



Resilient by Nature: a process to integrate Climate Resilience with Biodiversity Net Gain

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1. Resilient by nature: a process to integrate Climate Resilience with Biodiversity Net Gain

1.1 Why integrate climate resilience with Biodiversity Net Gain

Biodiversity Net Gain (BNG) is when development has a measurably positive impact ('net gain') on biodiversity, compared to what biodiversity was there before development (Defra, 2025)¹. In practice, achieving BNG includes following the mitigation hierarchy and enhancing and creating wildlife-rich habitats.

England's mandatory BNG (Box 1) requires that created or enhanced habitats are secured for a minimum of 30 years. Over this period, shifting climate conditions and more frequent extreme weather events can threaten the establishment and maintenance of BNG habitats. To meet mandatory requirements, identifying climate risks early and integrating resilience measures directly within BNG designs, and long-term management and monitoring plans, is crucial.

Box 1. England's mandatory Biodiversity Net Gain

In February 2024, BNG became mandatory for most developments seeking planning permission under schedule 7A of the Town and Country Planning Act 1990 (as inserted by Schedule 14 of the Environment Act 2021). These developments must achieve a minimum 10% increase in 'biodiversity units', as measured by the Statutory Biodiversity Metric (Defra, 2025)². **The Mandatory Biodiversity Net Gain in England – A Guide** provides guidance on mandatory BNG in England under the Town and Country Planning Act.

Beyond mandatory requirements, there are several other drivers for integrating climate resilience with biodiversity enhancements. These range from international to national to local, and include:

1 Reference: [Biodiversity net gain - GOV.UK](#)

2 Reference: [Biodiversity net gain - GOV.UK](#)

	UN Sustainable Development Goals - Provide a global framework for sustainable development, emphasising the importance of climate resilience and biodiversity conservation.
	Adaptation Reporting Power under UK Climate Change Act (2008) - Infrastructure owners must report to the Department for Environment, Food and Rural Affairs (Defra) every five years on climate risk and adaptation actions. Integrating climate resilience with BNG can help to demonstrate action on climate adaptation.
	Infrastructure planning and consenting - Several National Policy Statements require climate resilience to be embedded in the design of new infrastructure - both built and natural assets, such as habitats for BNG. This requirement applies to planning and consenting routes such as Development Consent Orders (DCOs) and Town and Country Planning Act (TCPA) applications.
	Local Authority Policies - Local authorities have statutory biodiversity duties and must prepare Local Nature Recovery Strategies (LNRS). Many have also declared climate and nature emergencies and promote resilient infrastructure through planning policies. Integrating climate resilience with BNG can help to meet these responsibilities.
	Organisational Strategies - Forward-thinking organisations are aligning their goals for climate resilience and biodiversity enhancements. Better integration of climate resilience and biodiversity at both strategic and project levels can generate efficiencies and unlock innovation.
	Corporate Reporting Frameworks - Climate resilience and biodiversity are increasingly reflected in reporting standards, e.g. International Financial Reporting Standards (IFRS) and Taskforce on Nature-related Financial Disclosures (TFND), encouraging companies to account for climate resilience and biodiversity, and the join up between the two.
	Risk Management - Climate change impacts are risks to infrastructure from the damage and disruption caused by, for example, droughts and flooding. Designing BNG in ways that strengthen resilience of infrastructure to climate change can help to better manage these risks.

1.2 This Guide

This guide introduces a four-step process for integrating climate resilience with BNG. It provides examples of climate risks to BNG habitats, and of practical resilience measures for BNG designs, landscape aftercare, and long-term management and monitoring.

The primary audience is BNG ecologists and landscape architects responsible for habitat creation and enhancement over the minimum 30-year BNG commitment (Box 2). The guide will also be useful for climate change practitioners, planners, project managers, architects, engineers, arboriculturists, local authorities and land managers involved in BNG and nature-based solutions.

While this guide focuses on England's mandatory BNG, it can be useful for policies across the UK for developments to enhance biodiversity. For example, Scotland's Net Positive for Biodiversity policy³ and the Net Benefits for Biodiversity policy in Wales⁴, which includes resilience of ecosystems.

