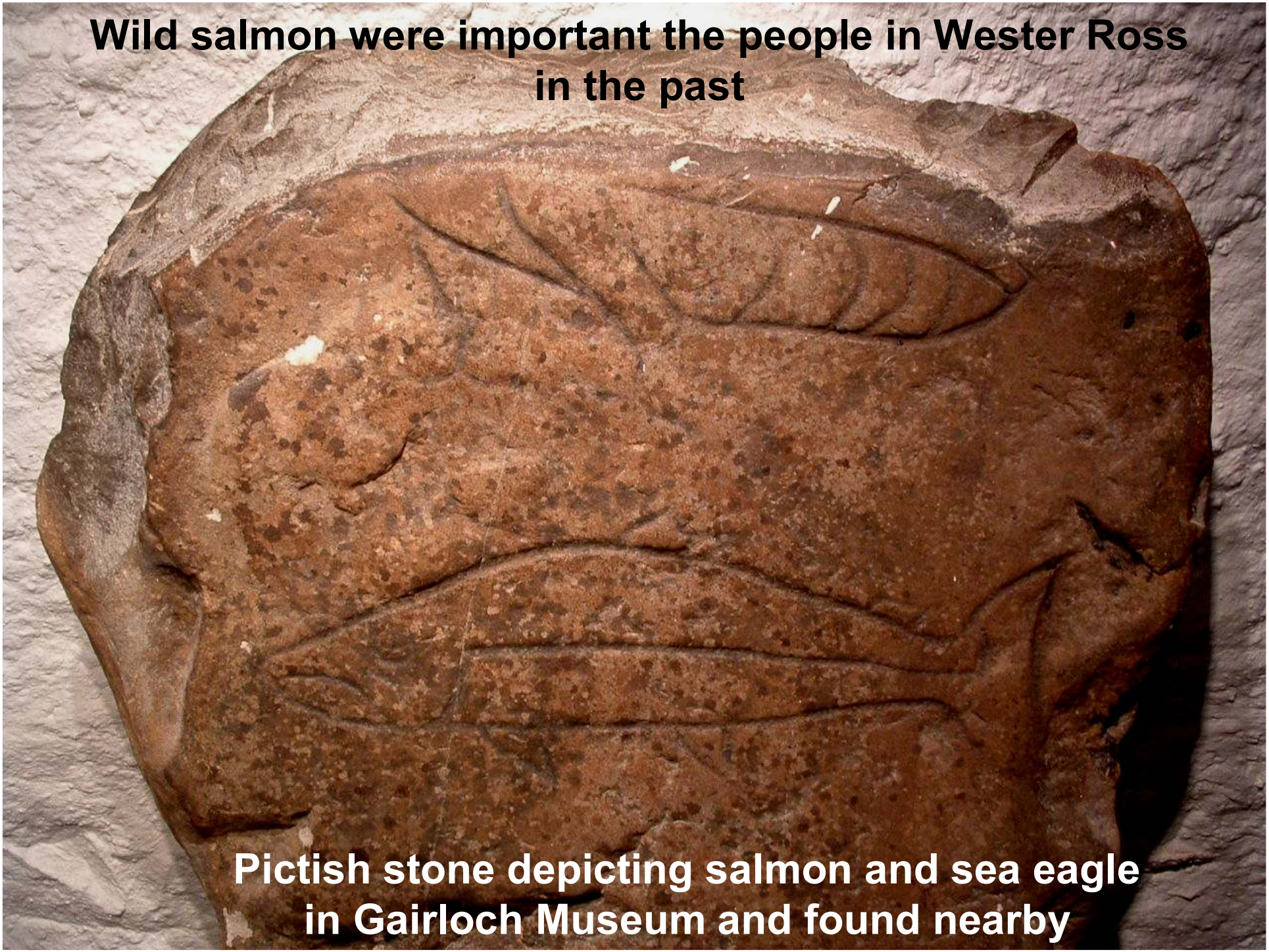
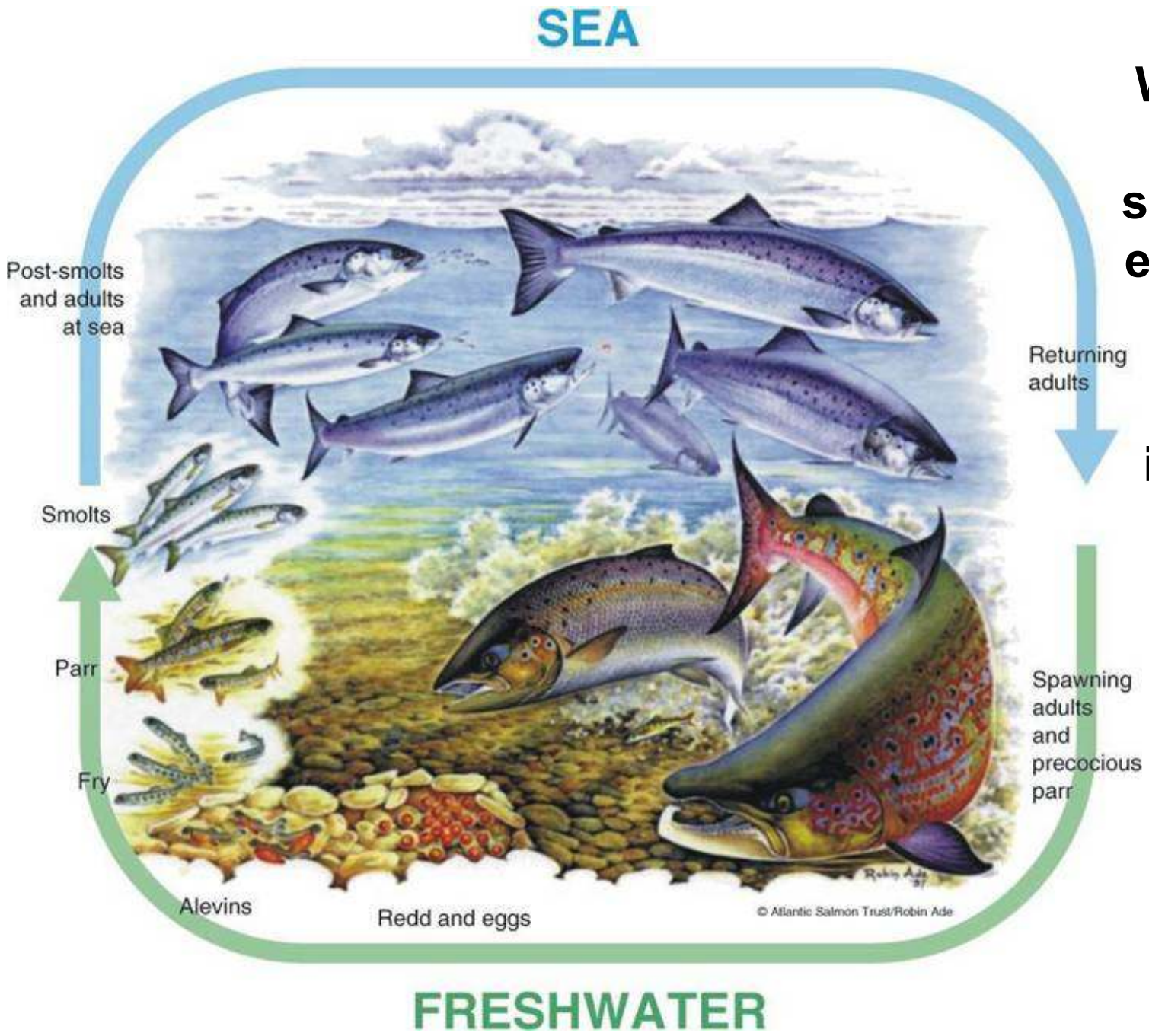
Land use and salmon smolt production: some observations & challenges for fisheries management in Wester Ross

Peter Cunningham, Wester Ross Fisheries Trust

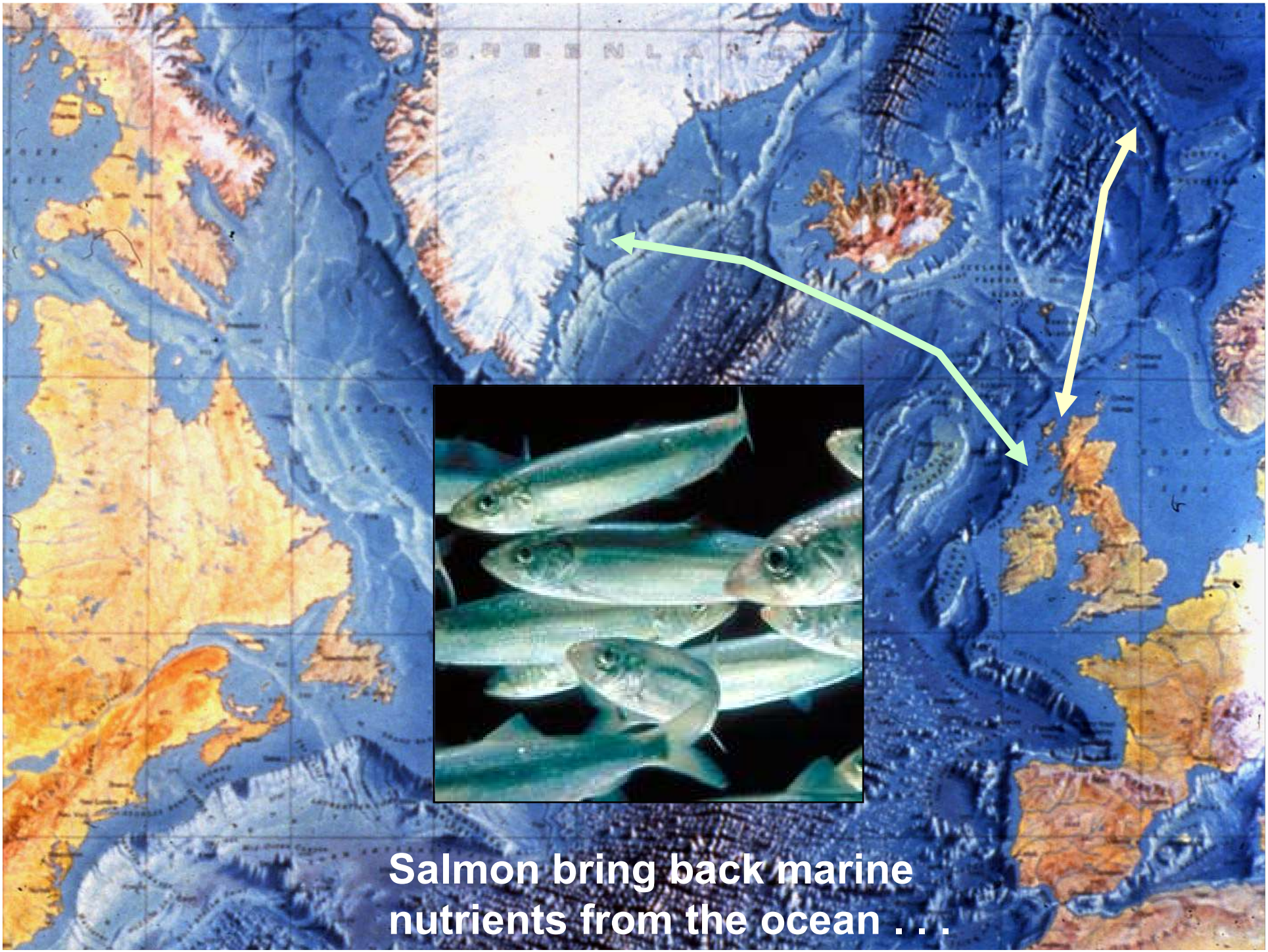

Wild salmon were important the people in Wester Ross in the past
Pictish stone depicting salmon and sea eagle in Gairloch Museum and found nearby


Wild salmon are still important to the local economy . . .
Ray Dingwall with fresh 17lb cock salmon caught by Gavin Ramsay, May 2007



Were wild Atlantic salmon an ecological keystone species

in Wester Ross?


Salmon bring back marine
nutrients from the ocean . . .

Wild salmon are an important food source for other wildlife

Otter kill, Shee Water

(Andrew Harwood)

scavenging otter

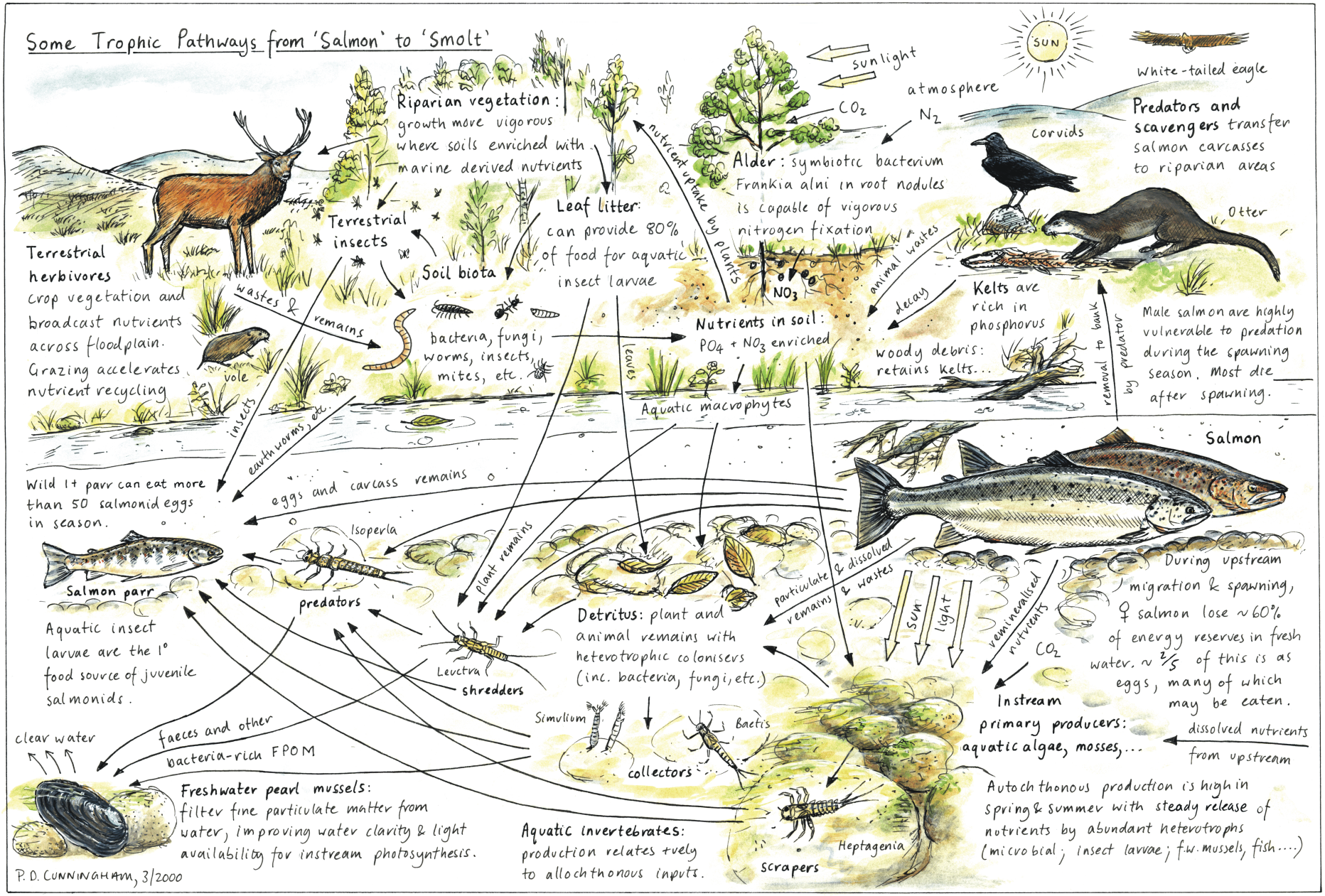
Pine marten

(self portrait)

