NCA Name: 10 - North Pennines

Description of Geodiversity

Geology Overview

The geology of the North Pennines is defined by the Alston Block, a structural unit consisting of a sequence of Carboniferous sedimentary rocks, including a succession of limestones, sandstones and shales, which dip eastwards towards the North Sea. These overlie Weardale Granite which is intruded into older Ordovician and Silurian slates and volcanic rocks exposed in Upper Teesdale. The buoyancy of the granite has enabled the landform to remain higher than the surrounding land.

The Carboniferous sedimentary succession is the most visible across the NCA, and forms most of the NCAs fells and broad dales. Summits are frequently capped by Millstone Grit, with underlying alternating limestones, sandstones and shales, which due to differing rates of erosion create terraced profiles to the broad dales and hillsides.

The geology of the North Pennines has resulted in a dramatic escarpment along the western boundary of the NCA. The escarpment includes a layer of igneous rock is intruded into the Carboniferous sedimentary rocks. It is known as the Whin Sill, and it stretches from Teesdale up to Berwick (beyond the NCA boundary). Its escarpment being formed by the presence of the Pennine Fault System, a normal fault which formed during rifting of the area in the Permian period.

The dolerite of the Whin Sill is a hard rock, which is resistant to erosion and creates a dramatic scarp slope which falls to the Vale of Eden. There are craggy outcrops along the escarpment, such as at High Cup Nick, Holwick Scar and Cronkley Fell. Where rivers flow over the hard rock, iconic waterfalls

formed, such as High Force Waterfall in Teesdale, Low Force and Cauldron Snout, all on the River Tees. When the dolerite was intruded, it metamorphosed the adjacent limestone rocks, which were heated to such high temperatures they formed a coarse-grained marble known as 'sugar limestone'. It is found along the boundary of the Whin Sill and supports unique plant species.

The Carboniferous sedimentary rocks feature mineral veins containing ores of lead, zinc and, in a few places, copper, many of which have been mined in the past. In addition to mineral extraction, quarrying activities within the north Pennines, including along the Whin Sill. Such activities (former and current) have become noticeable features in the landscape of the NCA.

Superficial deposits present include peat and glacial till. The peat deposits are found predominantly across the higher ground, whilst the unsorted sediment deposited by glaciers are found within dales, and on the lower slopes of hills. Peat deposits and glaciofluvial deposits are also found along the valley floors.

An overview of the bedrock geology of the NCA is shown in **Figure A.5,** and superficial deposits in **Figure A.6.**