³ Reference: [National Planning Framework 4](#)

⁴ Reference: [Planning Policy Wales - Edition 12](#)

Box 2. Supporting BNG Practitioners

This guide is designed to support BNG Practitioners whether independent, part of a small ecology team, or working within medium to large consultancies. The aim is to provide practical steps and examples that can be adapted to the role and scale of the project. This may mean using the guide to carry out a high-level climate risk assessment and recommend resilience measures, when reporting results of a biodiversity metric calculation. Or if involved in the project design, it may involve working with landscape architects to include resilience measures within the BNG habitat design, and with drainage engineers to highlight the importance for BNG habitats of retaining water during summer droughts and enabling the flow of water during intense summer downpours and winter rains. If joining a project later in the process, the guide can help review BNG habitat designs, identify opportunities to increase resilience, and advise on landscape aftercare and long-term management.

From making recommendations, to inputting into BNG and project designs, to writing management and monitoring plans, the intention of this guide is to give practitioners the information and examples to integrate climate resilience into BNG in a way that works for their project, their role, and their practice.

1.2.1 What this Guide is not

This guide is not intended as legal or technical advice. Instead, it sets out a process to follow, with examples to help practitioners apply the process on BNG projects.

Because climate risks vary by region, locality and habitat type, the guide does not attempt to provide a definitive list of climate risks or resilience measures for BNG. The examples included are illustrative only, designed to bring the concepts to life and show how they can be used in practice. For project-specific decisions, this guide should be used alongside expert advice, especially in ecology, BNG, landscape and climate resilience.

Table 1.2.1: This Guide

What this Guide is	What this Guide is not
Guidance on a four-step process on integrating climate resilience within BNG design, landscape aftercare and long-term management and monitoring.	A detailed methodology for conducting a climate resilience assessment of BNG.
Guidance on applying this process as either a high-level or detailed climate assessment, depending on the scale and complexity of the BNG project.	Replacement of climate resilience, landscaping or BNG expertise.
A source of example climate risks and resilience measures for BNG, with links to additional resources.	A definitive list of climate risks or resilience measures for BNG design, landscape aftercare and long-term management and monitoring.

1.3 Core principle

A core principle of this guidance is to integrate climate resilience for BNG habitats to withstand the increasing intensity of climate impacts.

Decline of BNG habitats can result from the cumulative effect of multiple, sequential extremes, which push habitats beyond their thresholds, for example heatwaves followed by drought, then intense rainfall or flooding. This guide highlights resilience measures that act as buffers, reducing the severity of these impacts. By anticipating the climate

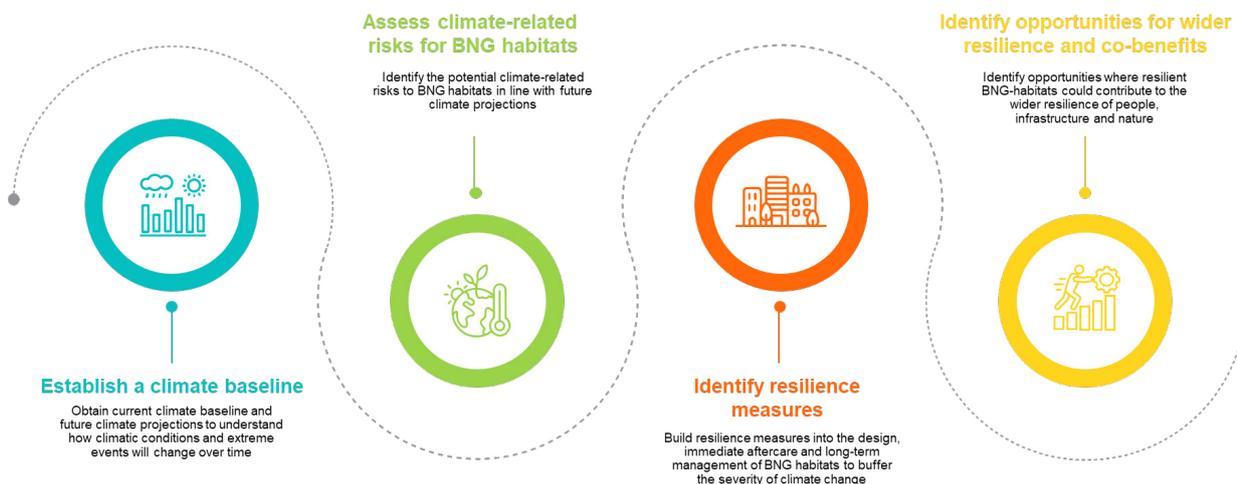
risks that are most likely to affect a site over the 30-year period for BNG, practitioners can apply resilience measures that reduce the severity of climate impacts, helping BNG habitats establish even as conditions become more variable. Species selection matters for resilience. With an initial focus on measures that reduce the severity of climate impacts on BNG habitats, species selection should be continually reviewed, especially as part of landscape aftercare and BNG monitoring to assess, if, over time, climate stressors prove too great for habitats to cope with.

