto: Alain Marti, RKRS

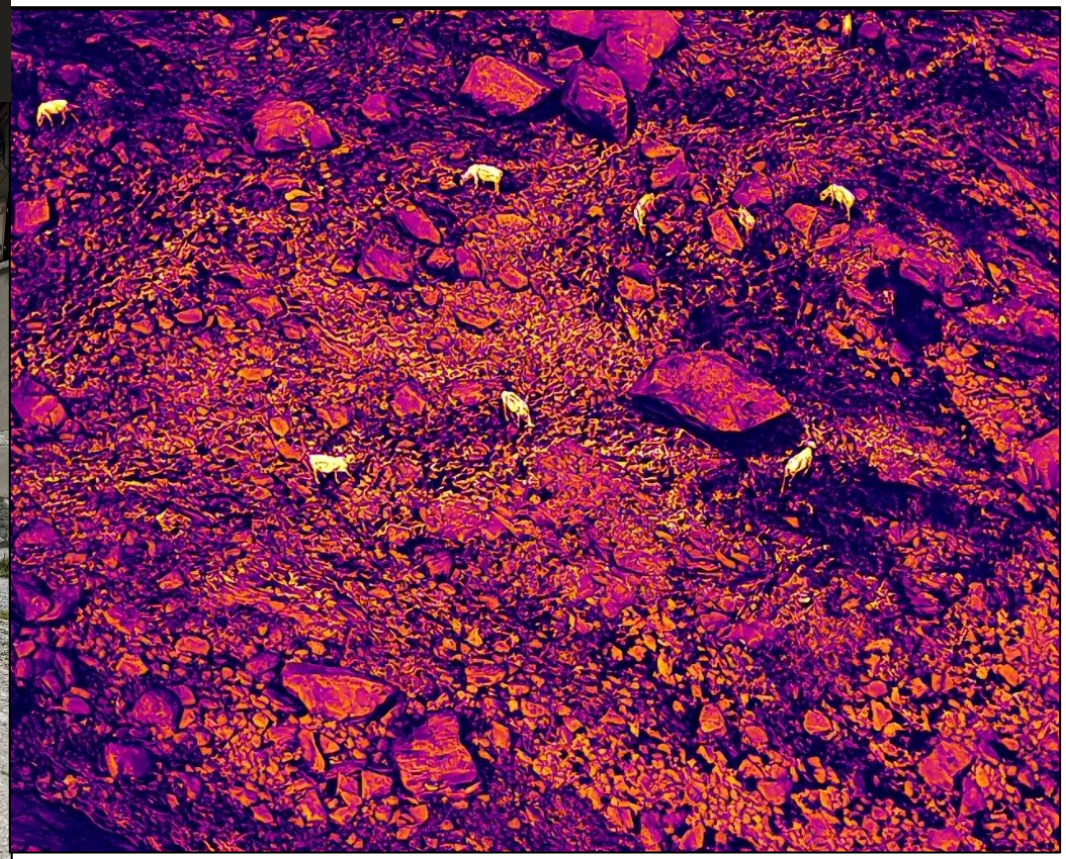

Foto: Alain Marti, RKRS

AI and Drones

https://icaerus.eu/drone-data-analytics-library/

Lebreton & Helary (2026): How to Count Sheep Without Falling Asleep: Turning AI and Drone Proofs of Concept into Practical Tools for Sheep Farmers, *Animal Science Cases*, ascs20260001.