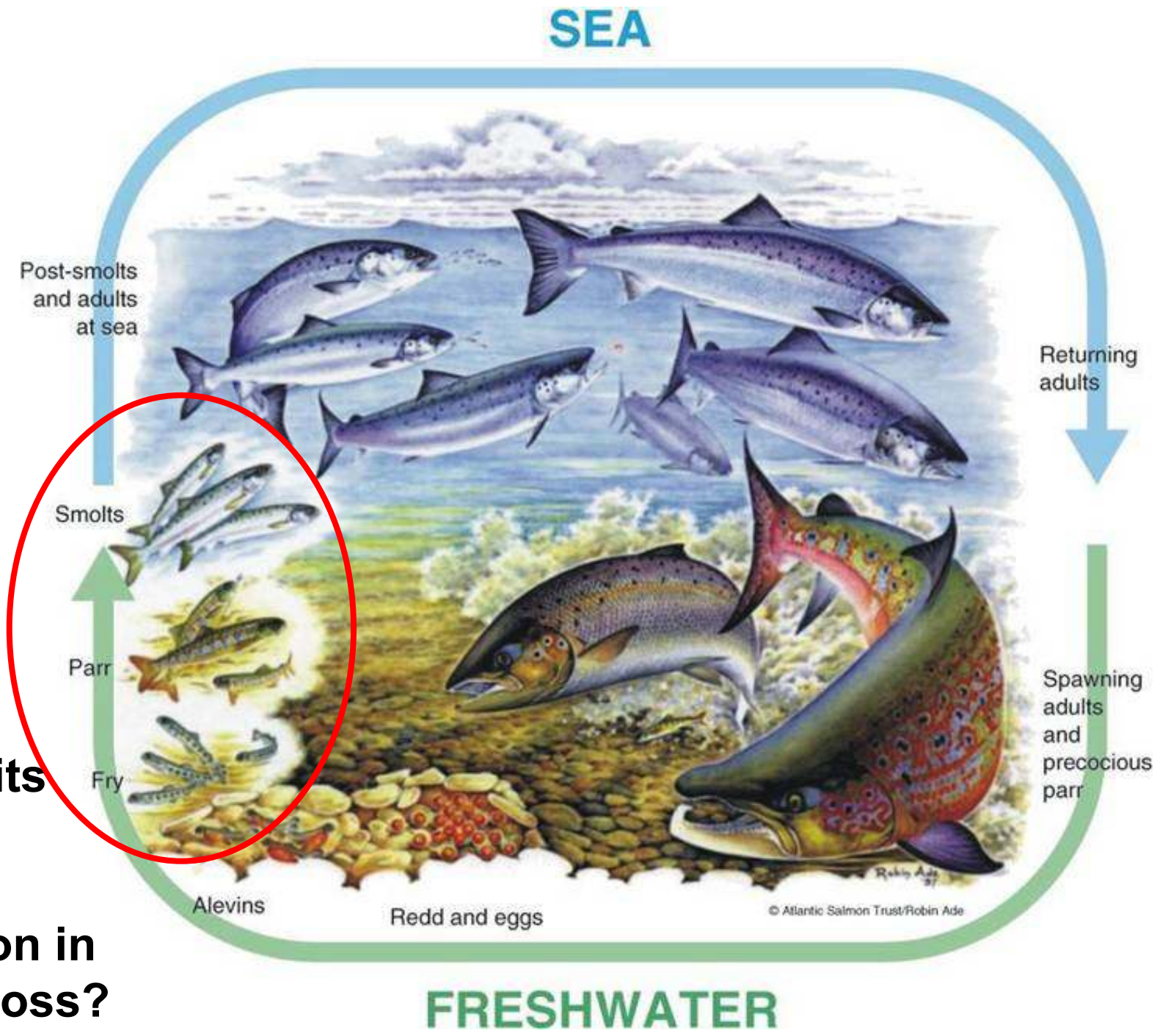

This partly digested grisle was regurgitated by a cormorant at Kinlochewe
photo by Ben Rushbrooke

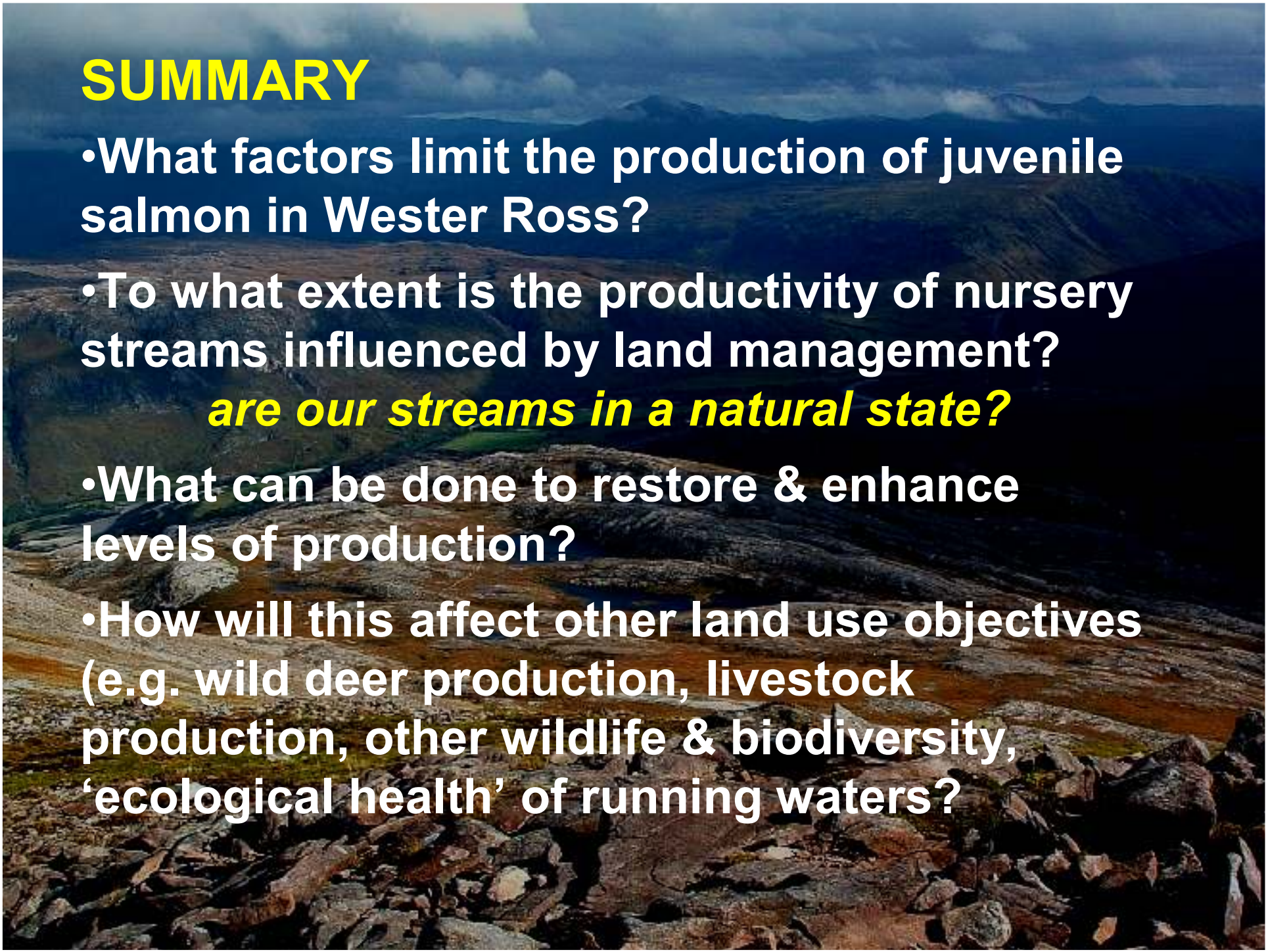

This little trout had 11 salmon eggs in its stomach. Possibly its best meal of the year!
8 9 10 11 12 13 14 15 16 17 18 19 20 21
4 5 7 8
photo by Ben Rushrooke

Adult salmon can provide food for juvenile salmon



What limits juvenile salmon production in Wester Ross?





SUMMARY

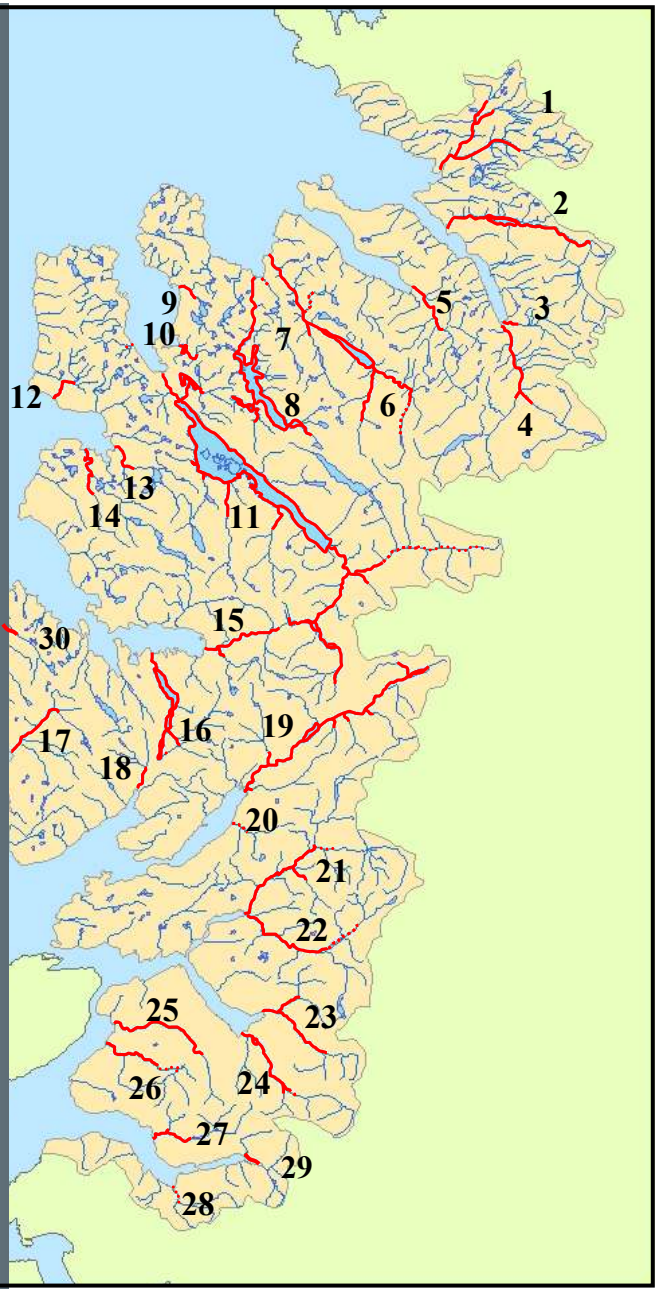
- What factors limit the production of juvenile salmon in Wester Ross?
- To what extent is the productivity of nursery streams influenced by land management?

  are our streams in a natural state?
- What can be done to restore & enhance levels of production?
- How will this affect other land use objectives (e.g. wild deer production, livestock production, other wildlife & biodiversity, 'ecological health' of running waters?


First find out if there are any salmon . . .
WRFT electro-fishing survey
photo by John Macpherson


Count and measure
the catch. . .

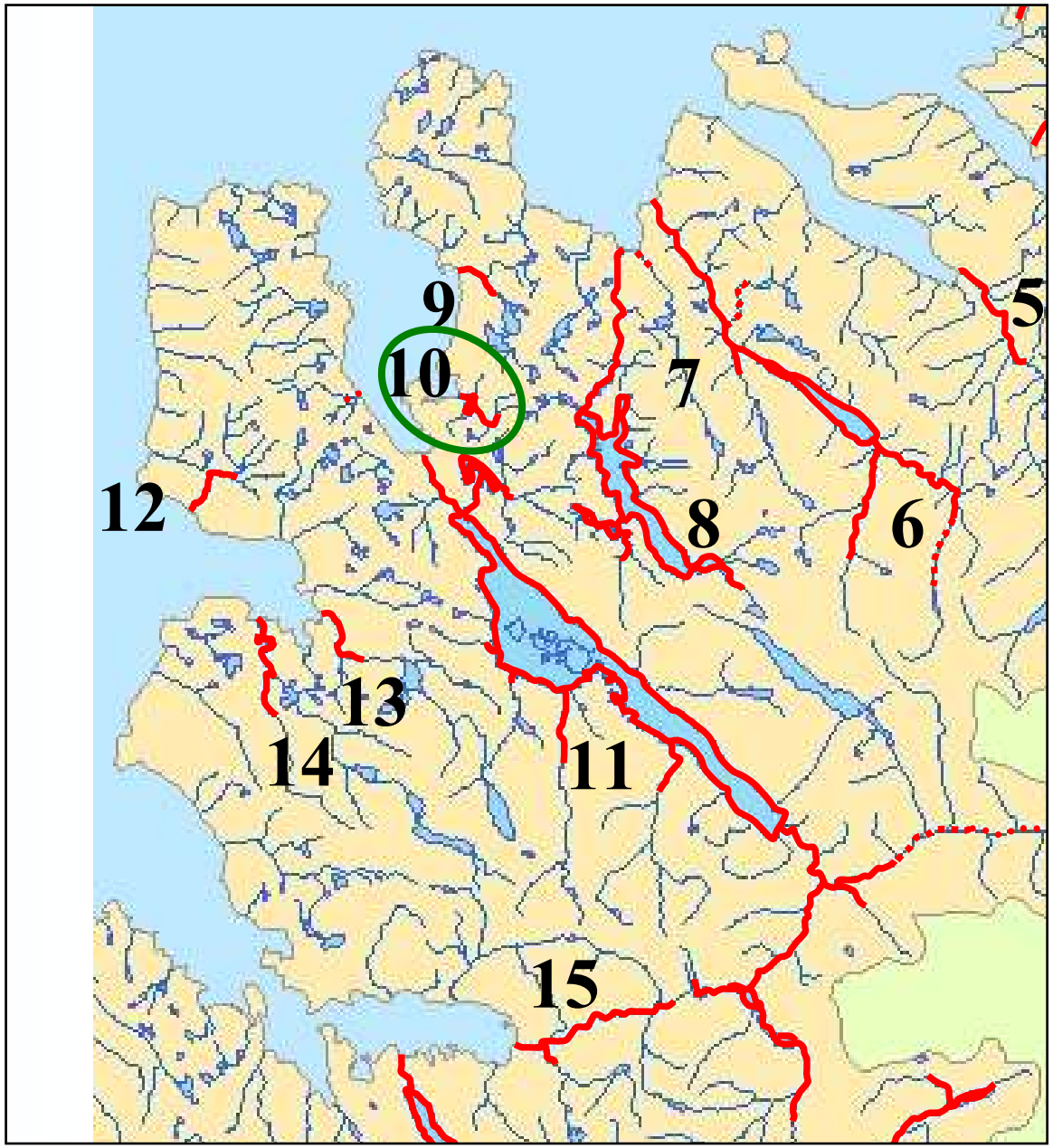
1. Kanaird
2. Ullapool
3. Lael
4. Broom
5. Dundonnell
6. Gruinard
7. Inverianvie
8. Little Gruinard
9. Allt Beith
10. Tournaig
11. Ewe
12. Sand
13. Kerry
14. Badachro
15. Torridon
16. Balgy
30. Cuaig
17. Applecross
18. Kishorn
19. Carron
20. Attadale
21. Ling
22. Elchaig
23. Croe
24. Shiel
25. Glenmore (Glenelg)
26. Glenbeag
27. Arnisdale
28. Barisdale
29. Kinlochhourn



Investigate where they occur . . .

distribution of juvenile salmon

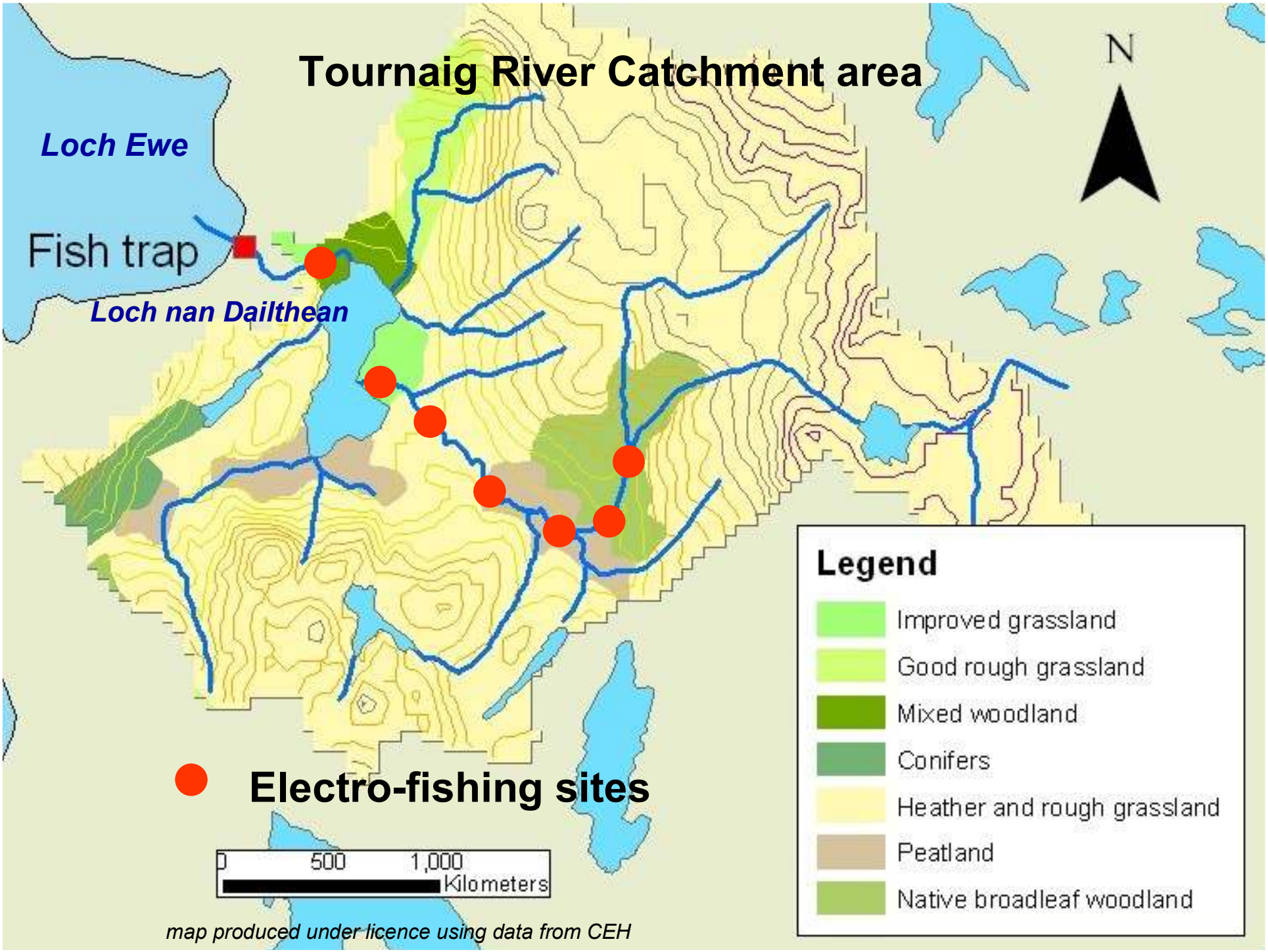
(based on WRFT electro-fishing surveys in 2006 & 7)



Tournaig trap project

What determines the number of salmon smolts produced?

