Catchment vegetation and wild salmon populations

Is it possible to make rivers more resilient to climate change?

Peter Cunningham
Biologist,
Wester Ross Fisheries Trust

Catchment Vegetation Revival Meeting
Kinlochewe, 26 April 2023

Background . . .

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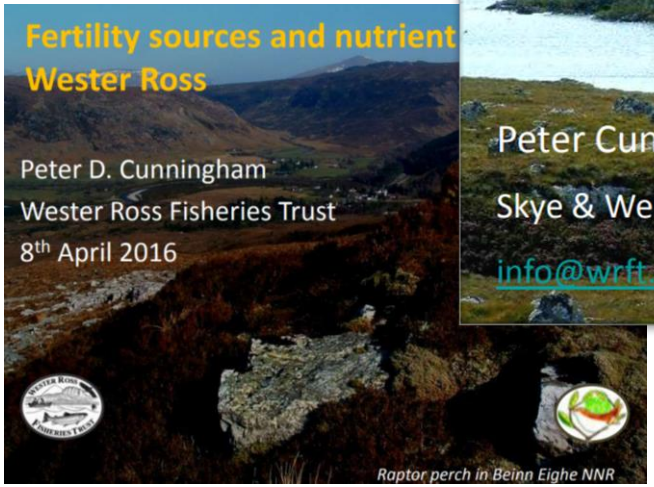

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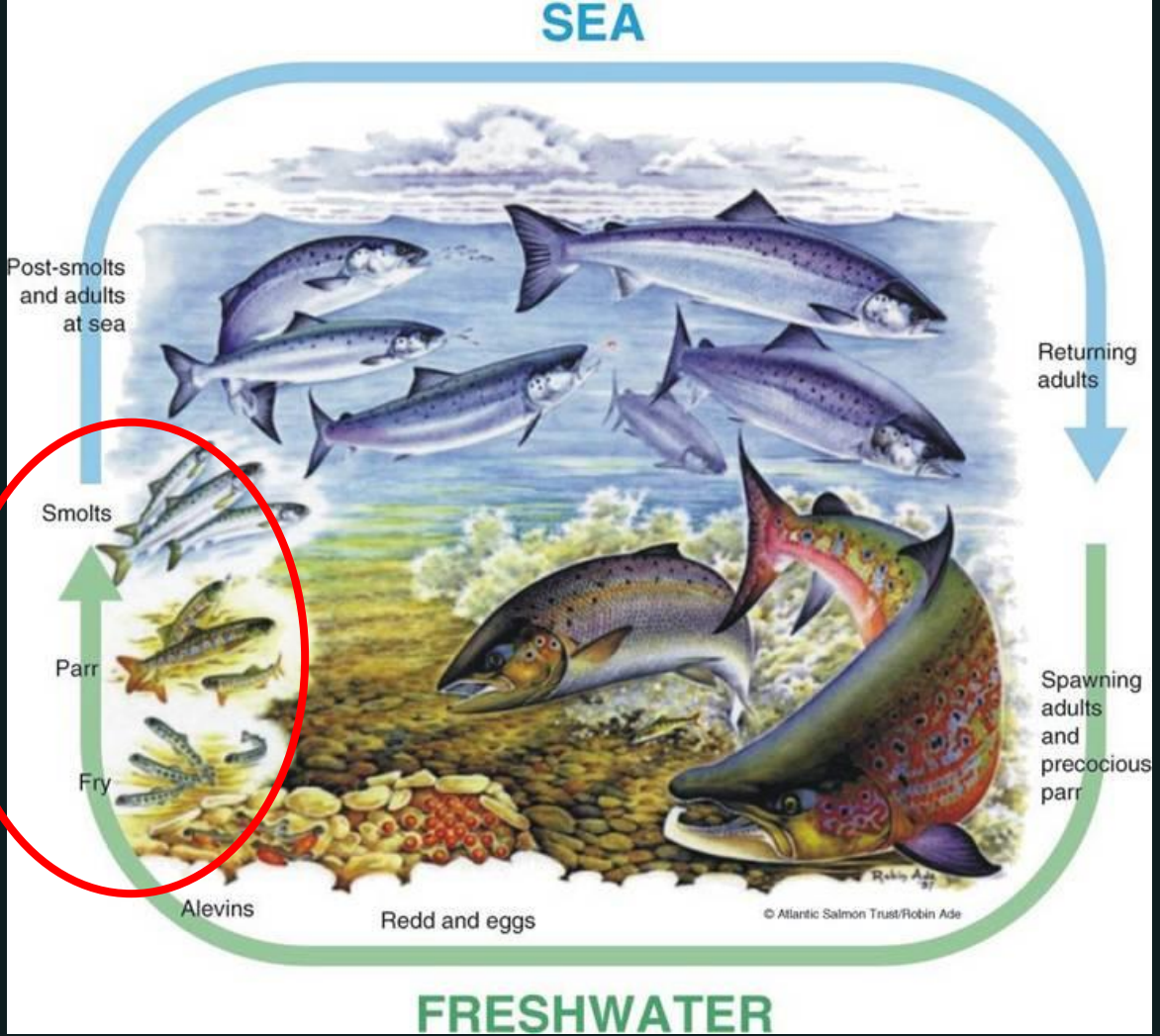
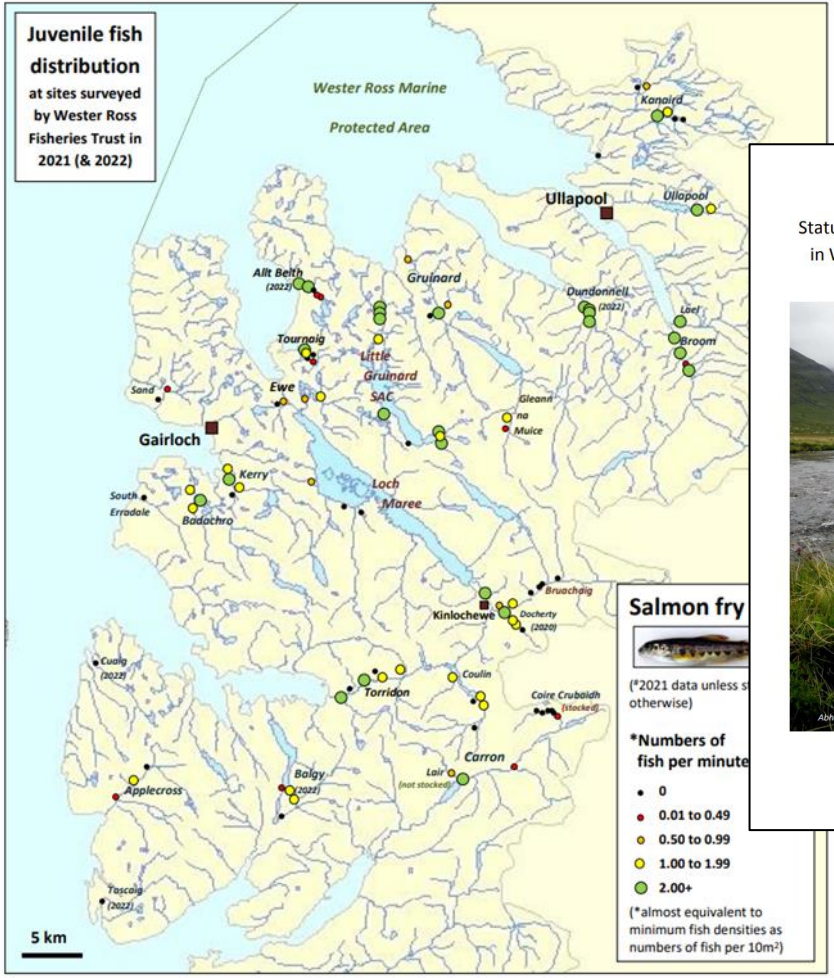
Wester Ross remains a stronghold for wild Atlantic salmon populations





Status of juvenile Wild Atlantic Salmon in Wester Ross, Northwest Scotland

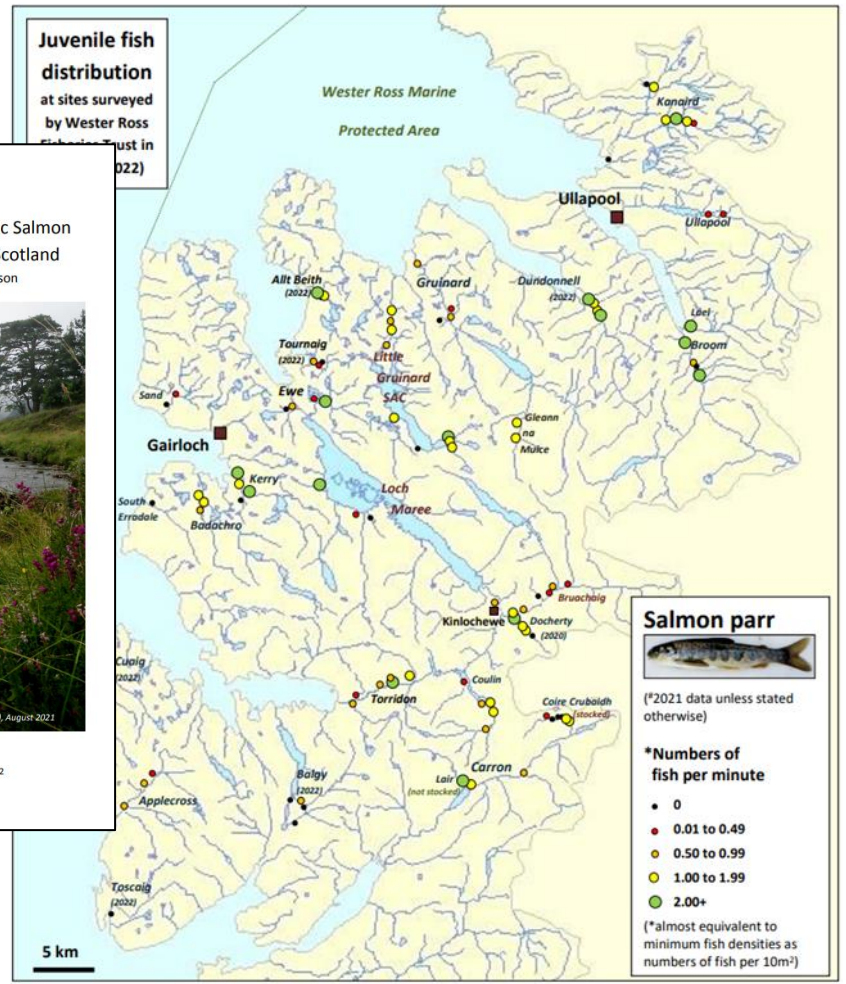
Report following 2021 field season

Abhainn Gleann na Muice (Gruinard River headwaters), August 2021

Peter Cunningham and Colin Simpson,

Wester Ross Fisheries Trust, February 2022

info@wrft.org.uk



Juvenile fish surveys monitor occurrence & abundance of juvenile salmon and condition of nursery habitat

Thank you to Alasdair Macdonald and Colin Simpson

Habitat in some streams for juvenile salmon has been degrading and is increasingly vulnerable to ‘washout’

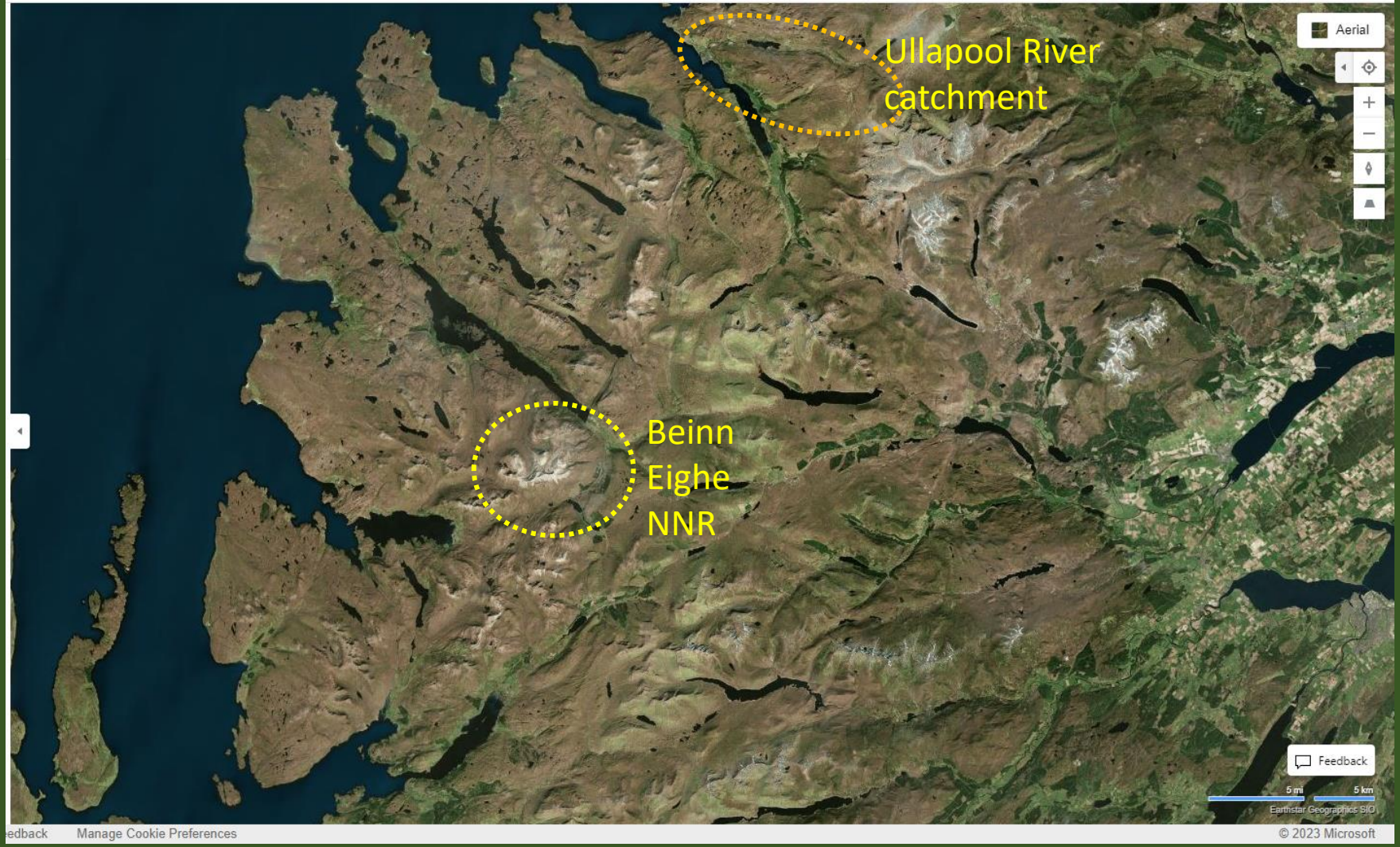
Gruinard River headwaters

(left) **Live alder trees**

•roots support river bank.
•fertile riparian corridor with green grass.
•many places for parr to hide in roots.

(right) **Dead alder trees**

•roots rot away and bank collapses.
•fertile riparian corridor eroded away.
•stream becomes wider and shallower.