Figure A.5: Bedrock Geology

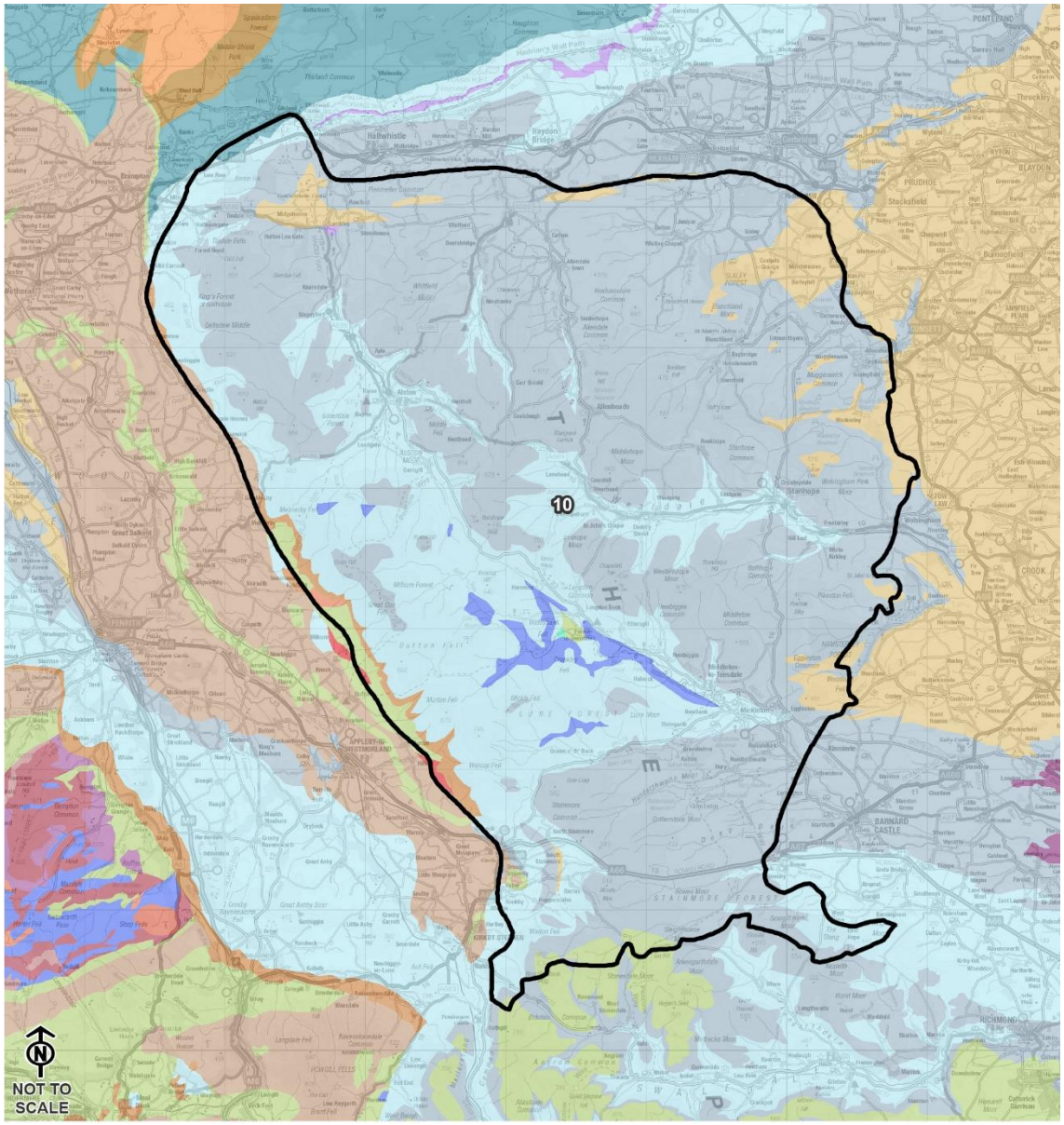