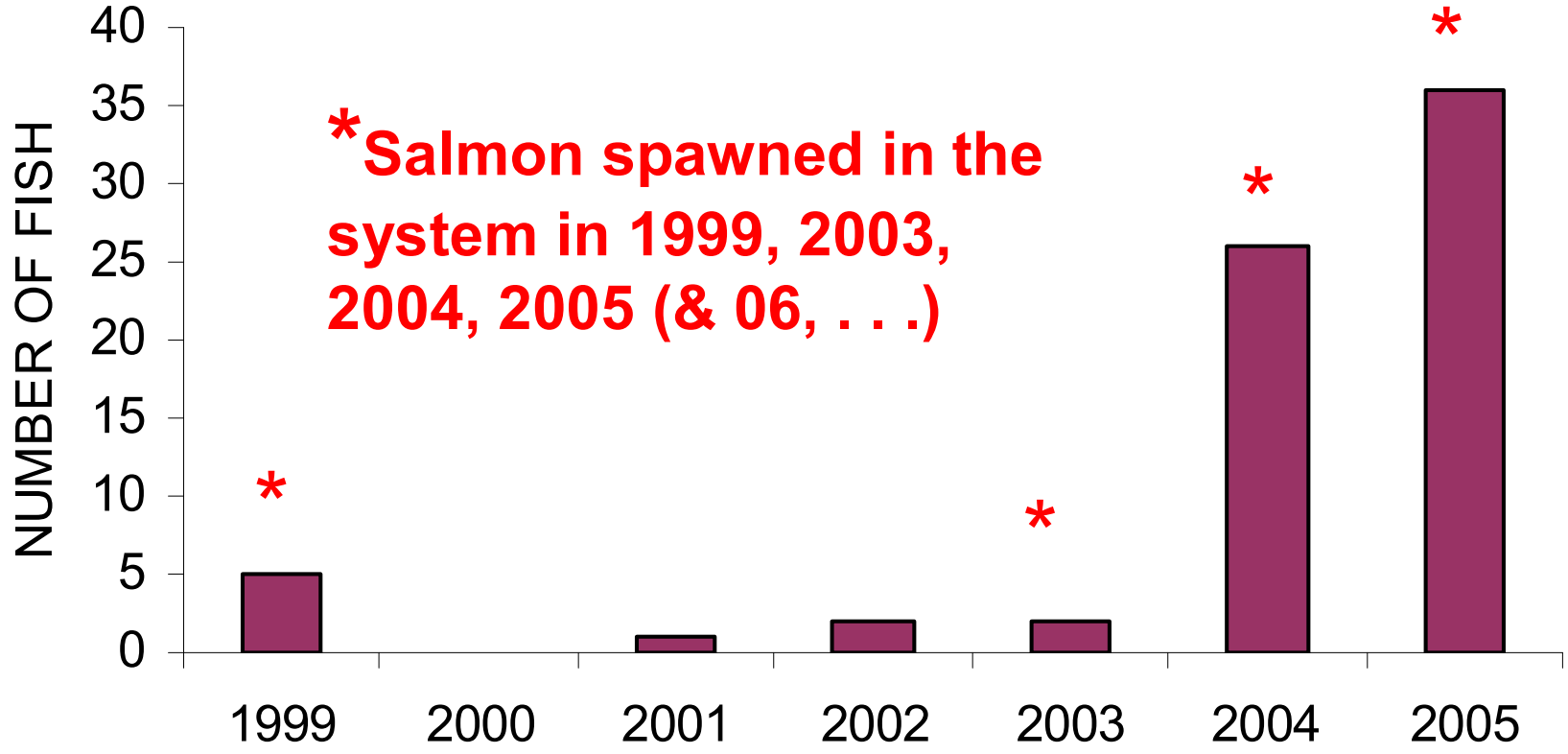
Thanks to Tournaig & Letterewe Estates, the National Trust for Scotland, HIE and SGERAD


Tournaig River Catchment area
Loch Ewe
Fish trap
Loch nan Dailthean
N
Legend
Improved grassland
Good rough grassland
Mixed woodland
Conifers
Heather and rough grassland
Peatland
Native broadleaf woodland
Electro-fishing sites
0
500
1,000
Kilometers
map produced under licence using data from CEH

Tournaig upstream salmon catches

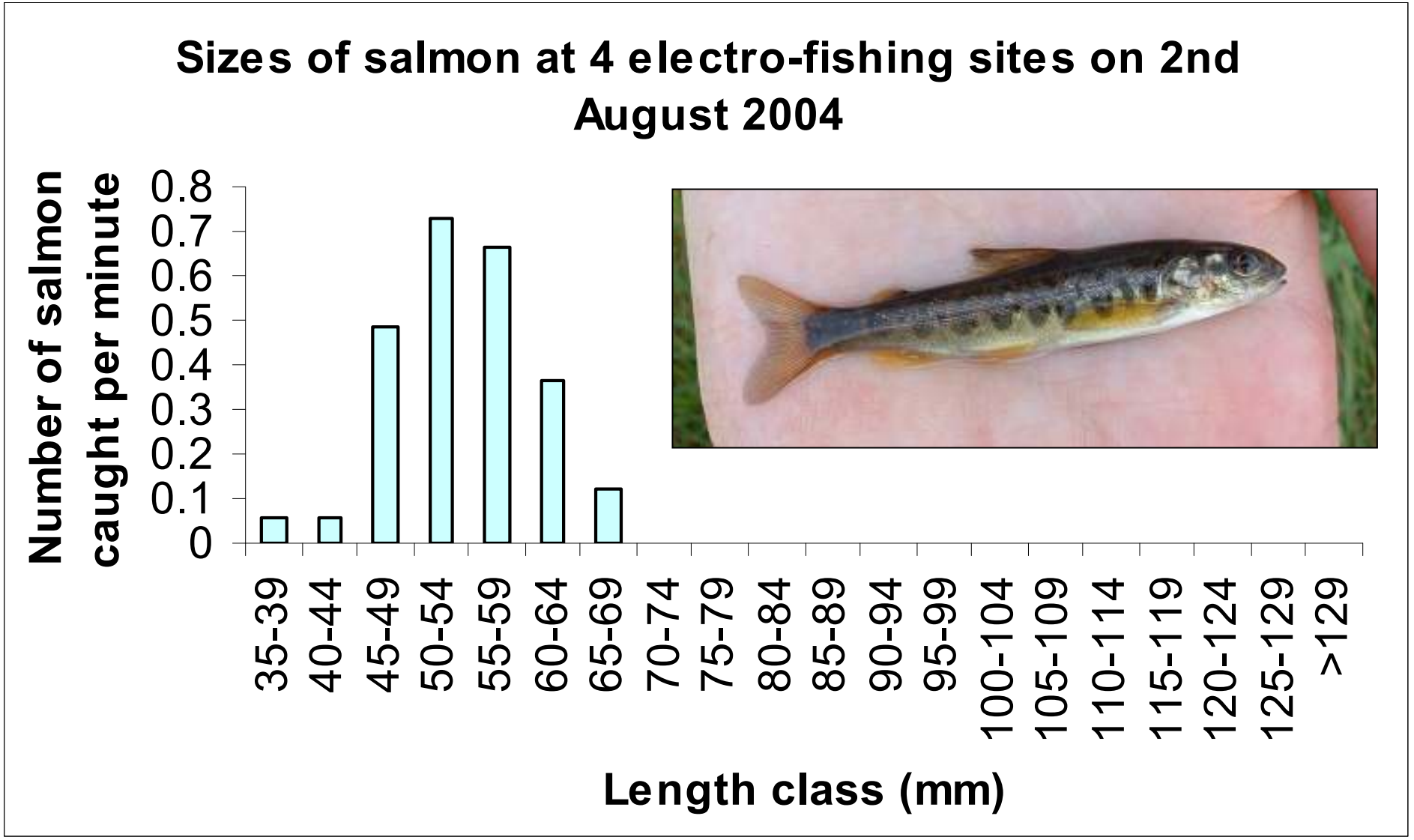
Ben removing a grilse from the upstream trap

Catches of adult salmon at Tournaig (to 2005)




Annual electro-fishing survey

Salmon spawned in the Tournaig system in 2003 for the first time since 1999

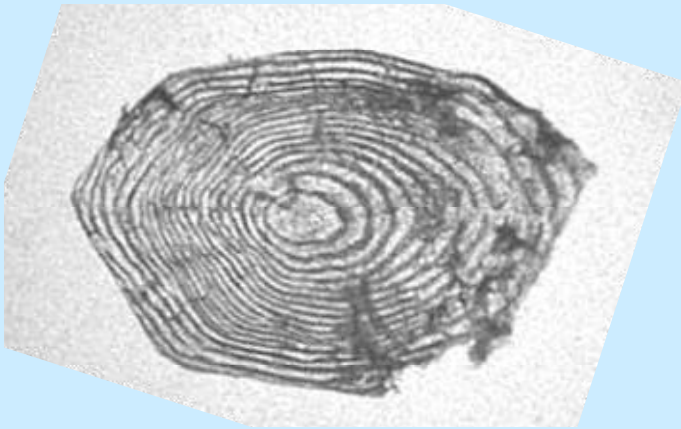


How many salmon smolts go to sea at Tournaig?

Ben emptying the downstream trap

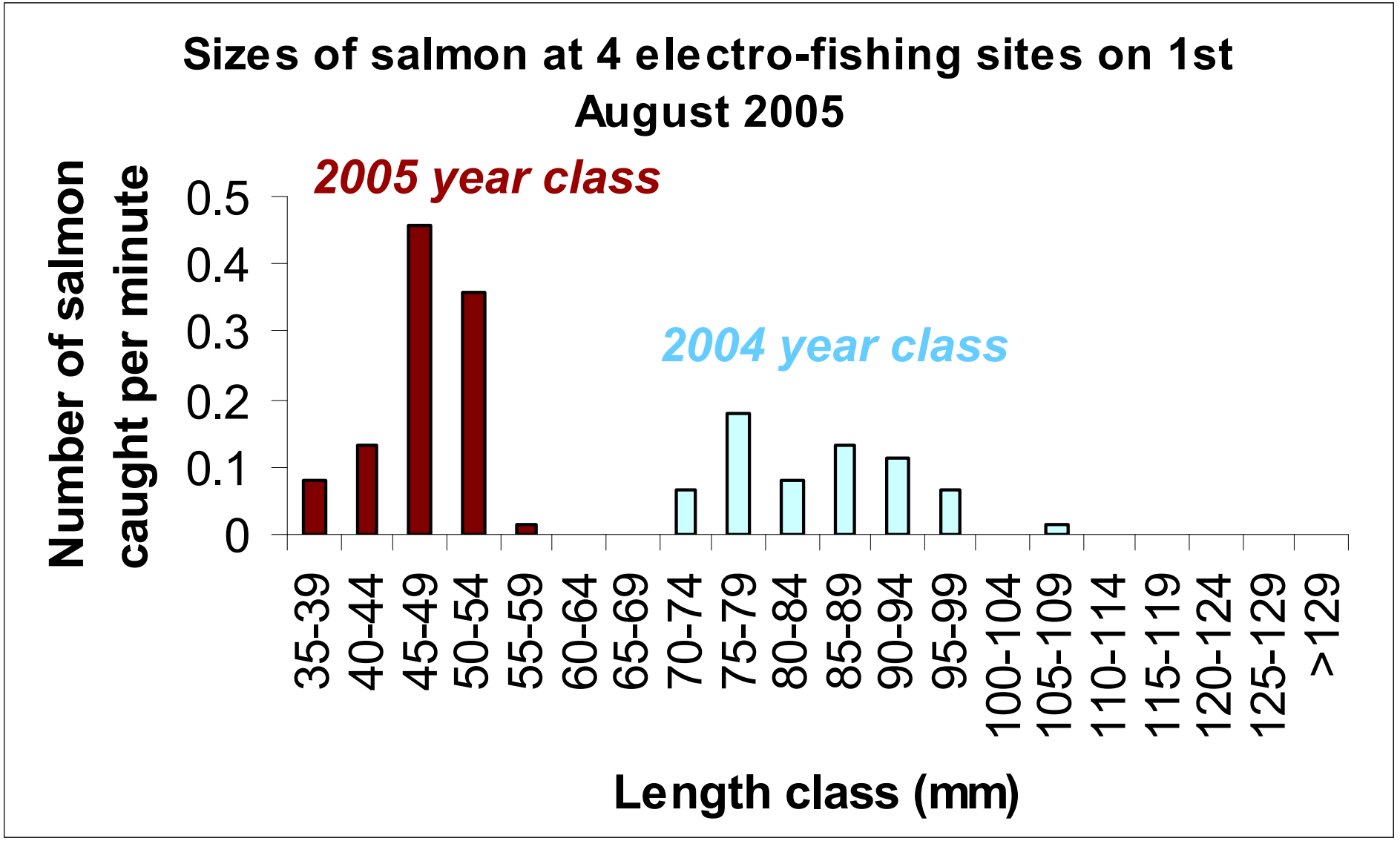
11smolts went to sea in 2005!! 107 mm SL

all were 1+ year old

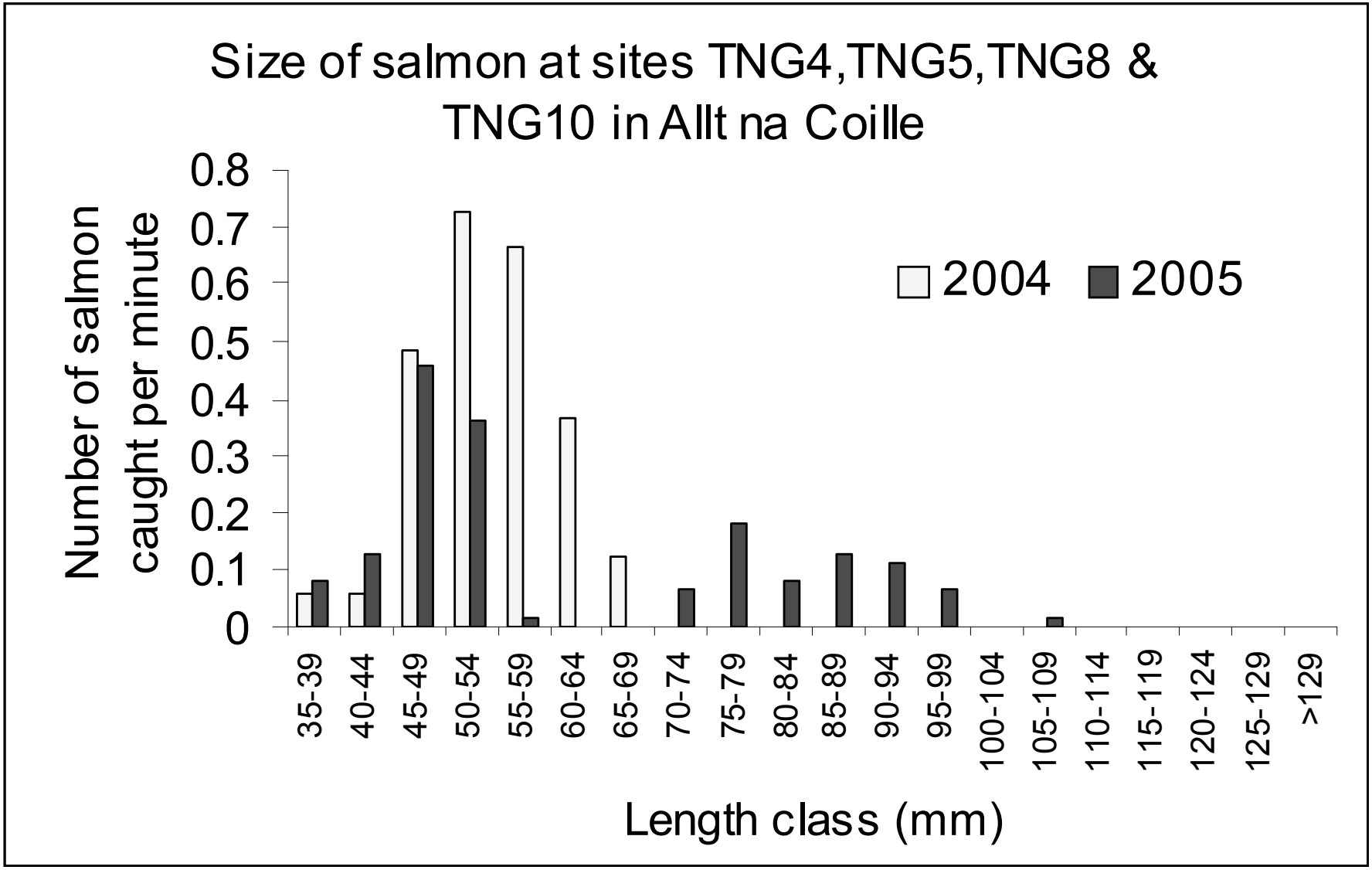


(Fish photos by Ben Rushbrooke)