This guide also covers single extreme weather events that can cause destruction and loss of BNG habitats. Finally, this guide highlights that ‘resilient’ BNG habitats can be designed to help communities and landscapes become more resilient too. Thoughtfully designed resilience measures for BNG habitats can contribute to natural flood management, urban cooling, improved water quality, and other wider climate resilience benefits.

2. Integrating climate resilience with BNG: an overview

This guide is based on a four-step process to integrate climate resilience with BNG. An overview of this process is shown in Figure 2.1.

Figure 2.1: A four-step process to integrate climate resilience with BNG



3. Determining the level of climate assessment

Before starting the process to integrate climate resilience with BNG, practitioners should decide whether to undertake a high-level or detailed climate assessment depending on the scale, context and complexity of the BNG habitat proposals. This section offers guidance to determine which level is appropriate, and Section 4 explains how to apply the assessment.

3.1.1 High-level climate assessment

A high-level climate assessment gives a broad understanding of climate impacts on habitats. It can inform the selection of resilience measures although usually to a generic level.

High-level climate assessments are most appropriate for BNG feasibility assessments on larger developments, and for small-scale BNG projects, such as those using the ‘small sites’ Biodiversity Metric calculation or with limited complexity and scale to the BNG proposals.

3.1.2 Detailed climate assessment

Detailed climate assessments are most appropriate for design stages of BNG on larger projects, especially those where climate experts are already gathering climate data, such as for Environmental Impact Assessments.

Detailed assessments involve gathering comprehensive data on climate baselines and projections that are directly relevant to the BNG habitat proposals. This is usually undertaken by climate experts. Climate data might already be collected for the proposed development. If so, it's a case of checking that the climate data is relevant to assess risks to BNG habitats. For example, projections on changes in growing seasons under climate change could be useful for the BNG habitat proposals but not usually collected as part of climate change assessments for infrastructure.

Climate experts with BNG Ecologists then use the data to assess climate risks to BNG habitats. Following which, they will identify appropriate resilience measures for the design, landscape aftercare and long-term management and monitoring.

Figure 3.1 summarises key actions when undertaking high-level and detailed climate assessments. These two levels of assessment can be used together. On major developments for example, undertaking a high-level climate assessment will inform a BNG feasibility assessment and prioritise actions for the detailed climate assessment, which is undertaken during the BNG design stage.



Figure 3.1: Key actions for high-level and detailed climate assessments

4. Undertaking the process for integrating Climate Resilience with BNG

This section describes how to apply each step of the process to integrate climate resilience with BNG, firstly as a high-level climate assessment and then as a detailed climate assessment.

4.1 High-level climate assessment



4.1.1. Establish a climate baseline

Current climate baseline

A current climate baseline is composed of today's typical climate conditions and recent trends, based on observed data. Obtaining the current climate baseline is vital for understanding today's climate and how it may evolve in the future. Climate baselines ideally span at least 20 years and capture natural climate fluctuations, setting the scene for future climate projections.

For high-level climate assessments, the [Met Office Climate Data Portal: Local Authority Climate Service](#) provides freely available tools and resources to help local authorities better understand climate change in their local area and support their adaptation journey. For BNG, this is a useful, practical and efficient resource to obtain climate data for the local authority that the BNG habitats are located within. Users enter the local authority, and the website displays graphs for several climate variables, including changes in:

- annual summer and winter temperatures
- summer maximum temperatures
- winter minimum temperatures
- summer and winter precipitation rates

These changes are shown relative to a climate baseline and under three scenarios of global warming: by 1.5 °C, 2 °C and 4 °C .