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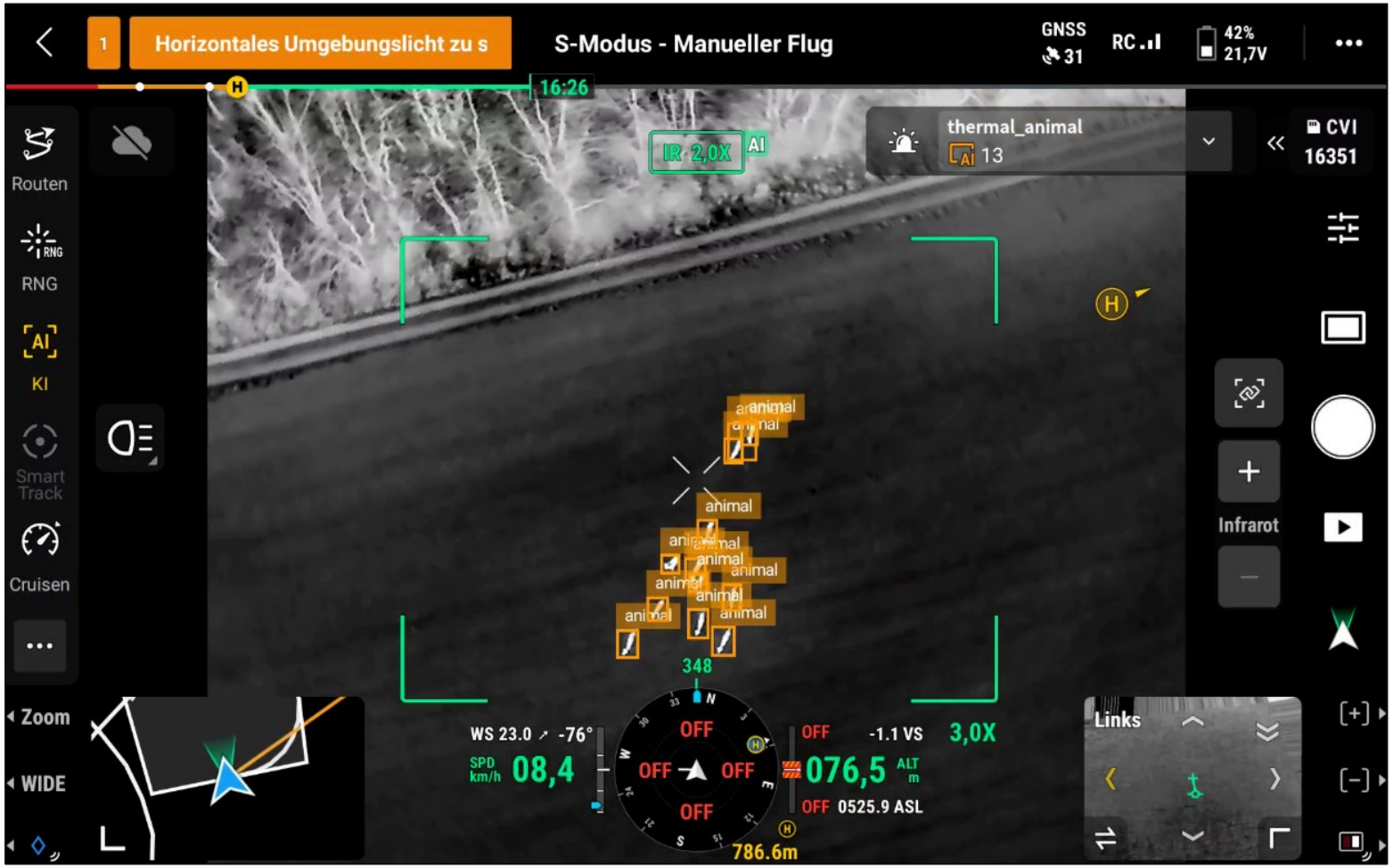
AI and Drones



Source: https://copterpro.de/shop/copterpro-ai/tiererkennungs-ki/

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Drones for human-wolf coexistence

- Many strategies to foster human-wolf coexistence (Meyer 2025):
  - One strategy: livestock protection with new technologies
- Startup: **Pax Lupus - autonomous wolf deterrent system**
- Autonomous and off-grid: solar-powered
- Central mast equipped with cameras and sensors
  - monitors a radius of up to 200m, day and night, detecting approaching wolves
- When a wolf is detected, deterrence escalates in stages:
  1. A small drone launches from the base station and flies toward the wolf
  2. If the wolf remains at the pasture's edge, the drone performs initial deterrence manoeuvres
  3. If the wolf enters the pasture, the drone escalates its response to drive it away
- Where network coverage is available, shepherds are notified in real time

© Pax Lupus GbR

Meyer, M. (2025). Eight Strategies for Human–Wolf Coexistence and Their Application to Swiss Governance Gaps. *Global Ecology and Conservation*, e03870.

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Digital animal monitoring & virtual fences

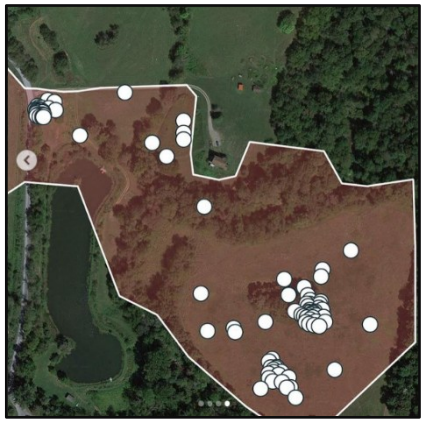
Monitoring: Tag4Farm (Identitas AG, Switzerland)