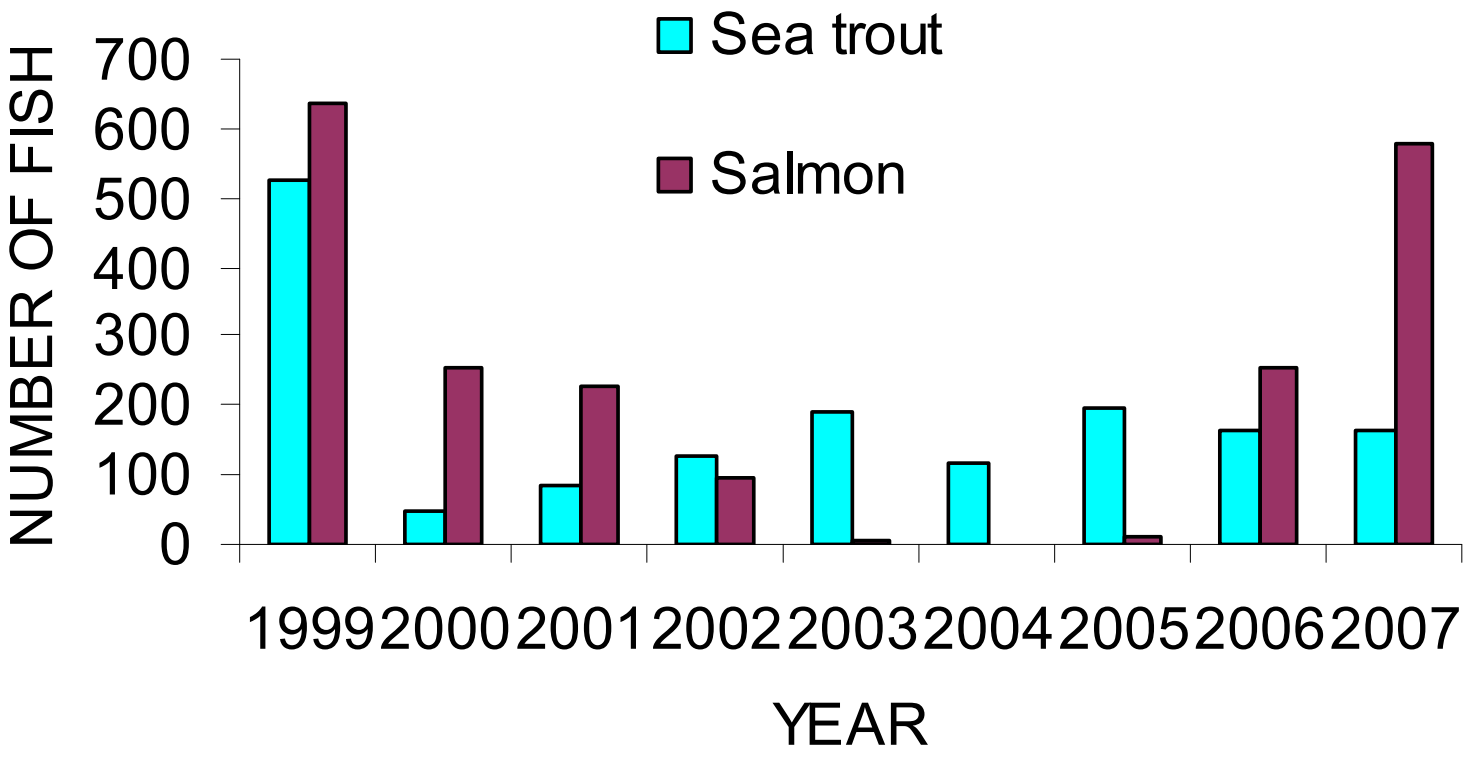
Salmon spawned again in 2004 . . .



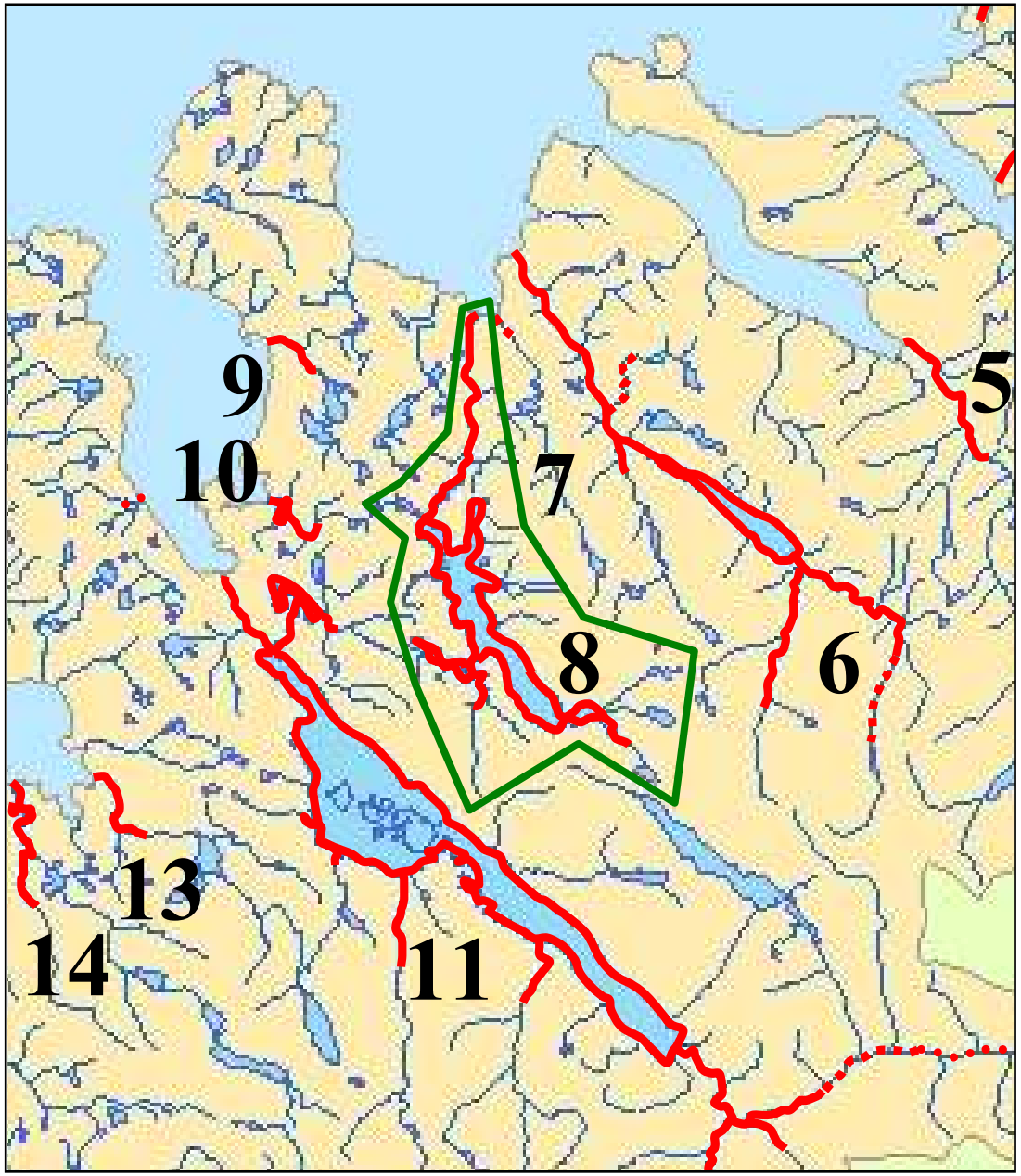
Salmon fry grew faster in 2004 than in 2005



Number of smolts descending at Tournaig




The rate of growth of juvenile salmon varies greatly.
18 month old salmon parr from the River Coulin (130m ASL)
6 month old salmon fry from the Cuaig River (15m ASL)

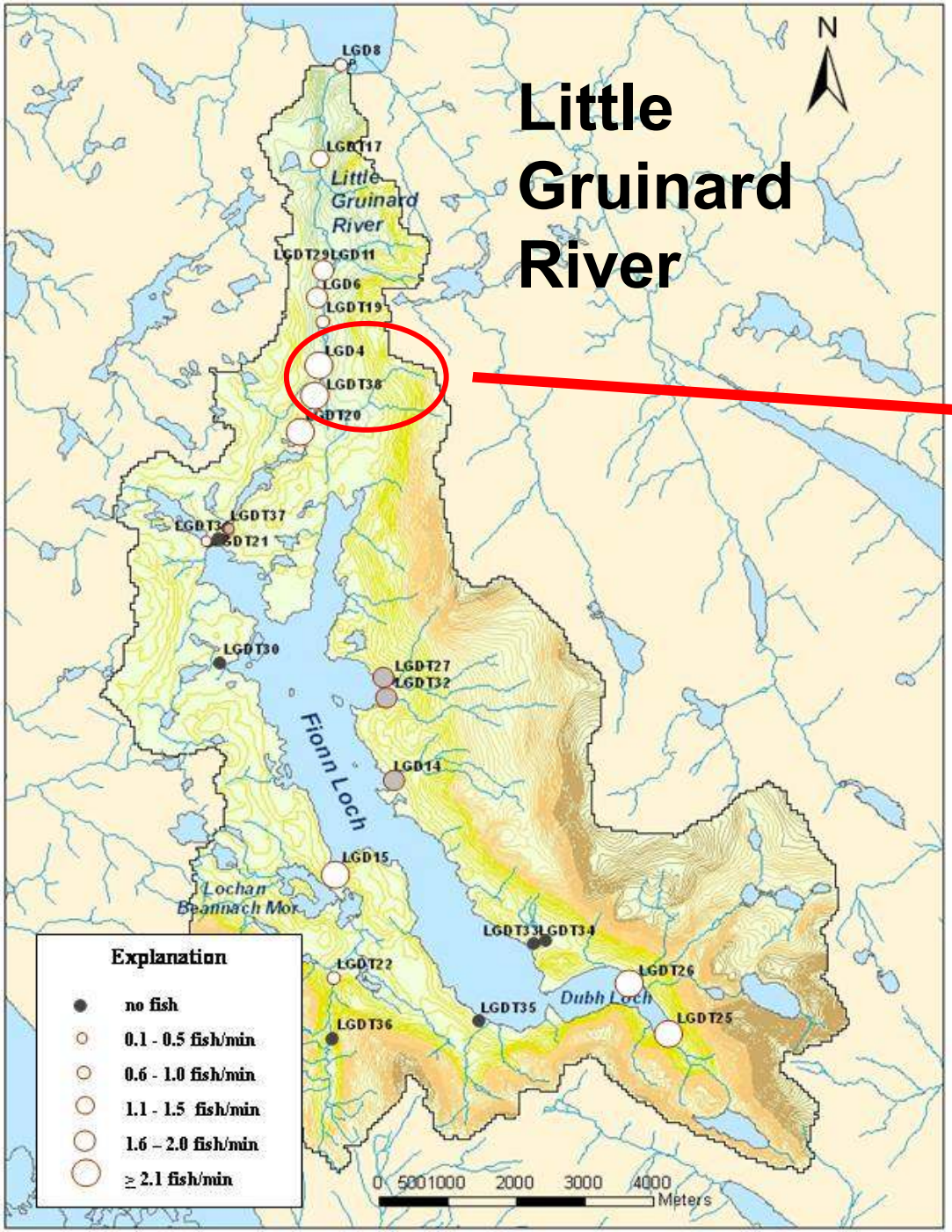


The Little Gruinard River

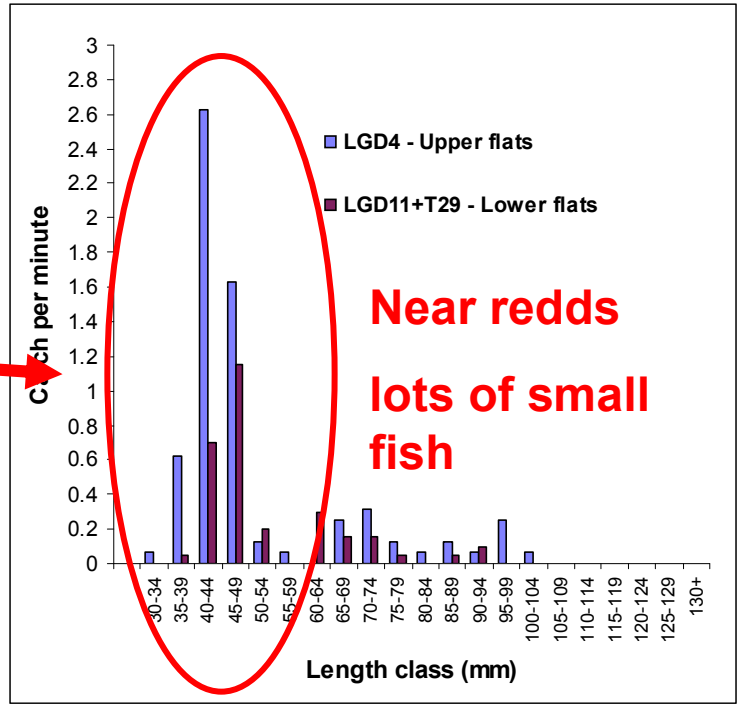
Special Area of Conservation (SAC) for the Atlantic salmon.

Densities of juvenile salmon are consistently high in the main river.

But many of them are very small . . .