A short video showing how to use the website is available here: [Explore the Climate of your Local Authority](#)

Regional climate summaries published by the Met Office are also useful for obtaining climate baseline information for high-level assessments. These are summaries of current climate characteristics of 11 regions of the UK, and cover temperature, hours of sunlight, rainfall, and wind. The summaries are presented in downloaded PDF format, are available here: [UK regional climates - Met Office](#)

Future climate baseline

Future climate baselines show how the climate is projected to change over time. Climate projections are not forecasts or fixed predictions – they are simulations that illustrate how climate might evolve under various emission pathways and factors described in Box 4.1.

The following factors are key considerations when obtaining climate projection data:

Selecting the most appropriate emissions scenario(s)	Representative Concentration Pathway (RCP) 8.5 represents a high emissions scenario and reasonable worst case from which to identify climate risks for BNG habitats and resilience measures.
Selecting the most appropriate future time horizon(s)	The time horizon should reflect the 30-year minimum period for statutory BNG requirements at least. It is recommended to go beyond the 30 years to maximise the resilience of BNG habitats. For example, using a longer time horizon that aligns with the design life of the infrastructure or development project.
Selecting the climate variables	<p>Temperature and precipitation are the key climate variables for high-level assessments, especially:</p> <ul style="list-style-type: none"> ○ Changes in mean summer and winter temperature ○ Changes in mean summer and winter precipitation <p>Section 4.2 describes a range of climate variables to consider for BNG habitats. For example, depending on the location, sea level rise might be relevant.</p>

As noted, the **Met Office Climate Data Portal: Local Authority Climate Service** displays future climate projections for a range of climate variables for each local authority area. It offers high-resolution projections, which are useful for practitioners obtaining climate data suitable for assessing risks to BNG habitats.

Box 4.1 A summary of factors underpinning climate projections

Climate projections predict how the climate may change over time based on several factors, including:

- **Emission scenarios:** These are possible future pathways for greenhouse gas emissions based on assumptions about population growth, energy use, technology, and policy. In general, higher emission scenarios are related to warmer global temperatures.
- **Representative Concentration Pathway (RCP):** RCPs are internationally agreed prescribed emission scenario trajectories for greenhouse gas and aerosol concentrations in the atmosphere. These various pathways are used in climate models to project various future climate conditions. There are four key RCP scenarios (RCP2.6, RCP4.5, RCP6.0 and RCP8.5) available in UKCP18, with RCP8.5 describing a reasonable worst-case scenario.
- **Time-horizons:** Refers to specific future periods for which climate projections are made, i.e. the chosen timeframe when assessing how climate conditions might change.
- **Climate variables:** These are measurable physical aspects of the climate system that can be tracked to understand and predict future changes. Examples of these variables include temperature, precipitation, wind speed, humidity and sea level rise.

Box 4.2 contains other sources of climate information that can be used for high-level climate assessments.

Box 4.2 Sources of information on climate projections

The Met Office provides climate projection data for the UK known as the UK Climate Projections 2018 (UKCP18). These climate projections predict how conditions may change up to the year 2100 and illustrate general trends in projected climate across the UK at a high-level:

- **UKCP18 Headline Findings** - a summary of the most recent climate projections for the UK, including local, regional and global data.
- **UKCP18 Factsheets** - overviews of the latest climate projections for the UK at a high-level, and includes temperature, precipitation, snow, wind, and sea level changes.
- **UKCP18 Key Results** - summaries of the key results from UKCP based on the Probabilistic Projections. The filters can be used to select spatial domain, region, variable, time horizon and emission scenario.

4.1.2 Assess climate risks to BNG habitats



Once climate data has been obtained, practitioners can assess what those future conditions actually mean for BNG habitats over the minimum 30-year period for BNG. A useful way to start is by examining the climate risks associated with specific future climate conditions. For example, over the 21st century, the UK is expected to experience hotter, drier summers. These conditions can expose BNG habitats to significant heat and drought stress, increasing the likelihood of habitat decline and degradation. At the same time, warmer, wetter winters are projected. These create ideal conditions for pests and diseases and increase risk of flooding, which can damage or degrade habitats.

Examples of climate risks to BNG habitats are shown in Figure 4.1. Appendix A describes potential climate risks to BNG habitats in more detail.

