Positive long-term effect of mulching on a nutrient-poor mountain meadow, Czechia

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Summary

This case study reports a 13-year management experiment on an oligotrophic mountain meadow in Šumava National Park, Czech Republic. After the end of hay-making and autumn grazing, three regimes were compared on permanent plots cut each July. Mulching left the cut biomass in place, mowing removed it, and fallow had no cutting. The site sits at 1160 m on acidic brown soils with cool, wet climate. Monitoring combined yearly vegetation surveys in nested 1 m² plots and pre-treatment biomass harvests.

Mulching maintained biomass while improving diversity and soil condition. Mean aboveground biomass averaged 319 g m^{-2} under mulching, 301 g m^{-2} under mowing, and 386 g m^{-2} in fallow. Species richness in mulched plots increased from 11.2 to 18.6 species per m² between 1997 and 2009, with a shift from grass dominance to forb-rich swards. By year nine, soils in mulched plots showed higher pHKCl (3.8 to 4.4), organic matter (4.6–6.3%), total N (0.31–0.45%), and greater plant-available P, K, Mg and Ca.

Functional trait analyses revealed communities under mulching moved toward acquisitive strategies with higher SLA, LNC and LPC and lower LDMC, SDMC, C:N and plant height. Many trait diversities increased with mulching, although SLA diversity converged. In contrast, mowing alone tended to deplete nutrients and fallowing drove litter build-up and grass competition, both reducing diversity. Detectable ecological divergence among treatments appeared only after 5–6 years, reflecting slow responses in cold, acidic conditions. The authors conclude that annual mulching is a practical, biodiversity-friendly alternative where traditional grazing has ceased, provided site fertility remains low.

Location

49.08, 13.55

Sector

Agriculture

Installation Date

1997 to 2009

Implementation status

Ongoing

Overview

Location of the project

Šumava National Park and Biosphere Reserve, Bohemian Forest Mts., Czech Republic. SW-facing slope.

Sponge measures implemented in the case study

Mulching

Objectives

Test whether mulching can maintain or enhance plant species and functional trait diversity and sustain biomass production in oligotrophic mountain meadows after cessation of traditional hay-making and autumn grazing.

Involved partners

Authority type	Authority name	Authority role	Comments	Authority responsibility
Research institute / University	Institute of Botany, Czech Academy of Sciences	Implementation	—	Responsible
Nature park	Administration of the Šumava National Park	Other	site access and liaison	Supporting
Research institute / University	University of South Bohemia, Faculty of Science	Other	field ecology, analysis	Supporting
Research institute / University	Institute of Ecology, Evolution & Diversity, Goethe University Frankfurt	Other	trait ecology	Supporting
Research institute / University	Institute of Systems Biology and Ecology, Czech Academy of Sciences	Other	soil and systems ecology	Supporting

Site Information

Climate Zone

Cool temperate moist

Temperature (°C)

4.80 °C

Elevation range

1160 m

Slope range

SW-facing slope, 2–8° inclination.

Vegetation class

Original vegetation acidophilous meadow dominated by Deschampsia cespitosa, Festuca rubra, Agrostis capillaris, Hypericum maculatum.

WFD Ecological status

Moderate

WFD Chemical status

Failing to achieve good

Water quality status

Soil chemistry reported later in the experiment: in mulched plots, increases by 2007 in pHKCl (≈3.8 to 4.4), organic matter (≈4.6–6.3%), total N (≈0.31–0.45%), and plant-available P, K, Mg, Ca; limited changes in mown and fallow plots.

Design and Implementation

Project scale

Micro

Project scale specifications

Micro-scale field experiment on a single meadow site. 12 ha surrounding context, experimental core 300 m × 400 m.

Project area

0.12 km² site footprint noted; vegetation and biomass measured in permanent 1 m × 1 m plots (five per treatment) with nested subplots.

Principles

1997 to 2009 continuous annual management and monitoring. Divergence among treatments became evident after 5–6 years.
Annual July defoliation under three regimes to compare biodiversity and productivity outcomes. Mulch left to decompose on site to recycle nutrients in an otherwise oligotrophic, acidic, cold-climate meadow.

Factor constraints

Cold mountain climate and acidic soils slow vegetation response and mulch decomposition, making long-term monitoring essential. Low inherent soil fertility. Gentle slopes.

Financing

Compensations

Non

Policy and Governance

Policy description

Experiment conducted within Šumava National Park and Biosphere Reserve to inform biodiversity-friendly, economically acceptable alternatives to traditional hay-making plus autumn grazing.