- Electronic livestock ear tag
- Tracking: Monitor the location of herds remotely
- Interactive map: Visualize herds location on a map.
- Marking of water points or hazard zones directly on the map and make this information available to staff
- Smart alerts: You are notified immediately in the event of unusual activity.
- Other tracking systems available (e.g. “Alptracker”)

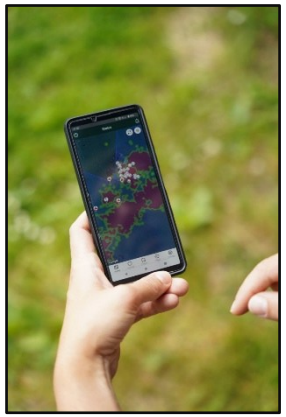
Virtual fences and how they work

Picture: Maximilian Meyer

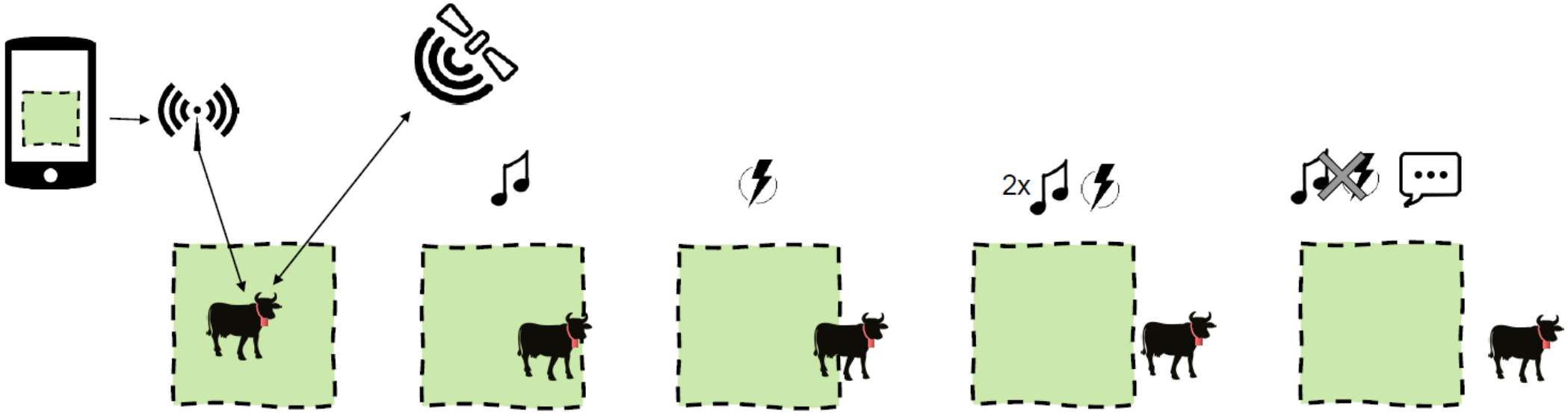
Picture: NoFence



Picture: NoFence



Picture: Maximilian Meyer



Source: Manuel Schneider, Caren Pauler

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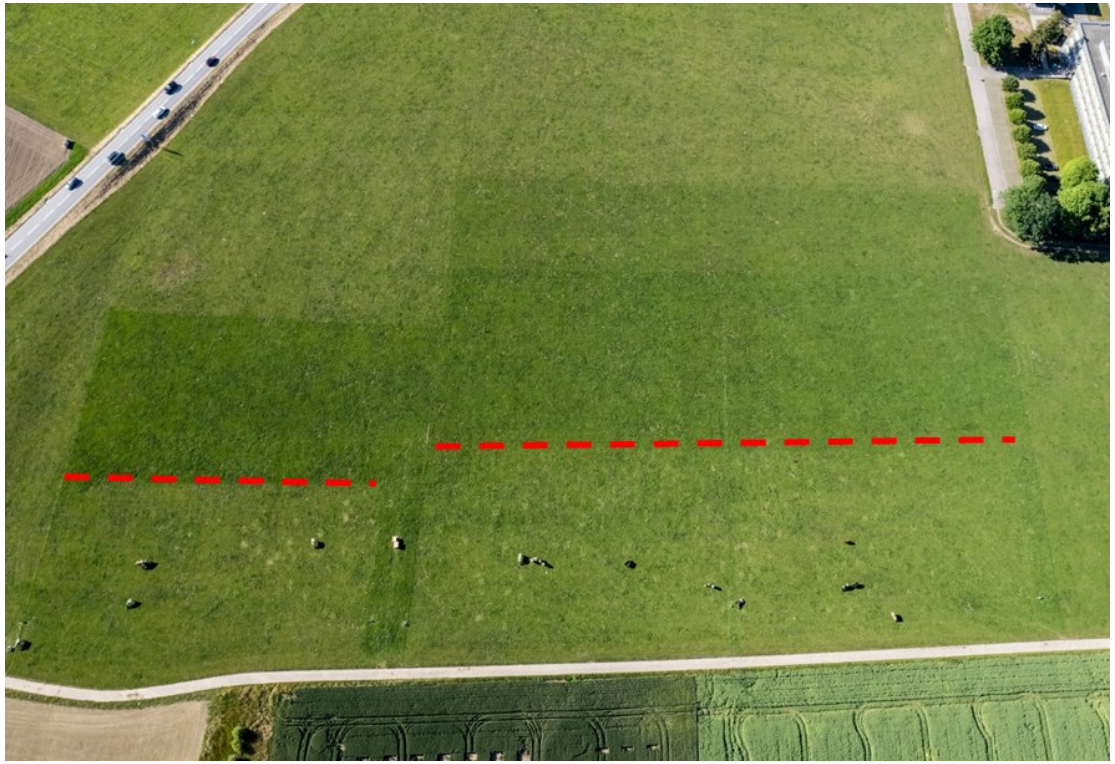
Digital pasture management through virtual fences