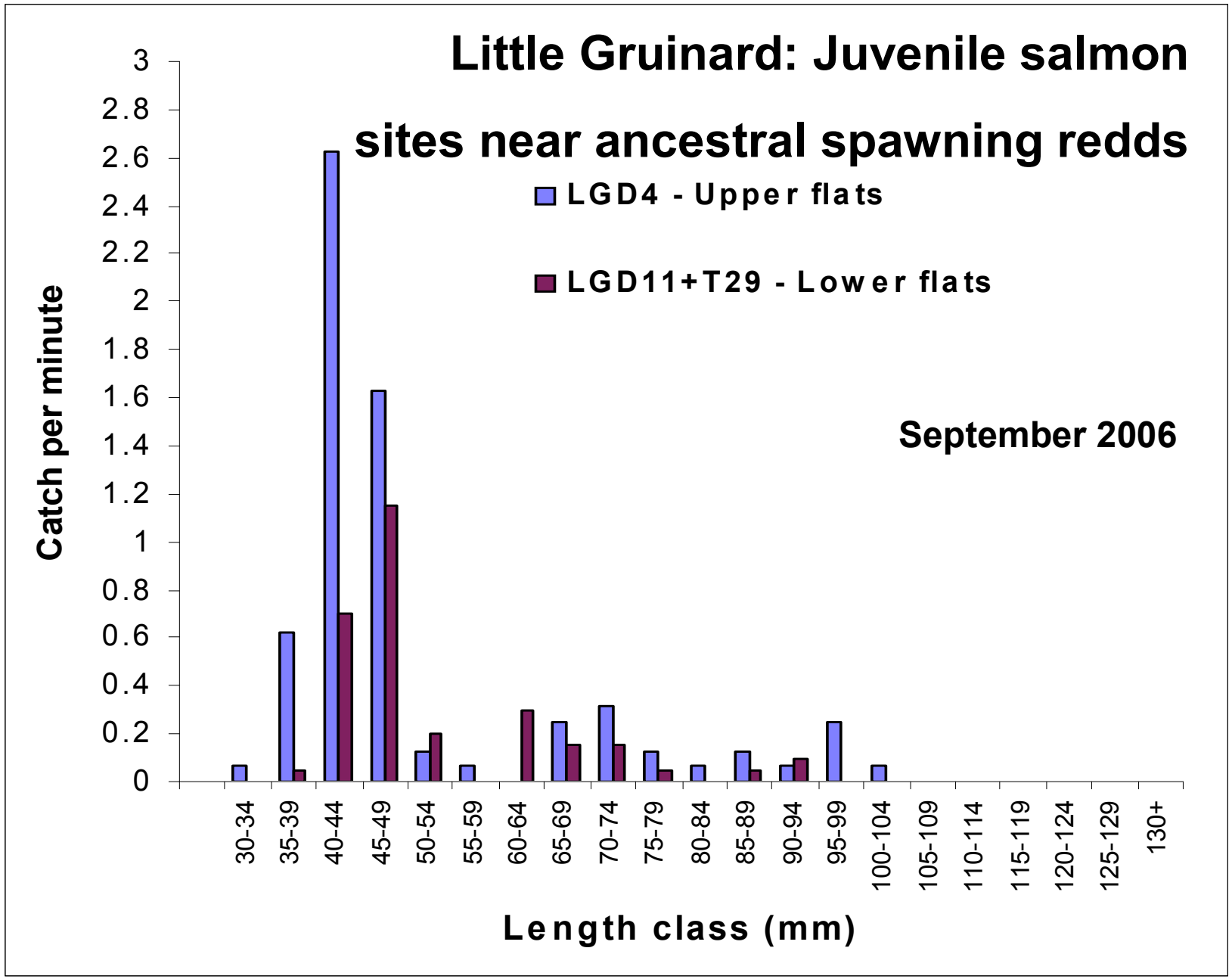


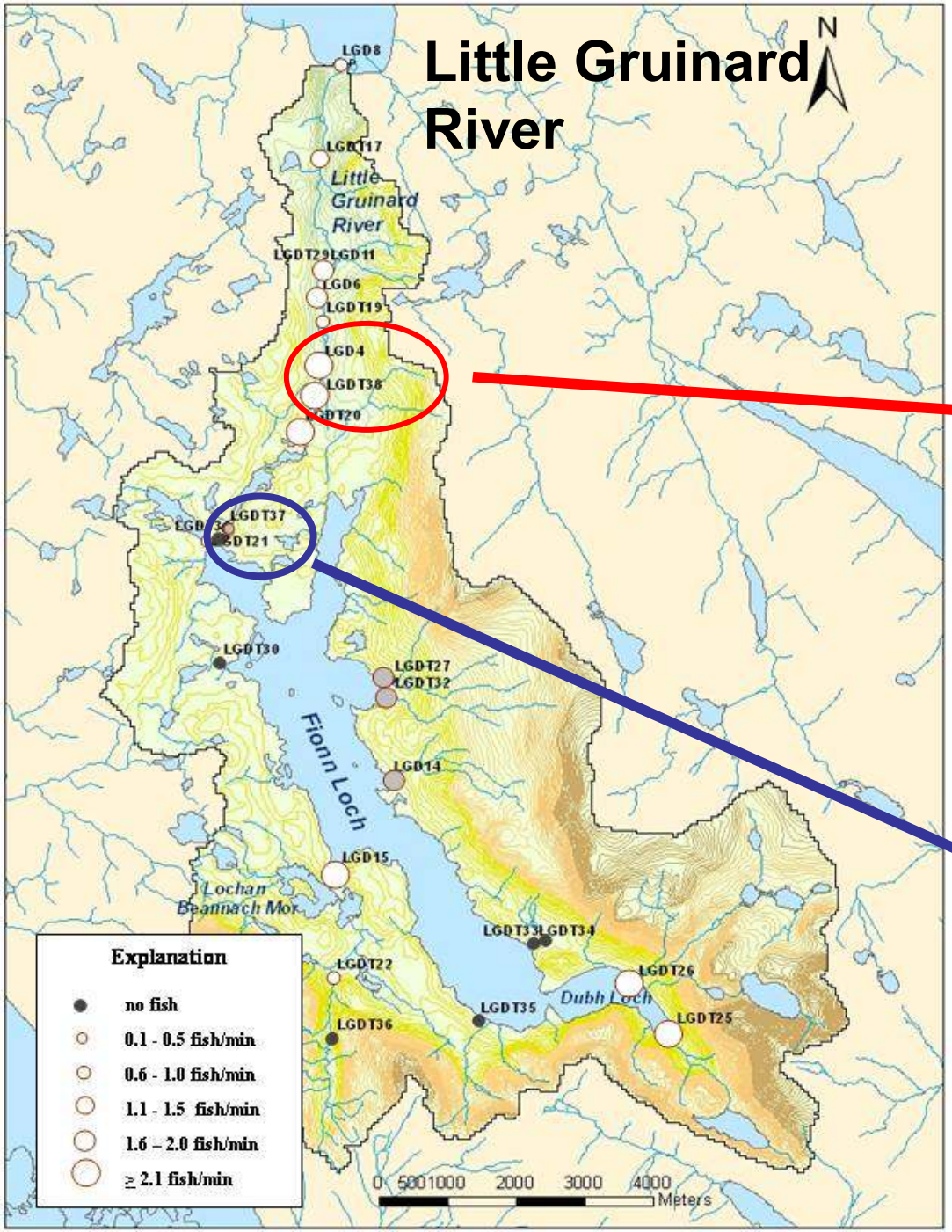
Juvenile salmon 2006



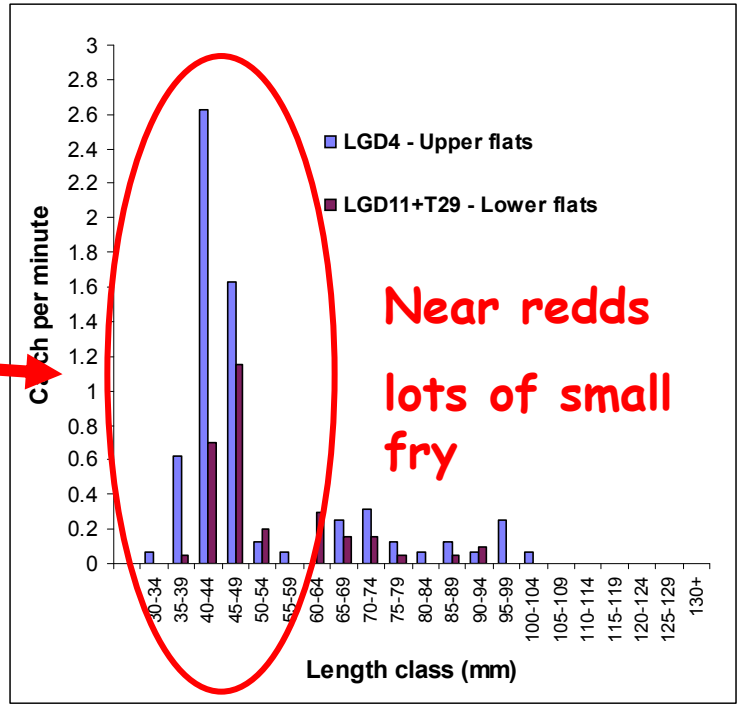

Lower Flats of
Little Gruinard
E-fish survey 23 August 2006

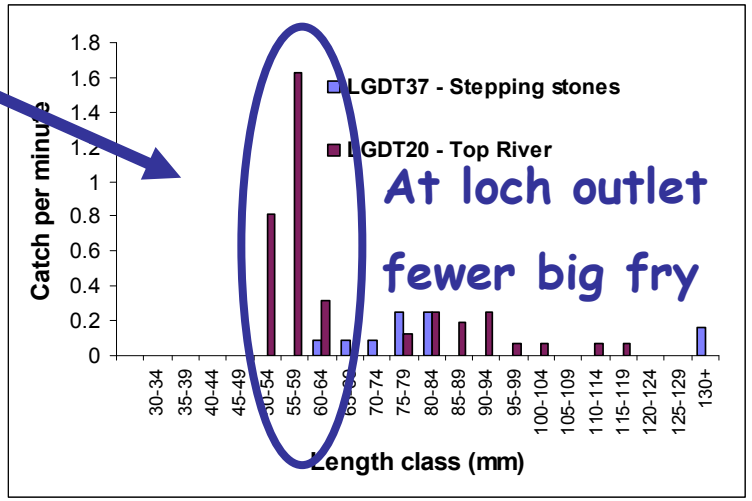

Small fry . . . . . and small parr


Little Gruinard: Juvenile salmon sites near ancestral spawning redds
LGD4 - Upper flats
LGD11+T29 - Lower flats
September 2006
Catch per minute
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
30-34
35-39
40-44
45-49
50-54
55-59
60-64
65-69
70-74
75-79
80-84
85-89
90-94
95-99
100-104
105-109
110-114
115-119
120-124
125-129
130+
Length class (mm)



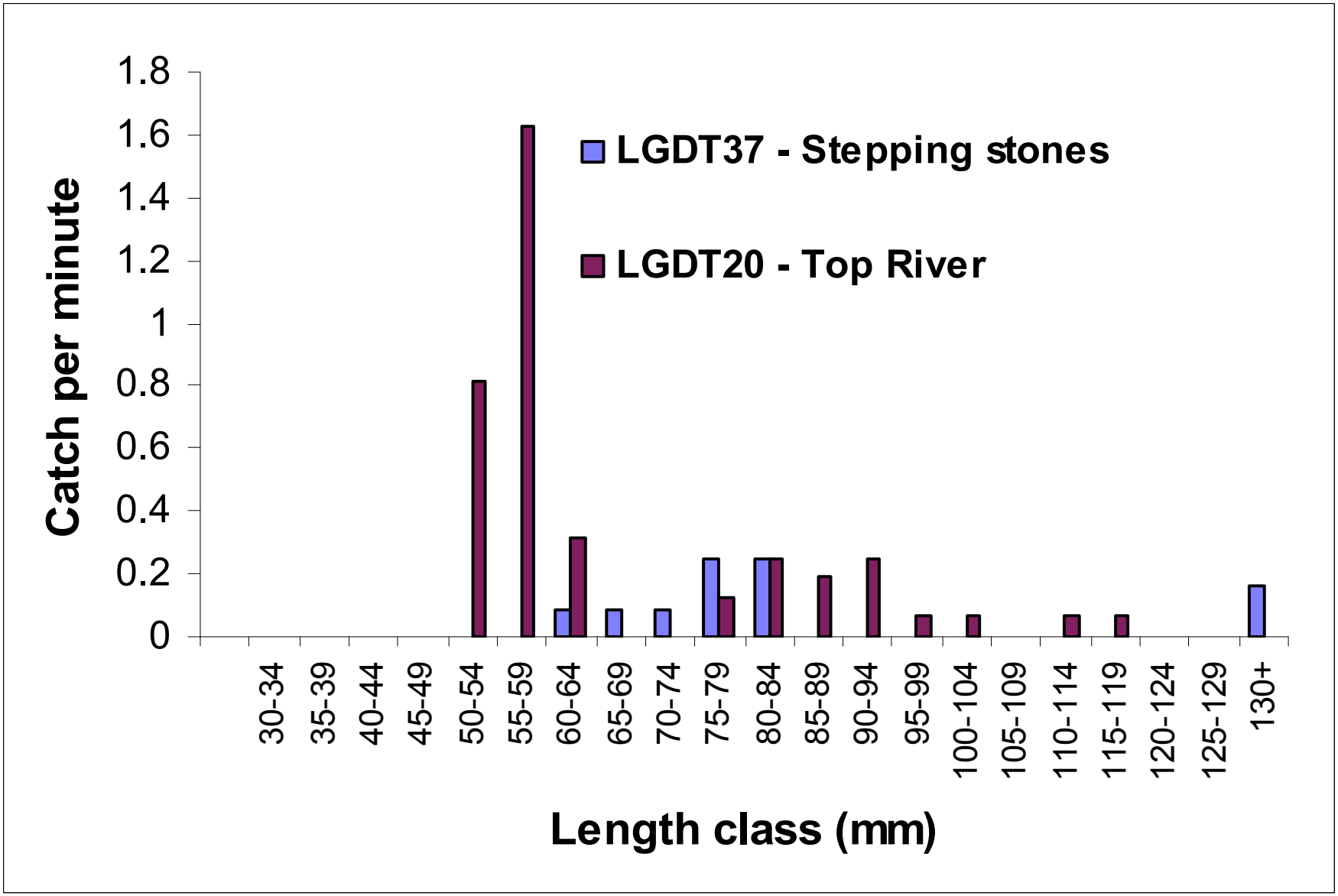
Juvenile salmon 2006



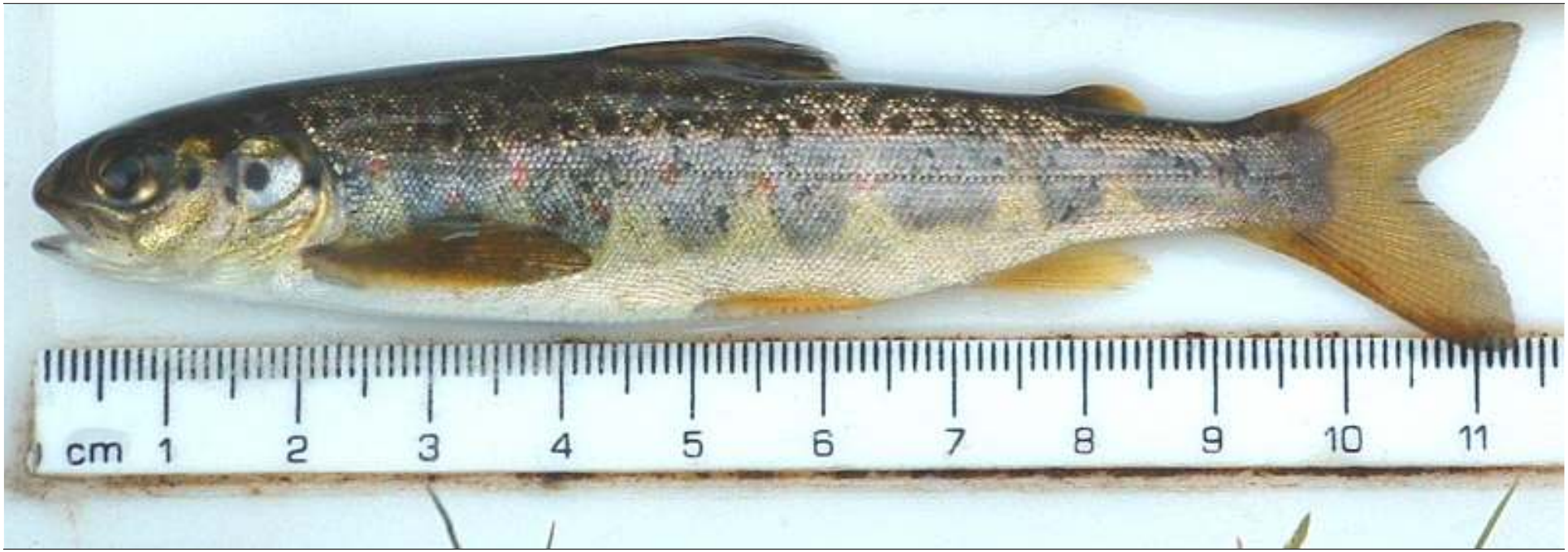


Stepping stones (below Fionn Loch)

Big one year old parr


Catch per minute
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
LGDT37 - Stepping stones
LGDT20 - Top River
30-34
35-39
40-44
45-49
50-54
55-59
60-64
65-69
70-74
75-79
80-84
85-89
90-94
95-99
100-104
105-109
110-114
115-119
120-124
125-129
130+
Length class (mm)

- ***Where juvenile salmon densities are high, growth tends to be slower.***
- ***Where juvenile salmon densities are low, growth tends to be faster.***




Why is there such variation in growth rates?
photo by Nick Benge

Growth and production of juvenile salmon may depend upon food availability

Stonefly and Mayfly larvae


Food availability varies according to catchment fertility.
Well fed one year old salmon and trout from the upper Balgy


Some rivers have been nutrient enriched and levels of fertility may have been enhanced.
Salmon farm in Loch Sgamhain at top of River Carron