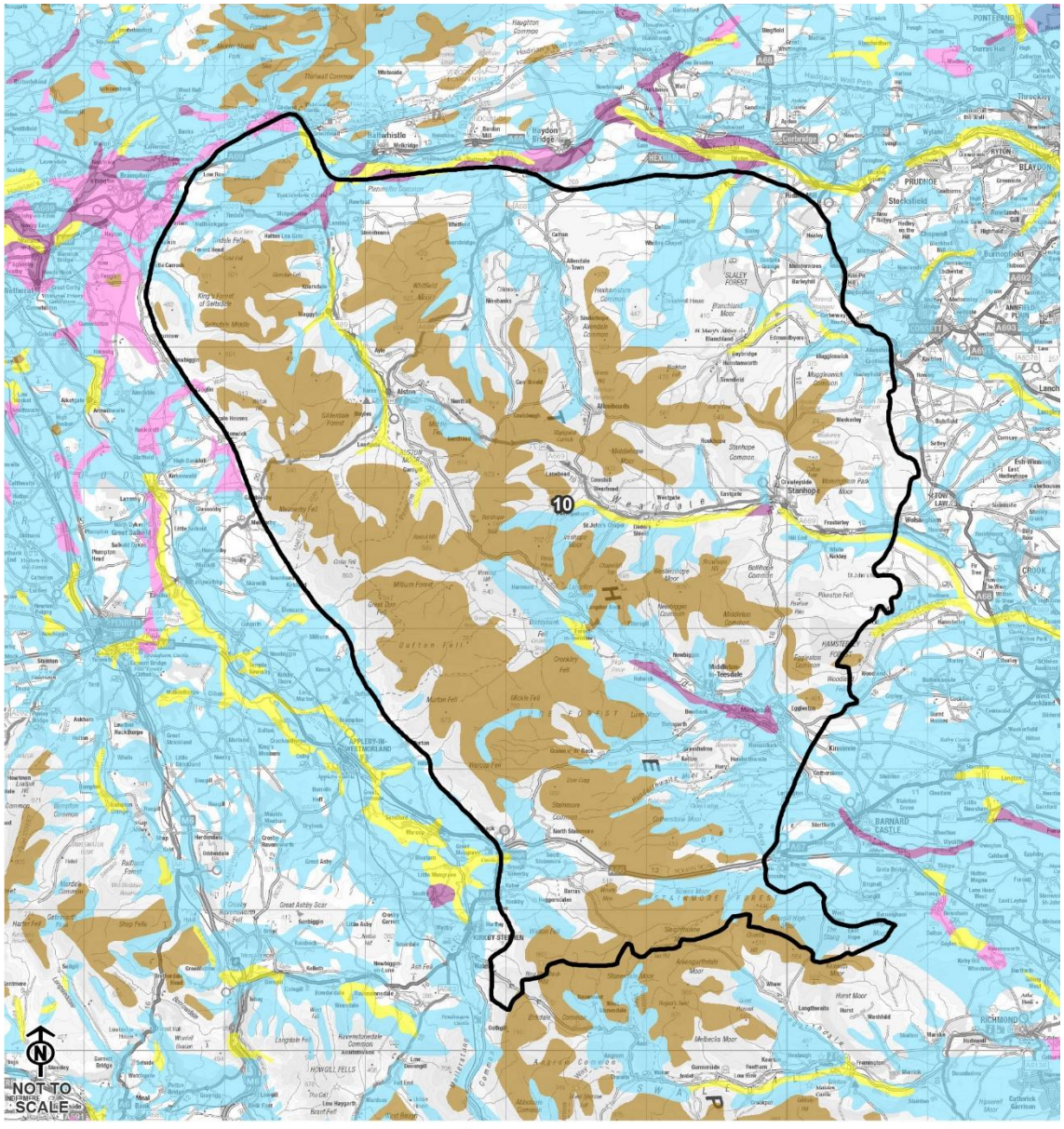
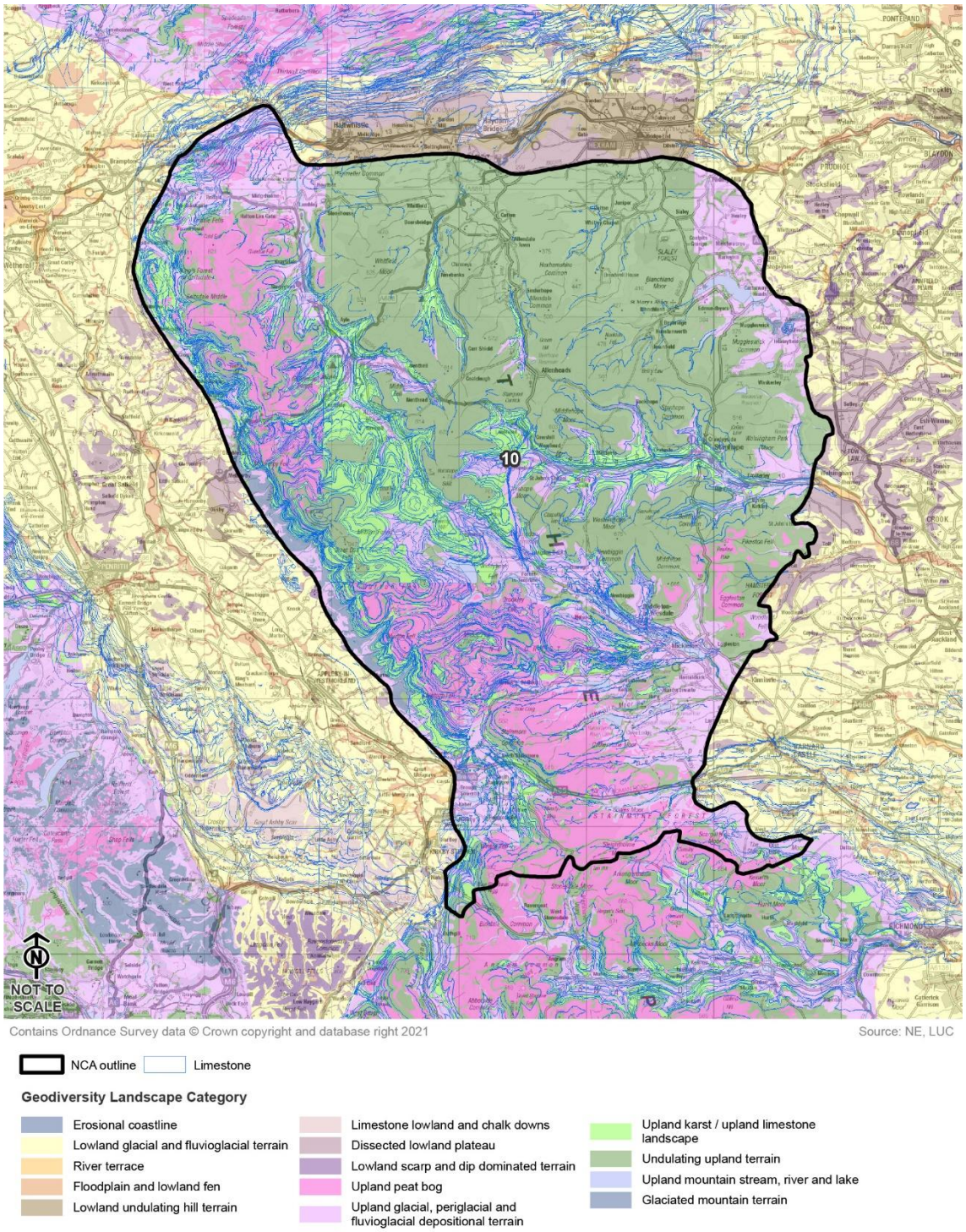


