Land Use Impacts of Wildlife Reintroduction

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16 April 2025

The University of Chicago


SAY NO
TO BEAVERS

"[A farmer] said as far as he was concerned, the impact of beavers on his business was bigger than Brexit, and I'll now show you how this has come to fruition" (President, National Farmers Union Scotland)

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This paper: Adaptation along extensive margin

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- Urban development: no change in fertile soil areas

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- Agriculture: are farmers planting more or less?
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Preview of results

- Agriculture: beavers increase land in ag use
- Urban development: no change in fertile soil areas
- Environmental change: noisy effect on river level and flow

Species reintroduction responds to biodiversity loss

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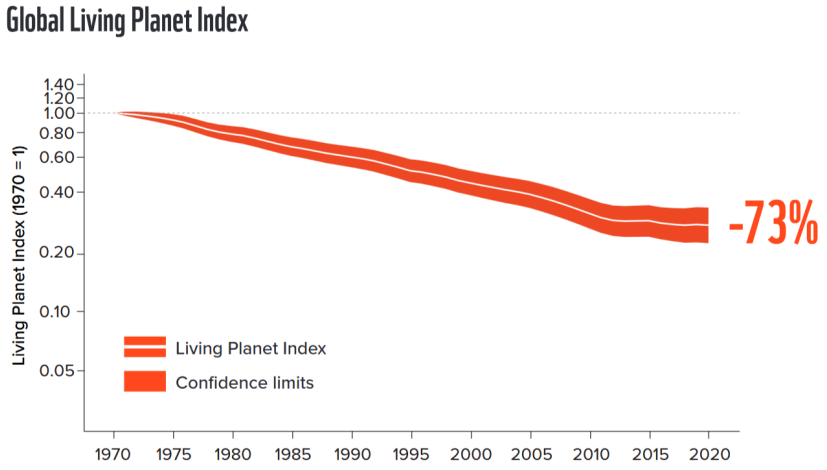
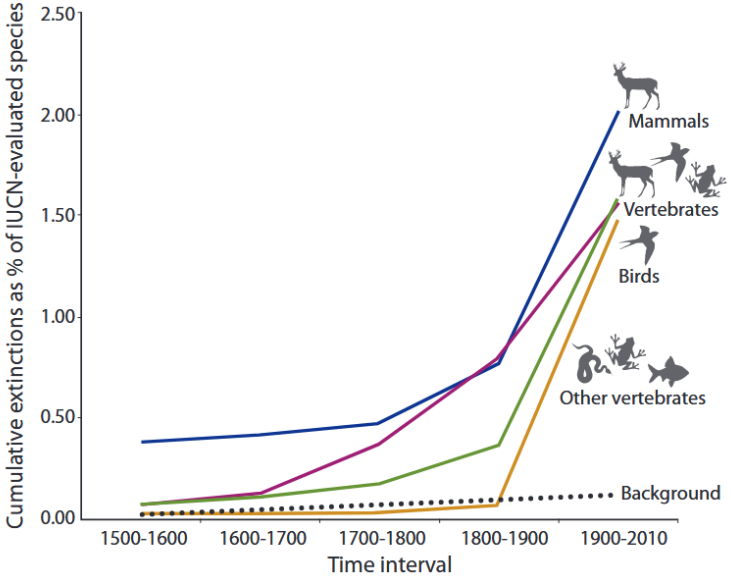
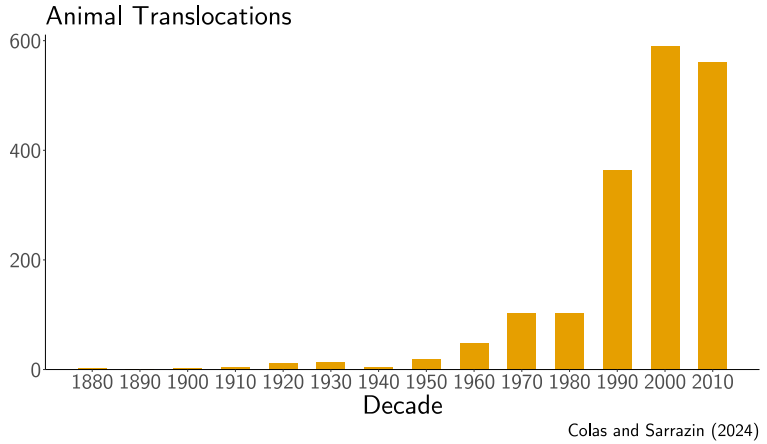
  - Population declines
  - Extinction far above background rate



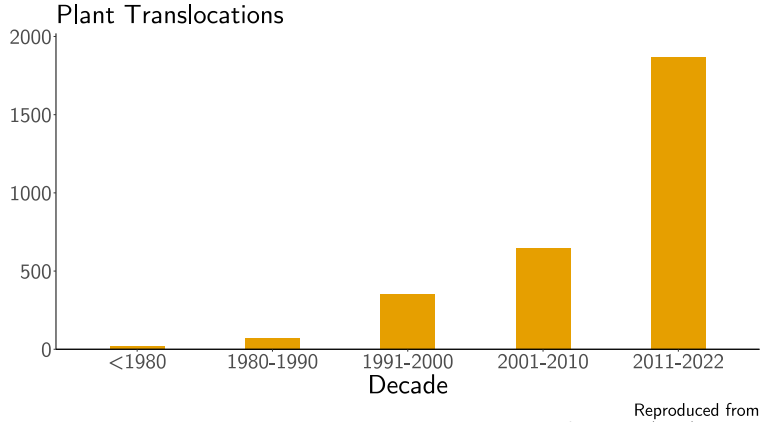


Species reintroduction responds to biodiversity loss

- Biodiversity loss
  - Population declines
  - Extinction far above background rate
- Translocation
  - Increasingly popular conservation policy