Ullapool River catchment
Beinn Eighe NNR
Aerial
Feedback
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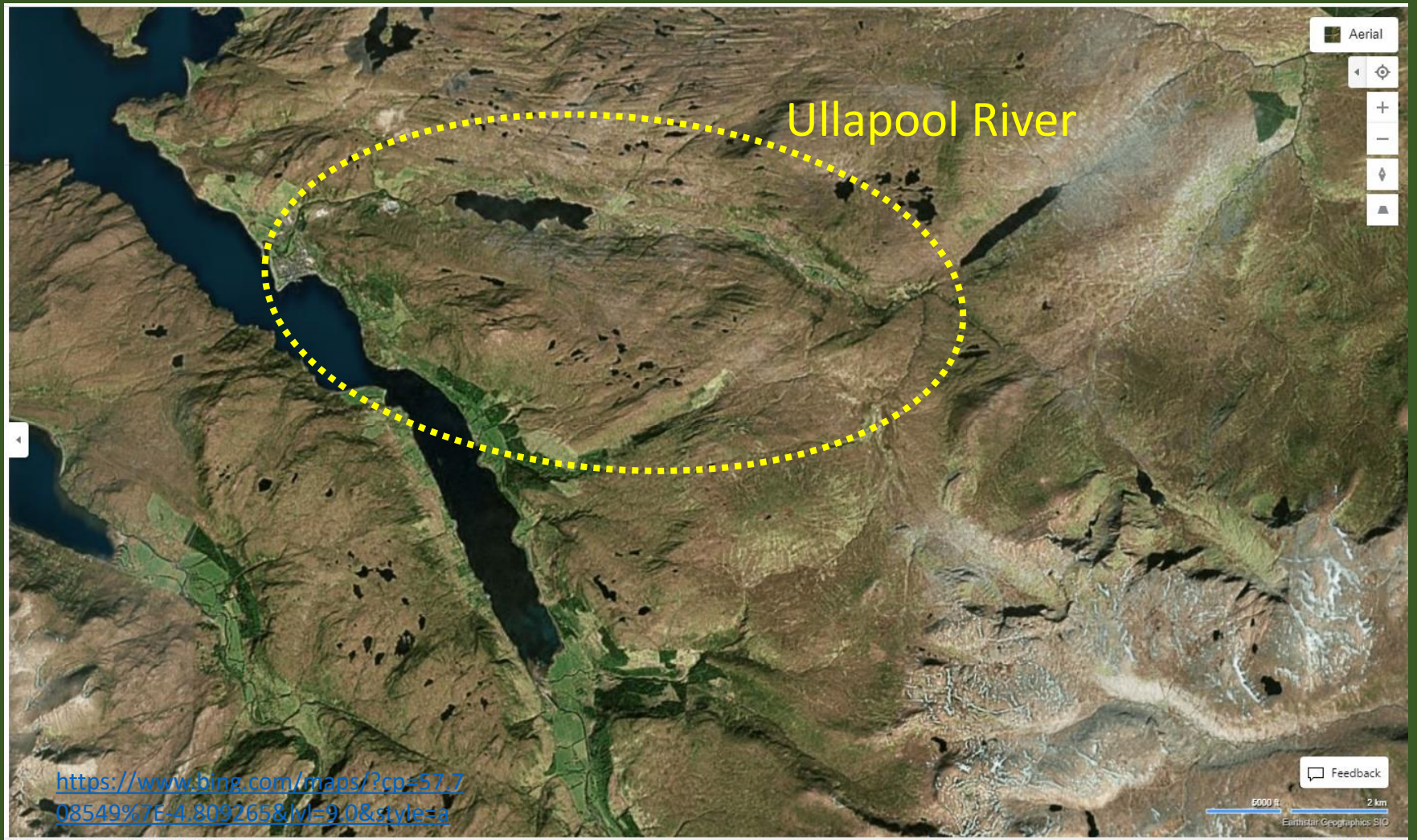
Ullapool River
Aerial
Feedback
6000 ft
2 km
Earthstar Geographics SIO
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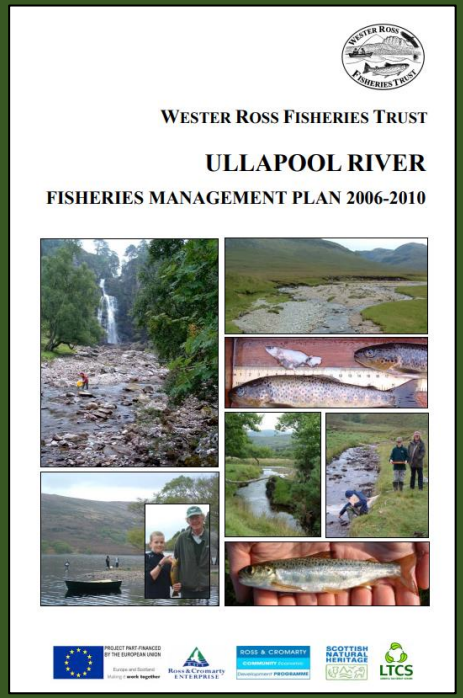
Records for rod caught salmon in the Ullapool River go back for 120+ years. Many more fish were taken in netting stations nearby.



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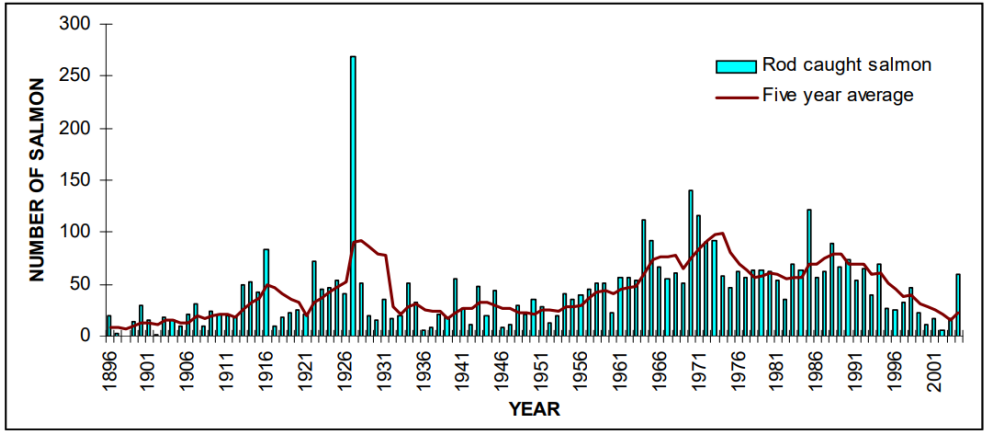


Figure 4.1: Recorded rod catch of salmon in the Ullapool River, 1896 – 2004, based on records in the Cromartie Estate and Rhidorroch Estate Game books

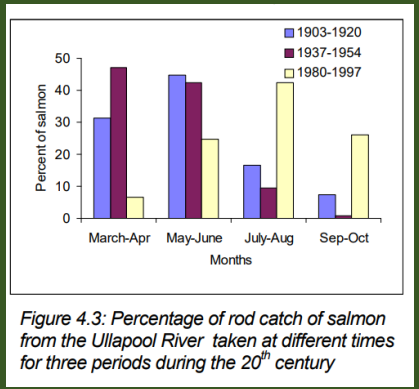
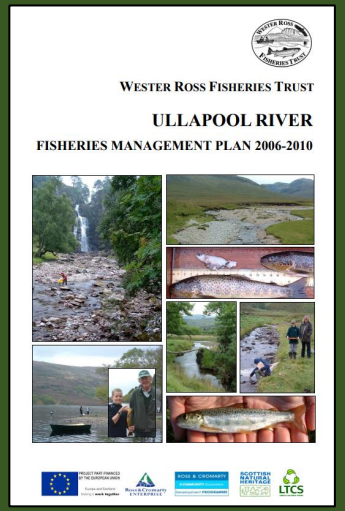


Figure 4.3: Percentage of rod catch of salmon from the Ullapool River taken at different times for three periods during the 20th century

Until the 1950s, rod catches were dominated by ‘spring’ salmon, mostly taken in March, April and May,

The Rhidorroch River is the major spawning stream for Ullapool River salmon



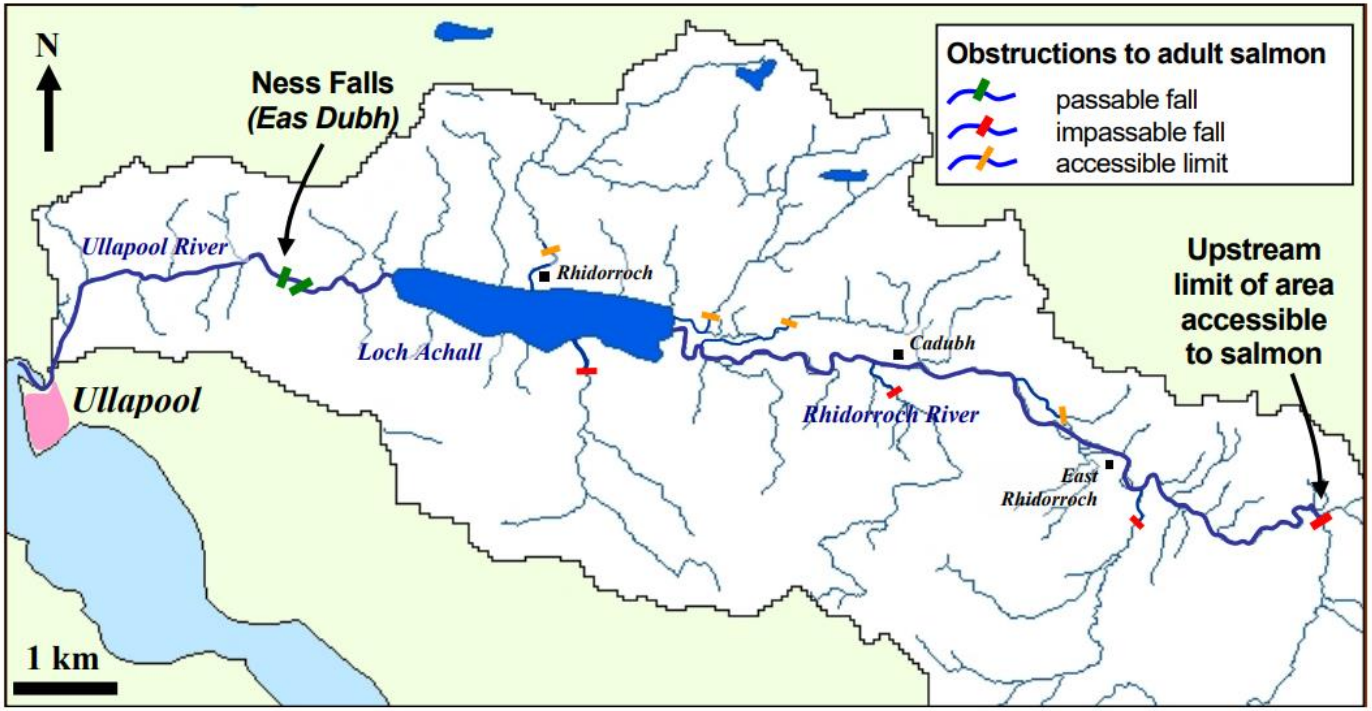
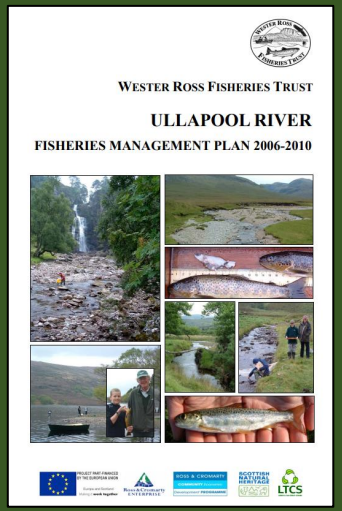
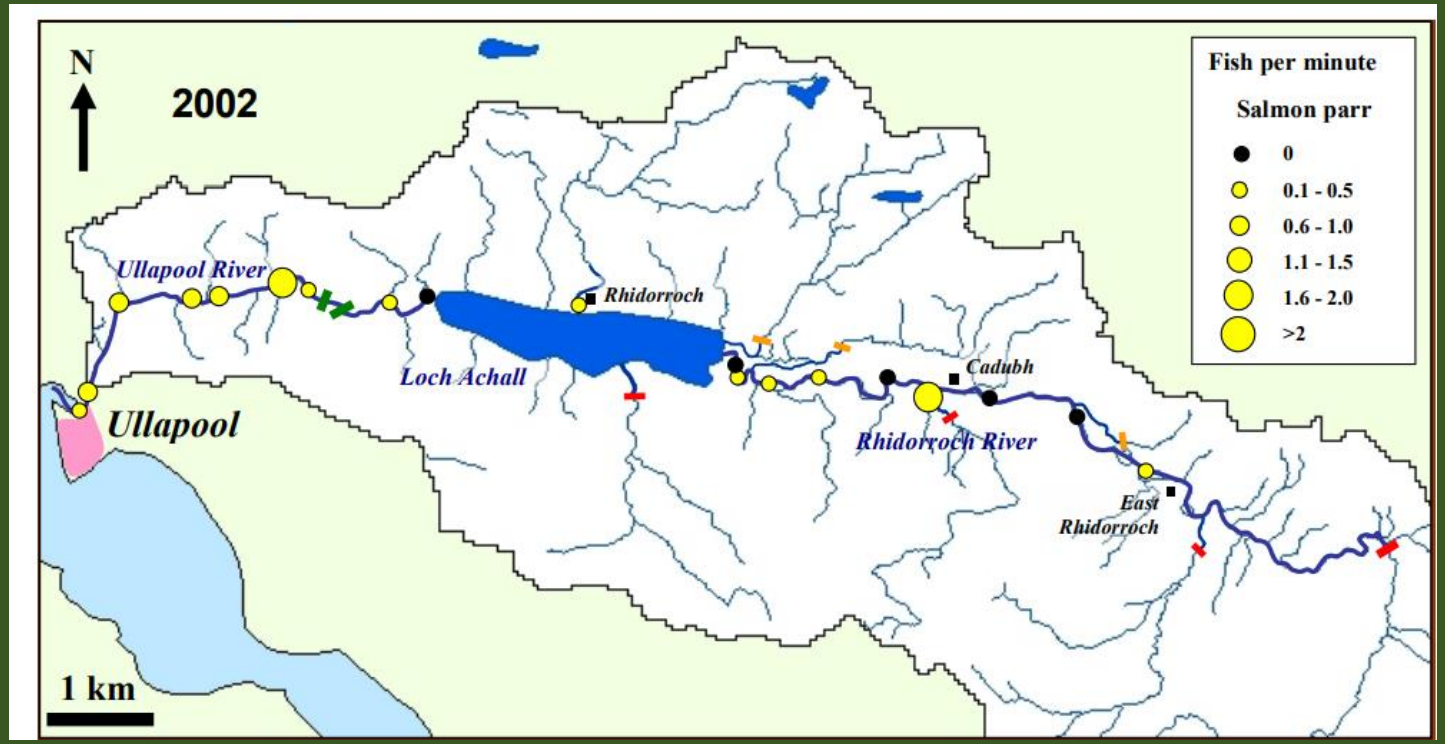
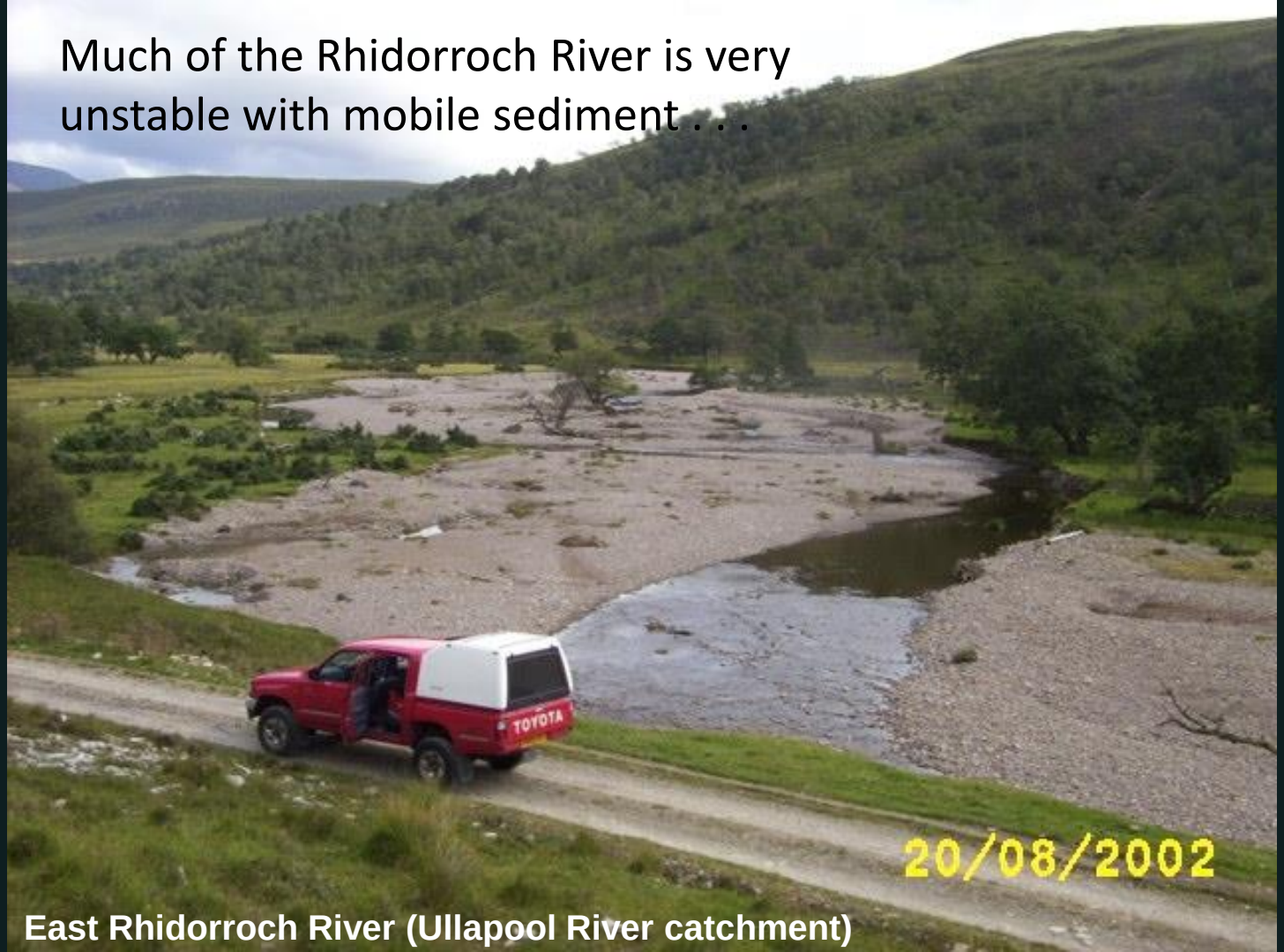


