C1.7 Permanent lake of glaciers and ice sheets

Summary

Permanent or near-permanent ice-covered lakes can occur in association with larger glaciers and ice sheets at high latitudes or altitudes in Iceland and Norway (including Svalbard), very rarely in the Alps. They develop in situations where there is melting within or on the surface of the ice, accumulating in cavities, depressions and crevices or on the edge of ice sheets, where they can be dammed by moraine. Ice blocks can occur and lakes may refreeze to some extent. They are characteristically without any higher vegetation or animals, but can have ultra-oligotrophic communities of cold-adapted microalgae most of them. If high mountain lakes or brooks are nearby, some aquatic mosses, macroalgae and macroinvertebrates may invade and in some cases also fish and waterfowl, particularly at lower elevation or in coastal areas. At irregular intervals volcanic eruptions beneath ice sheets in Iceland can cause disastrous outburst floods.

Synthesis

Limited data were available for this habitat type. There were no territorial data from Iceland and Norway, the countries with most occurrences of the habitat in EU28+. For the EU28+ the habitat has been assessed as Data Deficient (DD) due to the lack of information. However, by assuming the quantitative data from Switzerland to be representative for the Alps and because of the few occurrences there, for the EU28 the habitat is assessed to be Vulnerable (VU) because of decline in area and quality, and a small distribution area in combination with threats and declines.

Overall Category & Criteria			
EU 28		EU 28+	
Red List Category	Red List Criteria	Red List Category	Red List Criteria
Vulnerable	A1, B2, C/D1, C1	Data Deficient	-

Sub-habitat types that may require further examination

Further studies are needed for this habitat type. Extreme circumstances, particularly in water bodies under the glaciers, can maintain interesting micro-organisms. At present it is unknown whether the Alpine examples differ from the Icelandic and Scandinavian ones.

Habitat Type

Code and name

C1.7 Permanent lake of glaciers and ice sheets

Glacier lake Jökulsárlón in Iceland (Photo: Wim Ozinga).

Glacier lake in Jostedalsbreen National Park, Norway (Photo: Rob Schoorl).

Habitat description

Glacier lakes are formed as a consequence of melting of a glacier or icesheet, typically bordering to melting glaciers. In some cases these waterbodies can occur under the glacier. Glacier lakes are formed in depressions or crevices filled by melting water. In areas without depressions melting water runs as subglacial brook or river, and later discharges to alpine brooks or rivers (type C2.2a, and C.3.5d). Glacier lakes are often dammed by a rock threshold or a moraine ridge. If water volume increases, the lake can outburst through the damming.

Permanent or almost permanent ice formations are characteristics of glacier lakes, constituting of continuous ice sheets that may cover the entire surface for all the year or recede to part of the lake during summer, being accompanied or replaced by floating ice blocks. They may locally, seasonally or permanently, extend to the whole depth of the lake. Glacier lakes are mainly abiotic environments. Benthic and planktonic microalgae form ultraoligotrophic communities consisting of cold-adapted species; usually lakes are without any higher vegetation. If high mountain lakes or brooks are nearby, some aquatic mosses, macroalgae and macroinvertebrates may invade glacier lakes. In some cases also fish and waterfowl spreads to glacier lakes, particularly in water bodies on lower elevation or in coastal areas. A good example is the Jökulsárlón glacier lagoon in Iceland where fishes drift in from the sea along with the tides. Glacier lakes are also in contact with various other arctic and alpine habitats, usually unvegetated or with very sparse vegetation. Typical adjacent habitats are rocks, screes, boulder and gravel fields, moraine ridges or sandur-formations. Permanent glacier lakes occur in Europe only in a few countries, a majority of them in Iceland and Norway, Because of the small size of glaciers in the Alps the habitat is very rare there.

Water bodies can also be formed under the glacier. A special type of these water bodies occurs in Iceland where large glaciers (particularly Vatnajökull) lie above active volcanoes. Volcanic activity can melt large quantities of water under the ice, resulting in large-scale outburst of melting water with mud, gravel and stone. Several glacier lake outburst floods (GLOFs) are known from Iceland during the last centuries. An example is the outburst of the volcano Grimsvötn, situated under the Vatnajökull ice cap, in the 1990s. Also Myrdalsjökull is famous for these catastrophic events, called jökulhlaup in Icelandic.

