Lochs

Scotland's lochs are generally in good condition. They are an important part of our landscape and provide benefits such as water for drinking and power generation.

Summary

Scotland's lochs are a distinctive part of its landscape and environment. Lochs supply much of our drinking water and renewable energy from hydropower. Almost two-thirds of lochs are good or high quality, although there are still some concerns, for example poor land management introducing excessive amounts of nutrients, and physical alterations causing changes to water levels and obstacles to fish migration.

These two most significant problems require integrated management of the catchments around lochs to reduce nutrient inputs, as well as striking the right balance between maximising the hydropower generated from lochs and protecting the wider environment.

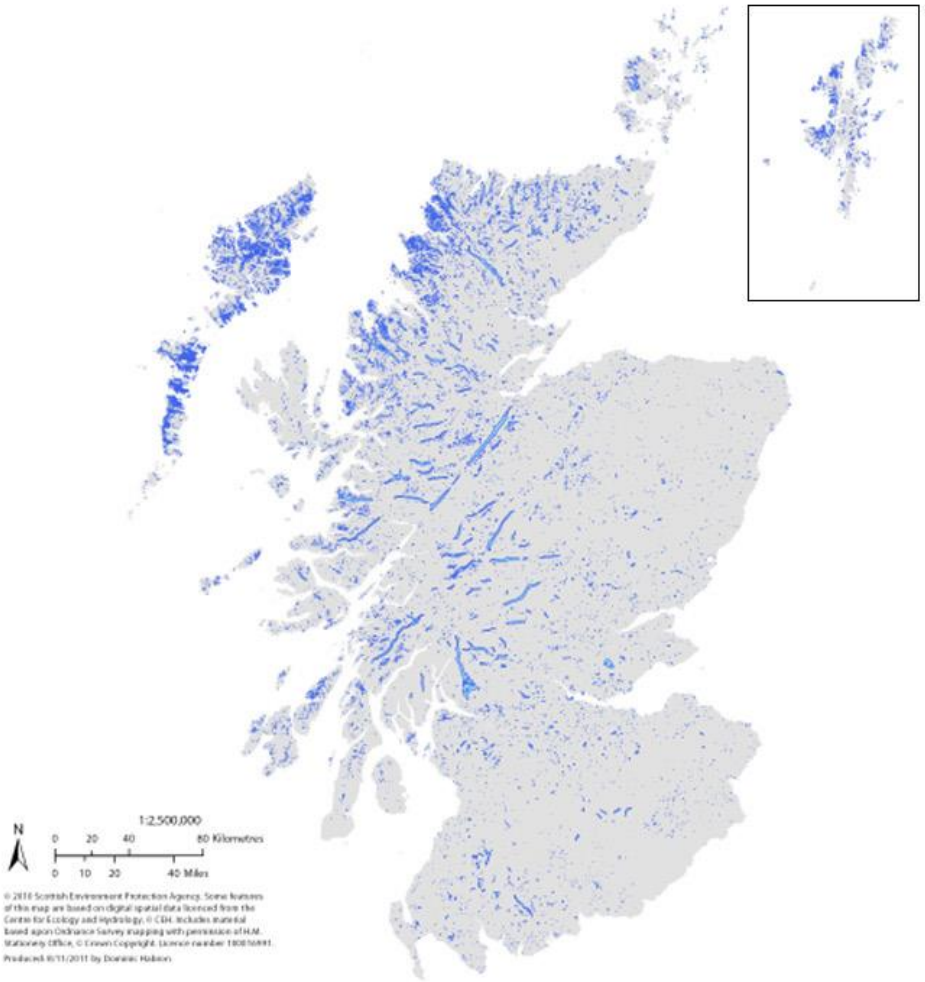
Introduction

Scotland's lochs are renowned worldwide as part of our cultural identity (e.g. Loch Lomond and Loch Ness). Our lochs are reputed for their beauty, and form a dramatic component of Scotland's landscape.

Lochs are valued recreational resources, used for boating, fishing, kayaking and nature watching, and they support tourism and other economic benefits.