Algal bloom below loch


Blue-green algal bloom in Loch Tollie: too much nutrient!
August, 1999

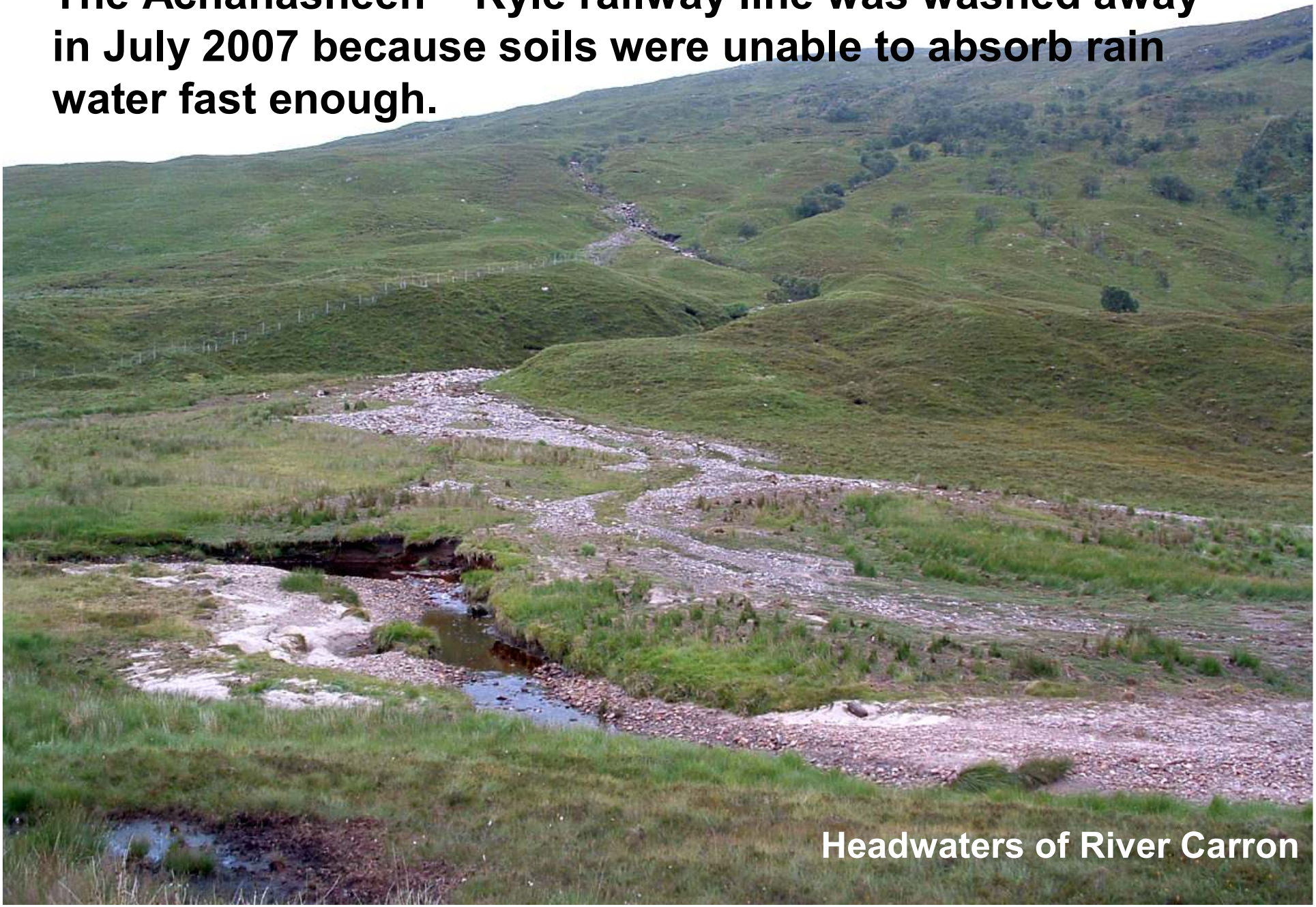

However, most river catchment areas in Wester Ross have very limited nutrient availability.
Kinlochewe River from top of Meall Ghuibhais (Beinn Eighe NNR)

Soils are poorly developed and infertile

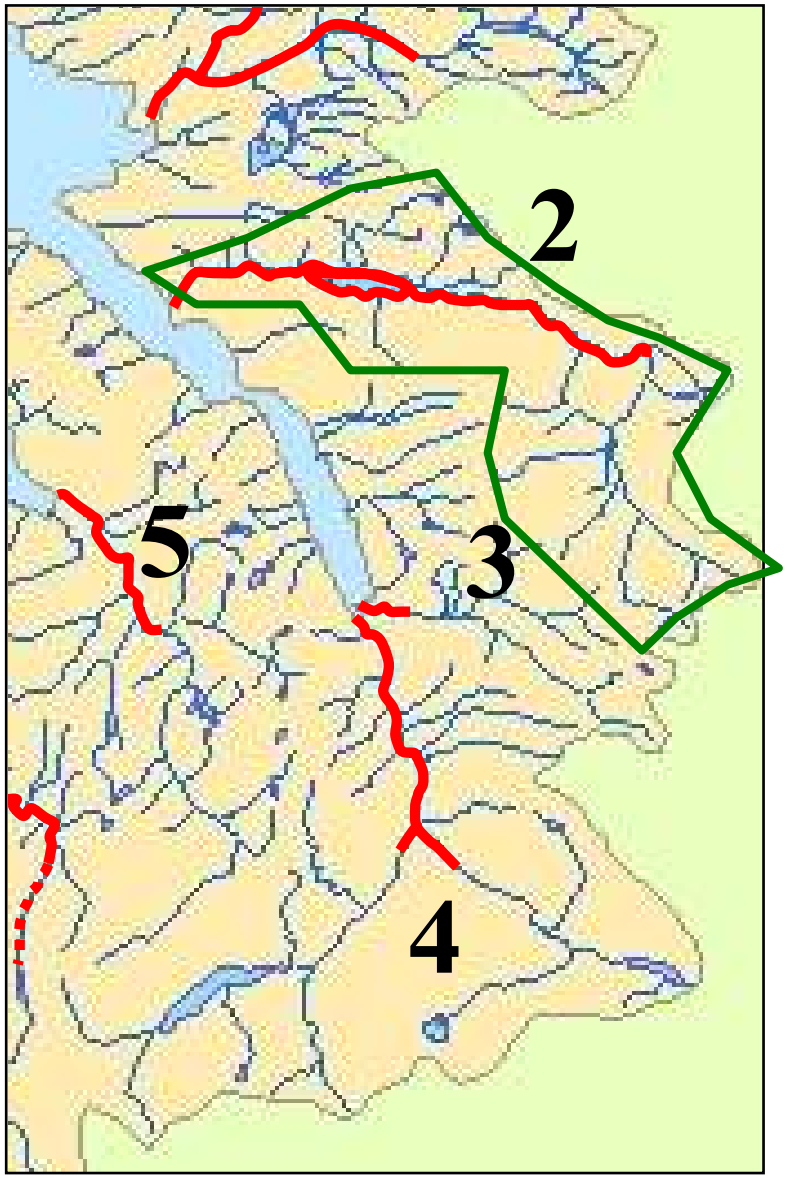
Extreme spates erode stream banks, removing fertile riparian soils


Extreme spates may wash out eggs, juvenile fish, insect life and other nutritious organic matter.
Taagan burn below Beinn Eighe NNR

The Achanasheen – Kyle railway line was washed away in July 2007 because soils were unable to absorb rain water fast enough.

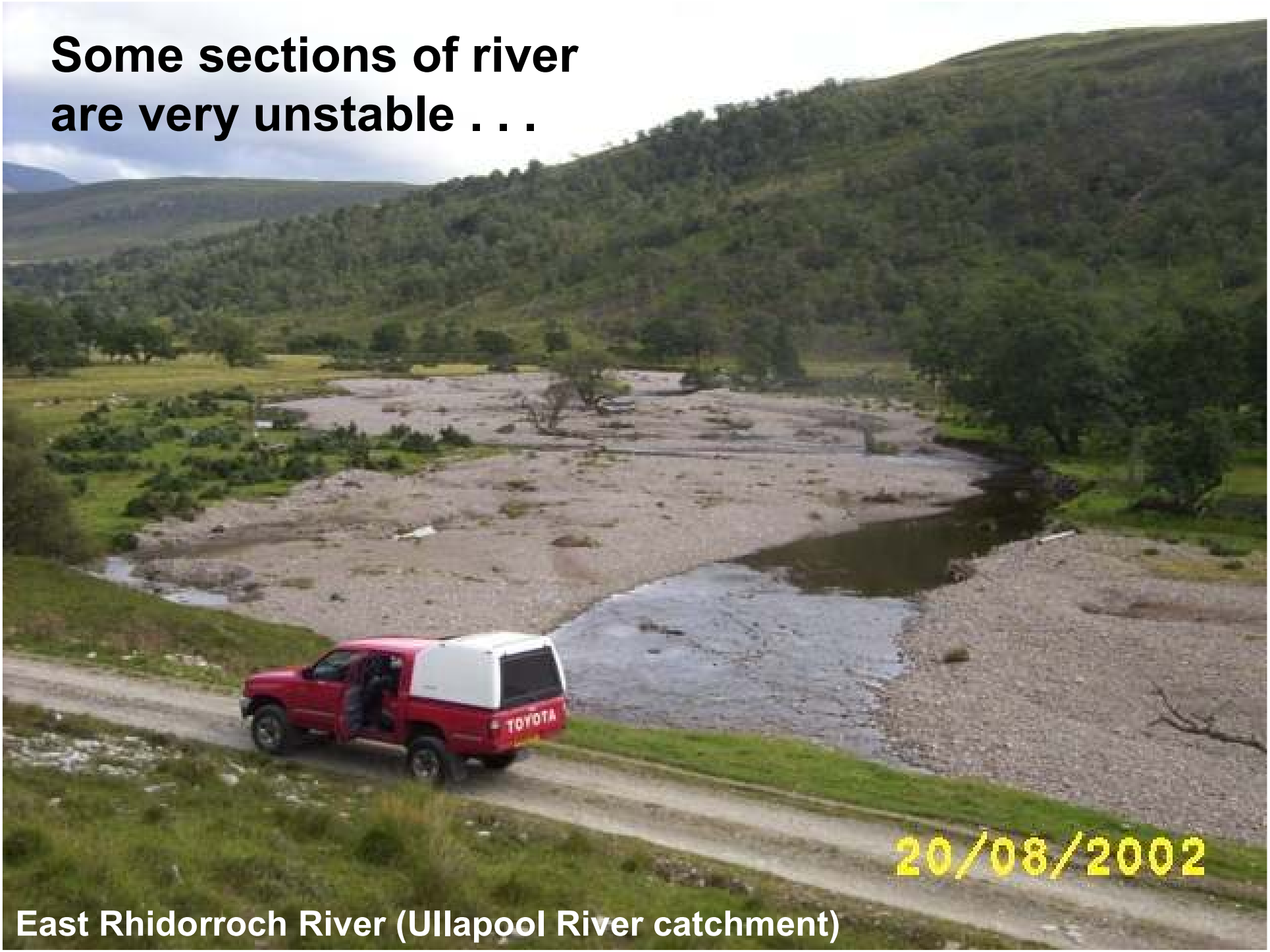


Headwaters of River Carron



Another example:

East Rhidorroch River (above Loch Achall, Ullapool River)

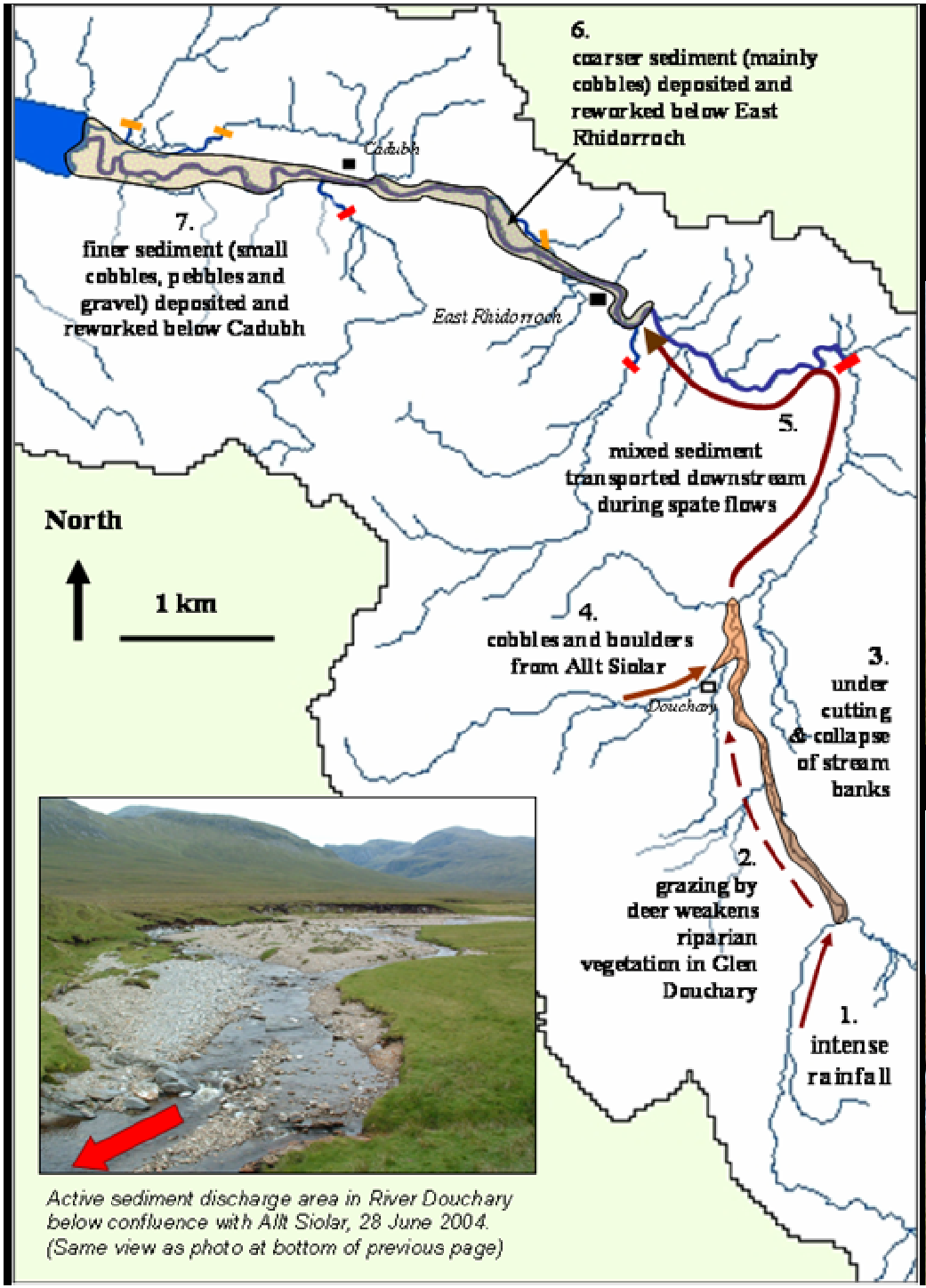

Some sections of river
are very unstable . . .
TOYOTA
20/08/2002
East Rhidorroch River (Ullapool River catchment)


December 2005

August 2006

August 2007

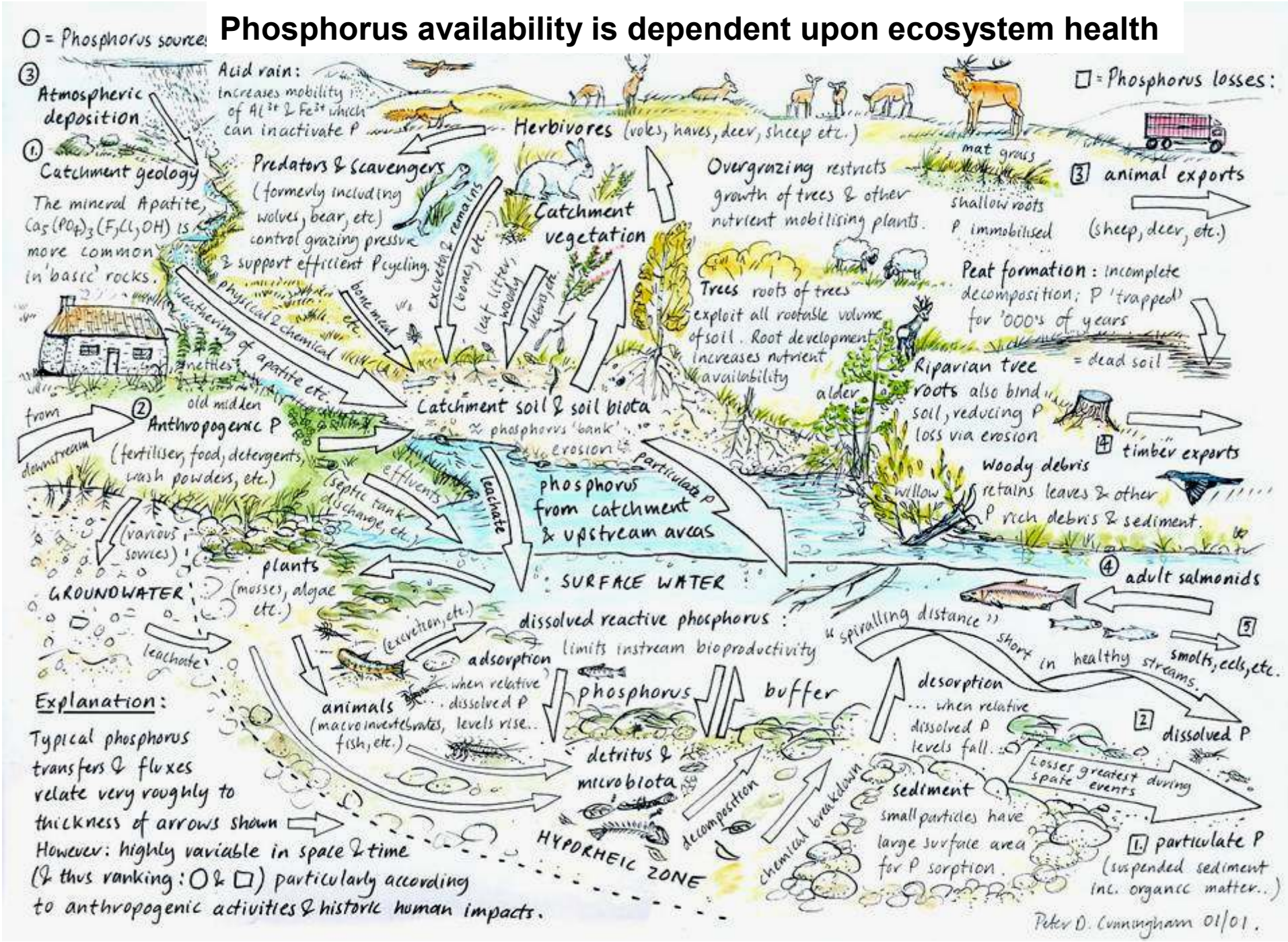
Problems originate in the upper river catchments



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


Soils are infertile because little nutrient,
especially phosphorus, reaches upland areas.