Colas and Sarrazin (2024)



Reproduced from Godefroid et al. (2025), Fig. 1d

Ecology is well understood, but net effect is often ambiguous

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- Benefits:

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- Costs:

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- Benefits: ecosystem services
- Costs: predation, zoonoses, invasive species
- Stakes may be high (Tierra Del Fuego)

Setting & Data

Beavers recently reappeared in Scotland

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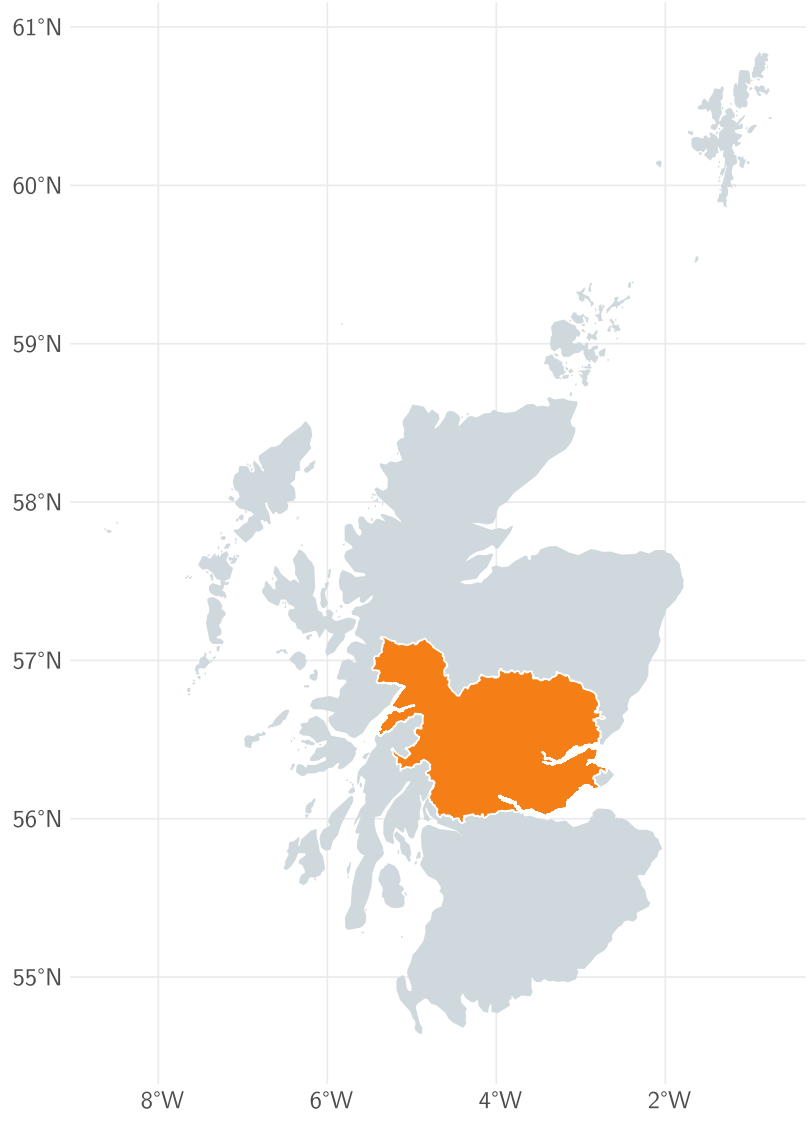
Today: Preliminary results, feedback

Setting: Unplanned Scottish beaver reintroduction

- Circa 2000 in highly agricultural Tayside



Setting: Unplanned Scottish beaver reintroduction

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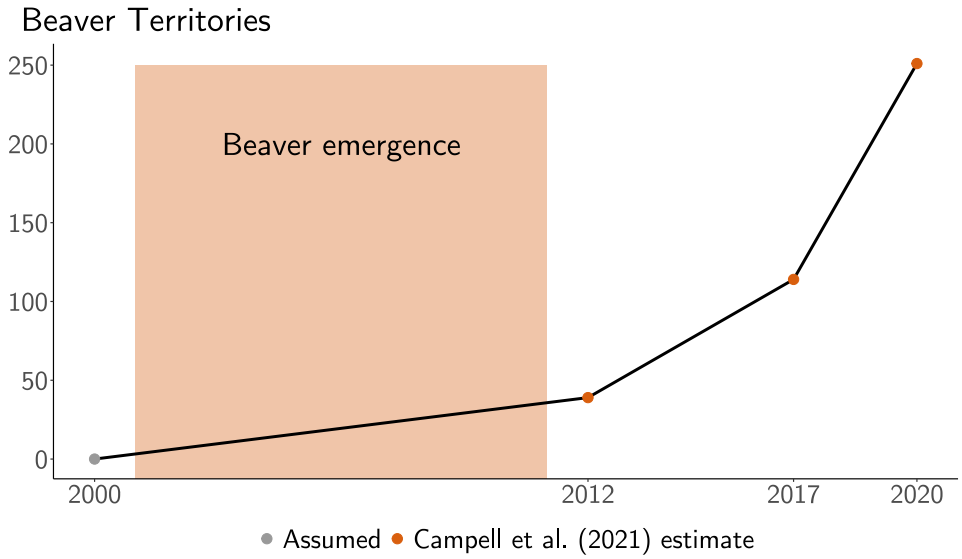
- Rapid expansion