Indicators of good quality:

- Long-term stable hydrology, reflected in a balance between accumulation of ice and melting of the glacier

Characteristic species:

Benthic and planktonic algae: mostly cyanoprokaryotes (*Nostoc* spp., *Lyngbya*, *Oscillatoria* spp., *Leptolyngbya*, *Planktothrix rubescens, Tolypothrix* spp.,), diatoms (*Achnanthes, Cyclotella, Cymbella, Pinnularia*), and green algae (*Botryococcus braunii, Mougeotia, Closterium*). *Mesotaenium berggrenii* and *Chlamydomonas nivalis*, belonging to a community of ice and snow algae, can occur in melted snow and icy slush in glacier lakes.

Classification

This habitat may be equivalent to, or broader than, or narrower than the habitats or ecosystems in the following typologies.

EUNIS:

C1.7 Permanent lake ice

EuroVegChecklist:

Mesotaenion berggrenii Bültmann et Takeuchi in Bültmann et al. 2014

Annex 1:

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Emerald :

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MAES:

Sparsely vegetated land

IUCN:

5.11. Alpine Wetlands [includes temporary waters from snowmelt]

Does the habitat type present an outstanding example of typical characteristics of one or more biogeographic regions?
Yes

Regions
Alpine
Arctic

Justification
Glaciers and glacier lakes are restricted to alpine and arctic regions.

Geographic occurrence and trends

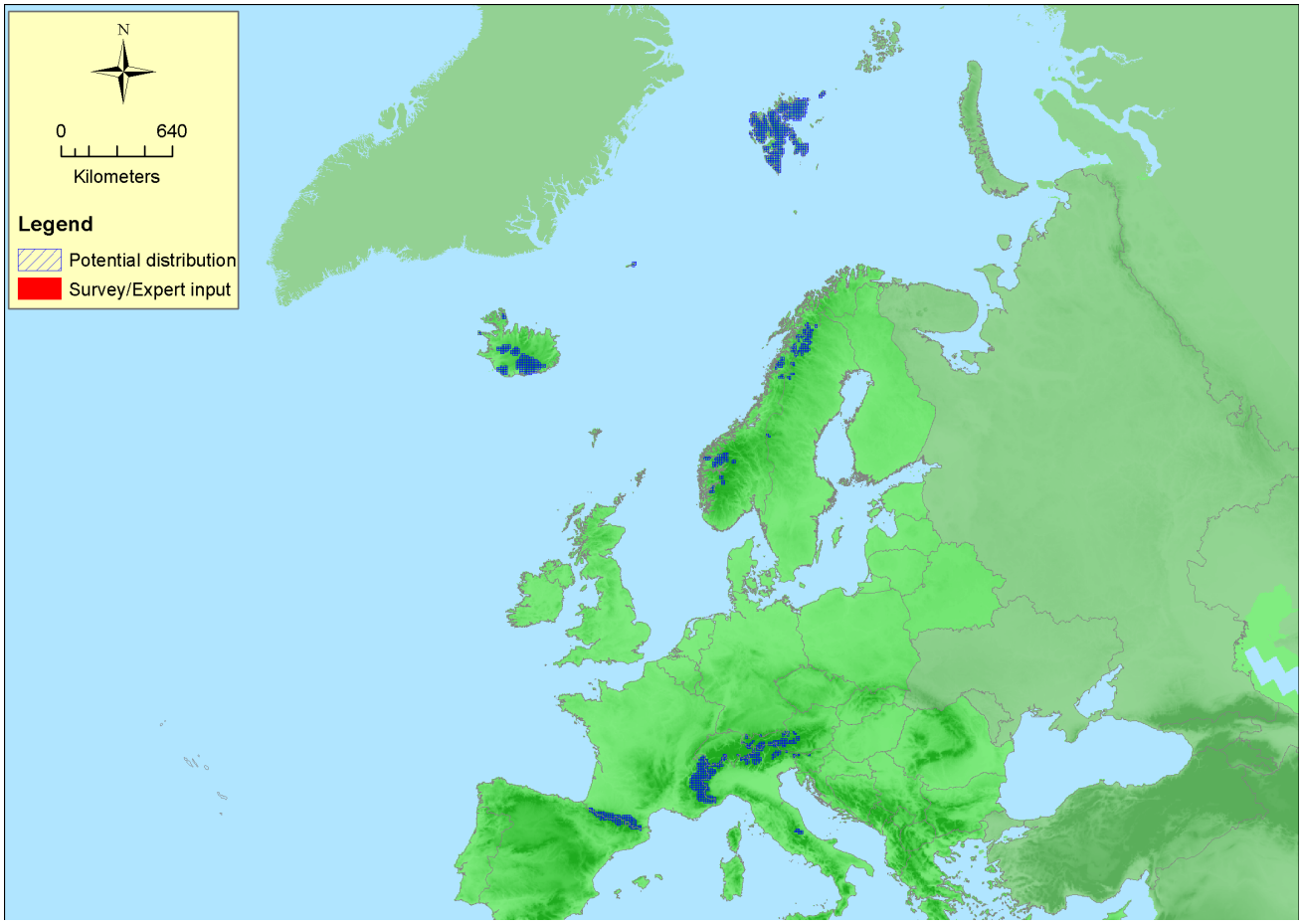
EU 28	Present or Presence Uncertain	Current area of habitat	Recent trend in quantity (last 50 yrs)	Recent trend in quality (last 50 yrs)
Austria	Present	Unknown Km^2	Stable	Stable
France	France mainland: Uncertain	Unknown Km^2	Unknown	Unknown
Italy	Italy mainland: Uncertain	Unknown Km^2	Unknown	Unknown
Sweden	Uncertain	Unknown Km^2	Unknown	Unknown