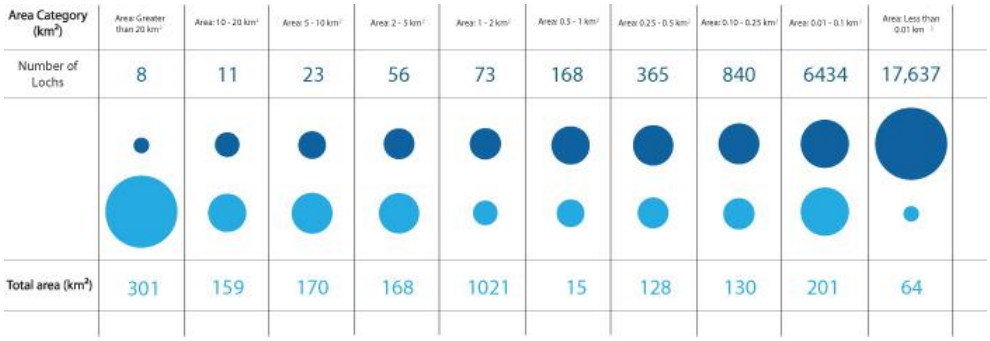
There are over 25,500 lochs[1] in Scotland, with the highest densities found in the Western Isles and Sutherland (Figure 1).

Figure 1: Location of Scottish lochs.



Scottish lochs vary considerably in area and volume (Figure 2).

Figure 2: Number and area of Scottish lochs[1]



Area Category (km^2)	Area: Greater than 20 km^2	Area: 10 - 20 km^2	Area: 5 - 10 km^2	Area: 2 - 5 km^2	Area: 1 - 2 km^2	Area: 0.5 - 1 km^2	Area: 0.25 - 0.5 km^2	Area: 0.10 - 0.25 km^2	Area: 0.01 - 0.1 km^2	Area: Less than 0.01 km^2
Number of Lochs	8	11	23	56	73	168	365	840	6434	17,637
Total area (km^2)	301	159	170	168	1021	15	128	130	201	64

References

[1] *M. Hughes, D. D. Hornby, H. Bennion, M. Kernan, J. Hilton, G. Phillips, R. Thomas (2004)* The Development of a GIS-based Inventory of Standing Waters in Great Britain together with a Risk-based Prioritisation Protocol ***Water, Air, & Soil Pollution: Focus***

Description of lochs

The Water Framework Directive (WFD) classification covers the 333 lochs that are greater than 0.5 km^2 in size; these encompass two-thirds of the total area of Scottish lochs (Table 1).

The WFD classification consists of measurements or modelling of a variety of biological and chemical parameters, and assessments of loch levels and changes to habitat. These individual results are brought together to give the overall result. They can also be combined to give an assessment of changes to the beds and banks, water quality or water levels.

The classification divides lochs into five classes, depending on the scale of human impact on the environment. High status water bodies show very little human alteration from undisturbed conditions, with good status water bodies having only low levels of human alteration. Moderate, poor and bad status water bodies show progressively greater impact from human activities.

If a loch has been significantly altered by human activity to provide an important socio-economic benefit, for example building a dam to provide water for electricity generation or for water supply, then it cannot meet good status. In these cases, the loch will be classified according to its potential. This assesses whether the loch is in as good a condition as it can be, accepting that it has been significantly physically altered.

More details on the classification scheme can be found in the 2008 State of the water environment report and the classification scheme is explained further in the policy statement on the Water Environment and Water Services (Scotland) Act 2003.

The full classification results for each individual water body can be found by following the links at the river basin planning webpage.

