Fires in the uplands: future impact of prescribed fires and woodland restoration on biodiversity and carbon stocks in the Cairngorms National Park

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1.Future of Cairngorms' uplands

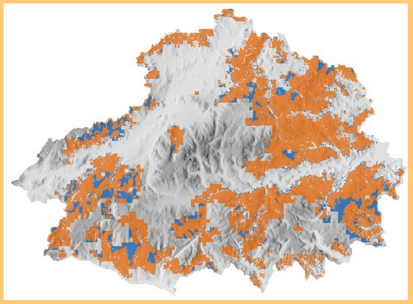
The Cairngorms National Park (CNP) is the UK's largest national park and hosts 25% of the endangered species of the UK. About 45% of the CNP is dominated by moorlands and 20% by woodlands. The CNP Partnership Plan 2022-2027 setobjectives to restore **35,000 hectares of woodlands** and **38,000 hectares of peatland** by 2045. There are debates about the impact of woodlands restoration and prescribed burning for game management on the biodiversity and ecosystem services provided by the uplands. We evaluated the impact of five land cover and land use scenarios on biodiversity and carbon sequestration to answer these research questions:

- How woodlands restoration and restriction on prescribed fire could affect biodiversity and carbon sequestration?
- What are the management implications of these outcomes for biodiversity conservation and carbon sequestration?

2. Prescribed fires and moorlands management

Prescribed fires are used by sporting estates to create a **mosaic of heather patches of different ages**, providing high-quality feeding and nesting habitats to red grouse (*Lagopedus lagopedus scotica*). Some species benefit from these prescribed fires while others are disadvantaged, and frequent fires prevent the regeneration of woodlands [1]. There is conflicting evidence about the impact of prescribed fires on **peat-forming vegetation** and long-term consequences on their **carbon storage** [1,2]. Prescribed fires reduce the fuel build-up and limit **risks of wildfires** in the summer, that could damage peats [3].

Prescribed fires allow **driven red grouse shooting**, an important income source for sporting estates. Employees of sporting estates assure other important **landscape management measures**, such as deer stalking, predator control or wildfire suppression. There was little regulation of prescribed fires at the time of the study, but there were debates about stricter legislation and compulsory training.



Areas managed by prescribed fires in the CNP (orange). Blue: areas where prescribed fires could be restricted

Heathers after a prescribed fire in the Cairngorms. Source: M. Valette

3. Assessing impacts of future woodland expansions and fire restrictions

Based on 10 interviews with stakeholders and the CNP forest strategy, we created 5 future land use scenarios, mixing 2 options for prescribed fire use and 3 options for woodlands restoration. We then used the Native Woodland Model [4] and INVEST [5], using published evidence regarding habitat preferences and carbon sequestration, to assess:

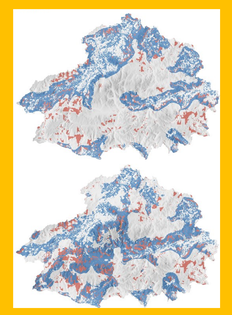
- diversity of vegetation types restored
- carbon sequestration and carbon pool for 40 and 100 years
- habitat quality for 5 open-habitat species, selected on interest for different stakeholders and conservation interest

4. Diversity of vegetation types restored

- Restoration of woodlands on carbon-poor soils: **higher diversity of vegetation types**, including willows, juniper and scrublands
- Restoration of woodlands on productive land: lower diversity and more common types of vegetation, such as birch and upland oak

5. Carbon sequestration

- Prescribed fires: **limited impact** on biomass storage compared to woodlands restoration
- Restoration of woodlands on productive land: highest carbon sequestration in the long-term, but **significant loss of soil-carbon** after 40 years and sequestration



Degradation habitat quality for red grouse for scenario 3 (top) and scenario 5 (bottom)

6. Habitat quality of open-ground species

- Expansion of woodlands **increases predation pressures** on moorlands, affected areas changing according to the reforestation strategy
- Restrictions on prescribed fires **negatively impact** habitat quality for 3 species, including economically-important red grouse, but benefits meadow pipit
- Woodland restoration on carbon-poor soils could increase significantly **interface moorland/ woodlands** and benefits black grouses

7. Implications for management of the uplands

- All scenarios present **trade-offs** between conservation of the biodiversity, risks of soils carbon loss and long-term carbon sequestration potential
- Woodlands restoration will **increase predation pressures** across the CNP, while restrictions on prescribed fires could impact sporting estates and their capacity to assure **predator controls**
- Scenarios maximising long-term sequestration and bringing more income to landholders are **risky:** soils-carbon loss in the mid-term, above-ground biomass exposure to wildfires and wind-damages risks and limited biodiversity benefits
- Need to understand the impact of prescribed fires on: (i) wildfires risks and (ii) carbon accumulation in the soils

Scenarios	Scenarios design		Number of NVC types restored and specific NVC	Impact habitat quality						Carbon storage (ktC)	
	woodland restoration	reduction prescribed fires		change	red grouse	curlew	mountain hare	meadow pipit	black grouse	40 years	100 years
Scenario 1: BAU	17 500 ha (productive land)	3 346 ha (-2%)	38 - Birch, Oak and Scots Pine woodlands	*moderate*	-13%	-13%	-13%	0%	-10%	-550	1 627
				important	-1%	-2%	-2%	-3%	-1%		
Scenario 2: productive restoration	35 000 ha (productive land)	11 084 ha (-6%)	40 - Birch, Oak and Scots Pine woodlands	*moderate*	-22%	-20%	-22%	0%	-14%	-1 329	3 095
				important	-3%	-5%	-5%	-5%	2%		
Scenario 3: productive restoration and PF restrictions	35 000 ha (productive land)	34 722 ha (-19%)	40 - Birch, Oak and Scots Pine woodlands	*moderate*	-22%	-20%	-21%	0%	-14%	-1 217	3 208
				important	-8%	-7%	-5%	0%	2%		
Scenario 4: carbon-sensitive restoration	35 000 ha (carbon-poor soils)	12 210 ha (-7%)	42 - Scrublands, Juniper and Willow	*moderate*	-23%	-24%	-25%	0%	-5%	359	2 330
				important	-4%	-6%	-6%	-5%	18%		
Scenario 5: carbon-sensitive restoration and PF restrictions	35 000 ha (carbon-poor soils)	38 219 ha (-21%)	42 - Scrublands, Juniper and Willow	*moderate*	-23%	-24%	-23%	0%	-5%	478	2 449
				important	-10%	-8%	-7%	0%	18%		

6. Acknowledgement

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7. References

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