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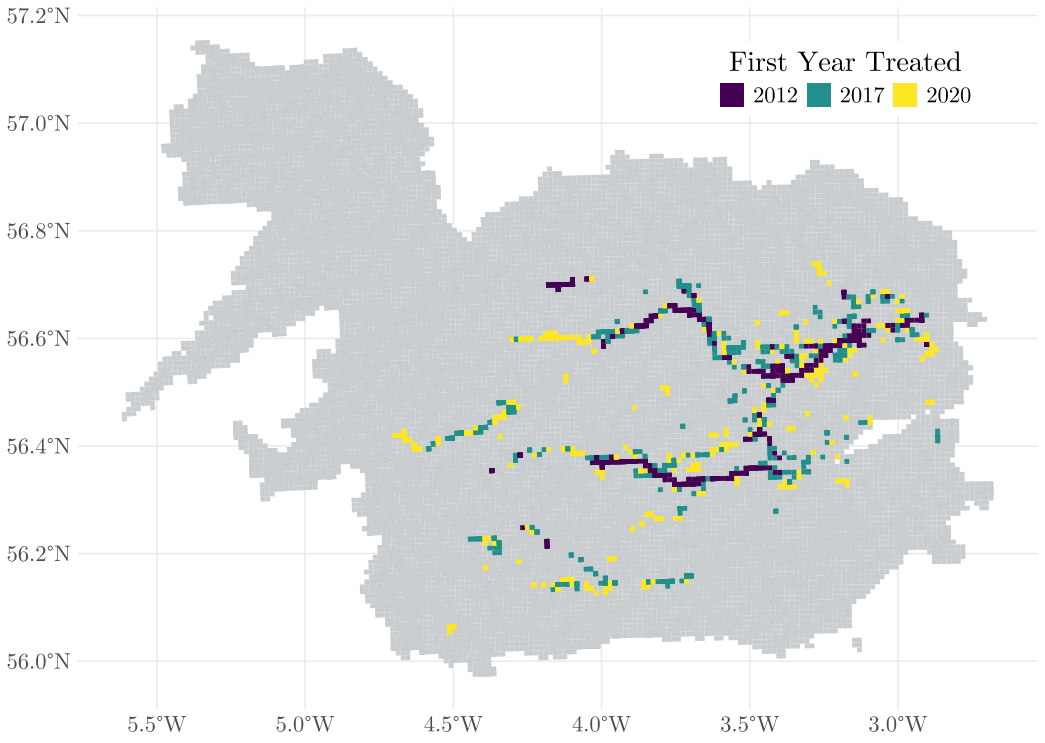
Setting: Unplanned Scottish beaver reintroduction

- Circa 2000 in highly agricultural Tayside
- Rapid expansion
- Impact uncertainty
  - Only survey studies. $225k impact (Hamilton and Moran 2015)