Figure 6.1: Parts of the Ullapool River that are accessible to adult Atlantic salmon.

However, low densities of juvenile salmon have often been recorded in the Rhidorroch River





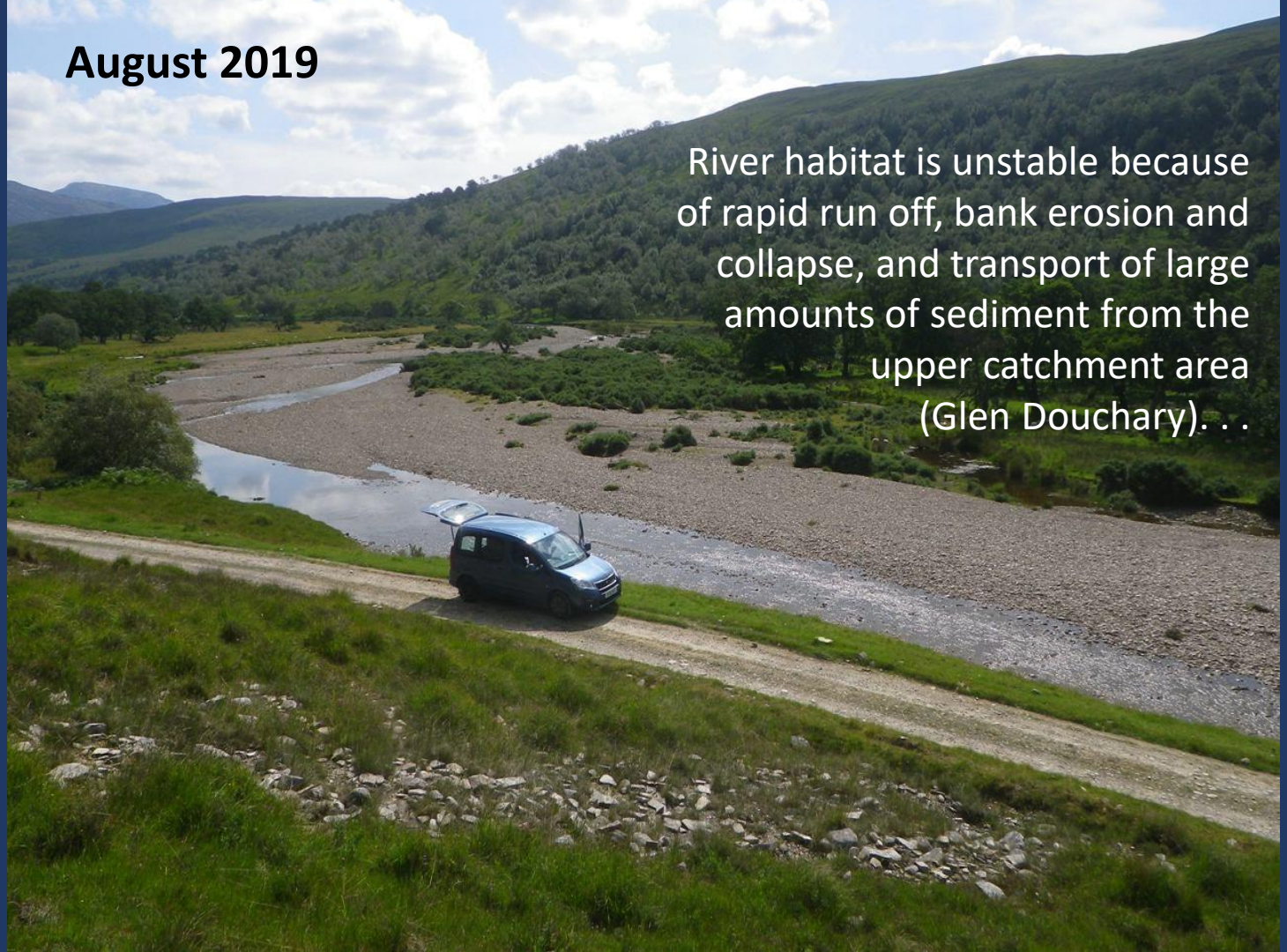


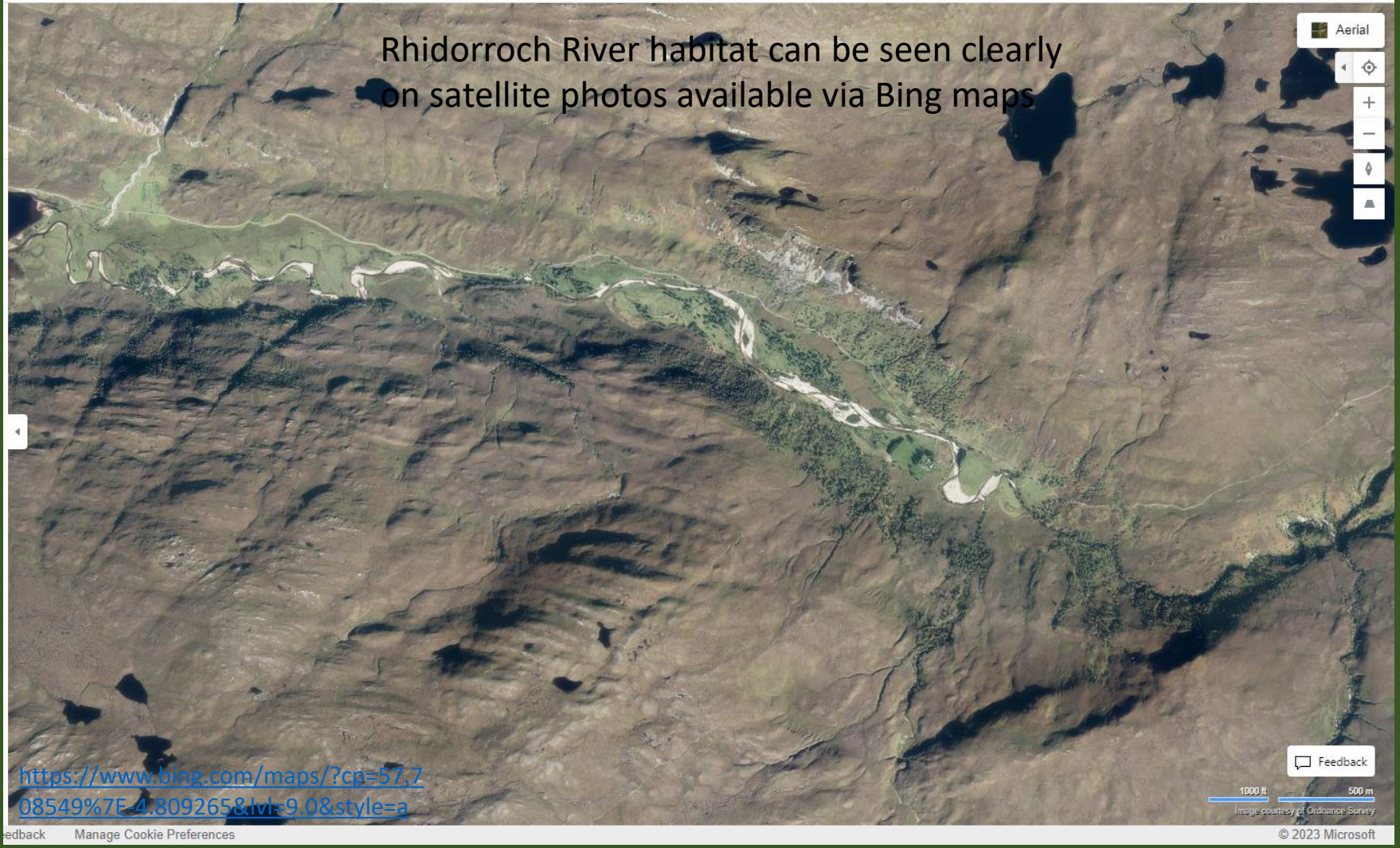
East Rhidorroch River (Ullapool River catchment)


December 2005


August 2006

August 2007


August 2019
River habitat is unstable because of rapid run off, bank erosion and collapse, and transport of large amounts of sediment from the upper catchment area (Glen Douchary). . .


Rhidorroch River habitat can be seen clearly
on satellite photos available via Bing maps
Aerial
Feedback
1000 ft
500 m
Image courtesy of Ordnance Survey
https://www.bing.com/maps/?cp=57.7
08549%7E-4.809265&lvl=9.0&style=a
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Rhidorroch River habitat can be seen clearly
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Aerial
Feedback
300 ft
100 m
Image courtesy of Ordnance Survey
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Rhidorroch River habitat can be seen clearly on satellite photos available via Bing maps


Rhidorroch River habitat can be seen clearly
on satellite photos available via Bing maps
Aerial
Feedback
100 ft
30 m
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Rhidorroch River (Ullapool River headwaters)
2nd September2015
Hurricane Bertha spate damage
Just 8 salmon fry and 4 salmon parr caught in 16 minutes e-fishing

Rhidorroch River
(Ullapool River headwaters)

- Hardly any fish in e-fish survey in summer 2019!
- Big changes in site since 2018 following another major spate event
- Habitat very unstable

Could river engineering provide solutions for habitat problems in the Rhidorroch River?

Workshop on engineering solutions to unstable rivers in September 2019

Field visit example:

upper River Nairn habitat restoration project (~£250k . . .)