State of lochs

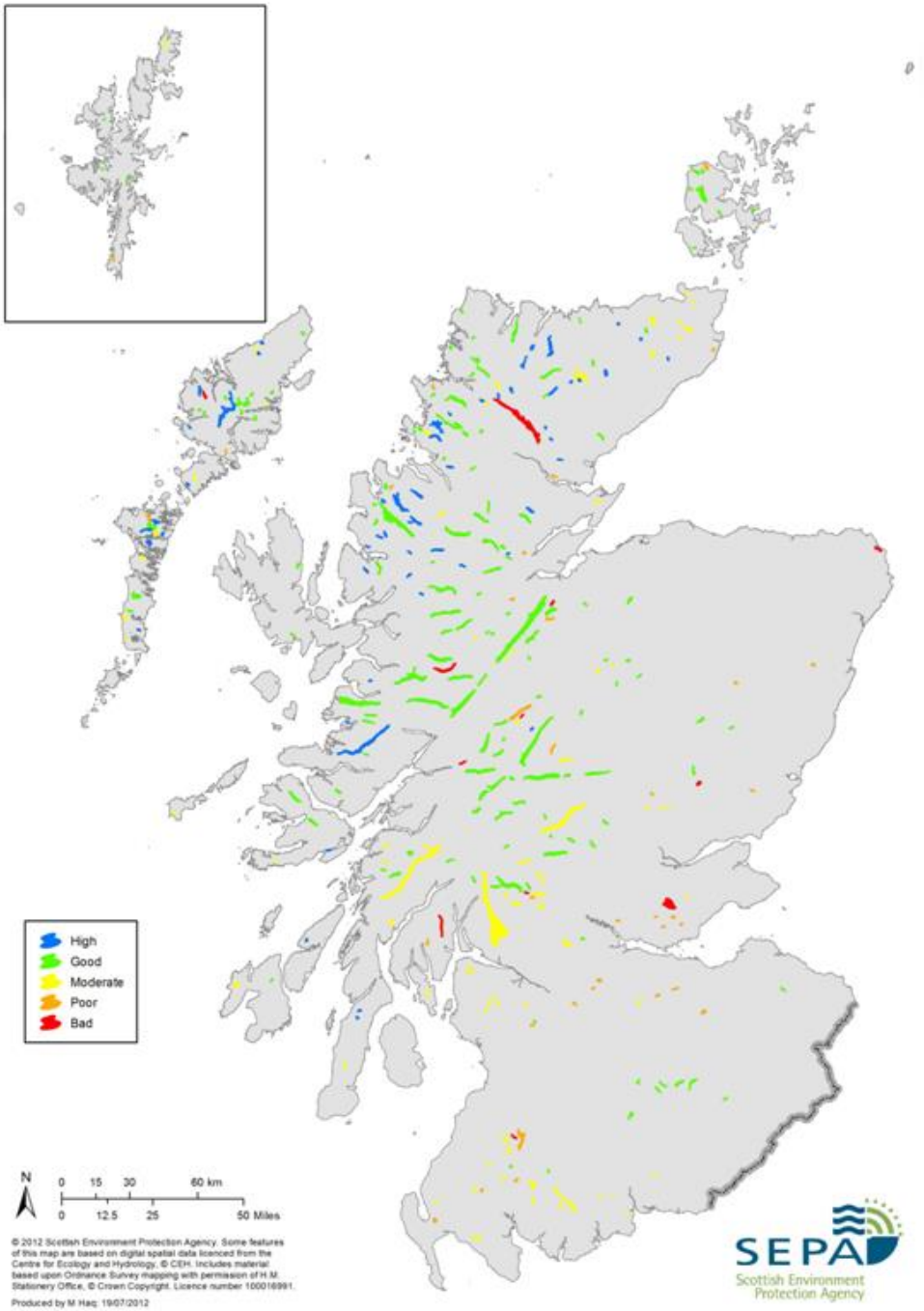
Classification results for Scottish lochs are shown in Table 2 and the overall status is illustrated in Figure 2.

Almost 65% of the total surface area of our lochs is at good or high overall status. Many lochs are relatively undisturbed by human activity, compared with the majority of lochs elsewhere in the UK and Europe. Figure 2 shows that the majority of the lochs in the Highlands are at high or good status/potential, although many of these are impacted by hydropower schemes. Lochs in the more intensively farmed areas are often polluted by nutrients in run-off from fields, and from changes to their habitats.

Table 2: Classification of Scotland's lochs, 2011

Indicator	**Status**									
	High		Good		Moderate		Poor		Bad	
	Area (km^2)	Area (%)	Area (km^2)	Area (%)	Area (km^2)	Area (%)	Area (km^2)	Area (%)	Area (km^2)	Area (%)
Overall status/ potential	117	11.8	519	52.5	241	24.4	46	4.7	66	6.7
Water quality	211	21.3	390	39.3	364	36.7	11	1.1	16	1.6
Water levels	585	59.0	59	5.9	26	2.6	92	9.3	230	23.2
Bed and shores	309	31.1	166	16.7	266	26.8	245	24.7	7	0.7

Figure 2: Overall status/potential, 2011 data



Water quality

Different pollutants cause different impacts on water plants and animals. Excessive inputs of nutrients may accelerate the growth of some algae and other water plants, causing oxygen depletion and major changes in the balance of different plants and animals. Aquatic animals can also be starved of oxygen as a result of inputs of organic matter (e.g. in animal waste) using up oxygen as it decays.