Phosphorus availability is dependent upon ecosystem health



Upland areas are not uniformly infertile . . .


Rocks and knolls in prominent positions in upland areas have been enriched with nutrients delivered by birds and mammals.
Look out over Kinlochewe in Beinn Eighe NNR

Eagle pellet (containing fur) and grouse dropping from a green knoll in the Tollie Hills


Biodiversity hot spot, Beinn Eighe NNR


The Island of Longa (Loch Gairloch) is enriched with nutrients from nesting sea birds and provides good winter grazing for sheep.


This green hummock is by the Strath Burn (above Gairloch). It is used by foxes . . .note the sheep bones!

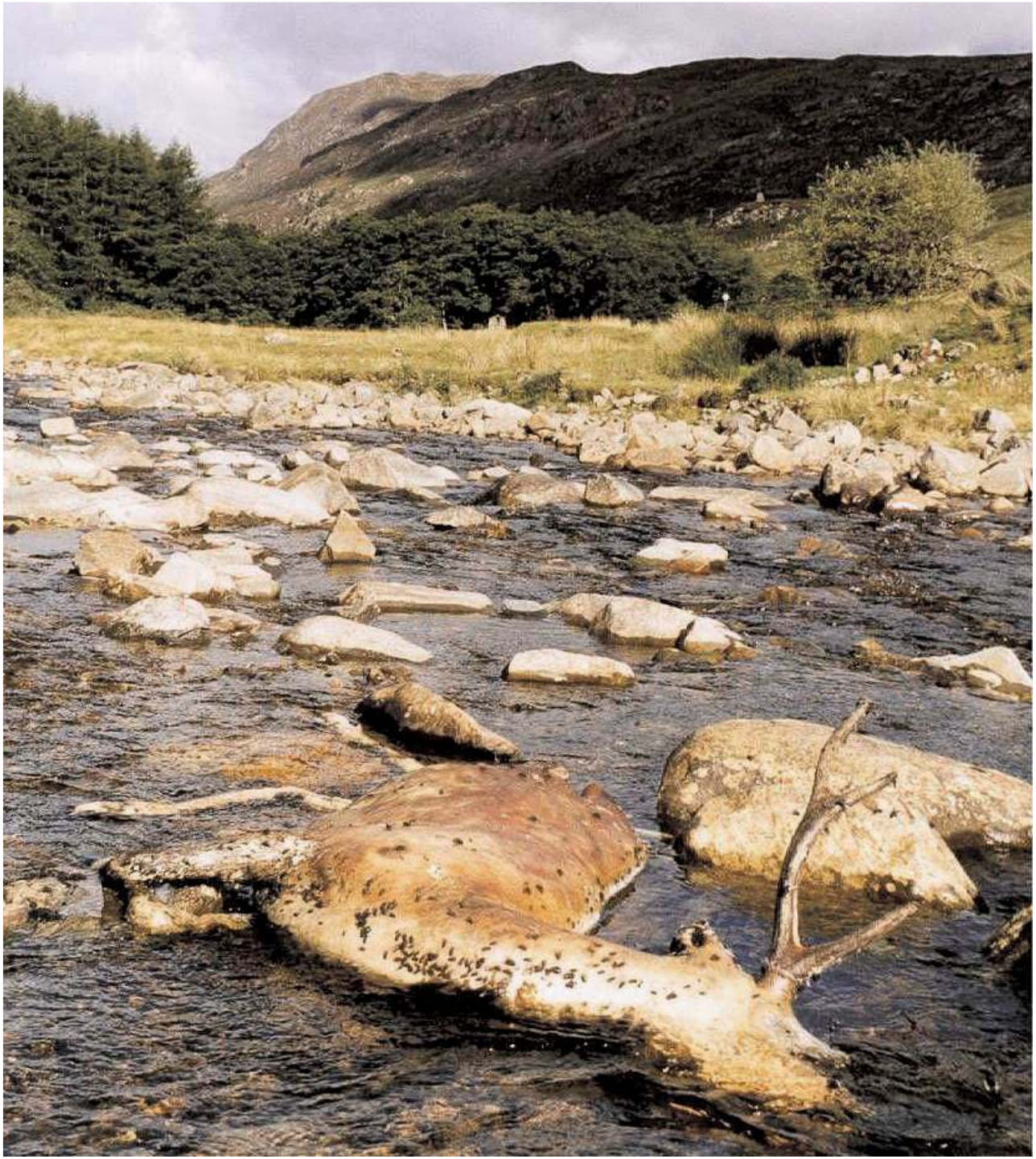

Otter spraint with
trout bones.


Have fertility levels changed as a result of land use and wildlife management practices?


Hillsides have been burnt to promote fresh growth.
Rainwater washes nutritious ash away.
29/01/2003

Why is there a greener patch in the bog?

Bog near Redpoint (2002)



A deer carcass contains ~3 kg of phosphate: mainly in bones.

The removal of deer, sheep or cattle from upland catchment areas represents an unnatural loss of nutrient from the ecosystem.

Where nutrients are recycled . . .

. . .from vegetation to sheep back to vegetation. . . .

- ***growth of plants - and insects - can be prolific***
- ***more insects: more food for trout and salmon. . . .***

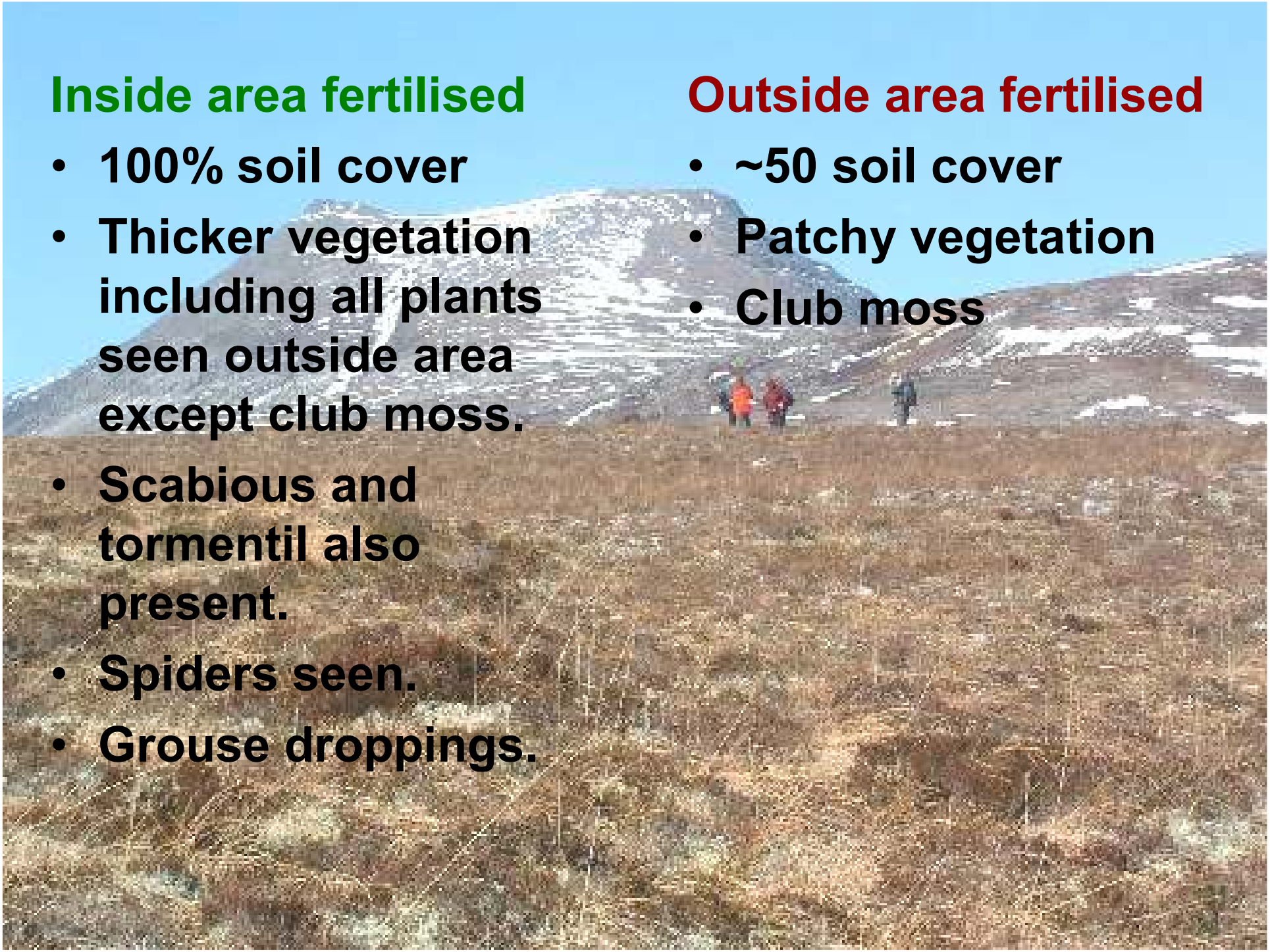
Red Deer

Milner *et al* (2002): A Highland Deer herd and its Habitat

•**Carcasses left on hill. .** improve efficiency of cull, carrion feeding beetles; vertebrates: foxes, badgers, shrews, ravens, golden eagles, sea eagles and hooded grows.

•**Vegetation [after decomposition of carcass]** had significantly higher nitrogen ; additional nutrient input associated with whole carcass. . Leaving carcasses on hill may therefore benefit grazing animals by enhancing the nutrient content of forage . . . Mineral concentrations are likely to increase as bone material degrades and bones provide an important source of calcium and other minerals for deer.


Fertilisation trials were carried out on Beinn Eighe NNR in the 1950s to find out how to enhance soil fertility.
Unfertilised area
Fertilised area
Details are sketchy, but 50 yrs on, results can still be clearly seen.
Looks like the trial was successful??



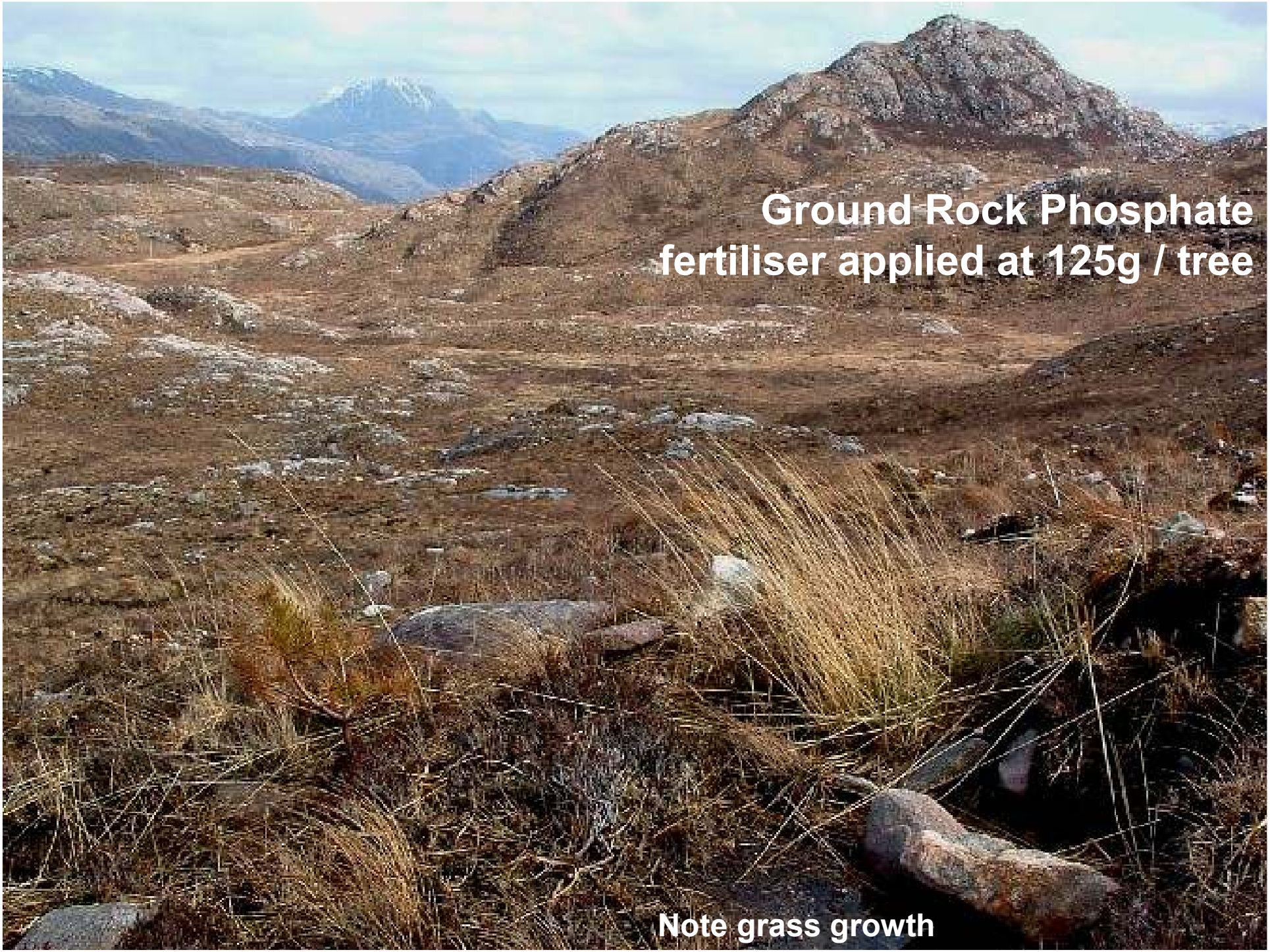
Inside area fertilised

- 100% soil cover
- Thicker vegetation including all plants seen outside area except club moss.
- Scabious and tormentil also present.
- Spiders seen.
- Grouse droppings.