+ Practical River Works workshop September 2019

Google Maps

google.com/maps/@57.3026865,-4.2662209,2137m/data=!3m1!1e3

Sign in

Project area

B851

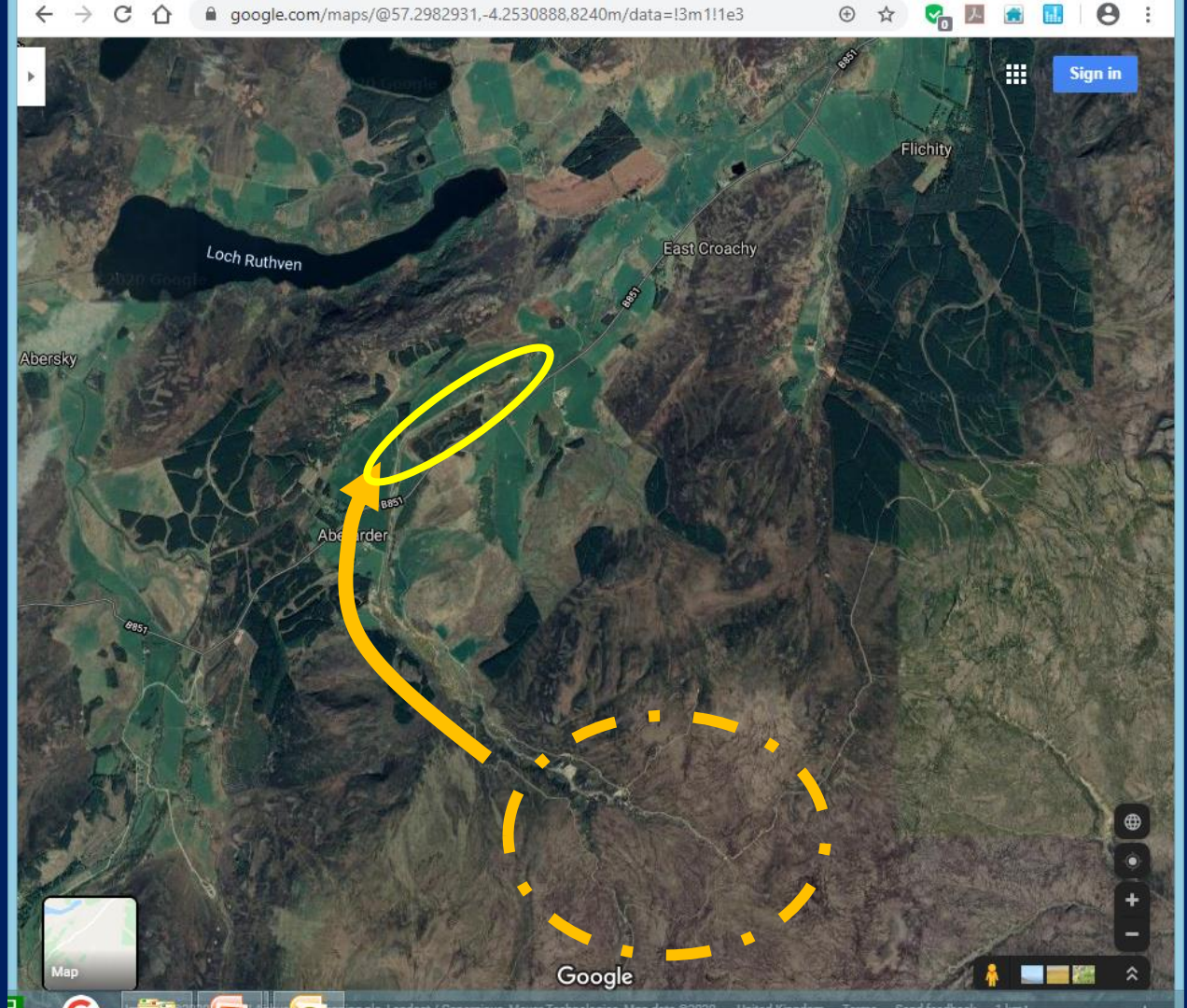
B851

B851

B851

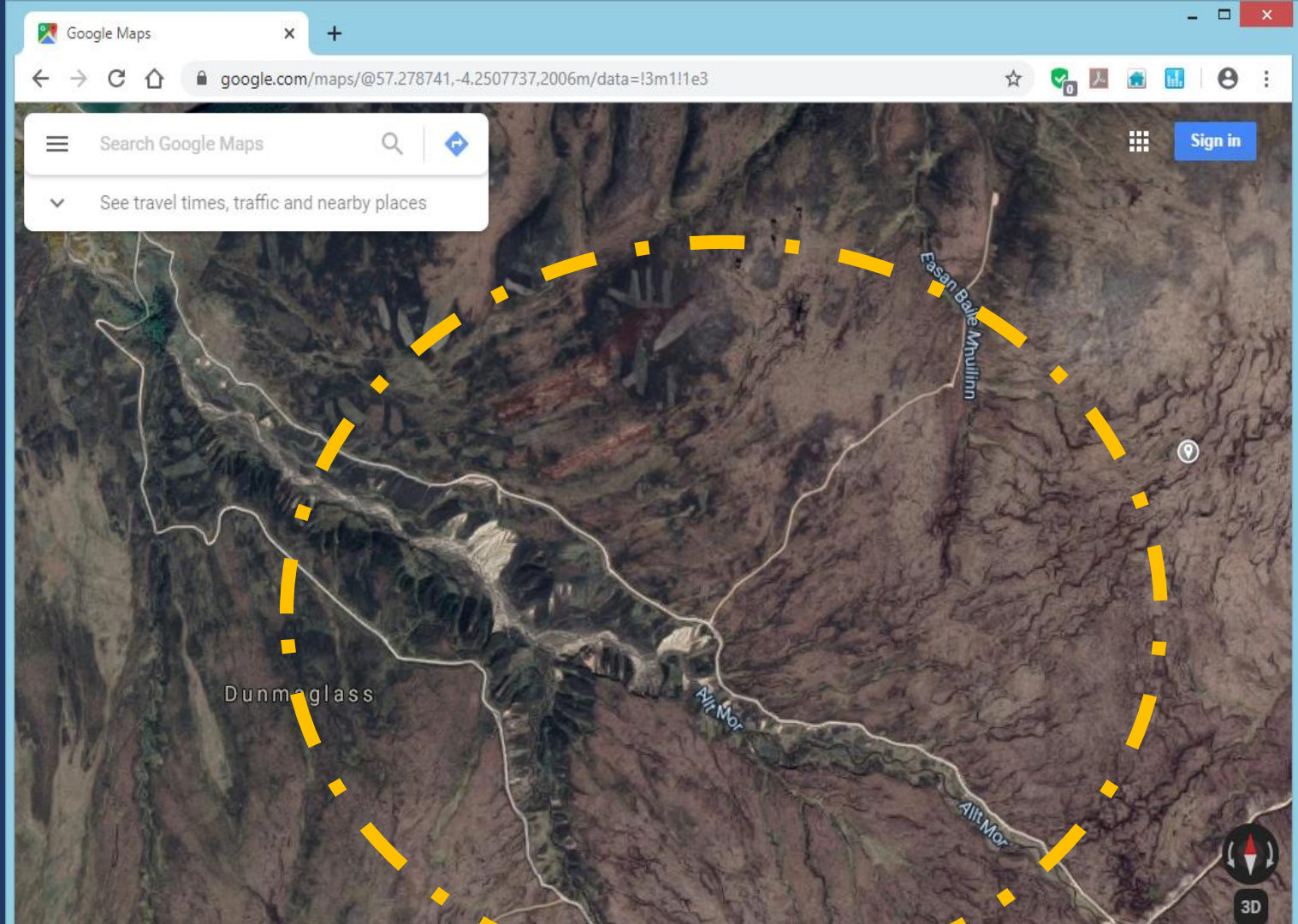
Not all problems resolved . . .

. . . much sediment (including boulders and cobbles) was being transported towards project area from upper catchment area.



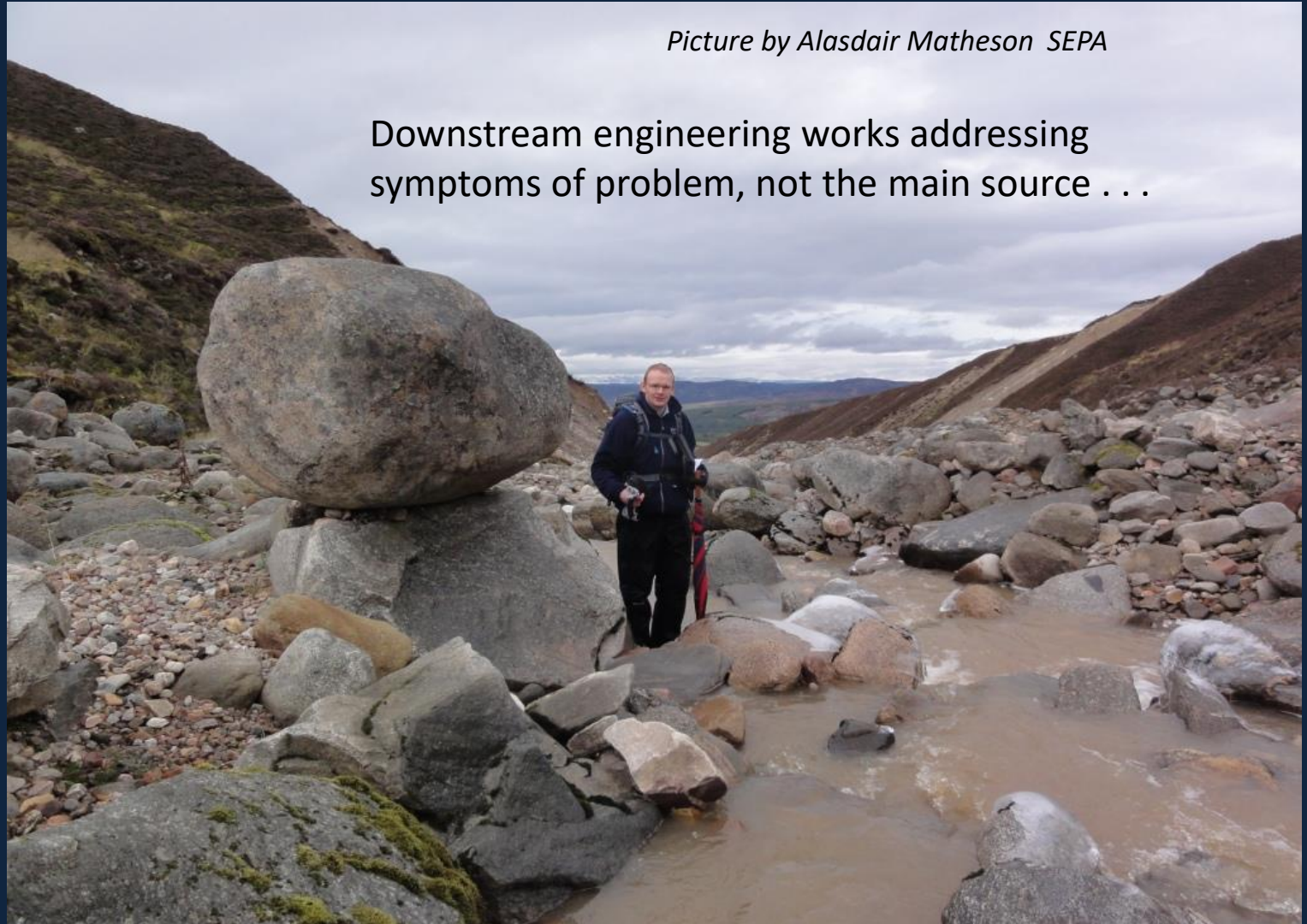
Source of problem in headwater areas . . .

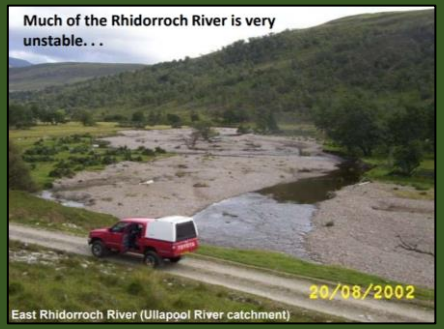
. . . rapid erosion and discharge of sediment

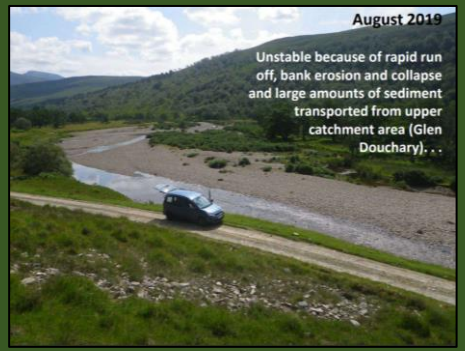


Large scale erosion, landslip and input of sediment in headwater areas above project area . . .

Picture by Alasdair Matheson SEPA

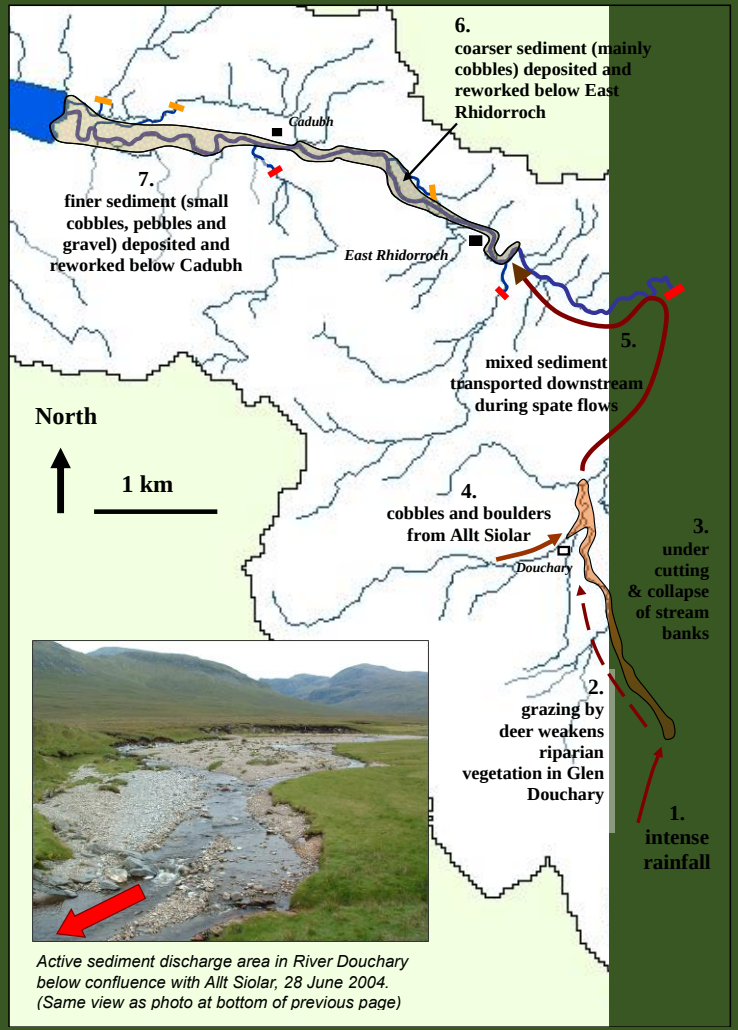

Picture by Alasdair Matheson SEPA
Downstream engineering works addressing symptoms of problem, not the main source . . .