Many of Scotland's lochs have naturally low levels of nutrients, and quite small amounts of additional nutrients can significantly alter their sensitive ecosystems and result in the loss of important species.

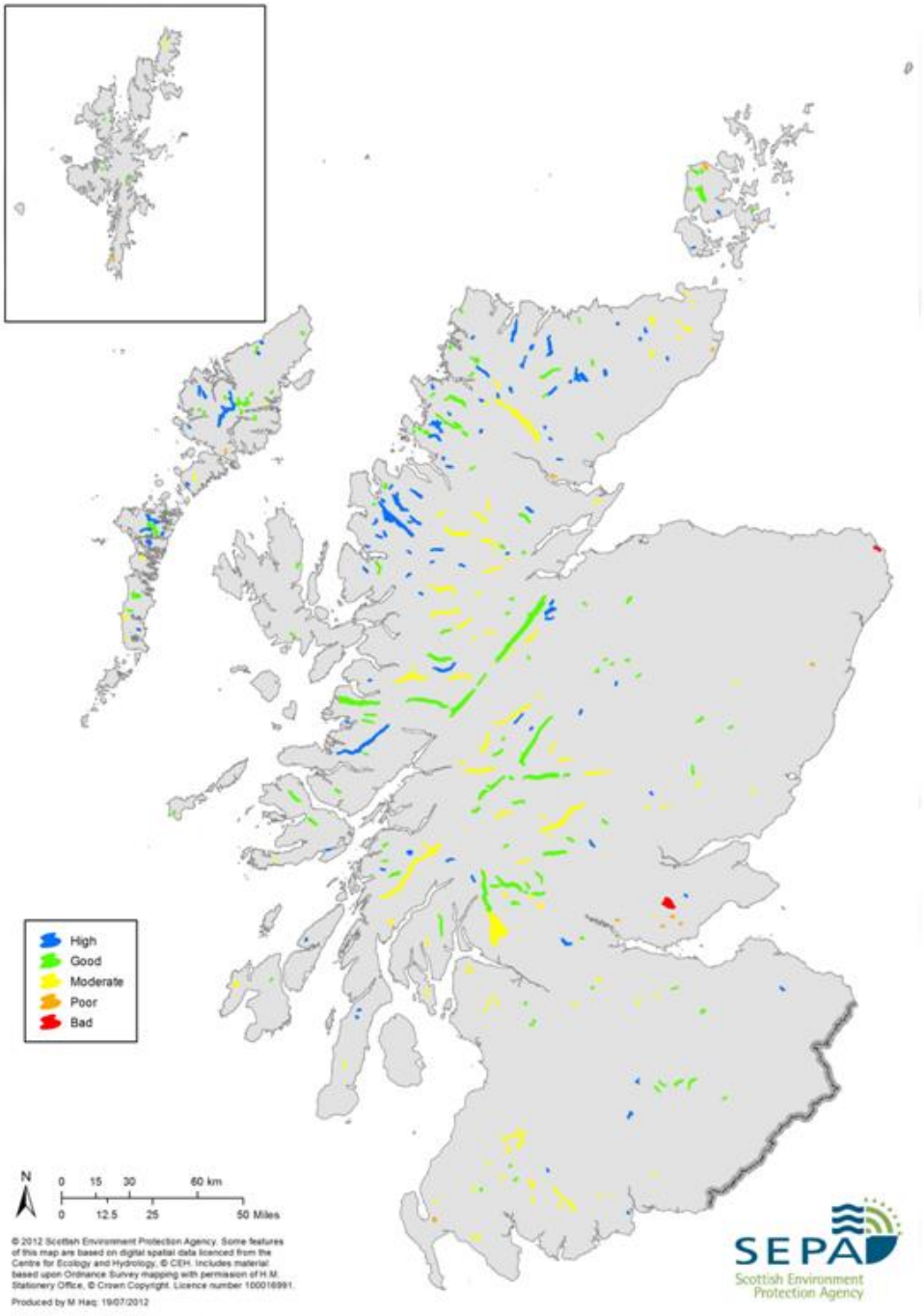
The greatest impact on loch water quality is due to the nutrient phosphorus, which can enter lochs from land use practices (e.g. fertiliser application), animal waste, fish farming and sewage. Sewage is rarely discharged into lochs, although there are some problems caused by discharges from septic tanks.