EU 28 +	Present or Presence Uncertain	Current area of habitat	Recent trend in quantity (last 50 yrs)	Recent trend in quality (last 50 yrs)
Iceland	Present	Unknown Km^2	Unknown	Unknown
Norway	Norway Mainland: Present Svalbard: Present	Unknown Km^2	Unknown	Unknown
Switzerland	Present	<1 Km^2	Decreasing	Unknown

Extent of Occurrence, Area of Occupancy and habitat area

	Extent of Occurrence (EOO)	Area of Occupancy (AOO)	Current estimated Total Area	Comment
EU 28	2038650 Km^2	Unknown	Unknown Km^2	EOO is potential range
EU 28+	6126550 Km^2	Unknown	Unknown Km^2	EOO is potential range

Distribution map



There is no detailed distribution data available. Therefore the distribution of glaciers is used as a potential (maximum) distribution.

How much of the current distribution of the habitat type lies within the EU 28?

<5%. Glacier lakes are extremely rare in the EU28. Most occurrences in Europe are situated in Iceland and Norway, but even their share of the world´s glacier lake area is not high.

Trends in quantity

Glaciers in the Alps have declined during the last centuries. In Norway glaciers have been retreating for the past 200 years. That may indicate also a decline in the number of glacier lakes in the longer term. However, quantitative data on recent or future trends are unknown.

- Average current trend in quantity (extent)
  EU 28: Decreasing
  EU 28+: Unknown
- Does the habitat type have a small natural range following regression?
  Yes
  Justification
  In Europe not, but within the EU28 the range is small and the area declining.
- Does the habitat have a small natural range by reason of its intrinsically restricted area?
  Yes
  Justification
  The habitat is very scattered and occurs only in areas with glaciers or icesheets,a nd in most cases in small areas.

Trends in quality

Human interference has increased during last decades (atmospheric pollution, recreation acitivities, raising temperatures). The effects of these influences on the biota and functioning of the Ice Lakes are poorly known.

- Average current trend in quality
  EU 28: Decreasing
  EU 28+: Unknown

Pressures and threats

The recession of glaciers has decreased number of glacier lakes, and this is expected to continue in the future. Melting of glaciers can temporarily increase number of water bodies, but in the longer-term decrease is clear. Subglacial water bodies in Iceland are determined by volcanism. In the Alps and in mainland of Europe glacier lakes are impacted by air pollutants, and human recreational activities.

List of pressures and threats

Human intrusions and disturbances

Outdoor sports and leisure activities, recreational activities

Pollution

Air pollution, air-borne pollutants

Natural System modifications

Human induced changes in hydraulic conditions

Geological events, natural catastrophes

Volcanic activity

Climate change

Temperature changes (e.g. rise of temperature & extremes)

Conservation and management

In the longer term survival of glacier lakes is dependent on the existence of glaciers. That requires mitigation of effects of climate change already in the near future. Input of CO_2 and other greenhouse gases is the main driver in the climate change, therefore mitigation of these gases is essential.