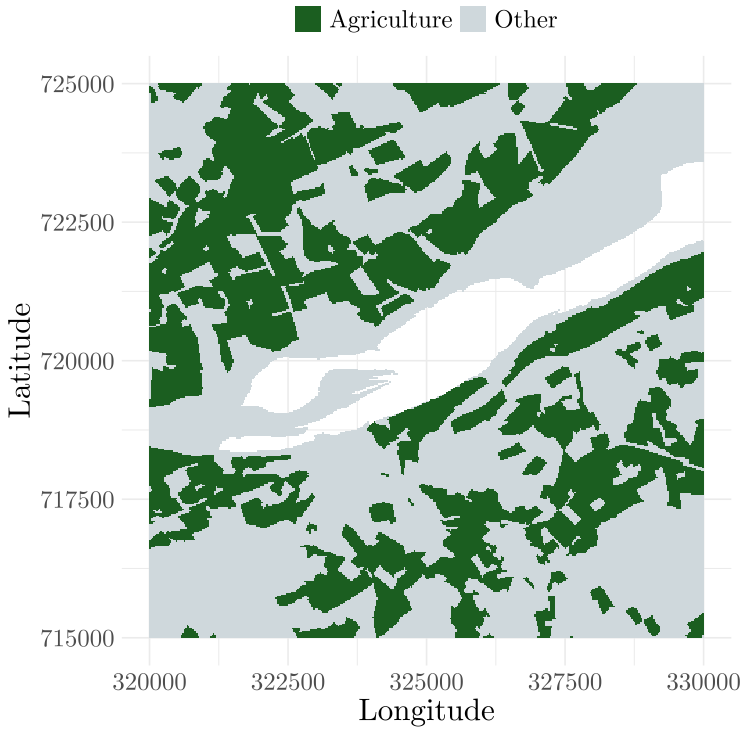
Data

- Beaver expansion surveys
  NatureScot



Data

- Beaver expansion surveys
- Land use raster UKCEH



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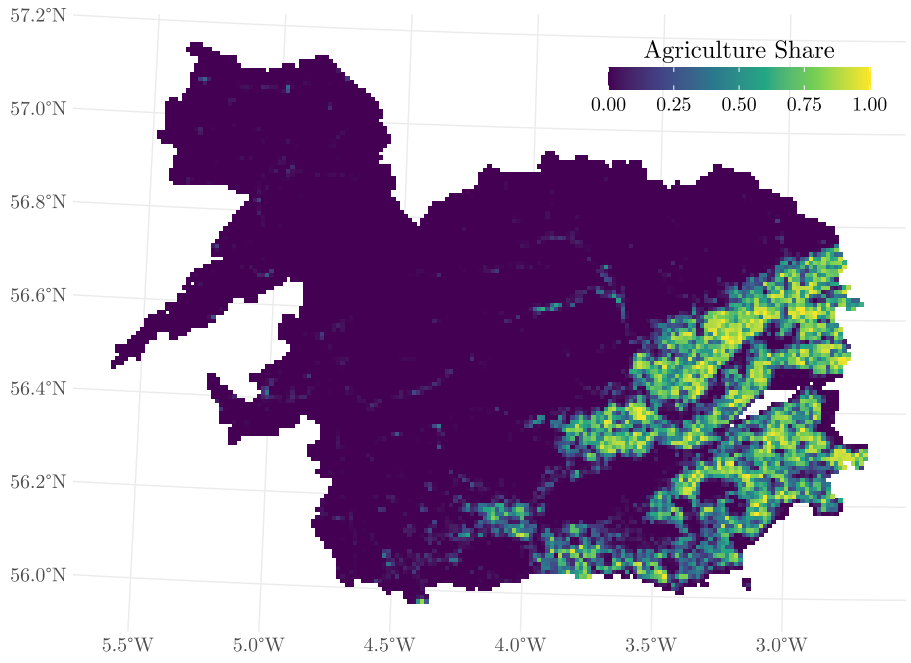
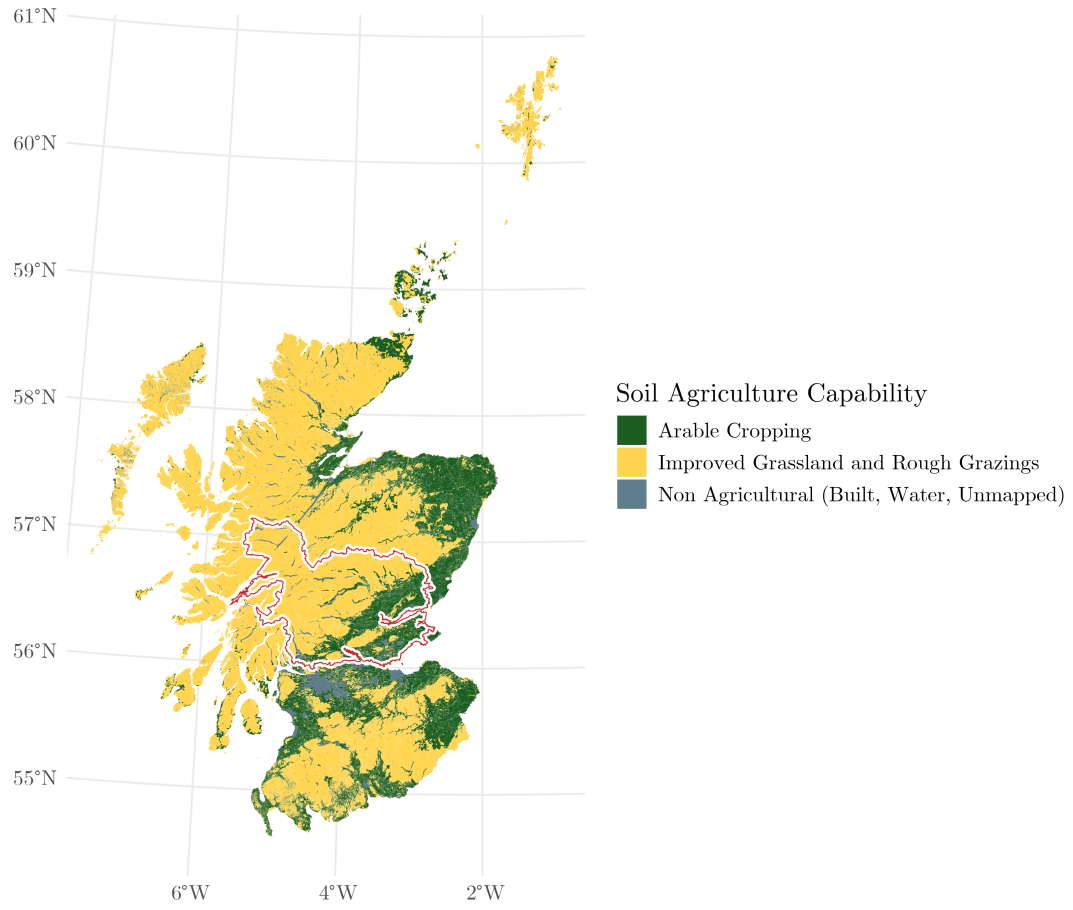