Of particular concern to health are blooms of cyanobacteria (blue-green algae). Apart from necessitating additional treatment of drinking water taken from reservoirs affected by a bloom, such blooms can result in the closure of lochs for water sports to protect human health.

Acidification (resulting from the atmospheric depositions from, e.g. the burning of fossil fuels, and sometimes exacerbated by coniferous plantations) has damaged some lochs, particularly those in the south-west. In general, there are reduced numbers of plant and animal species in acidified lochs; for example, acidification has resulted in extinction of several populations of Arctic charr and brown trout in lochs in south-west Scotland.

The state of water quality in lochs is shown in Figure 3. Sixty per cent of the total area of our lochs has good or high water quality (Table 2), with many of those lochs at less than good status being affected by land management practices or acidification.

Figure 3: Water quality of lochs in 2011.

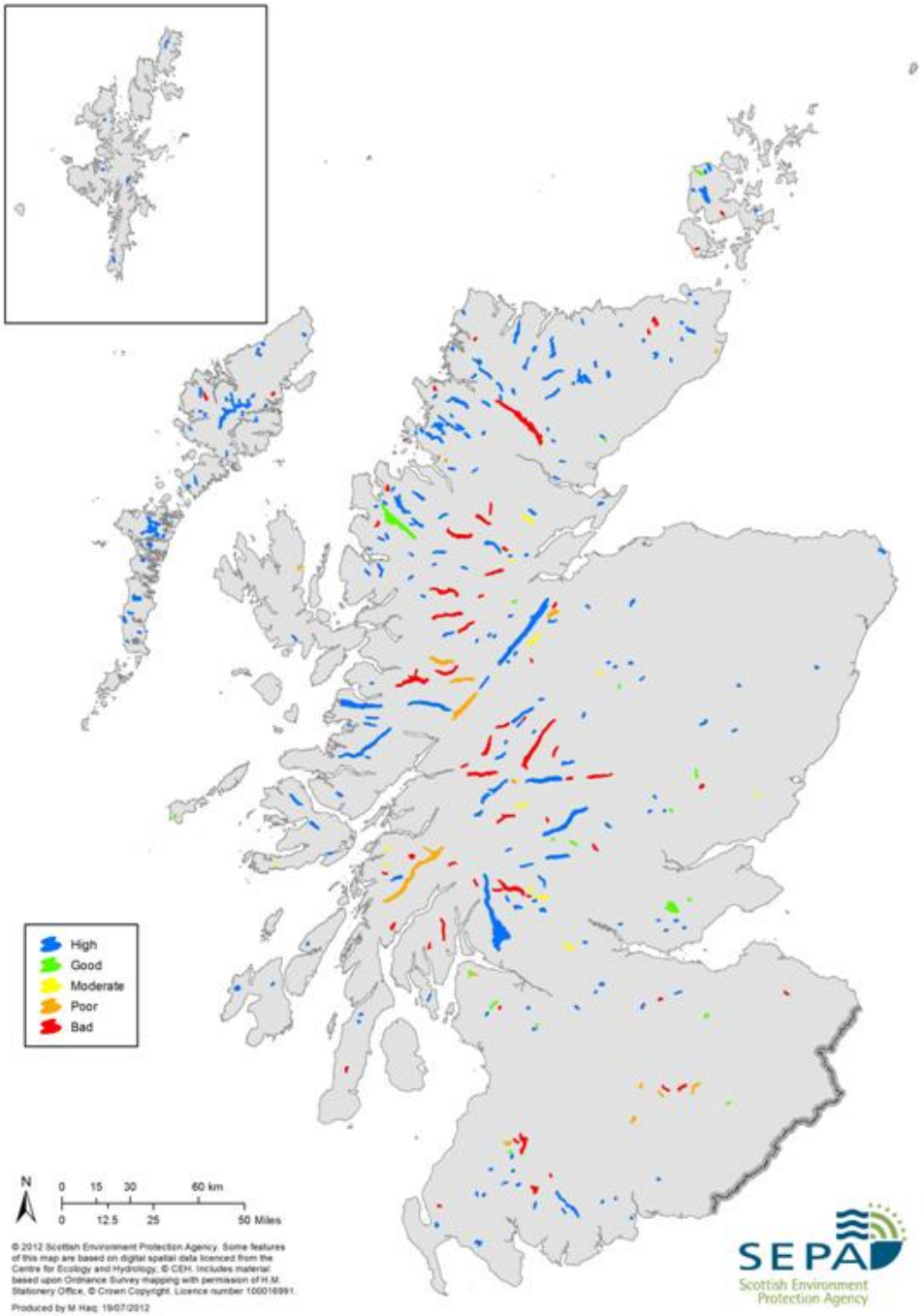


Water flows

The ecosystems of lochs are affected by changes in their water levels. Lochs need to hold enough water to maintain the habitats of animals and plants, and to reduce vulnerability to pollution and high summer temperatures. Natural changes in water levels occur in most lochs throughout the year; however, fluctuations that are too rapid damage habitats and reduce species numbers.

Figure 4 shows the condition of water levels in lochs. Sixty-five per cent of the total area of our lochs is at good or high status for water levels (Table 2). Many of the lochs impacted by alterations to water level are in the Highlands (mainly affected by hydropower schemes), or near major conurbations (where they are used for water supply).

Figure 4: Condition of water levels in lochs in 2011



Beds and banks

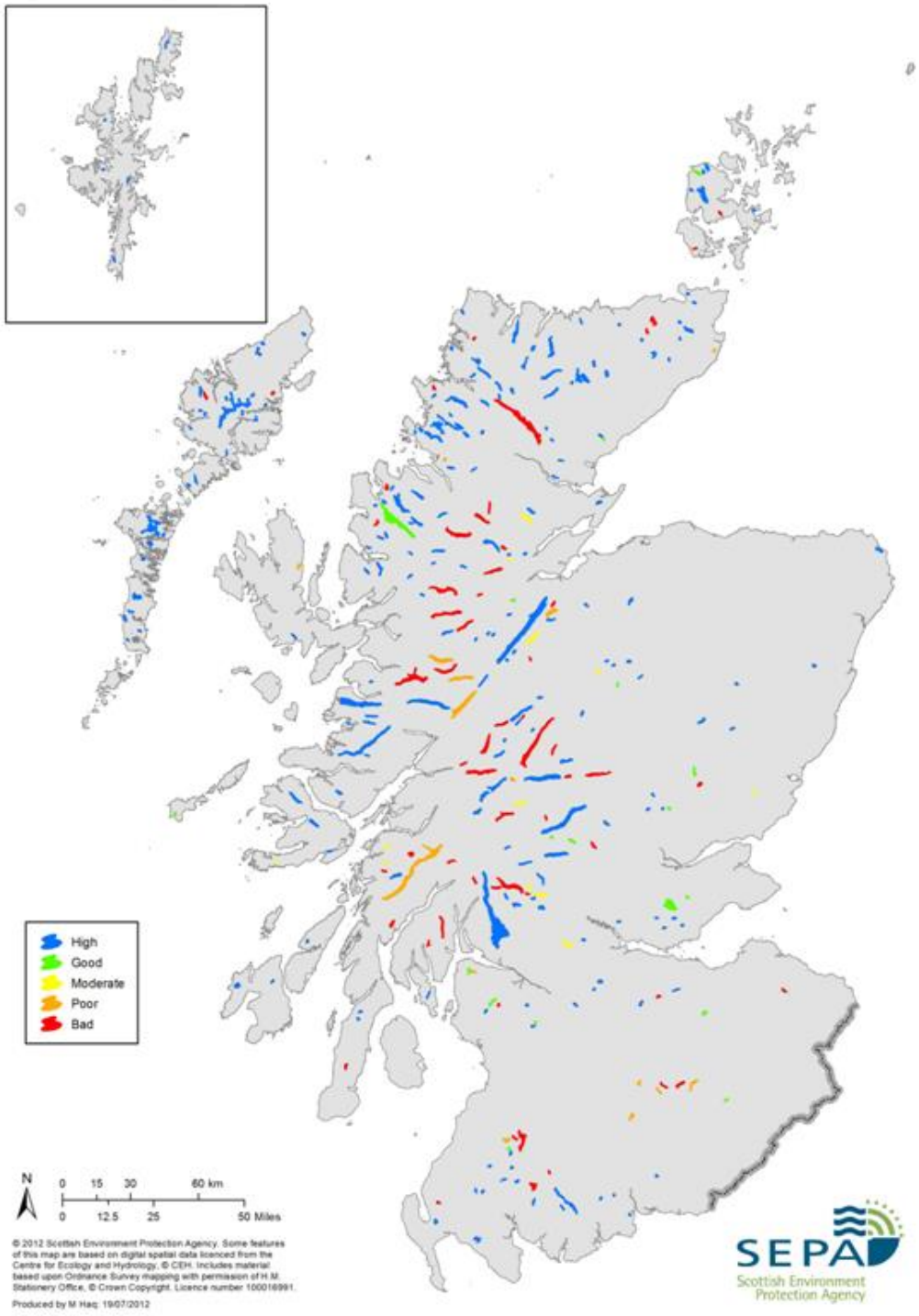
The beds and banks of lochs provide habitats on which many plants and animals depend. Some, such as rooted plants, live attached to the bed.