Figure A.6: Superficial Geology



Geodiversity

Figure A.7: Geodiversity Landscape Categories



Geodiversity Landscape Categories

Six geodiversity landscape categories are found within the NCA. These are:

- Undulating upland terrain;
- Upland glacial, periglacial and fluvioglacial depositional terrain;
- Upland karst/ upland limestone landscape;
- Upland peat bog;
- Upland mountain stream, river and lake; and
- Glaciated mountain terrain.

The North Pennines is characterised as a distinct area of upland moorland plateau dissected by broad pastoral vales. Extensive areas of this NCA falls within geodiversity landscape categories defined as being upland in nature, as shown in **Figure A.7. Figure A.7** illustrates that large areas within the north of the NCA are characterised as **undulating upland terrain**, particularly to the north of Weardale and on the upland plateau between Weardale and Teesdale. This undulating upland is dissected by valleys and tributaries which flow into the larger dales.

Upland peat bog is prevalent in the north-west of the NCA between the A689 and the area around the A686. The southern half of the NCA also features extensive **upland peat bog**, stretching from the Lune Forest area southwards to Stainmore Forest. Smaller pockets of peat are found near Eggleston Common in the south-east of the NCA, with elongated linear sections of peat within the broad dales of Teesdale and Weardale, as shown in **Figure A.7**.