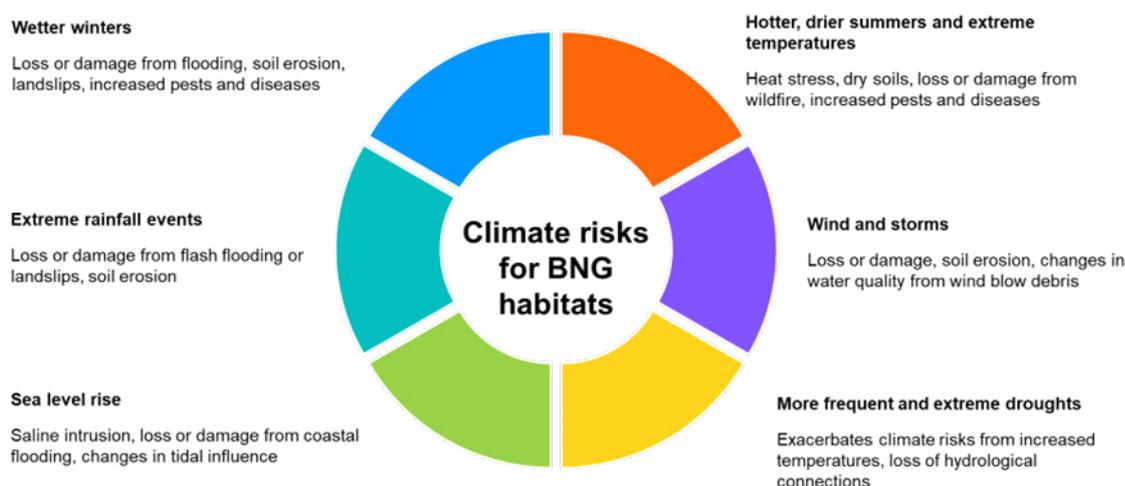


Figure 4.1 Examples of climate risks to BNG habitats

After considering risks linked to individual climate conditions, practitioners then look at how these risks interact. This is important because it is the combined impacts that often pose the greatest climate risks to BNG habitats.

For example, hotter, drier summers can place habitats under heat and drought stress and cause soils to dry. When this is followed by intense summer downpours, the now dry, fragile soils are far more vulnerable to erosion. It is this sequence of impacts that can cause significant habitat loss and degradation.

In practice, understanding the cumulative impacts from multiple climate risks is essential for identifying resilience measures that reduce the severity of these impacts on BNG habitats.

4.1.3 Identify resilience measures

With the climate risks to BNG habitats understood, practitioners can identify resilience measures that help habitats withstand the changing conditions. These measures typically focus on three key areas:



○ BNG habitat and landscape design

This includes design elements that buffer the severity of climate risks. For example, systems to store water during summer droughts and enable the flow of water during winter rains. Careful placing of habitats, landscape features that protect BNG habitats from extreme weather, and mosaic habitats are other elements that integrate resilience within designs.

○ Landscape aftercare

Aftercare should include plans to prepare for, and respond to, extreme weather. This could involve plans for preparing for and responding to heatwaves, droughts, heavy rainfall or storms. These plans are especially important to support newly created or enhanced habitats through the most vulnerable stages of establishment.

○ Long-term management and monitoring plans

Over the 30-year BNG period, practitioners should monitor how well resilience measures are performing and how BNG habitats are establishing under changing climate conditions. This helps identify when additional resilience measures are needed to keep BNG habitats on track to reach their target type and condition.

For high-level climate assessments, such as those informing a BNG feasibility study, broad resilience measures are typically outlined to show that climate risks have been considered and can be effectively managed.

Appendix B sets out examples of resilience measures across habitat design, landscape aftercare, and long-term management.

4.2 Detailed climate assessment

4.2.1 Establish a climate baseline

Current climate baseline

A current climate baseline is composed of today's typical climate conditions and recent trends, based on observed data. Obtaining the current climate baseline is vital for understanding today's climate and how it may evolve in the future. A robust current climate baseline, ideally spanning at least 20 years, captures natural climate fluctuations and sets the scene for future climate projections.



For a detailed climate assessment, options to obtain a climate baseline include the following:

○ Obtain monitoring data

This includes daily records of weather (e.g. rainfall, wind, temperature, flow gauges) to understand the current climate and how it may have changed over time. The Met Office [location-specific long-term averages](#) offers climate averages for 30-year periods across a range of climate indicators, for available local weather stations in the form of averages tables, averages graphs, averages maps, with the option of location comparison.