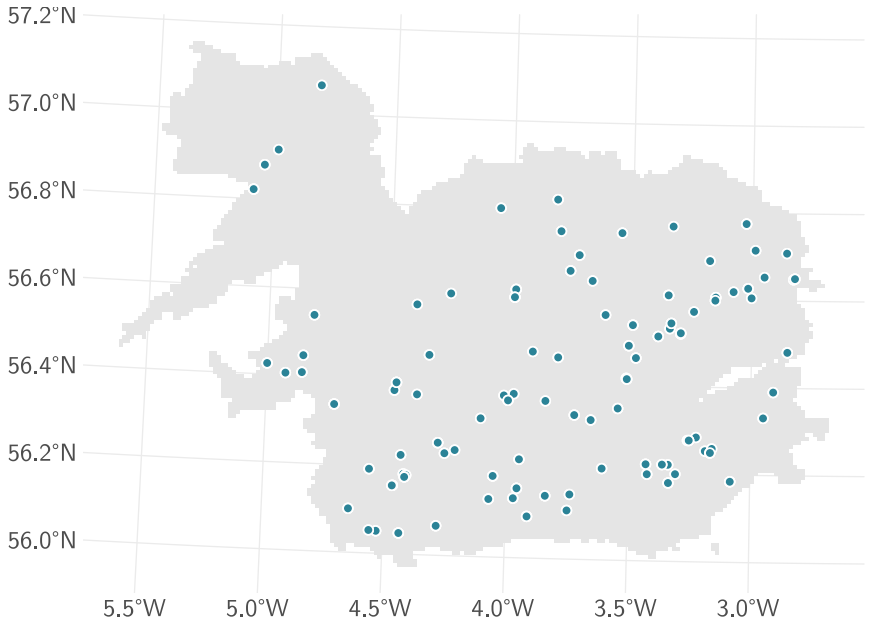
Data

- Beaver expansion surveys
- Land use raster
- Soil capability
  Hutton Institute



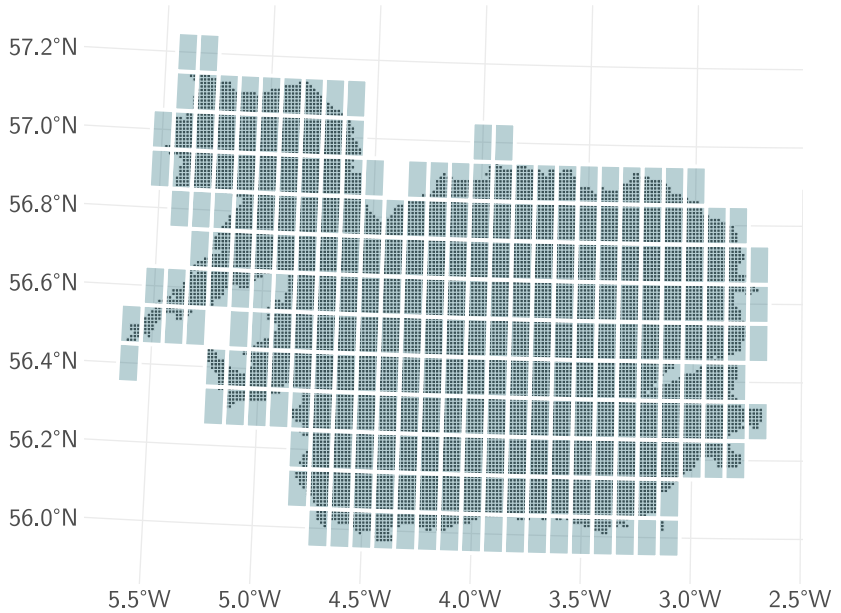
Data

- Beaver expansion surveys
- Land use raster
- Soil capability
- Hydrometry: level and flow
  SEPA



Data

- Beaver expansion surveys
- Land use raster
- Soil capability
- Hydrometry: level and flow
- Temp and precip ERA5



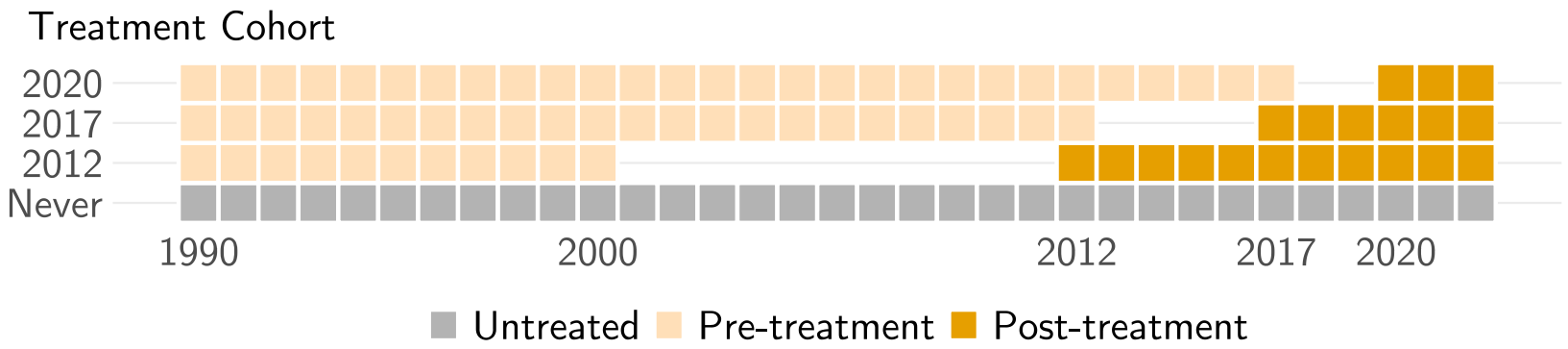
Methods

Methods

- Static,
  two-period DID

$$y_{it} = \alpha_i + \gamma_t + \beta^b D_{it} + \mathbf{X}_{it} + \epsilon_{it}$$