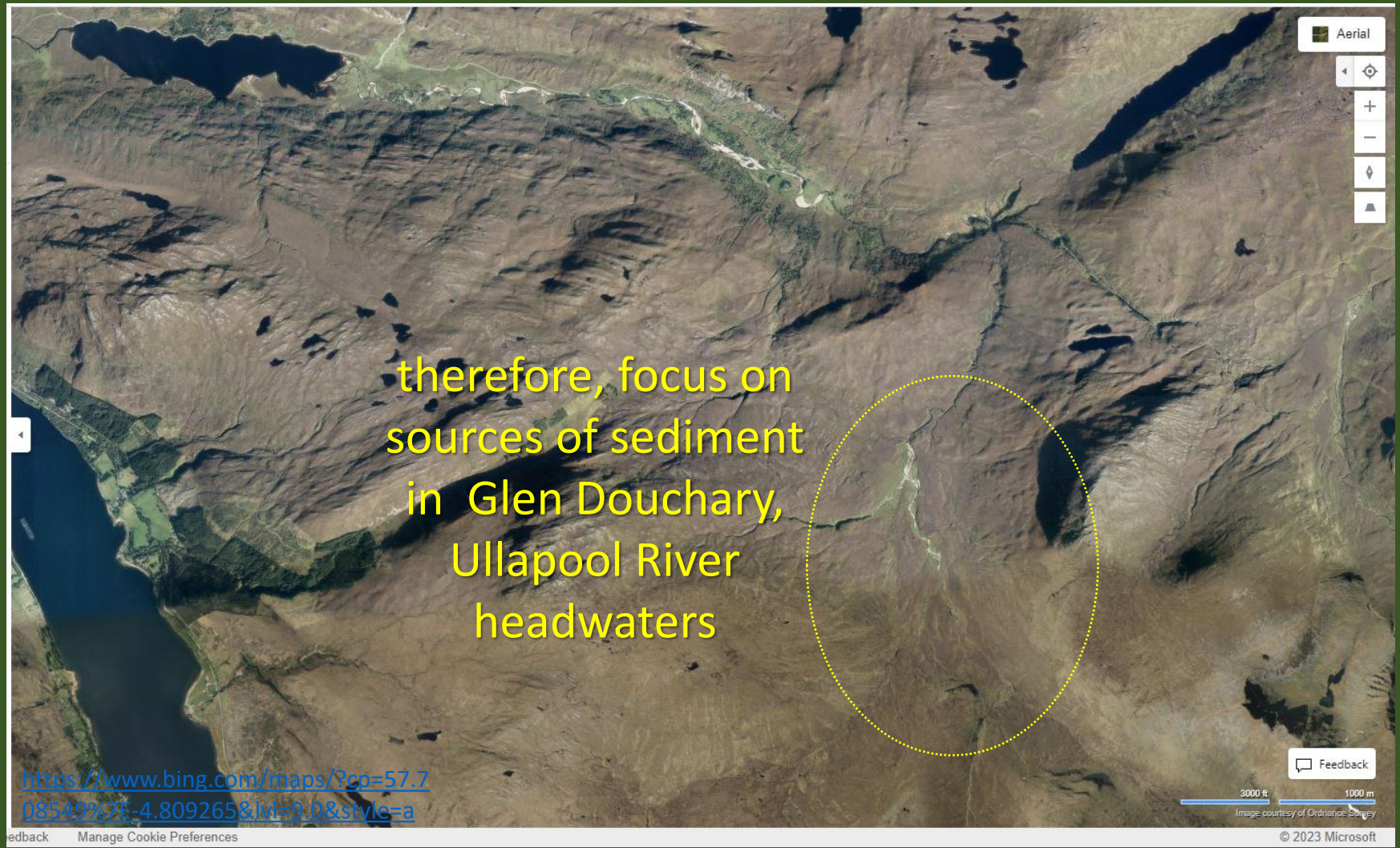


So for the Ullapool River:

project aim to initially focus on reducing sources of sediment entering the river in upper catchment area rather than focussing on river banks and river channel in downstream areas



Active sediment discharge area in River Douchary below confluence with Allt Siolar, 28 June 2004. (Same view as photo at bottom of previous page)



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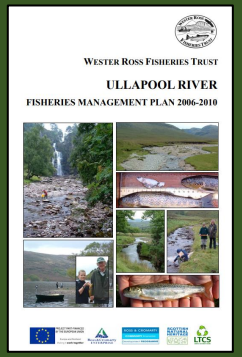
An initial survey took place in 2005, however at the time there were limited opportunities to fix problems



https://www.wrft.org.uk/files/Ullapool%20FMP%202006.pdf

6.7 The Rhidorroch River

6.7.1 Overview

Because the Rhidorroch River has the largest portion of potentially productive salmon habitat within the Ullapool River system, additional investigations were undertaken to identify the causes of habitat problems and find out whether there were any opportunities for improving conditions for production of juvenile salmon.

The Rhidorroch River is naturally unstable throughout its length, with highly mobile substrate, braided channels (below East Rhidorroch), bank erosion and collapse, and frequent scouring events associated with 'bed-load transportation' of sediment. Habitat for juvenile salmon is less than ideal: instability is likely to be a major factor limiting both recruitment of fry and the growth and survival of salmon parr.

Salmon have access within the river as far as the 'Smokey Falls'. The condition of the habitat below

Active erosion (above) and bank collapse (below) downstream of confluence with Allt na Creige Duibhe.

However a new opportunity arose in 2023 to assess sediment input and transfer from upper Rhidorroch River catchment

working in collaboration with Angus Davidson Ltd. And with funding from the Wild Salmonid Support Fund

We recorded areas of bank collapse and erosion, identifying sources of sediment entering the river

Bank collapse at confluence of Douchary River and Allt na Creige Duibhe (NGR 225731, 888246)

13 May 2022

We recorded areas of bank collapse and erosion, identifying sources of sediment entering the river

Bank collapse at confluence of Douchary River and Allt na Creige Duibhe (NGR 225731, 888246)

13 May 2022

We recorded areas of bank collapse and erosion, identifying sources of sediment entering the river

Bank collapse, River Douchary,
at NGR 225286 888810

13 May 2022

We recorded areas of bank collapse and erosion, identifying sources of sediment entering the river

Erosion and remobilisation of alluvial sediment, River Douchary, at NGR 224727 , 890540

13 May 2022

Comparison River Douchary, where the gradient increases below Douchary at NGR 224755 890791

2004

13th May 2022

Drone survey

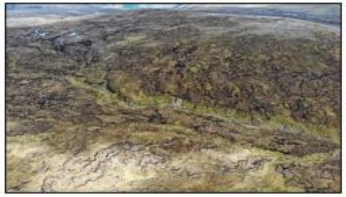
Drone survey

Drone survey

Many sources and deposition areas for sediment identified

DRAFT Rhidorroch River sediment project report v 12 Apr. 23

Catchment-scale assessment of sediment transfer into the Rhidorroch River (Ullapool River headwaters, Wester Ross) and management proposals to limit sediment movement for the conservation of wild Atlantic salmon (*Salmo salar*)




Peter Cunningham (Wester Ross Fisheries Trust) info@wrft.org.uk

Colin Morrison (Angus Davidson Ltd.) davidsonangus@angusdavidsonltd.com

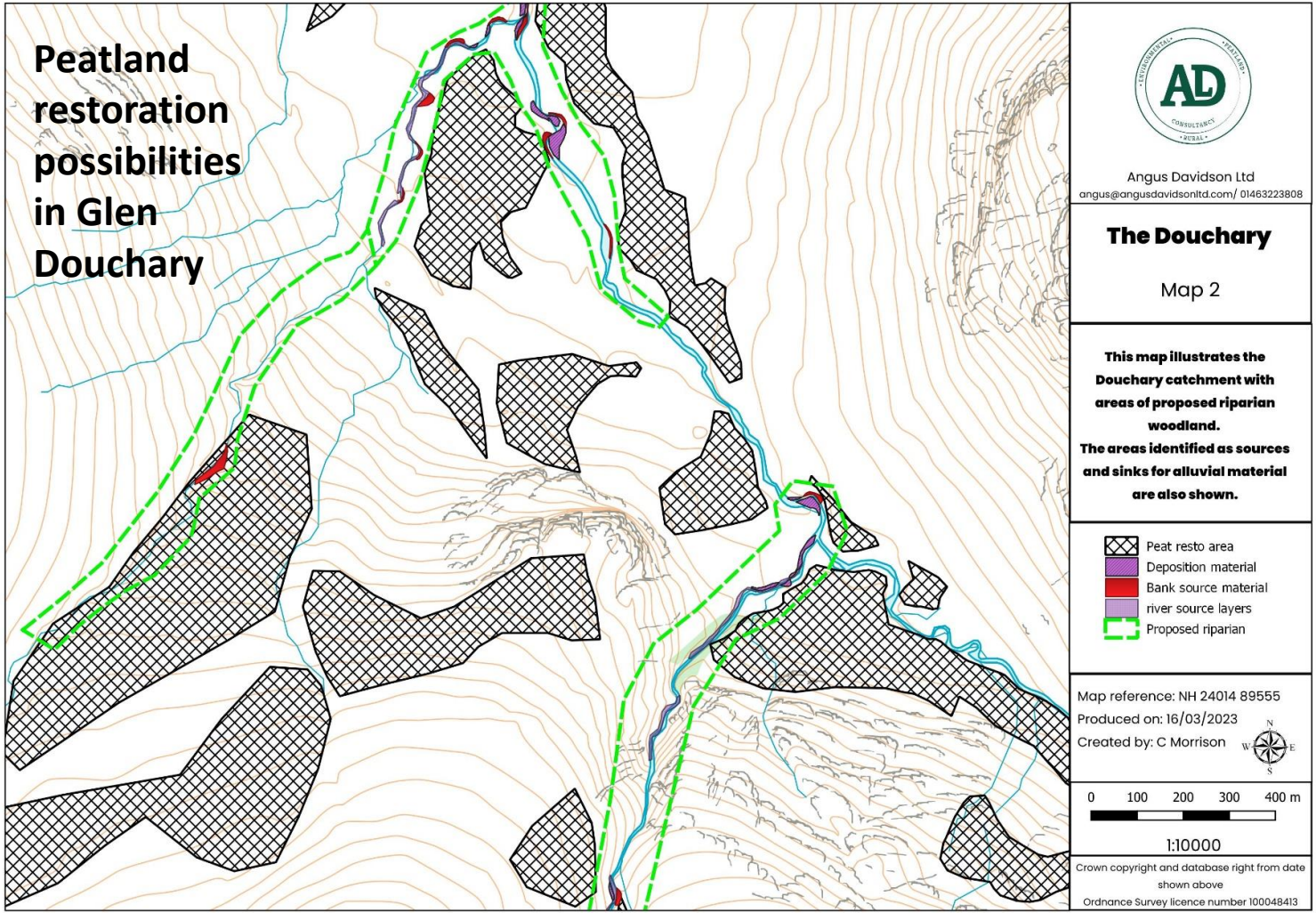
April 2023

Supported by:

Actions proposed (report drafted):

1. **Peatland restoration** to reduce the rate of rainwater run off, and the input of sediment into river

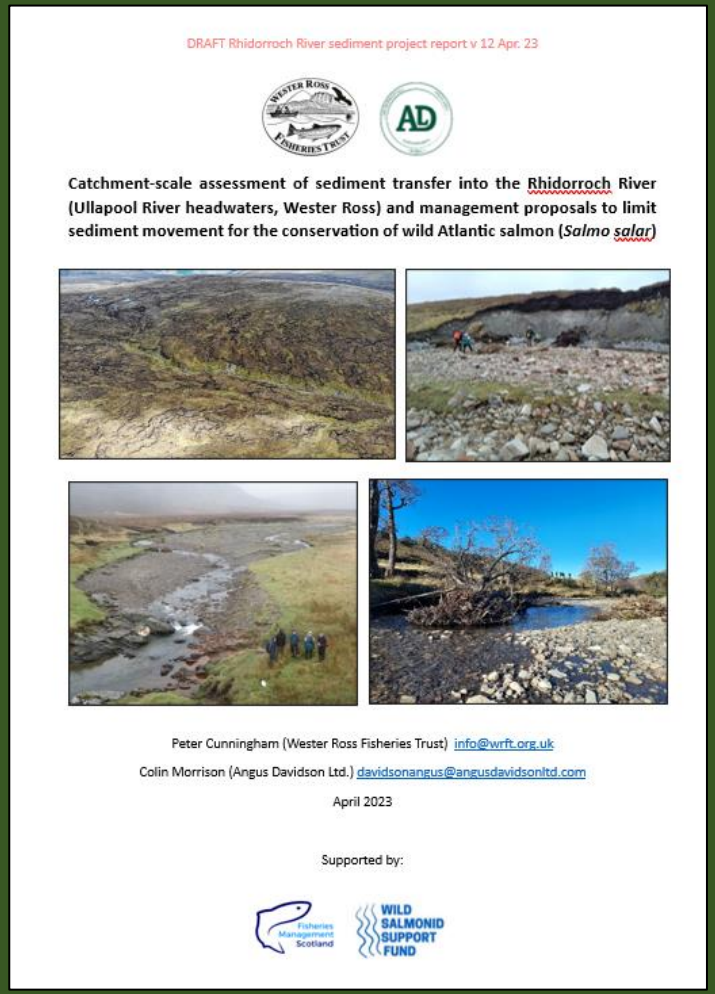
Peatland restoration possibilities in Glen Douchary



Peatland restoration aims to reduce erosion and loss of peat through restoration of vegetation cover

(example of peatland restoration above Achnasheen, May 2021)


Peatland restoration: channels are blocked and pools ‘seeded’ with sphagnum moss
(peatland restoration above Achnasheen, May 2021)



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Catchment-scale assessment of sediment transfer into the Rhidorroch River (Ullapool River headwaters, Wester Ross) and management proposals to limit sediment movement for the conservation of wild Atlantic salmon (*Salmo salar*)

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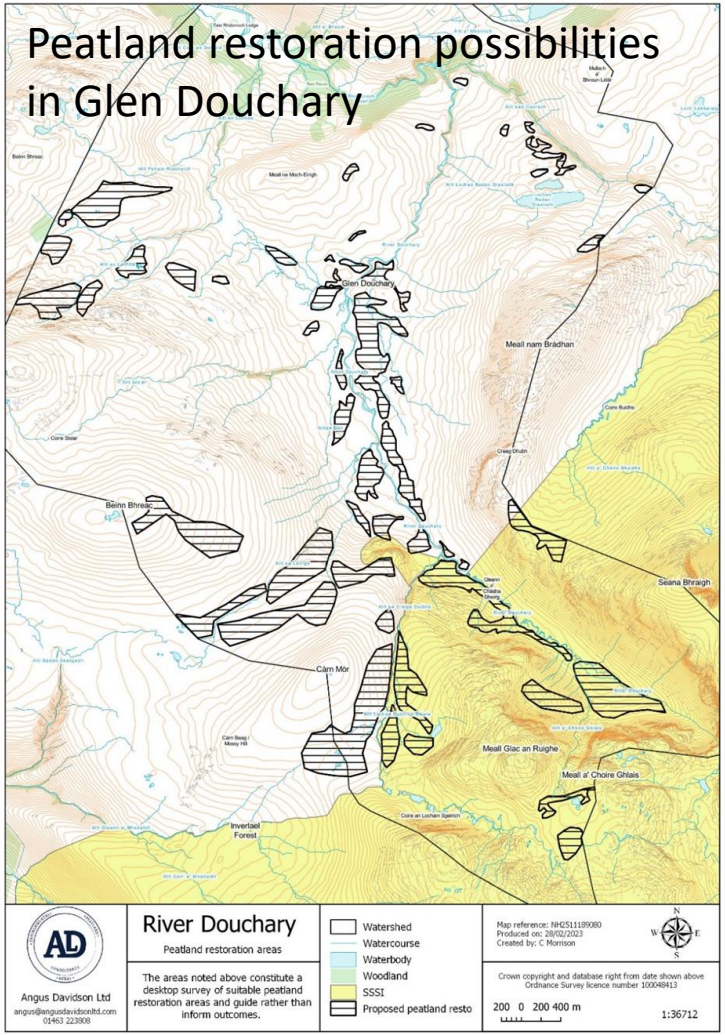
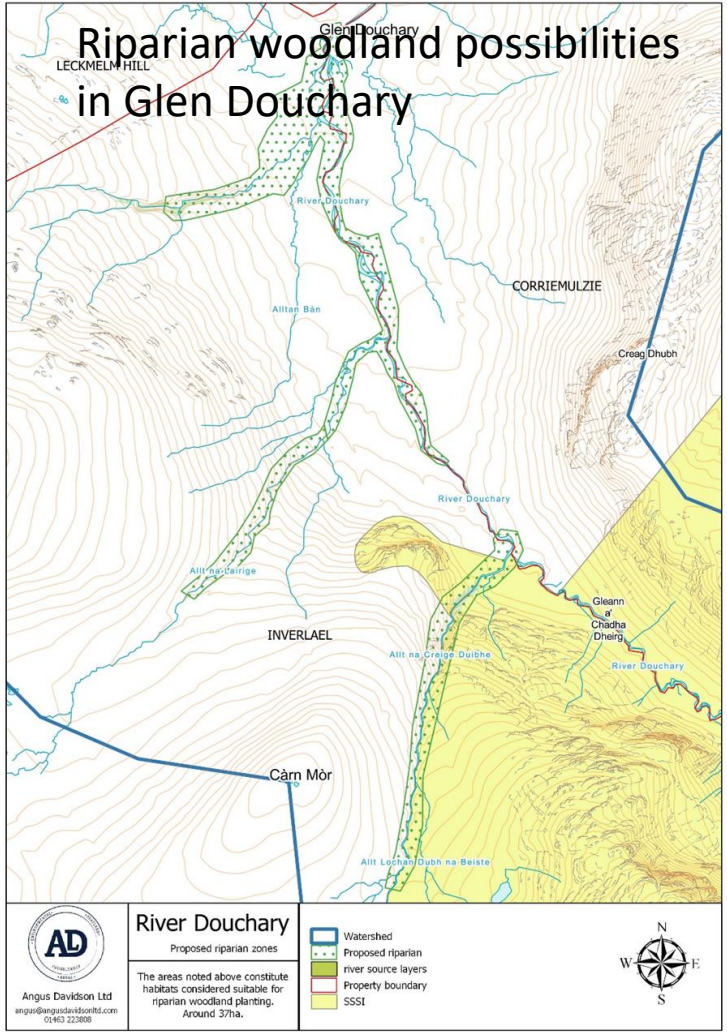
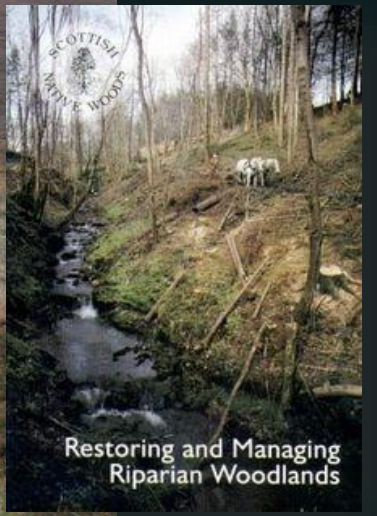
Peatland restoration possibilities in Glen Douchary