Outside area fertilised

- ~50 soil cover
- Patchy vegetation
- Club moss


Gairloch Estate:
Balle Mor native
woodland restoration

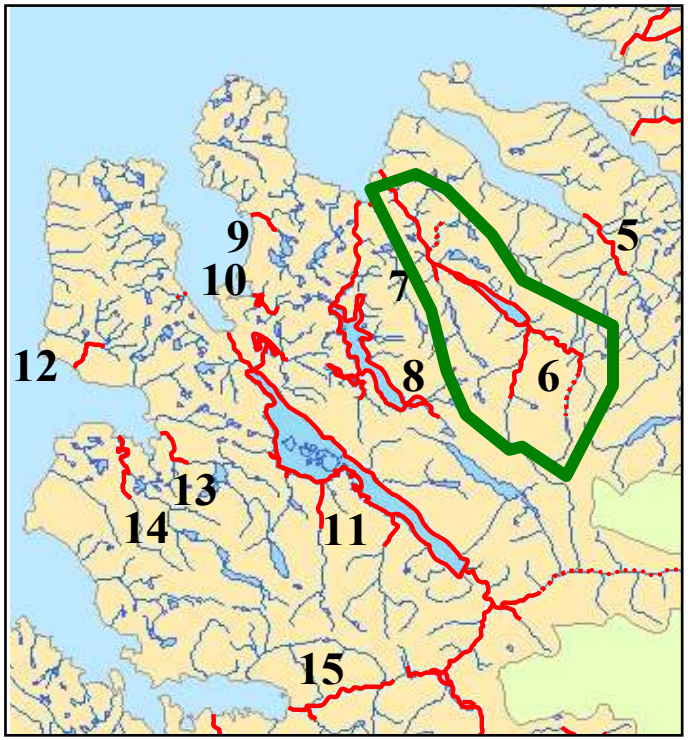

Ground Rock Phosphate
fertiliser applied at 125g / tree
Note grass growth

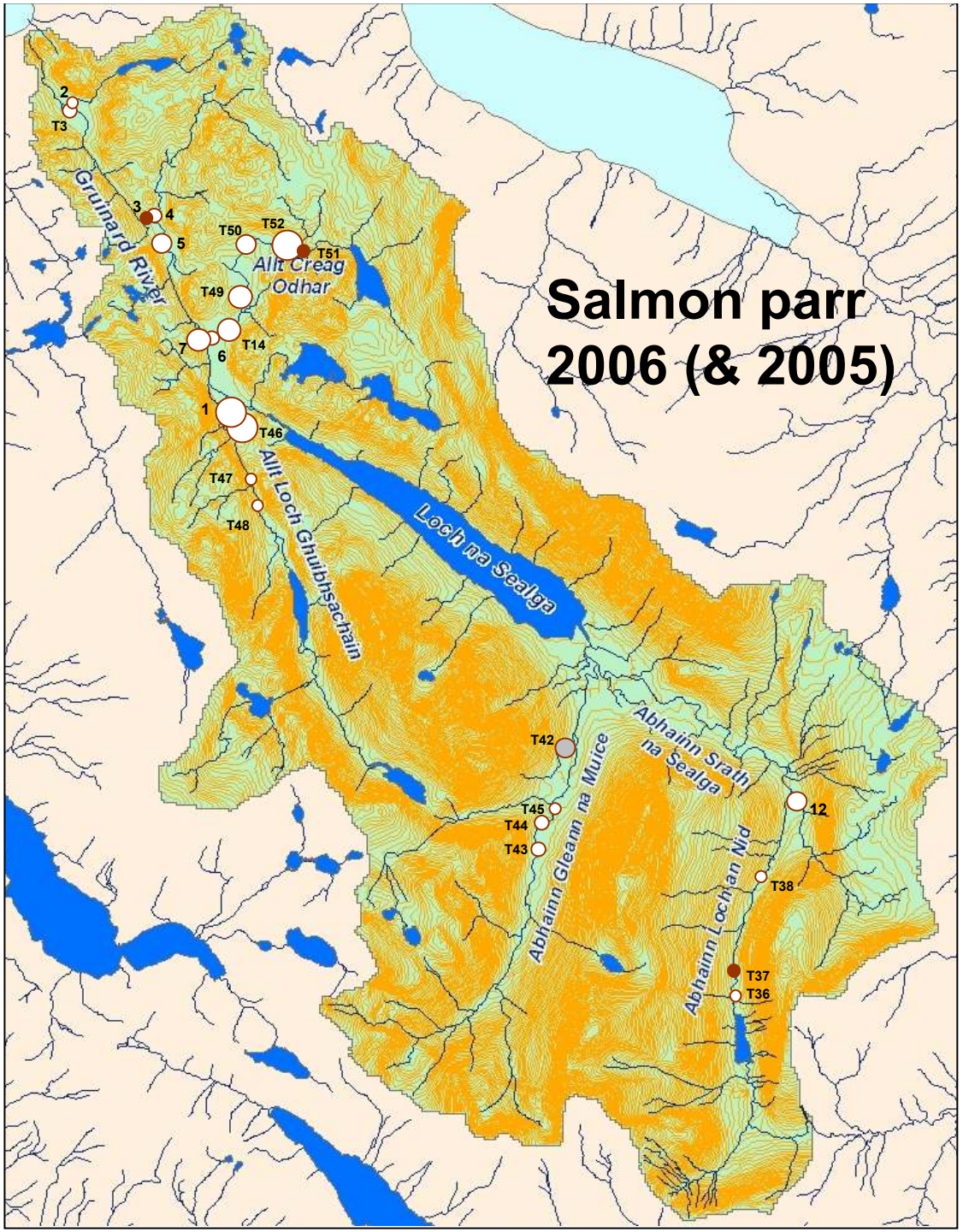

Should fertility restoration programmes be promoted for other upland catchments?
Abhainn Strath na Sealga (Gruinard River)

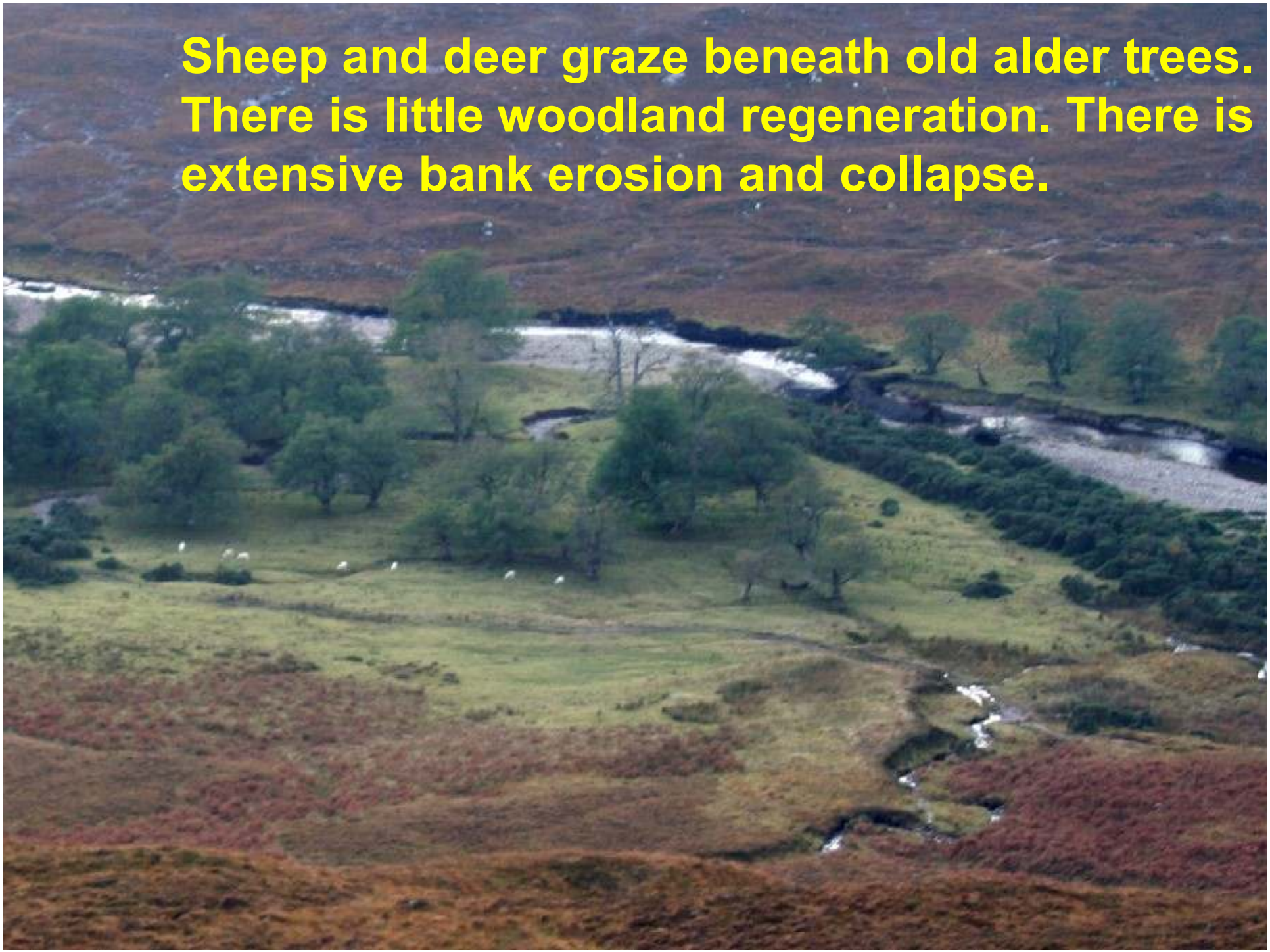
Most juvenile salmon grow slowly in the headwaters of the Gruinard River

Gruinard River catchment

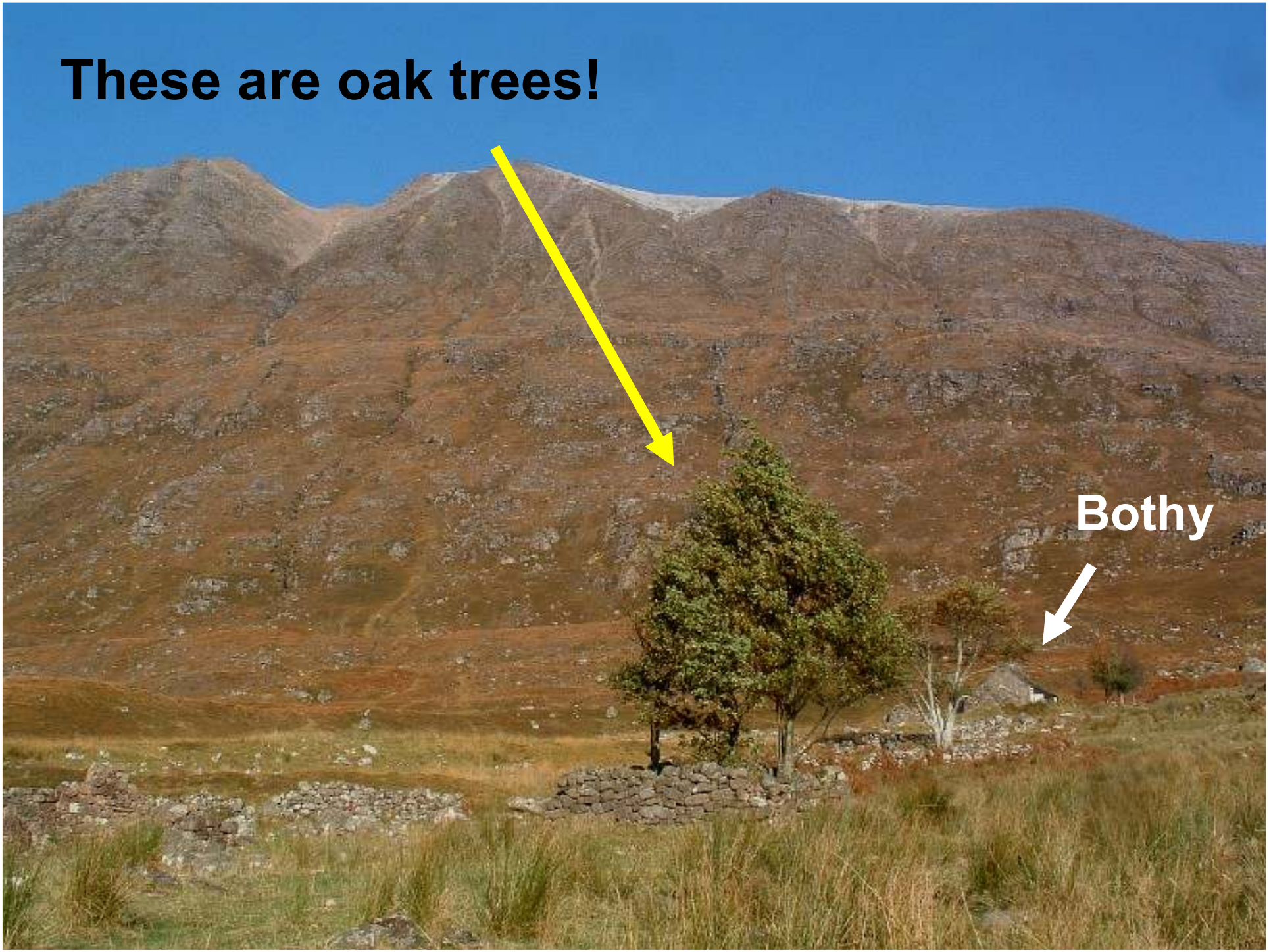
cattle, sheep and deer grazing area






Sheep and deer graze beneath old alder trees. There is little woodland regeneration. There is extensive bank erosion and collapse.


More nutrients?
Yes please!!


These are oak trees!
Bothy

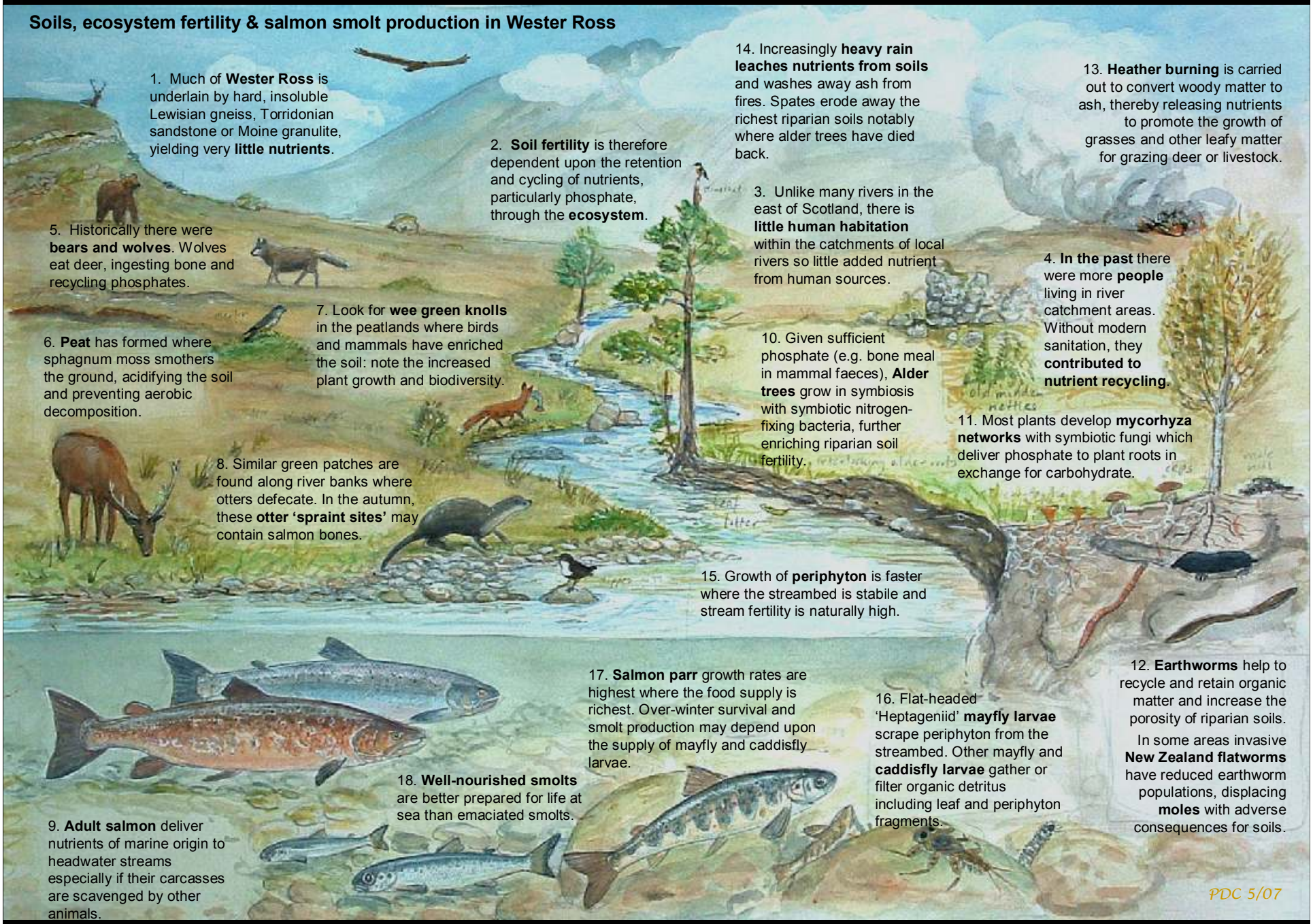
Sheneval bothy at the foot of An Teallach is popular with hill walkers (and salmon poachers!) . . .

Nearby soils are richer in earthworms and support a (?healthy) population of moles . . .

The stream is green and mossy . . .


Juvenile salmon in Allt Sheneval grow faster!

Soils, ecosystem fertility & salmon smolt production in Wester Ross



1. Much of **Wester Ross** is underlain by hard, insoluble Lewisian gneiss, Torridonian sandstone or Moine granulite, yielding very **little nutrients**.

2. **Soil fertility** is therefore dependent upon the retention and cycling of nutrients, particularly phosphate, through the **ecosystem**.

3. Unlike many rivers in the east of Scotland, there is **little human habitation** within the catchments of local rivers so little added nutrient from human sources.

4. **In the past** there were more **people** living in river catchment areas. Without modern sanitation, they **contributed to nutrient recycling.**

5. Historically there were **bears and wolves**. Wolves eat deer, ingesting bone and recycling phosphates.

6. **Peat** has formed where sphagnum moss smothers the ground, acidifying the soil and preventing aerobic decomposition.

7. Look for **wee green knolls** in the peatlands where birds and mammals have enriched the soil: note the increased plant growth and biodiversity.

8. Similar green patches are found along river banks where otters defecate. In the autumn, these **otter 'spraint sites'** may contain salmon bones.

9. **Adult salmon** deliver nutrients of marine origin to headwater streams especially if their carcasses are scavenged by other animals.

10. Given sufficient phosphate (e.g. bone meal in mammal faeces), **Alder trees** grow in symbiosis with symbiotic nitrogen-fixing bacteria, further enriching riparian soil fertility.

11. Most plants develop **mycorhyza networks** with symbiotic fungi which deliver phosphate to plant roots in exchange for carbohydrate.

12. **Earthworms** help to recycle and retain organic matter and increase the porosity of riparian soils.

In some areas invasive **New Zealand flatworms** have reduced earthworm populations, displacing **moles** with adverse consequences for soils.

13. **Heather burning** is carried out to convert woody matter to ash, thereby releasing nutrients to promote the growth of grasses and other leafy matter for grazing deer or livestock.

14. Increasingly **heavy rain leaches nutrients from soils** and washes away ash from fires. Spates erode away the richest riparian soils notably where alder trees have died back.

15. Growth of **periphyton** is faster where the streambed is stabile and stream fertility is naturally high.

16. Flat-headed 'Heptageniid' **mayfly larvae** scrape periphyton from the streambed. Other mayfly and **caddisfly larvae** gather or filter organic detritus including leaf and periphyton fragments.

17. **Salmon parr** growth rates are highest where the food supply is richest. Over-winter survival and smolt production may depend upon the supply of mayfly and caddisfly larvae.

18. **Well-nourished smolts** are better prepared for life at sea than emaciated smolts.

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Thank you!