Treatment timeline



Treated cohorts do not exhibit positive pre-trends

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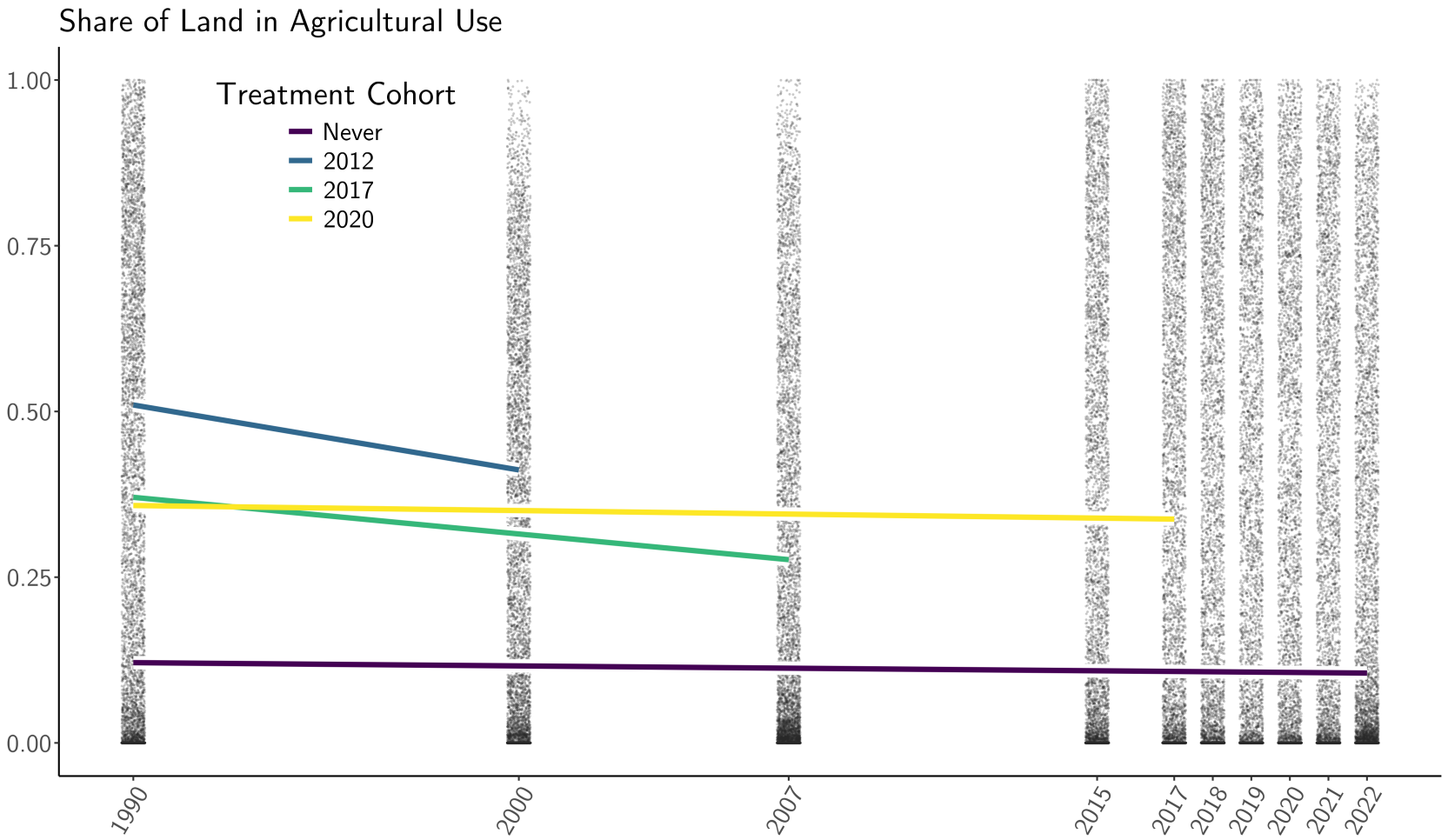


▸ Balance table

Results

Beaver entry increases land in ag use

Dep Var: Share agricultural, Treatment Cohorts: 2012, 2017, 2020, Soil: all types

	All Cells		River Cells		Non-River Cells	
	(1)	(2)	(3)	(4)	(5)	(6)
Beaver Presence	0.017***	0.028***	0.020***	0.031***	-0.007	0.005
	(0.005)	(0.005)	(0.006)	(0.006)	(0.014)	(0.014)
Observations	28,384	27,970	17,752	17,598	10,632	10,372
Within R^2	0.002	0.041	0.003	0.039	0.000	0.047
Mean Dep. Var.	0.126	0.125	0.126	0.125	0.126	0.126
Weather controls		✓		✓		✓