Figure A.7 illustrates that many areas which transition from the broad dales to the undulating upland feature glacial till deposits, and therefore are classified as **upland glacial, periglacial and fluvioglacial terrain**. This geodiversity landscape category is often found adjacent to **upland karst/ upland limestone landscape**, which features limestone as the underlying bedrock.

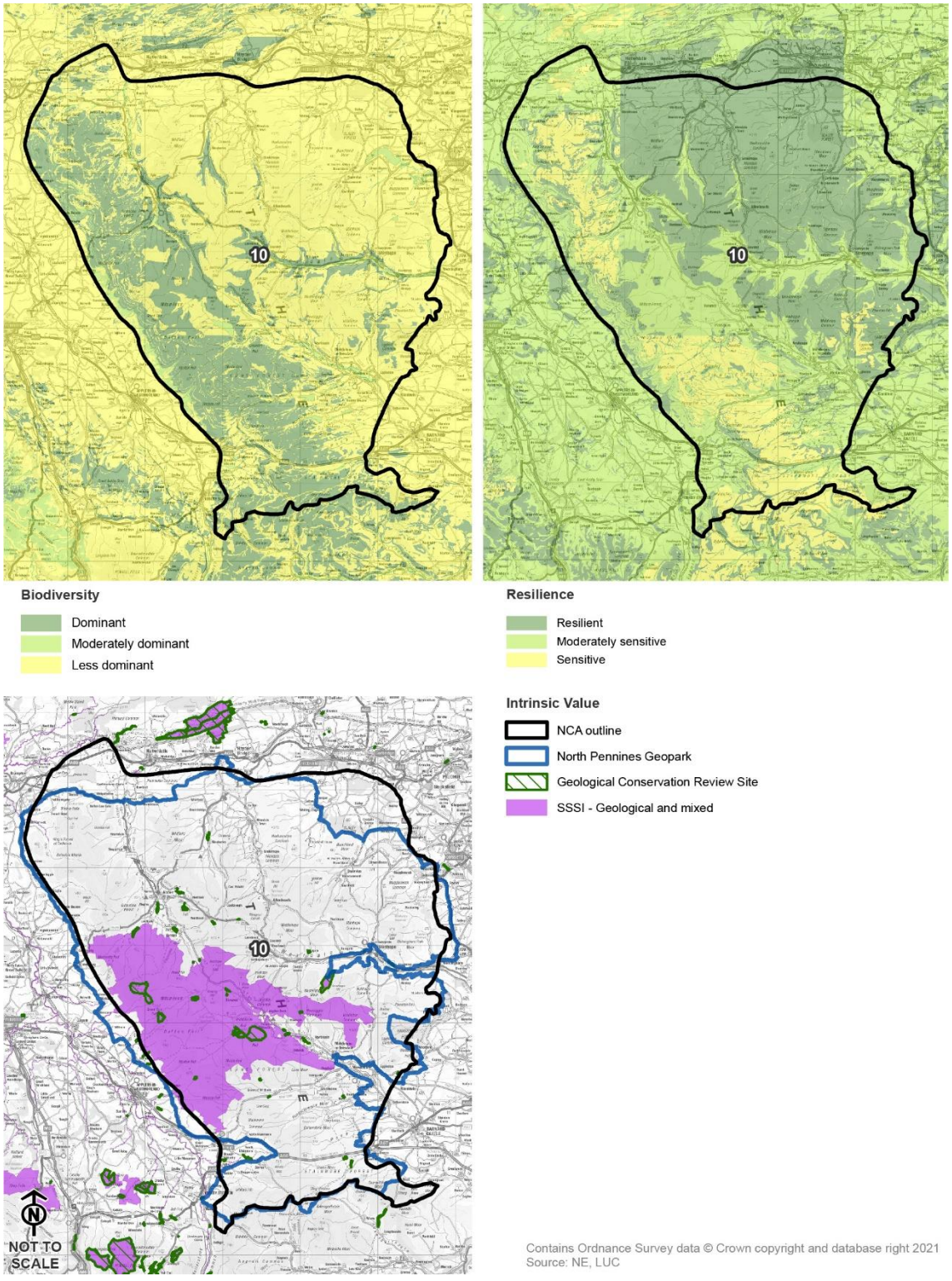
The most westerly boundary of the NCA, on the lower slopes of the Pennine escarpment features areas of land classified as **glaciated mountain terrain**, whilst discrete locations along dales and tributary valleys are classified as **upland mountain stream, river and lake** due to their upland nature.