Source: Fuchs et al. (2024)

Fuchs, P., Stachowicz, J., Schneider, M. K., Probo, M., Bruckmaier, R. M., & Umstätter, C. (2024). Stress indicators in dairy cows adapting to virtual fencing. *Journal of animal science*, *102*, skae024.a

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The future: Digital animal monitoring & virtual fencing

Monitoring of animal activity and their grazing behavior has the potential for improving livestock management. (Umstätter, Martini & Adrion 2020)

1. Health improvement of livestock from optimised process control and objective real-time data
2. Innovative processes generate new farming systems and markets

3. People with more diverse backgrounds and interests could become active in agriculture in future.
4. Small farms could benefit from digitalisation.

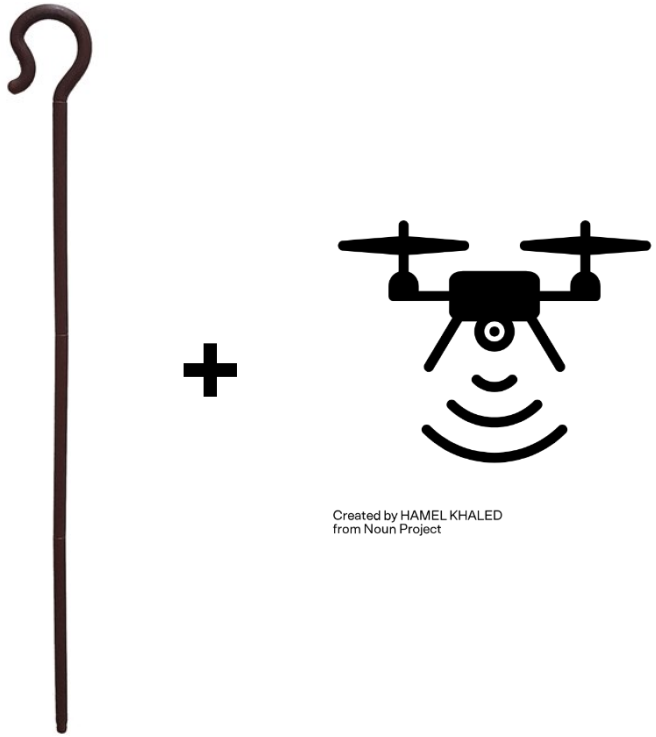
However:

1. Heterogeneous perception of new technologies by mountain farmers (Marescotti et al. 2021)
2. Legislative challenges for virtual fence in Switzerland

Umstätter, C., Martini, D., & Adrion, F. (2020). Opinion Paper: Digital Animal Monitoring–What is on the Horizon?. *agricultural engineering. eu*, *75*(1).
Marescotti, M. E., Demartini, E., Filippini, R., & Gaviglio, A. (2021). Smart farming in mountain areas: Investigating livestock farmers' technophobia and technophilia and their perception of innovation. *Journal of Rural Studies*, 86, 463-472.

Conclusion

Picture: Maximilian Meyer



Created by HAMEL KHALED
from Noun Project

Picture: Maximilian Meyer

There are more technological innovations one can look at:
Electric tractors, water monitoring systems, etc.














Thanks!

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