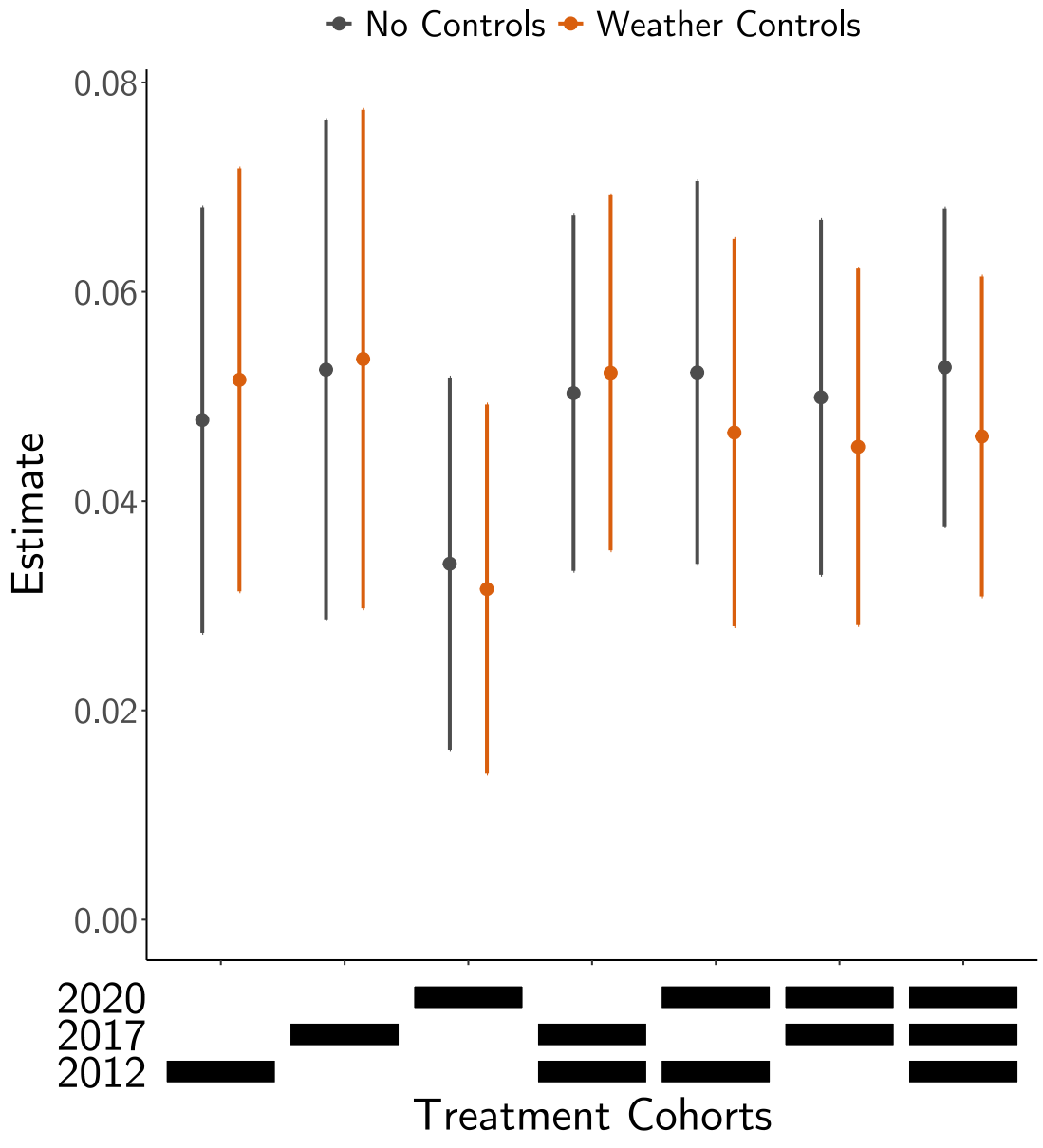
Arable land drives effect

Dep Var: Share agricultural, Treatment Cohorts: 2012, 2017, 2020, Soil: arable cropping

	All Cells		River Cells		Non-River Cells	
	(1)	(2)	(3)	(4)	(5)	(6)
Beaver Presence	0.054***	0.045***	0.053***	0.046***	0.036*	0.026
	(0.007)	(0.007)	(0.008)	(0.008)	(0.021)	(0.020)
Observations	7,812	7,668	5,196	5,128	2,616	2,540
Within R^2	0.014	0.039	0.017	0.045	0.002	0.019
Mean Dep. Var.	0.434	0.433	0.408	0.407	0.485	0.487
Weather controls		✓		✓		✓

▸ Grassland ▸ Non-Ag

Effect is robust across treatment cohorts



Beaver entry does not increase development in ag areas

Dep Var: Share Developed, Treatment Cohorts: 2012, 2017, 2020, Soil: arable cropping

	All Cells		River Cells		Non-River Cells	
	(1)	(2)	(3)	(4)	(5)	(6)
Beaver Presence	0.002	0.002	0.003	0.003	-0.006	-0.005
	(0.002)	(0.002)	(0.002)	(0.002)	(0.005)	(0.005)
Observations	7,812	7,668	5,196	5,128	2,616	2,540
Within R^2	0.000	0.001	0.001	0.001	0.000	0.002
Mean Dep. Var.	0.034	0.033	0.032	0.032	0.037	0.036
Weather controls		✓		✓		✓

▸ Grassland ▸ Non-Ag

Unclear evidence on environmental change

Dep Var: River flow (mean), Treatment Cohorts: 2012, 2017, 2020, River sample: On-river cells