List of conservation and management needs

No measures

Measures needed, but not implemented

Conservation status

Glacier lakes do not correspond with any Annex I type.

When severely damaged, does the habitat retain the capacity to recover its typical character and functionality?

No

Effort required

Red List Assessment

Criterion A: Reduction in quantity

Criterion A	A1	A2a	A2b	A3
EU 28	-30 %	unknown %	unknown %	unknonwn %
EU 28+	unknown %	unknown %	unknown %	unknown %

It is likely that the habitat has decreased in area within the EU28, because of a decline of glaciers due to climate change. We assume that the -30% decline indicated for Switzerland holds also for the other Alpine countries (Austria and maybe France and Italy), while for Sweden data are unknown. For the EU28+ the situation is more complex, with - besides Switzerland - fluctuating amounts in Iceland (due to volcanic catastrophes) and declining glaciers in Norway. The changes in Switzerland cannot be assumed to be representative for Norway and Iceland. As too little quantitative data are available, the change in quantity for the EU28+ is indicated as unknown.

Criterion B: Restricted geographic distribution

Criterion B	B1				B2				B3
	EOO	a	b	c	AOO	a	b	c	
EU 28	unknown Km^2	Yes	Yes	No	<50	Yes	Yes	No	No
EU 28+	>50000 Km^2	Yes	Yes	No	>50	Yes	Yes	No	No

The habitat is very rare in the EU28 with no reliable data available, but an AOO estimated to be smaller than 50. The EOO of the EU28 is also small, but whether it is smaller than the threshold of 50000 km2 is unknown. For the EU28+ both AOO and EOO are much larger. There is a continuing decline going on in quantity (a) and a threatening process to cause continuing declines in the next 20 years (b).

Criterion C and D: Reduction in abiotic and/or biotic quality

Criteria C/D	C/D1		C/D2		C/D3	
	Extent affected	Relative severity	Extent affected	Relative severity	Extent affected	Relative severity
EU 28	75-100 %	slight %	unknown %	unknown %	unknown %	unknown %
EU 28+	unknown %	unknown %	unknown %	unknown %	unknown %	unknown %

Criterion C	C1		C2		C3	
	Extent affected	Relative severity	Extent affected	Relative severity	Extent affected	Relative severity
EU 28	75-100 %	30 %	unknown %	unknown %	unknown %	unknown %
EU 28+	unknown %	unknown %	unknown %	unknown %	unknown %	unknown %

Criterion D	D1		D2		D3	
	Extent affected	Relative severity	Extent affected	Relative severity	Extent affected	Relative severity
EU 28	unknown %	unknown%	unknown %	unknown%	unknown %	unknown%
EU 28+	unknown %	unknown%	unknown %	unknown%	unknown %	unknown%

Both Austria and Switzerland indicated large areas (75-100%) that are slightly affected. The decline in quality relates mainly to the abiotic conditions. These figures are considered representative for the situation in the EU28 (with outside the Alps non or very few occurrences in Sweden). For the EU28+ no

quantitative assessment of changes in quality can be done, due to data gaps for Norway and Iceland.

Criterion E: Quantitative analysis to evaluate risk of habitat collapse

Criterion E	Probability of collapse
EU 28	unknown
EU 28+	unknown

There is no quantitative analysis available that estimates the probability of collapse of this habitat type.

Overall assessment "Balance sheet" for EU 28 and EU 28+

	A1	A2a	A2b	A3	B1	B2	B3	C/D1	C/D2	C/D3	C1	C2	C3	D1	D2	D3	E
EU28	VU	DD	DD	DD	DD	VU	DD	VU	DD	DD	VU	DD	DD	DD	DD	DD	DD
EU28+	DD	DD	DD	DD	LC	LC	LC	VU	DD	DD	DD	DD	DD	DD	DD	DD	DD

Overall Category & Criteria			
EU 28		EU 28+	
Red List Category	Red List Criteria	Red List Category	Red List Criteria
Vulnerable	A1, B2, C/D1, C1	Data Deficient	-

Confidence in the assessment
Low (mainly based on uncertain or indirect information, inferred and suspected data values, and/or limited expert knowledge)

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