Riparian woodland possibilities in Glen Douchary



Benefits of riparian woodlands well known



Riparian woodland restoration scheme (WGS), Upper Kanaird River
(picture taken a few years ago . . . trees well established now)


Some estates have developed enclosed woodlands
to stabilise streams and enhance food availability
WGS enclosure, Coulin Estate (headwaters of River Ewe) ~2005

Coulin farmhouse burn: young woodland . . .
growing well

WGS enclosure, Coulin Estate (headwaters of River Ewe) 2019

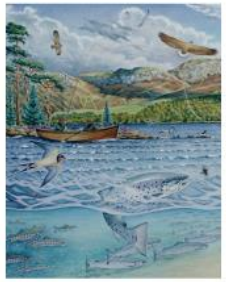
Coulin farmhouse burn:

riparian woodland enclosure planted in 2004

TREES FOR FISH . . .

Between June and September each year many thousands of adult salmon and sea trout return from the sea underneath the road bridge at Poolewe and swim up the River Ewe into Loch Maree where the fishery for sea trout was once world famous. By October, many fish have continued their journey back towards their natal streams, some heading up the Kinlochewe and A'Ghairbhe Rivers to Loch Clair and on into Loch Coulin.

This stream, known locally as the 'Farmhouse burn', is one of the most important spawning areas for sea trout, which lay their eggs in river gravels in late October or November. The eggs slowly develop during the cold winter months and little trout fry swim up from between the stones in April or early May in search of food.



To improve the habitat for fish, Coulin Estate with support from the Forestry Commission through the Woodland Grant Scheme (WGS) have established 2 enclosures to restore riparian (stream side) woodlands. This enclosure has been planted with alders, willows, birch, rowan and and other species.

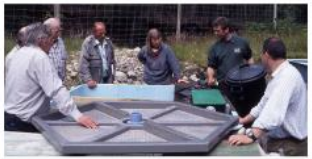
Stonefly (2 tails) and mayfly larvae (3 tails) are food for juvenile trout (above) and salmon (below)

Native woodlands also provide habitat for many birds – including Stonechat, warblers and other small song birds. Look for dipper, grey and pied wagtails which also feed on insects along the stream.

Otter, and Black-throated diver, which attempt to breed on several lochs in the area also benefit from healthy populations of trout and salmon.

By restoring more varied habitat, production of insects, earthworms and other small animals will increase. Leaf litter is also a food source for some of the aquatic insect larvae that are also important food items for young fish.

Tree roots, especially those of alder, help to stabilise river banks preventing erosion. Roots also provide additional cover (protection) for small fish, which can hide from larger fish and other predators.



Coulin Estate is committed to the restoration of healthy and productive fisheries for wild sea trout, salmon and other special wildlife. If you meet the keeper, ask him about some of the other projects on the estate.

Wester Ross Fisheries Trust, 2004
tel: 01445 712 899 info@wrft.org.uk

https://www.scotlandbigpicture.com/riverwoods

Riparian woodland outing Coulin Estate, October 2022

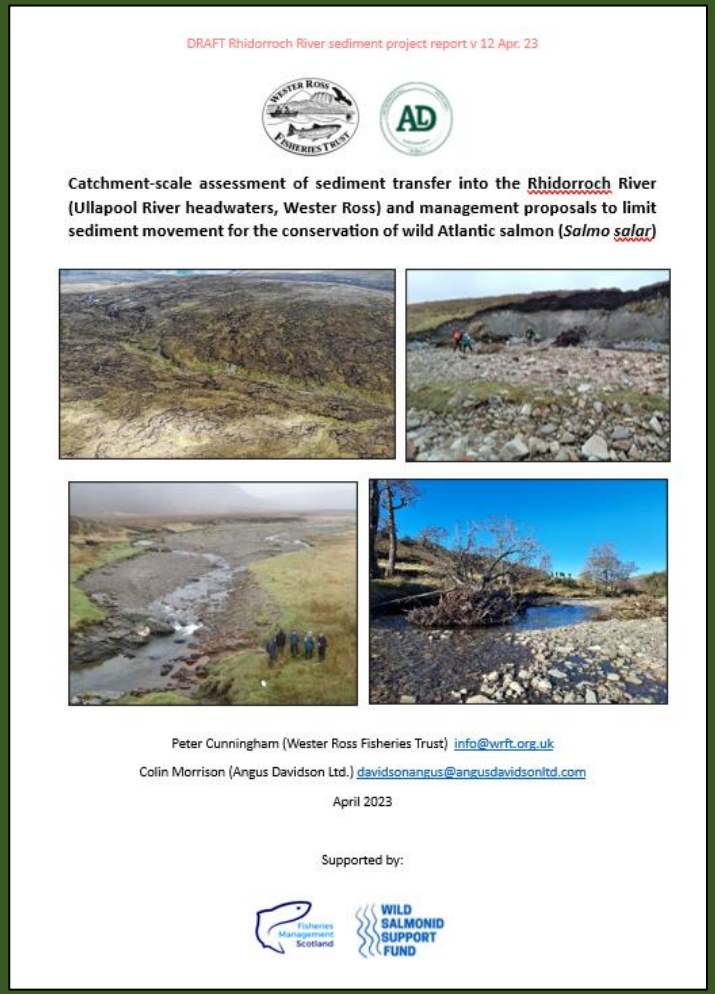
Thank you to Neil Morrison (Coulin Estate), Doug Bartholomewe & co . . .

Photos by Caroline (Caz) Austin, The Woodland Trust

Some riparian trees were planted by Rhidorroch River

(. . . in addition to addressing sediment sources in headwater areas,

trees take many years to grow big enough to provide streambank protection)



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April 2023

Supported by:

Actions proposed:

1. **Peatland restoration** to the reduce rate of rainwater run off, and the input of sediment into the river.
2. **Riparian woodland restation** to protect river banks.
3. **Restore ecosystem fertility** . . ?

What is fertility?

Soil fertility: refers to the ability of a soil to support plant growth

Picture by Ben Rushbrooke

From:
'Feed the land' presentation
https://www.wrft.org.uk/files/FeedtheLand_PeterCunningham%20(min%20size).pdf

Soil fertility: the ability of a soil to supply plant nutrient.

?Ecosystem fertility: the ability of an ecosystem to circulate life-sustaining nutrients to its component parts.

(from 'Refertilising Scotland' presentation at 'Reforesting Scotland' meeting in Torridon Community Centre, September 2010)

Reforesting Scotland

Fertile & productive ecosystems need not be dependent upon fertile soils if nutrients can be recycled and circulated within the biota.

Picture by Ben Rushbrooke

From:
'Feed the land' presentation
https://www.wrft.org.uk/files/FeedtheLand_PeterCunningham%20(min%20size).pdf

What can hummocks tell us about ecosystem fertility and the potential of catchment areas in Wester Ross to support more vegetation?

Hummocks above Achnalt, 28 May 21

Above Achnasheen, 28 May 21

Hummocks are formed by moss(es) which grow(s) faster on the hummock than in surrounding areas. Why do they grow faster?

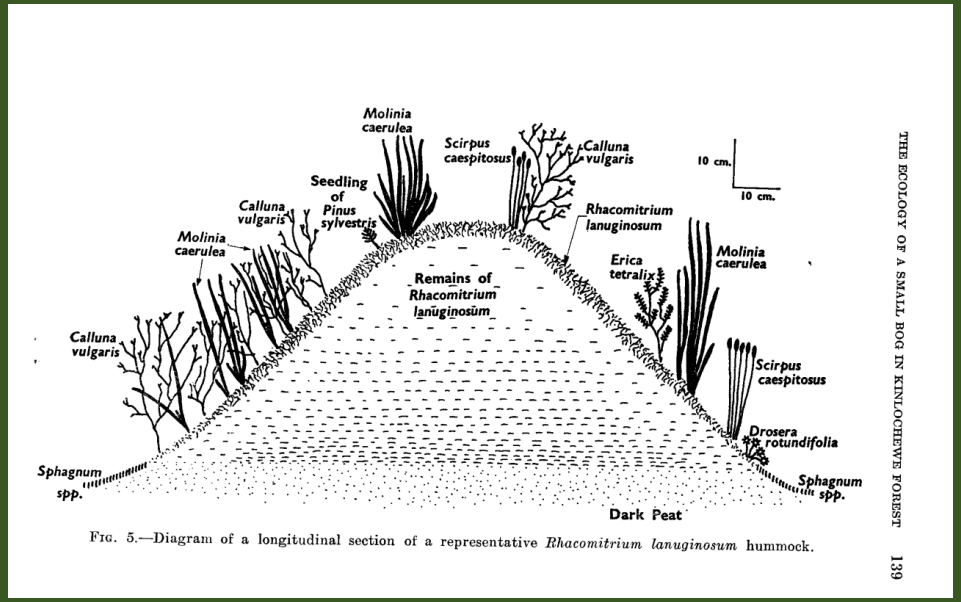


Fig. 5.—Diagram of a longitudinal section of a representative *Rhacomitrium lanuginosum* hummock.

Diagram from Gimingham *et al* (1961) The Ecology of a small bog in Kinlochewe Forest, Wester Ross
https://www.researchgate.net/publication/279512075_The_Ecology_of_a_small_bog_in_Kinlochewe_Forest_Wester_Ross

Examples of mossy hummocks:

Above the Allt Grishan (near Gairloch), 29 April 2020

Examples of mossy hummocks:

Applecross River headwaters, June 2022

with many
bird droppings
on moss

Examples of mossy hummocks:

Melvaig Hill, 19th June 2020 ‘Bearberry knoll’ . . .

Prominent hummock
>1.5m high,
with crowberry, blaeberry,
bearberry, ling heather

Examples of mossy hummocks:

Above Peterburn, 29th April 2020

with leg of bird. Why?

Examples of mossy hummocks:

Above Aultgrishan, 31st May 2020

with ?pipit droppings.
Meadow pipits are often associated with mossy hummocks in peatland areas.

Examples of mossy hummocks:

Coulin Farmhouse burn (near watershed), November 2021

with remains of ?ovary of frog (left behind by an otter?)

Examples of mossy hummocks:

By the Bharranch Burn, above Loch Clair, November 2021

with part of a salmon fin
(left by an otter?)

Examples of mossy hummocks:

Gairloch Hills, 5th June 2022

. . . with crowberry, blaeberry, ling heather and view to Slioch. Imagine if there was more vegetation like this in the Gairloch hills?

Examples of mossy hummocks:

Bruachaig River headwaters, above Leckie, 8th July 2022

The bone is where we found it.
Was it left here by a fox? Why?

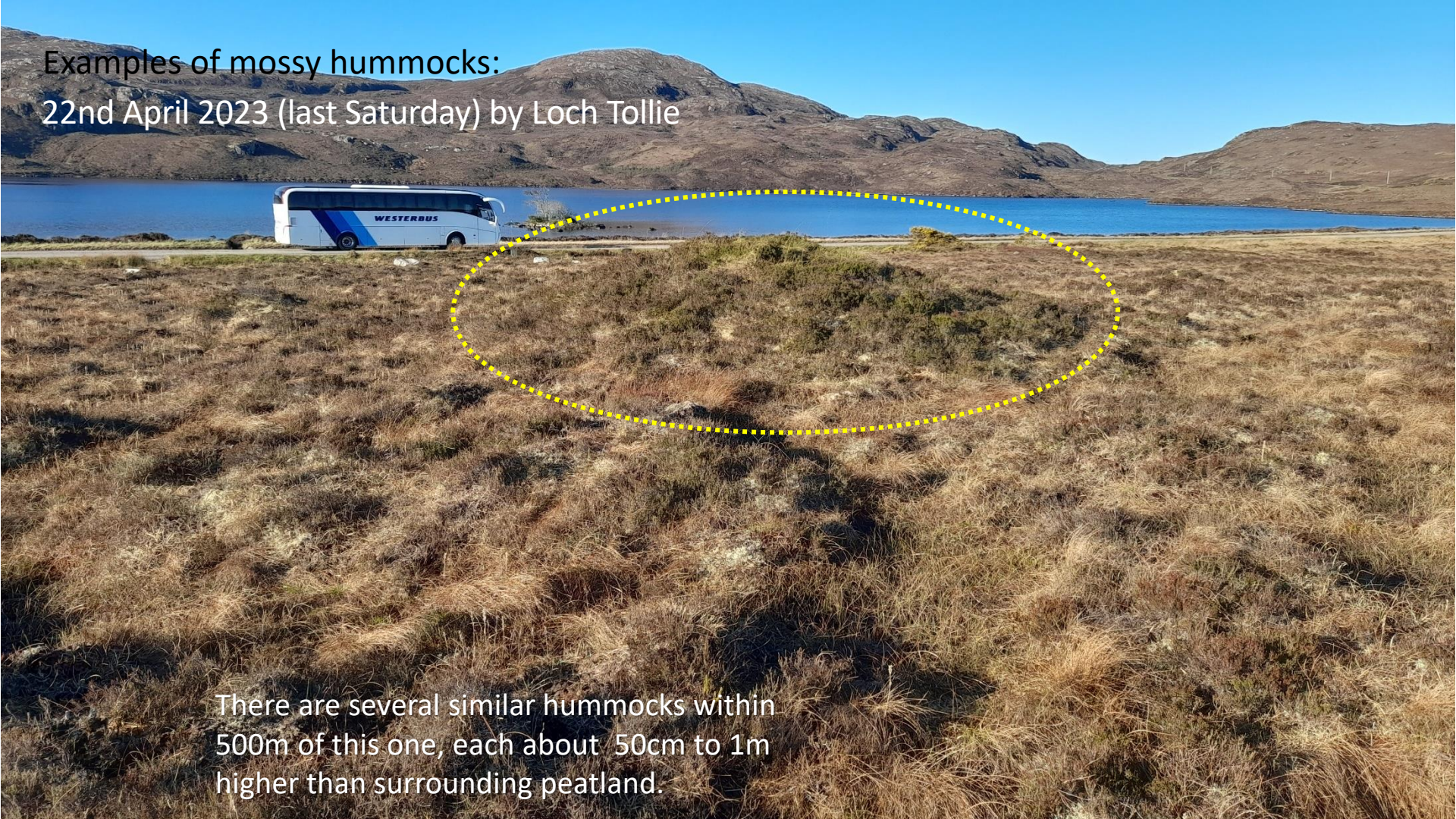
Note proximity of small stream. Meadow pipit habitat?