A breakdown of the NCA area, by Geodiversity Landscape Category is provided in the table below.

Table A.5: Geodiversity Landscape Categories in NCA 10

Geological Landscape Category	Total Area within NCA (km^2)	% of NCA Area
Undulating upland terrain	985.8	45.9
Upland glacial, periglacial and fluvioglacial depositional terrain	423	19.7
Upland karst/ upland limestone landscape	322.9	15
Upland peat bog	323.3	15.1
Upland mountain stream, river and lake	60	2.8
Glaciated mountain terrain	30.6	1.4

Figure A.8: Intrinsic Geodiversity Value, Links to Biodiversity and Resilience to Change



Intrinsic Geodiversity Value

As shown in **Figure A.8**, almost the entirety of the NCA area (87.8%) is covered by the North Pennines UNESCO Global Geopark, an international designation which recognises the importance of the dramatic landforms and intrusions of hard Whin Sill rock within the Pennines. In addition, the NCA features many geological sites and features, including minerals, which are recognised by the UNESCO Global Geopark. Therefore, the geology and geodiversity value of the North Pennines NCA (NCA10) is considered to be of international significance.

In addition, there are 25 Sites of Special Scientific Interest (SSSI) which have been designated entirely (19 sites) or partially (6 sites) for their geological significance. These are of national importance. These SSSIs cover a total area of 390.1 km^2 (18.2% of the NCA area). The three most prominent SSSIs within the NCA boundary which are designated for geological interest include the Upper Teesdale (143.7 km^2), Moorhouse and Cross Fell (137.8 km^2), and the Appleby Fells (105.2 km^2) SSSIs. These are located in the west of the NCA, between Teesdale and the western boundary of the NCA. There are also 36 Geological Conservation Review (GCR) Sites within the NCA boundary, with a total area of 12.4 km^2 (0.6% of the total NCA area).

SSSIs and GCR sites are generally located within the Pennines range of hills. A large proportion of SSSI sites are found within mines or quarries. Similarly, most GCR sites also correspond to mineral extraction sites. Their small size indicates that most are limited to outcrops and exposures within extraction sites. Other SSSIs have been designated within cavern systems which formed, over time, by the erosion of limestone by water, notably at Fairy Hole Caves.

There is strong link between mineral extraction sites and sites designated for geological importance. Many minerals have been mined across the NCA since the 12th century, including lead, silver, iron, zinc and copper ores. Additionally, the Whin Sill and nearby limestone was heavily quarried in the past.

Many materials extracted, such as sandstone, limestone and Millstone Grit, have been used as building materials within the NCA, particularly within the

broad dales. The geodiversity of the NCA ultimately contributes greatly to the local vernacular of the villages and farmsteads within the area, helping create a strong sense of place.

The extensive upland peat bogs contribute towards the intrinsic geodiversity value of the NCA, with designated sites of geological and biodiversity interest. They also contribute strongly towards the perceptual qualities of the NCA, including degree of remoteness and tranquillity as their presence has limited development within the raised plateau landscapes in the west and south of the NCA. This tranquillity provides inspiration for many writers and artists, such as Sir Walter Scott and Charles Dickens. Moorlands across the NCA retain well preserved historic remains including settlements, ritual sites, and shielings.