Alterations to beds and banks caused by activities such as bank reinforcement (e.g. for road building and to prevent wave damage) can reduce the area, diversity and quality of habitats available. Loss of vegetation on banks and shores can also make the loch more vulnerable to pollution and erosion, and reduce the food available in the loch. The impact of man-made obstacles (such as weirs and dams) on migratory fish (such as salmon) is included in the assessment of beds and banks.

Figure 5 shows the condition of beds and banks, and the impact of fish barriers in lochs.

Although the shores of lochs have been less heavily impacted by development than many of Scotland's rivers, road schemes, housing, commercial and recreational developments have all led to the loss of shoreline and inshore shallow water areas of lochs. This loss has a potential impact on the wide range of plant and animal species dependent on these shallow and well-lit areas of lochs.

Figure 5: Condition of the beds and banks and impact of fish barriers in lochs in 2011.



Invasive non-native species (INNS) and biodiversity

The wildlife of Scotland's lochs is generally in good condition; see the wildlife topic rivers and lochs for more details.

The condition of lochs can be affected by invasive non-native water plants or animals. Once they establish a foothold, they tend to thrive at the expense of native water plants and animals.

The WFD classification includes an assessment of the impact of the species that pose the greatest risk to lochs; currently, information on where invasive NNS are causing problems is limited, but in 2011, two lochs (Loch Ken and Strathclyde loch, 8 km^2 area in total) were at moderate status because of invasive NNS, with 32 lochs (covering a total of 120 km^2) being downgraded to good status. Invasive NNS are recognised as a significant risk to Scotland's lochs.

Pressures affecting lochs

Scotland's lochs are affected by a number of different pressures, caused by activities within Scotland and elsewhere (e.g. acidification resulting from power stations globally).

The 2008 river basin plan (a 6-yearly report) summarised the main pressures affecting Scotland's lochs:

- hydropower (changes to water levels and obstacles to fish migration);
- agriculture (nutrients, changes to habitats);
- drinking water supply (changes to water levels and obstacles to fish migration);
- atmospheric deposition of pollutants, leading to acidification;
- small dams and other obstacles to fish migration.

Climate change

For waters already under pressure from nutrient inputs, the higher temperatures expected as a result of climate change may further stimulate excessive and damaging growth of water plants. The potential increase in extreme rainfall events may result in more of the soil and nutrients from agricultural land being washed into surface waters.

Invasive NNS already pose a significant threat to the ecosystems of our lochs. Our current relatively cool climate prevents many species from other parts of the world from establishing and posing a risk to native plants and animals. However, a warming climate may tip the balance in favour of some of these currently benign species, with a resulting threat to the ecological quality of our lochs.

Hydropower and water supply

Reservoirs are built for hydropower generation and water supply. Hydropower schemes are found predominantly in the uplands of the central Highlands and northern areas of Scotland. Water supply reservoirs are mainly found near to larger towns and cities in the south of Scotland.

Most hydropower schemes and drinking water supply reservoirs were built in the latter half of the 20th century, and generally involved damming an existing river or loch. Water supply reservoirs tend to be filled-up over the winter, and are then gradually drawn-down through the summer as the water is used. Hydropower schemes are often filled and drawn-down more frequently, and the loch experiences relatively rapid fluctuations in water level. These rapid fluctuations can lead to a draw-down scar, similar in appearance to the rings in a dirty bath. This scarred area provides an unstable and poor quality habitat for plants and animals, and has a detrimental effect on the appearance of the loch.