	All Soil		Arable		Grass/Graze		Non-Ag	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Beaver Presence	-0.164	-0.251	-0.371	-0.360	0.229	0.213	0.012	-0.182
	(0.245)	(0.247)	(0.326)	(0.329)	(0.436)	(0.503)	(0.838)	(0.558)
Observations	110	108	60	58	36	36	14	14
Within R^2	0.011	0.040	0.044	0.068	0.025	0.241	0.000	0.450
Mean Dep. Var.	17.572	17.887	23.127	23.904	9.630	9.630	14.191	14.191
Weather controls		✓		✓		✓		✓

Unclear evidence on environmental change

Dep Var: River level (mean), Treatment Cohorts: 2012, 2017, 2020, River sample: On-river cells

	All Soil		Arable		Grass/Graze		Non-Ag	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Beaver Presence	-0.033	-0.041	-0.039	-0.047	-0.030	-0.064	-0.053	-0.051
	(0.026)	(0.027)	(0.038)	(0.041)	(0.024)	(0.046)	(0.059)	(0.066)
Observations	136	134	72	70	48	48	16	16
Within R^2	0.026	0.049	0.029	0.062	0.017	0.155	0.155	0.195
Mean Dep. Var.	0.570	0.573	0.588	0.593	0.529	0.529	0.614	0.614
Weather controls		✓		✓		✓		✓

Unclear evidence on environmental change

Dep Var: River level (max), Treatment Cohorts: 2012, 2017, 2020, River sample: On-river cells

	All Soil		Arable		Grass/Graze		Non-Ag	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Beaver Presence	0.059	-0.018	-0.124	-0.066	0.193	0.065	0.209	0.229
	(0.076)	(0.071)	(0.098)	(0.101)	(0.155)	(0.140)	(0.226)	(0.234)
Observations	136	134	72	70	48	48	16	16
Within R^2	0.009	0.262	0.044	0.294	0.073	0.388	0.117	0.375
Mean Dep. Var.	2.243	2.251	2.418	2.439	1.971	1.971	2.270	2.270
Weather controls		✓		✓		✓		✓

Conclusion

Wrap up

Summary

- Beavers reemerged in Scotland
- Increased agricultural land use
- No impact on development in fertile areas

Next Steps

- Environmental mechanism: flood detection using Sentinel imagery
- How do cropped areas' distance to river change?
- Elevation: comparing low-lying areas along rivers to elevated areas
- Distinguishing between upstream and downstream cells

Thank you!

Balance

	Treated	Control	Diff in Means
Share Ag. Use	0.356	0.109	0.247***
Cell on river	0.882	0.611	0.271***
Share Ag. Soil	0.673	0.238	0.436***
Temp	7.221	6.805	0.416***
Precip	14.168	17.557	-3.389***

return

Agriculture: Grassland subsample

Dep Var: Share agricultural, Treatment Cohorts: 2012, 2017, 2020, Soil: improved grassland/grazing

	All Cells		River Cells		Non-River Cells	
	(1)	(2)	(3)	(4)	(5)	(6)
Beaver Presence	-0.007	-0.005	-0.004	-0.003	-0.021*	-0.019*
	(0.005)	(0.005)	(0.005)	(0.005)	(0.011)	(0.011)
Observations	19,208	18,982	11,620	11,534	7,588	7,448
Within R^2	0.001	0.034	0.000	0.032	0.005	0.042
Mean Dep. Var.	0.005	0.005	0.006	0.005	0.005	0.004
Weather controls		✓		✓		✓

return

Agriculture: Non-Agricultural sample

Dep Var: Share agricultural, Treatment Cohorts: 2012, 2017, 2020, Soil: non-agricultural

	All Cells		River Cells		Non-River Cells	
	(1)	(2)	(3)	(4)	(5)	(6)
Beaver Presence	-0.003	0.003	-0.002	0.007	-0.035	-0.033
	(0.013)	(0.012)	(0.014)	(0.014)	(0.022)	(0.023)
Observations	1,346	1,312	934	934	412	378
Within R^2	0.000	0.074	0.000	0.064	0.005	0.047
Mean Dep. Var.	0.059	0.059	0.048	0.048	0.085	0.088
Weather controls		✓		✓		✓

return

Urban development: Grassland subsample

Dep Var: Share Developed, Treatment Cohorts: 2012, 2017, 2020, Soil: improved grassland/grazing

	All Cells		River Cells		Non-River Cells	
	(1)	(2)	(3)	(4)	(5)	(6)
Beaver Presence	0.006***	0.006***	0.007***	0.008***	-0.003	-0.003
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Observations	19,208	18,982	11,620	11,534	7,588	7,448
Within R^2	0.003	0.010	0.007	0.015	0.000	0.002
Mean Dep. Var.	0.002	0.002	0.003	0.003	0.001	0.001
Weather controls		✓		✓		✓

return

Urban development: Non-Agricultural subsample

Dep Var: Share Developed, Treatment Cohorts: 2012, 2017, 2020, Soil: non-agricultural

	All Cells		River Cells		Non-River Cells	
	(1)	(2)	(3)	(4)	(5)	(6)
Beaver Presence	0.041***	0.038***	0.046***	0.038***	0.038	0.043
	(0.014)	(0.014)	(0.013)	(0.014)	(0.051)	(0.052)
Observations	1,346	1,312	934	934	412	378
Within R^2	0.009	0.035	0.022	0.056	0.002	0.013
Mean Dep. Var.	0.261	0.261	0.188	0.188	0.427	0.443
Weather controls		✓		✓		✓

return