Examples of mossy hummocks:

Tollie hills, 22nd April 2023 (last Saturday)

?Meadow pipit droppings on moss . . .

. . . is this how hummocks form?


Examples of mossy hummocks:
22nd April 2023 (last Saturday) by Loch Tollie
WESTERBUS
There are several similar hummocks within 500m of this one, each about 50cm to 1m higher than surrounding peatland.

Peatland nutrition, hummock formation and carbon sequestration in Wester Ross

This poster, based on observations in moorland areas of Wester Ross, considers how plant growth and peat formation may be faster in places where phosphate levels are elevated because of enrichment by birds and animals within the ecosystem.

1. Phosphorus (P) availability often limits the growth of plants, including mosses, in upland landscapes.

2. Hummocks form in peatland areas where birds perch because phosphate, concentrated in bird droppings, acts as a fertiliser promoting plant growth.

4. Fox, pine-marten and otter visit hummocks to mark their territories. They may leave behind bones in addition to P-rich urine and faeces. Why?

3. Prominent hummocks are favoured perches for crows and raptors which deposit pellets rich in bone fragments (Ca & PO_4) in addition to P-rich guano.

7. Red deer like to graze around hummocks and translocate P back into surrounding areas.

5. Hummocks support high biodiversity with mosses, lichens, crowberry, blaeberry, insects, spiders, small mammals and other biota which may be absent from other areas nearby. How many species can you find?

8. *Racomitrium* hummocks are often associated with meadow pipits.

6. Red grouse selectively browse phosphate-enriched vegetation around hummocks.

9. Meadow pipits feed on insects and spiders, often around peatland pools.

10. Phosphate addition can contribute to faster growth of peatland plants but also faster decomposition of plant remains.

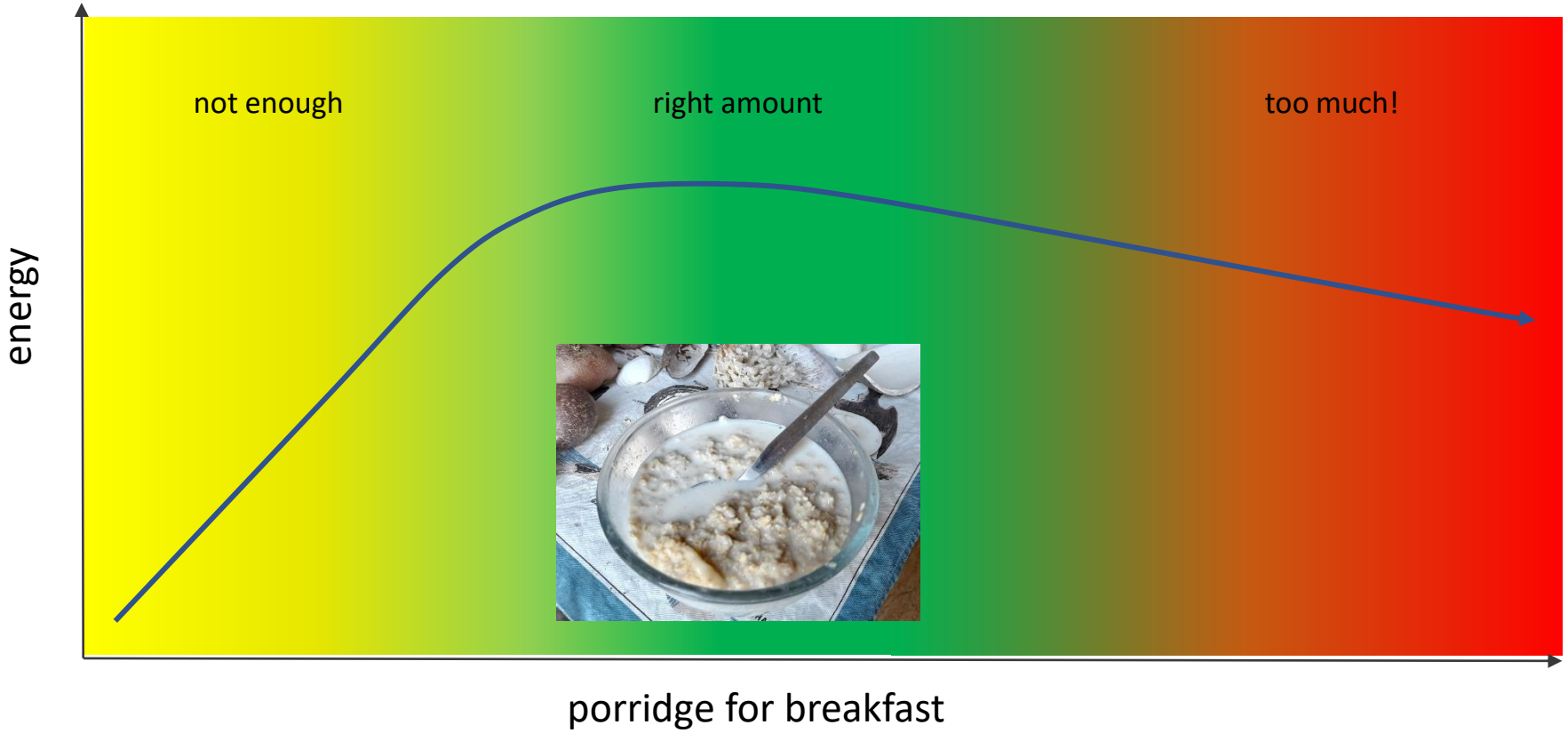
The consequences for peat formation and biodiversity may vary according to background levels of PO_4.

11. Hummock formation demonstrates that ecosystem-derived phosphate addition can increase carbon sequestration within culturally oligotrophied (phosphorus-depleted) landscapes.

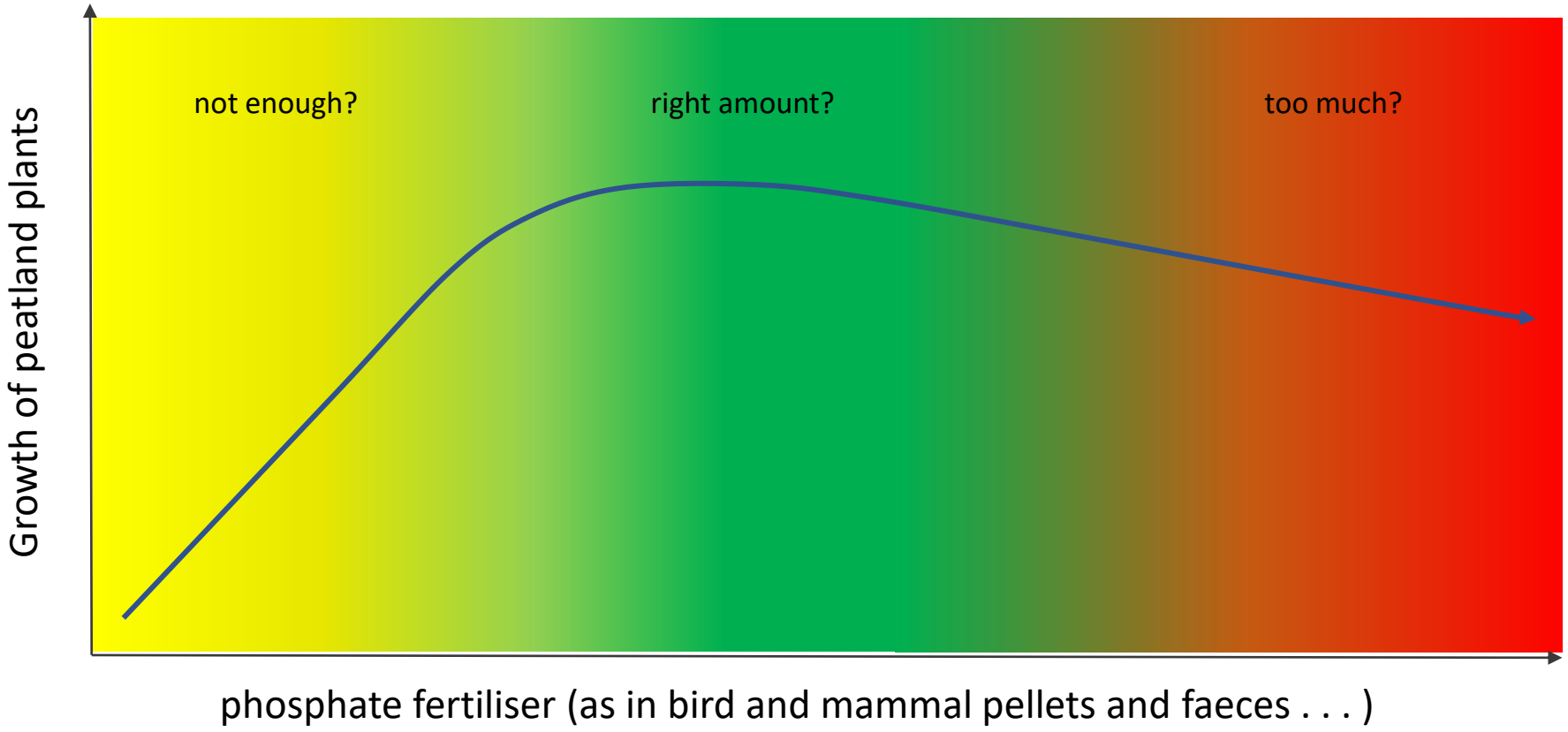
12. What are the optimum levels of ecosystem-derived phosphate deposition to maximise peat formation and carbon sequestration, and to support biodiversity and wildlife production in Wester Ross?

PDC, April 2023

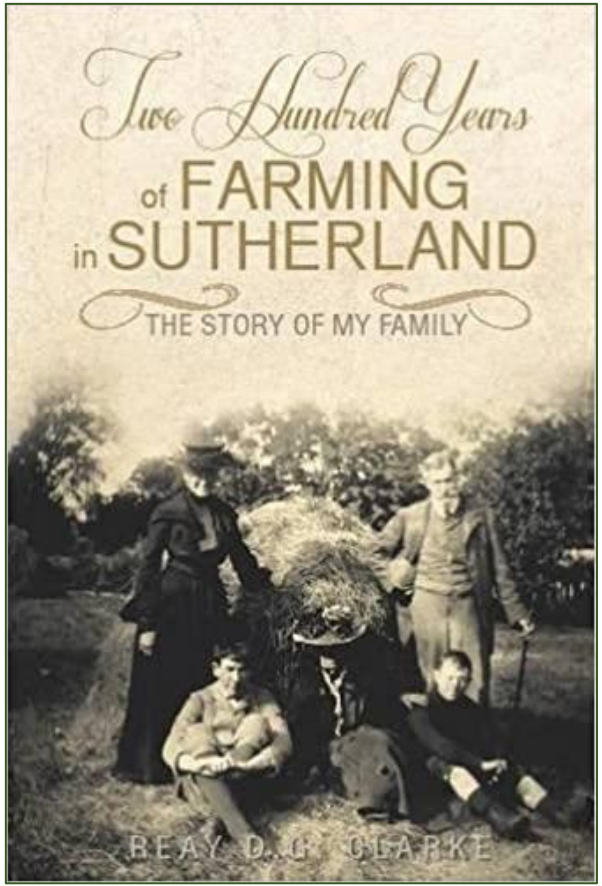
How much nutrient is required?



How much nutrient is required for peatland plants to grow?

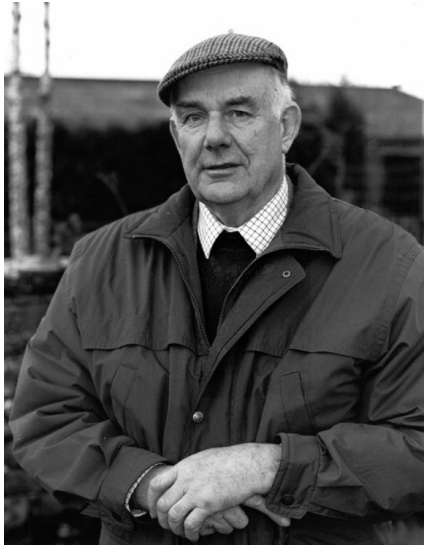


Reay Clarke (2014) ‘200 years of sheep farming in Sutherland’



‘. . . the more he read, the more he was convinced that the fertility of the Highlands was going in reverse and with many of the projects he took on, it was with an aim of reversing that trend’

From obituary of Reay D G Clarke, 1923 to 2017.
https://www.rossandcromartyheritage.org/home/easter-ross-communities/edderton/edderton-folk/reay-d-g-clarke/



https://www.rossandcromartyheritage.org/home/easter-ross-communities/edderton/edderton-folk/reay-d-g-clarke/

Much phosphate has been exported from catchment areas

http://www.thefield.co.uk/stalking-2/where-to-go-stalking-in-scotland-in-2016-29934

Muirburn and wildfire in Wester Ross also contribute to phosphate export with losses in smoke and ash that is washed away

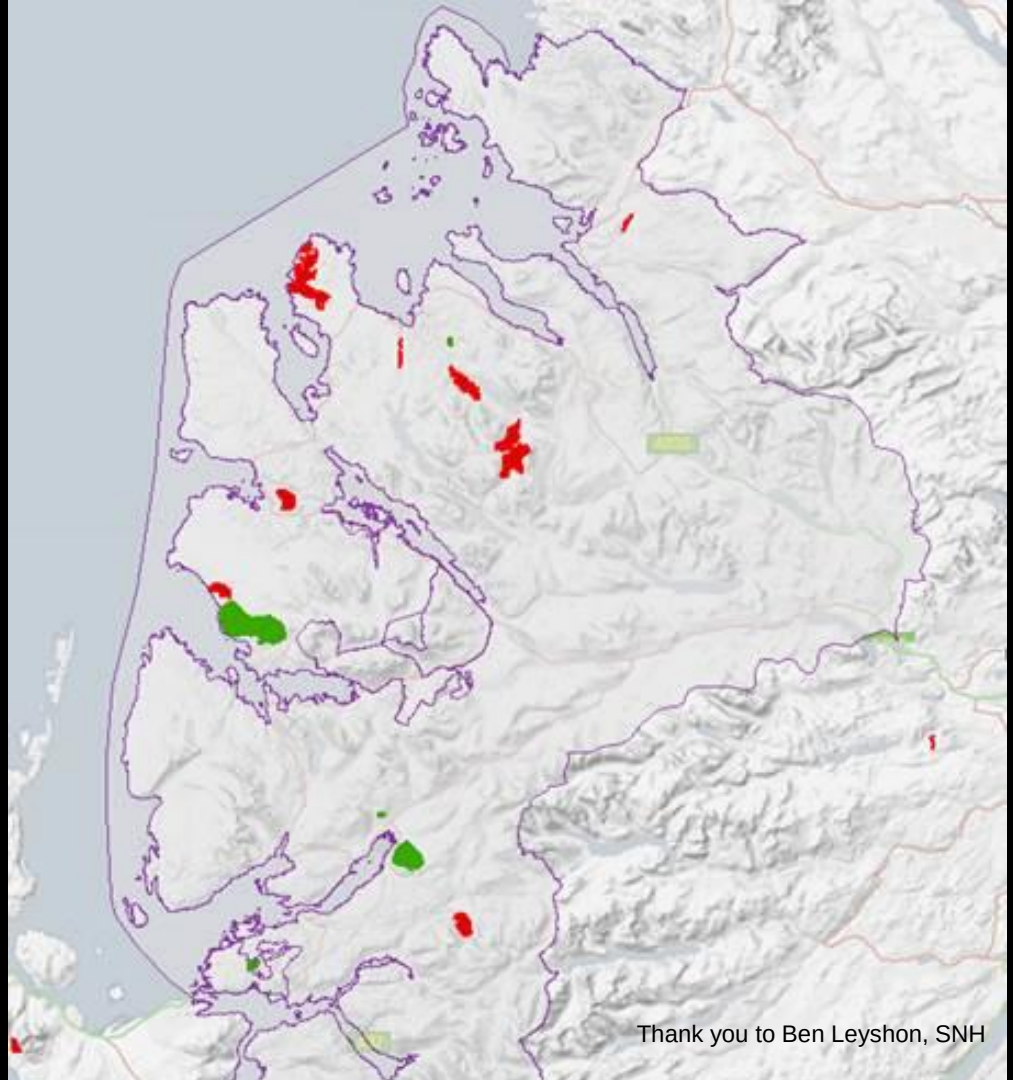
- There were nine separate cases affecting designated areas in WR covering the period 2011-2014. We do not have data post 2014.