○ Supplement the Met Office data with analogous information

Monitoring data can be supplemented with information from local press records regarding recent extreme events and the extent of impacts relevant to the assessment area. This can help to draw parallels between those historical events and potential future impacts, although can be resource-intensive.

○ Draw from the [State of the UK Climate](#)

This annual publication presents the latest analysis of UK climate trends and demonstrates shifting climate baselines, the increasing frequency of record-breaking events, and the growing normalisation of temperature and rainfall extremes.

○ Draw from the independent UK Climate Change Risk Assessment (CCRA)

Produced every five years by the Climate Change Committee (CCC) as a requirement under the Climate Change Act 2008, this outlines the priority climate risks and opportunities facing the UK. The accompanying national summaries offer valuable insights into recent climate trends and impacts, and can also be used to inform a current climate baseline.

Future climate baseline

With data on climate baselines obtained, the next step is to obtain climate projection data on how climatic conditions and extreme events may change over time. Importantly, climate projections are not forecasts or fixed predictions – they are simulations that illustrate how climate might evolve under various pathways.

The Met Office provides climate projection data for the UK through the UK Climate Projections (UKCP), which model how conditions may change up to the year 2100. At time of writing, UKCP18 was the most up-to-date set of climate projections for the UK.

When conducting a detailed climate assessment, there are three key decisions to consider when selecting climate data:

- Selecting the most appropriate emissions scenarios
- Selecting the most appropriate future time horizons
- Selecting the climate variables

Selecting the most appropriate emissions scenarios

Representative Concentration Pathways (RCPs) are scenarios used in climate modelling to project future greenhouse gas concentrations and their potential impacts on climate change.

Within UKCP18, there are four RCPs (as shown in Table 4.1) to choose from, each mapping out a different potential future depending on levels of global GHG emissions.

Table 4.1: RCPs in UKCP18⁵

RCP	Change in temperature (°C) by 2081-2100	Description
RCP2.6	1.6 (0.9 – 2.3)	Strong GHG mitigation scenario with rapid emissions reductions
RCP4.5	2.4 (1.7 – 3.2)	Stabilisation scenario with moderate GHG mitigation
RCP6.0	2.8 (2.0 – 3.7)	Stabilisation scenario with less aggressive GHG mitigation
RCP8.5	4.3 (3.2 – 5.4)	High emissions scenario with minimal GHG mitigation efforts

The RCP8.5 emissions scenario is recommended for detailed climate assessments. It represents a high and reasonable worst-case emissions scenario for future climate projections. In turn, this enables practitioners to assess climate risks to BNG habitats and identify resilience measures based on potentially worst-case future climate change. This approach can be especially helpful to develop plans to prepare for, and respond to, extreme weather events during construction and long-term management phases.

If using RCP8.5, a consideration is not to ‘over-engineer’ resilience for BNG. Rather, include pragmatic resilience measures together with monitoring how well the resilience measures are performing, and how BNG habitats are responding to climate change, with the aim to ascertain if additional resilience measures are required.

For BNG practitioners working with climate resilience experts, they might see multiple scenarios used for the climate resilience assessments. For example, obtaining projections for RCP6.0 (which approximately represents a 2.8 °C global warming future), in addition to RCP8.5 (which equates approximately to 4 °C global warming future). This can help to assess the potential levels of climate risks to BNG habitats, in order to inform both measures and monitoring for resilience.

As a generic example, proposed woodland creation for BNG is assessed as being likely to establish under RCP6.0, but could experience drought stress under RCP8.5. With this information, practitioners include drought response plans within the landscape aftercare and long-term management phases. They also investigate options for rainwater capture on site, as a means of storing winter rains to use during summer droughts.

Selecting future time horizons

Future time horizons for the climate projection data should cover the 30-year minimum period for statutory BNG requirements. It is recommended that a period beyond the 30 years is selected to inform the assessment of climate risks to BNG habitats. A longer time horizon could be selected that aligns with the design life of the proposed infrastructure or development. Practitioners can select several future time periods to help capture the evolving impacts of climate to inform the choice and application of resilience measures.