Land ownership

Experimental management started in 1997 and ran for 13 consecutive growing seasons to 2009. Project finished (field phase complete).

Target remarks

Maintain plant species richness and functional diversity while sustaining biomass in nutrient-poor mountain meadows when traditional practices cease.

Pressure remarks

Abandonment of traditional management, nutrient depletion under mowing-only, grass domination and litter accumulation under fallowing, regional biodiversity decline in seminatural meadows.

Part of a wider plan

Non

Public consultation

Non

Has contractual arrangements

Non

Impacts and Monitoring

Monitoring System

Monitoring parameters

Five permanent 1 m × 1 m plots per treatment with nine 0.33 m × 0.33 m subplots each; annual vegetation cover surveys from 1997–2009; annual pre-treatment biomass harvests at set July dates; soil chemistry compared early and at year 9; extensive plant trait datasets compiled from European grassland trait databases.

Maintenance

Maintenance requirements

Annual July cutting under the assigned regime for each plot. Mulch left in place on mulched plots; hay removed on mown plots; no cutting on fallow.

Impact Assessment Methodology

Biophysical impact assessment method

Ordination and constrained ordination (PCA, RDA), community-weighted means (CWM), Rao’s quadratic entropy for functional diversity (FD), beta-diversity partitioning per Jost, regression of biomass versus diversity and trait metrics.

Socio-economic Impacts

Direct benefits

Mulching maintained or enhanced plant species and functional diversity while keeping relatively high biomass production. It countered nutrient loss seen under mowing-only and avoided the diversity decline and litter build-up seen under fallowing.
Under mulching, FD for SLA decreased over time despite increases in mean SLA, indicating convergence for this trait even as other traits diverged. Fallowing led to grass dominance and litter accumulation with gradual diversity loss. Mowing-only led to gradual nutrient depletion and reduced productivity.

Biophysical impacts: Hydrology

Hydrological effects

Not assessed

Biophysical impacts: Biodiversity

Information on improved biodiversity

Species richness in mulched plots increased from 11.2 to 18.6 species per 1 m² over 13 years. Proportion of forbs rose from ~20% to ~60%, grasses declined from ~75% to ~20% in mulched plots. Functional trait shifts toward acquisitive strategies: higher LNC, LPC, SLA; lower LDMC, SDMC, C:N, and plant height. Functional diversity increased for many traits under mulching.

Biophysical impacts: Water & Soil Quality

Information on water quality overall

Mulched plots showed by year 9 increases in soil pH, organic matter, total N and exchangeable P, K, Mg, Ca; mown and fallow changed little. Mechanism attributed to mulch mineralisation and enhanced microbial activity and legumes.

Biophysical impacts: Others

Information on other biophysical impacts

Aboveground biomass averaged 319 g m^{-2} in mulched, 301 g m^{-2} in mown, 386 g m^{-2} in fallow plots. Diversity and productivity were positively associated within treatments.

Lessons Learned

Key lessons

Mulching is a suitable, biodiversity-friendly management alternative for oligotrophic, acidic mountain meadows, promoting niche complementarity and preventing competitive exclusion. Detectable ecological divergence required 5–6 years, so short studies risk missing real trends. Management outcomes are climate and soil constrained in cold, acidic sites.

Drivers

Driver type	Driver role	Comments

Balancing different objectives	Main driver	Need for economically acceptable alternatives after abandonment of traditional hay-making and grazing, and for biodiversity conservation in seminatural meadows.

Success factors

Success factor type	Success factor role	Comments
Other	Main factor	Consistent annual timing of management
Conducted assessments (incl. economic)	Secondary factor	long-term monitoring, access to comprehensive trait data
Successful coordination between authorities	Main factor	collaboration between research institutes and the national park administration

Cost effectiveness

No cost data. Ecologically, mulching provided a good compromise maintaining diversity and relatively high biomass without external fertiliser inputs.

Flexibility / Adaptability

Findings apply to low-productivity, acidic, cool mountain meadows. Authors caution that mulching can be inappropriate in productive lowland meadows due to auto-eutrophication and biodiversity loss reported elsewhere. Context-specificity is key.

Sources

Sources

Long-term functioning of a species-rich mountain meadow under different management regimes

Positive long-term effect of mulching on species and functional trait diversity in a nutrient-poor mountain meadow in Central Europe