- We also have the coarser mapping from the European Forest Fire Information Service (EFFIS). The screenshot shows fires in

2019 in red

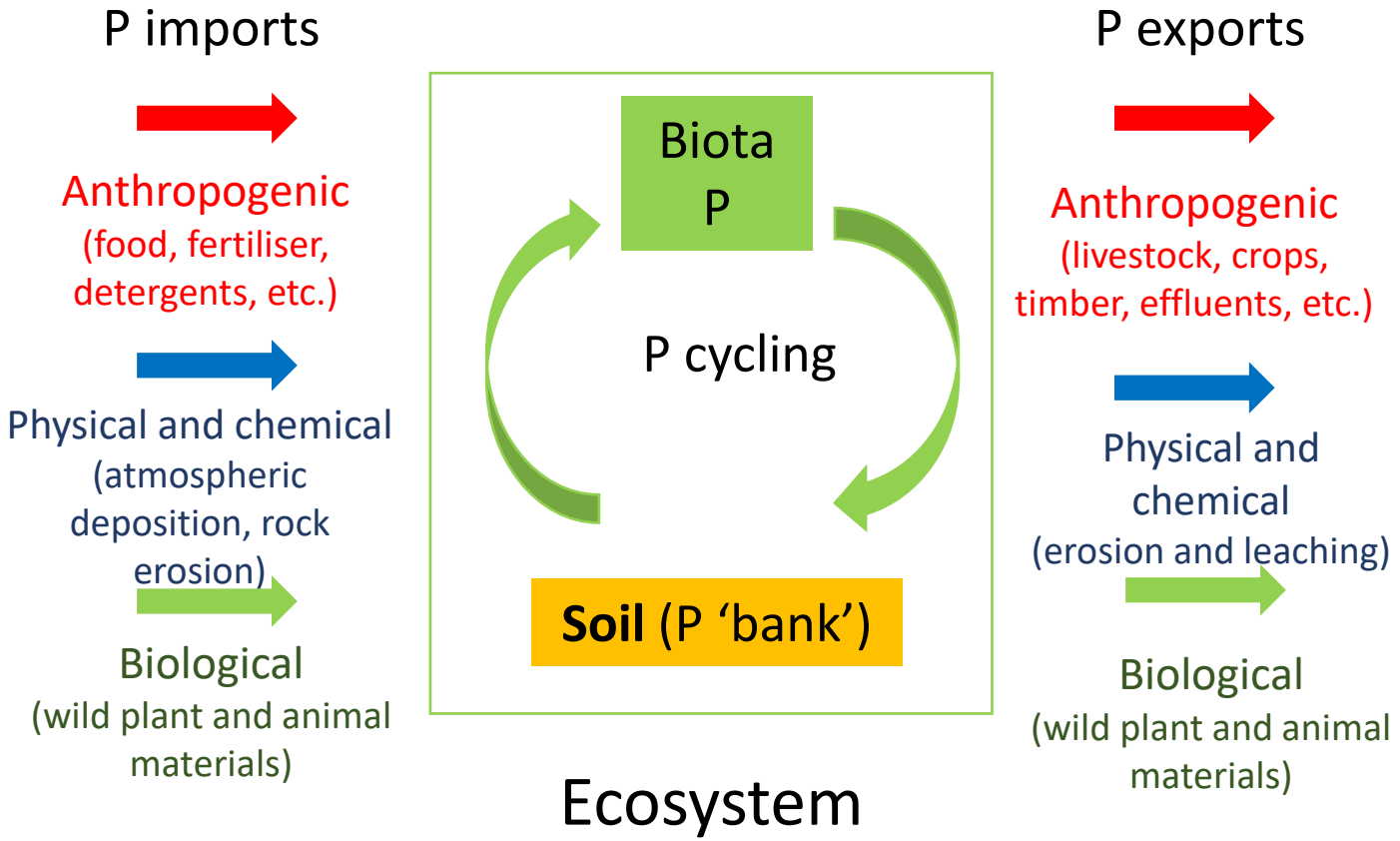
2018 in green

[PS. two delegates at workshop fought a wildfire on night of 25th April 2023 in nearby hills]



Thank you to Ben Leyshon, SNH

Example of phosphorus budget for upland area



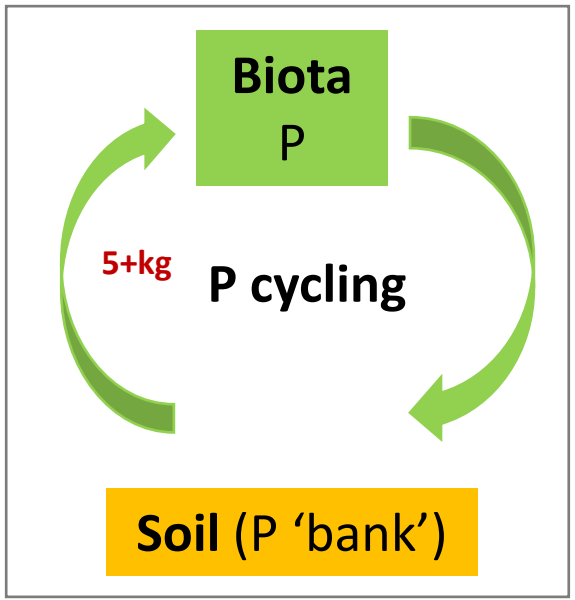
Hypothetical annual phosphorus budget example for 1km^2 of uninhabited unfertilised habitat in Glen Douchary (i.e. open hill) burned every 100 years and stocked at 8 deer per km^2 where 1 deer is culled and the carcass removed each year

P imports 4kg

Anthropogenic 1kg
(Feed blocks for deer 0.2kg; other humans & dogs . . . 0.8kg)

Physical and chemical 2kg
(Rain and dust from atmosphere 1kg P; Rock 1kg P)

Biological (wild) 1kg
(Translocation by mammals, bird droppings 1kg or more if birds come inland)



P exports 9kg

Anthropogenic 3kg
(Exported deer carcasses 1kg; smoke and ash if burned every 100 years, 2kg [based on loss of 200kg P with each fire])

Physical and chemical 3kg
(soil and peat erosion and leaching 3kg, possibly very much more where soil poached)

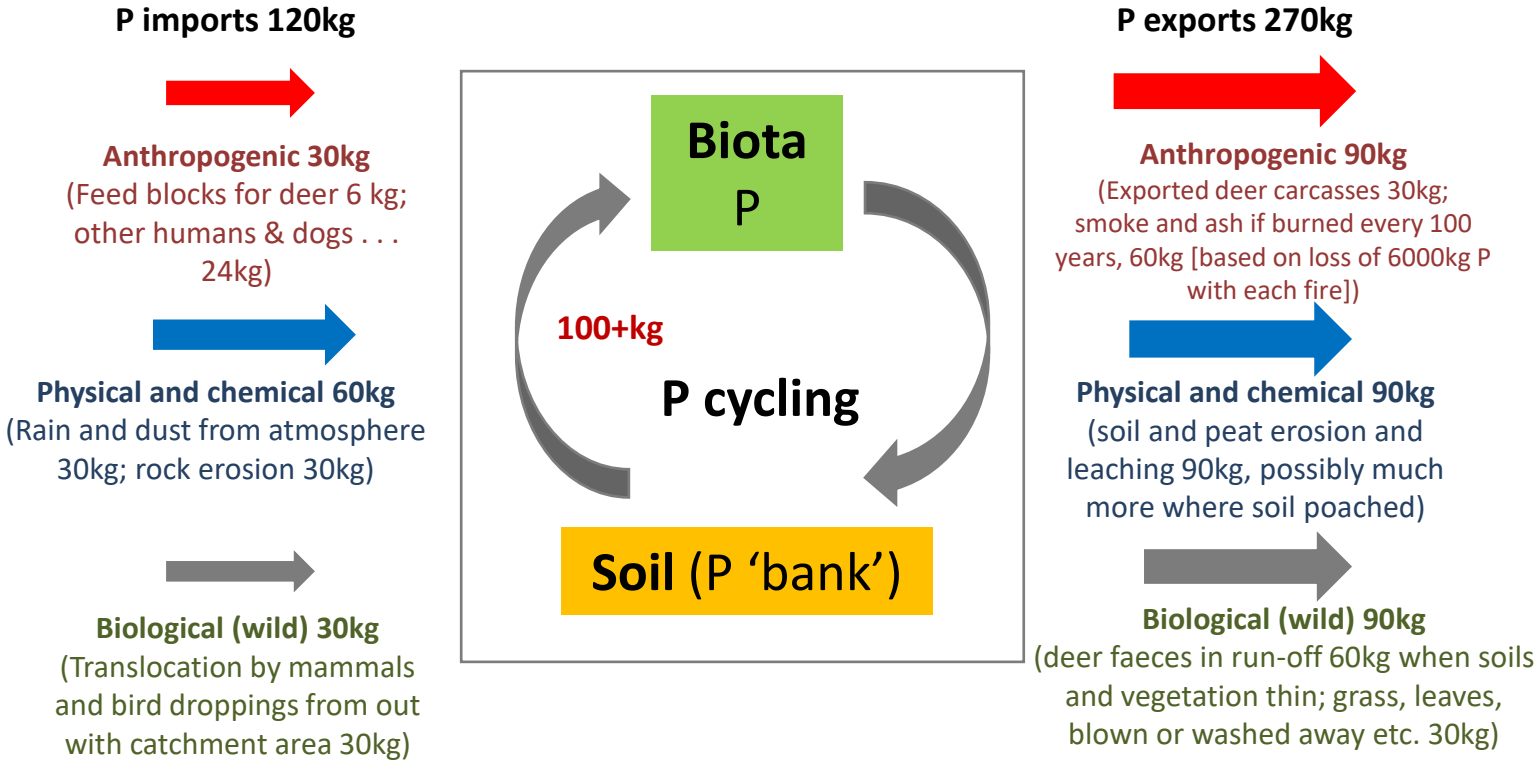
Biological (wild) 3kg
(deer faeces in run-off 2kg when soils and vegetation thin; grass, leaves, blown or washed away etc. 1kg)

Ecosystem: possible net loss of >5kg P per km^2 per year?

Example of hypothetical annual phosphorus P budget for River Douchary catchment area (about 30km^2)

burned every 100 years and formerly stocked at up to 8 deer per km^2

where 30 deer are culled and the carcasses removed each year



Ecosystem: possible net loss of >100kg P from the River Douchary catchment per year?

Spreading manure, North Erradale, 22 April 2023

(this is not proposed as a means of addressing P deficit in hills, though demonstrates commitment to improving quality of in-bye land. What happens to the productivity of ‘common grazing’ areas if phosphate deficits are not made good . . . ?)

Incinerated farm salmon morts?

Could this phosphorus rich local resource be utilized to produce an organic P-rich fertilizer for grazing areas, rather than ending up in landfill?

https://theferret.scot/salmon-deaths-farms-nine-million/

Here are the waste disposal routes for Scottish farmed salmon mortalities (data sourced from 'Case Information' as published by the Scottish Government's Fish Health Inspectorate for salmon farm inspections between September 2019 and December 2020) headed by Dundas Chemicals, ensiling, incineration, Biogas Energen, Whiteshore Cockles and TWMA Shetland*:

Disposal Method/Location	# of cases cited
Dundas Chemicals	43
Ensiled (on site)	39
Incinerator on site or at other farm location	33
Biogas Energen Cumbernauld (Deerdykes)	28
Whiteshore Cockles (Uist)	27
TWMA Shetland	19
Shetland Waste to Energy (incinerated)	8
Keenan Recycling (Aberdeenshire)	7
Gask Biogas (Turriff)	6
Gray Composting (Aberdeenshire)	4
SSF yard at Twatt (Orkney) for incineration	4
Pelagia Bressay Shetland	4
SSE Barkip	3
Hazco (Grangemouth)	3
Scottish Water Horizons Cumbernauld	2
Buried on site with permission from SEPA	2
Anglo Scottish Biosolids (Falkirk)	2
DK Waste (composting) South of England	2
Landfill (unspecified)	1
Incinerated on Bressay	1
Domestic waste	1
WI-IWM (Creed in Stornoway)	1
Frozen on site	1
Norwegian boat with on-board ensiler transported to Denmark for biofuel	1

* Note that 242 waste disposal routes were cited out of 220 cases (some cases indicated multiple waste disposal routes depending on the quantities of morts)

"Millions of Scottish salmon carcasses are quite literally going up in smoke via incinerators and waste energy plants," said Don Staniford, Director of Scottish Salmon Watch. "Scottish salmon's mort mountain is now so high that it powers the National Grid. Next time you turn

https://donstaniford.typepad.com/files/pr-burned-buried-ensiled-march-2021.pdf

A little fertiliser, fairly often (instead of a lot of fertiliser all at once) . . ?

http://l7.alamy.com/zooms/db5ee27981cc47e59486d73529045ff4/bush-toilet-loo-with-a-view-s15x3n.jpg

Thank you

WRFT members, supporters, and volunteer helpers, many estates and estate staff (keepers and ghillies) . .

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Peter Jarosz & Emma Watson admin@wrft.org.uk

Wester Ross Fisheries Trust

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