Links to Biodiversity

As shown in **Figure A.8**, 30.1% (646.17 km^2) of the area within the NCA is covered by geodiversity landscape categories which are identified as having a dominant factor on biodiversity. 65.7% (1408.8 km^2) of the NCA has a less dominant factor on links with biodiversity. The remining 4.2% (90.6 km^2) has a moderately dominant impact on biodiversity.

A breakdown of the dominance of geodiversity landscape categories on biodiversity is provided below:

Table A.6: Geodiversity Landscape Categories and Links to Biodiversity

Geological Landscape Category	Degree of dominance on biodiversity	Total Area within NCA (km^2)	% of NCA Area
Undulating upland terrain	Less dominant	985.8	45.9

NCA Name: 10 - North Pennines

Geological Landscape Category	Degree of dominance on biodiversity	Total Area within NCA (km^2)	% of NCA Area
Upland glacial, periglacial and fluvioglacial depositional terrain	Less dominant	423	19.7
Upland karst/ upland limestone landscape	Dominant	322.9	15
Upland peat bog	Dominant	323.3	15.1
Upland mountain stream, river and lake	Less dominant	60	2.8
Glaciated mountain terrain	Less dominant	30.6	1.4

The areas with the most dominant links to biodiversity tend to be concentrated along the Pennines escarpment running along the length of the NCA in the west. This is due to the presence of limestone and dolerite forming the Whin Sill. The Whin Sill supports whin grassland which is rare.

'Sugar Limestone' is metamorphosed limestone near the Whin Sill. It supports the unique 'Teesdale Assemblage' of arctic and alpine plants. This includes Teesdale sandwort, Teesdale violet, alpine meadow rue, bird's eye primrose, spring gentian and alpine bartsia which have survived from the glacial period **[See reference** 1**]**. The 'sugar limestone' grasslands of Upper Teesdale are one of the most botanically rich areas in upland Britain.

Other areas featuring geodiversity landscape categories which have a more dominant influence on biodiversity tend to be focussed along valleys and dales within the NCAs. In all cases, geodiversity landscape categories with the greatest influence over biodiversity align with areas of **upland peat bog** and **upland karst/ upland limestone landscape**.

Geological landscape categories which have a dominant factor on biodiversity include **upland peat bog.** This covers extensive areas of higher ground within the NCA (15.1% of total area). It supports mosaics of moorland vegetation which are of international importance. It also supports several important bird species including hen harrier, merlin, peregrine, golden plover, curlew and dunlin. 46% of the higher land within the NCA is designated as a Special Protection Area (SPA) for its bird populations.

Although often in categories identified as having a less dominant factor on biodiversity, the presence of valleys and dales supports a wide range of species. This includes otter, water vole, dipper, Atlantic salmon, brown trout and white-clawed crayfish.

Resilience to Change

As illustrated in **Figure A.8**, 47.4% of the area within the NCA is covered by geodiversity landscape categories which are identified as being resilient to change. A further 37.6% of the area is identified as being of moderate resilience to change, whilst the remaining 15.1% of the NCA area is less resilient to change.

A breakdown of the dominance of geodiversity landscape categories on resilience is provided below:

Table A.7: Geodiversity Landscape Categories and Resilience to Change

Geological Landscape Category	Resilience to Change	Total Area within NCA (km^2)	% of NCA Area
Undulating upland terrain	Resilient	993.5	46.3

NCA Name: 10 - North Pennines

Geological Landscape Category	Resilience to Change	Total Area within NCA (km^2)	% of NCA Area
Upland glacial, periglacial and fluvioglacial depositional terrain	Moderately sensitive	424.5	19.8
Upland karst/ upland limestone landscape	Moderately sensitive	323.8	15.1
Upland peat bog	Sensitive	323.3	15.1
Upland mountain stream, river and lake	Moderately sensitive	49.9	2.3
Glaciated mountain terrain	Resilient	30.6	1.4

Geodiversity landscape categories which are currently active and undergoing change, such as **upland peatland bog**, will be sensitive to anthropogenic and indirect anthropogenic changes such as land management practices. In contrast, **undulating upland terrain** and **glaciated mountain terrain**, which are both strongly influenced by the underlying bedrock geology will be more resilient to change, as changes in land use or development pressure is unlikely to significantly alter the landform of these areas. Other upland categories which have notable active geomorphological elements (e.g. streams and rivers, karst landforms, and glacial or fluvioglacial deposits) will experience moderate resilience, as whilst the general landform will remain similar, there may be some changes to the characteristics of active processes.