The dams that hold back the water can also pose a problem, as they can prevent or impede the passage of migratory fish, such as salmon, which try to spawn in the tributaries upstream of the dam.

The trapping of gravel and coarser sediments behind dams can lead to erosion of gravel habitats downstream, by interrupting the supply of new gravel downstream, and the nutrient-rich sediment collects behind dams, which can cause problems associated with nutrient enrichment.

The drive to increase the proportion of Scotland's energy generated by renewable power (such as hydropower) must be balanced with the damage that these schemes can cause to the aquatic environment.

Agriculture

Well-managed land presents minimal risk to lochs, but poor land management can lead to problems from diffuse pollution, as shown in Figure 3. Diffuse pollution arises from land use activities across a catchment, and cannot be ascribed to a single source; for more details on the interactions between land use and water courses, see the soils topic. Problems include excessive inputs of nutrients and sediment as well as other harmful chemicals such as pesticides and pathogens such as *Cryptosporidium* and *Escherichia coli*.

Burning of fossil fuels (acidification)

Acidification of lochs has resulted from the atmospheric deposition of acidic compounds of nitrogen and sulphur, principally released from burning of fossil fuels. When dissolved in rain water, these compounds can cause acidification of freshwaters in areas where the rocks and soil lack alkaline materials to neutralise the acids. Coniferous forests can sometimes exacerbate the problem by scavenging the pollutants from the atmosphere and transferring them to the soil and water. Some lochs are showing signs of recovery from acidification, although others will recover more slowly, and their full recovery may be prevented by impacts from nitrogen deposition and climate change.

Small dams, weirs and other obstacles to fish migration

There are large numbers of small weirs or dams in lochs across Scotland, many erected over 50 years ago. They were initially used to control the water level for activities such as fishing, boating, local water supply or electricity generation. Although small, these obstacles can impact on migratory fish, and prevent or reduce successful spawning upstream.

Invasive NNS

At present there is little information available about invasive NNS in Scottish lochs. However, because removal of introduced species is extremely difficult, if not impossible, invasive NNS have been recognised as a risk to the biodiversity of our lochs and thus a pressure on the loch ecosystem.

Consequences of a change in lochs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Lochs provide a variety of benefits to society; these benefits can be categorised according to the ecosystem services provided (for a description of ecosystem services, read the benefits from nature topic). Damage to lochs can result in loss of the obvious benefits (e.g. drinking water, fishing, water sports and electricity generation), as well as associated benefits such as health benefits and tourism income resulting from the opportunities presented by a diverse and beautiful environment.

Response by society

The river basin management plan sets out Scotland's objectives for further improving our lochs. River basin planning is a collaborative approach to managing and improving the environment, and offers opportunities for more effective co-ordination between partners.

Table 3 shows the target for achieving this; by 2027, the objective is for 98% of our lochs to be at good or high status/potential for habitats, water quality, invasive NNS and flows.

Table 3: Targets for improvements to the status of lochs to be achieved through the Water Framework Directive

	Loch area (km^2)		
Overall status/potential	**2015**	**2021**	**2027**
High	147	147	148
Good	542	563	820
Moderate	139	218	24
Poor	153	53	1
Bad	11	11	0
Total	**992**	**992**	**992**
Proportion of total at good or better status (%)	**69**	**72**	**98**

The scope of WFD improvements is far greater than that of any previous initiatives, and includes:

- ongoing work with farmers and other land managers to reduce diffuse pollution from a range of land management activities (e.g. concerted work in priority catchments);
- working with operators to reduce the impact of water regulation (dams and reservoirs) on wildlife;
- invasive Non native species;
- projects to remove barriers to fish passage, where appropriate, or reduce their impact.

Scotland's Land Use Strategy sets out the key principles for taking a strategic approach to the use of Scotland's land. These principles are embedded in river basin management plan (RBMP) practice and will be given increased emphasis in future RBMP delivery programmes.

Biodiversity will be enhanced through a range of initiatives and legislation; more detail is provided in the wildlife topic on rivers and lochs.

International agreements to reduce the emissions of sulphur compounds have led to reduced acid depositions in recent years and to a limited recovery in some lochs in Galloway, one of the worst-affected areas.