As such, extensive areas along the Pennines ridge in the west, and to the south of the NCA are identified as being sensitive. This corresponds to areas of **upland peat bog**. Peripheral locations along the ridge of hills, around **upland peat bog**, and across extensive areas in the north of the NCA (including between Weardale and Teesdale) are expected to be most resilient to future change. Geological landscape categories within the dales and valleys, and

surrounding limestone dominated areas, have moderate resilience due to the ongoing geomorphological processes occurring.

Geodiversity Significance

Table A.8: Geodiversity Significance Criteria and conclusions

	Criteria	Justification	Significance
Geology	Rarity	■ Most of the NCA is covered by the North Pennines UNESCO Global Geopark which recognises the importance of the dramatic landforms and intrusions of hard Whin Sill rock within the Pennines. ■ The Whin Sill is only found in this part of the country. It is of international importance due to the species it supports.	E
	Representativeness	■ The distinctive landform of the NCA, including the dramatic escarpment, tells a narrative of the processes associated with tectonic movement, igneous intrusions, and changing local environments. ■ Hard rock of the Whin Sill provides good examples of erosional processes, including the formation of waterfalls.	E
	Contribution to geological understanding and research interest	■ The complex and varied geology of the NCA has been well studied. Designated sites, including the UNESCO Global Geopark, contributes towards understanding of geological processes in the area. ■ The designated UNESCO Global Geopark and research conducted in the area are of international importance.	E
	Contribution to education and engagement	■ The geodiversity of the NCA is dramatic, resulting in a highly scenic landscape. It attracts people from across the world and	E

	Criteria	Justification	Significance
		encourages engagement through its Global Geopark status.	
Benefits	Benefits/ services to society provided by geodiversity	■ Designated sites, including UNESCO Geopark, provide accessible exposures for interpretation, understanding and continued research. ■ Geological features contribute towards sense of place and history. ■ Disused quarries provide important habitats. ■ Locally extracted minerals provided local building materials, contributing strongly to local vernacular.	**E**
Bio.	Links to Biodiversity	■ 65.7% of the NCA geology has a less dominant effect on biodiversity. ■ 30.1% of the NCA geology has a dominant effect on biodiversity. ■ 4.2% of geology has a moderately dominant effect on links with biodiversity. ■ Categories with a dominant or moderately dominant effect on biodiversity tend to correspond to areas of peatland and karst/limestone landscape.	**H**
Sense of Place	Contribution to sense of place through physical character	■ The geology has created a distinctive landscape of highly dramatic peaks which has contributed significantly to the character and sense of place. ■ The hills of the Pennines are recognised as being of international importance. The vast majority of the NCA is designated as the North Pennines UNESCO Global Geopark. ■ The vast majority of the NCA is designated as the North Pennines AONB.	**E**

NCA Name: 10 - North Pennines

	Criteria	Justification	Significance
	Contribution to sense of place through historic character	■ Use of local building materials, has strongly influenced the local vernacular of the NCA, particularly in the broad dales. ■ Minerals have been extracted the 12th Century, including lead, silver, iron, zinc and copper ores. Extraction of whinstone, sandstone, limestone and millstone grit has continued.	H
	Contribution to sense of place through natural beauty	■ The NCA has been a source of inspiration for several artists and writers both in the past and at present. Notably, the NCA has provided inspiration for Charles Dickens and Sir Walter Scott. ■ The landscape features highly prized views and high levels of remoteness and tranquillity.	E