⁵ ukcp18-guidance--representative-concentration-pathways.pdf

Selecting the climate variables

The key climate variables typically used within a detailed climate assessment are described in Table 4.2.

Table 4.2: Key climate variables for detailed assessment

	Climate variable	Description	Source
	Average temperature (°C)	Seasonal average temperature. (°C) change from defined baseline.	Met Office UKCP18 Interface
	Average maximum temperature (°C)	Seasonal average maximum temperature. (°C) change from defined baseline.	Met Office UKCP18 Interface
	Extreme temperature (100-year return period) (°C)	Describes the extreme temperature event which has a 0.01% chance of occurring each year.	Met Office UKCP18 Interface
	Met Office Heatwave	Metric is events per year. Occurrence of heatwave following Met Office definition: a UK heatwave threshold is met when a location records a period of at least three consecutive days with daily maximum temperatures meeting or exceeding the heatwave temperature threshold. What is a heatwave? - Met Office	Met Office Climate Data Portal
	Tropical nights (Tmin >20°C)	Days with minimum temperature above 20 °C.	Met Office Climate Data Portal
	Very hot days (Tmax >35°C)	Days with maximum temperature above 35 °C.	Met Office Climate Data Portal
	Total rainfall (mm)	Seasonal total average rainfall. % change from defined baseline.	Met Office UKCP18 Interface
	Rainfall extreme: Total 1-day rainfall (100-year return period)	Describes the total 1-day rainfall for an extreme rainfall event which has a 0.01% chance of occurring each year.	Met Office UKCP18 Interface
	Rainfall extreme: Total 5-day rainfall (100-year return period)	Describes the total 5-day rainfall for an extreme rainfall event which has a 0.01% chance of occurring each year.	Met Office UKCP18 Interface
	Start of crop growing season	Metric is day of year (e.g. 1st Jan = 1, 2nd Jan= 2 etc.). First day of first five-day period with average temperature above 5.6 °C.	Met Office Climate Data Portal
	Growing season length	Metric is days. Length between start and end of growing season.	Met Office Climate Data Portal
	Wildfire: Met Office Daily Hazards Assessment (Yellow)	Days per year with Met Office Fire Severity Index components above specific thresholds for Yellow warning used in the Natural Hazards Partnership Daily Hazard Assessment. A yellow warning indicates that the fire hazard is likely to have some impact such as travel disruption, but most people can continue with daily routine. In contrast more severe impacts are possible with other yellow warnings, although their certainty is much lower.	Climate Risk Indicators (CRI) Explorer
	Wildfire: Met Office Daily Hazards Assessment (Amber)	Days per year with Met Office Fire Severity Index components above specific thresholds for Amber warning used in the Natural Hazards Partnership Daily Hazard Assessment. An Amber warning indicated there is an increased likelihood of impacts from severe weather, which could potentially disrupt plans. This means there is the possibility of travel delays, road and rail closures, power cuts and the potential risk to life and property.	Climate Risk Indicators (CRI) Explorer
	Mean sea level rise (m)	Marine projections for mean sea level rise. (m) changes from defined baseline.	Met Office UKCP18 Interface

Obtaining climate data

To support data collection for the detailed climate assessments, several high-quality tools are available. Each offers unique strengths in resolution, variable coverage, and usability. Table 4.3 provides a summary comparison to help practitioners select the most appropriate for their project.

Table 4.3: Examples of tools to obtain climate projection data for detailed climate assessment

Tool	Purpose	Recommended resolution for detailed assessment	Key features
Met Office UKCP18 Interface	Access high-quality climate projections	25km for probabilistic projections 12km for probabilistic projections of extremes	Wide range of climate variables at various resolutions (25km, 12km and 2.2km); ideal for site-specific and regional analysis
Met Office Climate Data Portal	Explore additional climate projections and variables	12km	Expanded variable coverage for detailed assessment
Climate Risk Indicators (CRI) Explorer	Visualise current and future climate risks	Local	Suite of indicators; supports interpretation and risk assessment

These tools can be used individually to explore specific climate variables or in combination to develop a more comprehensive understanding of future climate risks. Layering insights from the UKCP18 Interface, Climate Data Portal, and CRI Explorer allows for a more nuanced picture - capturing both site-specific projections and broader regional or national trends.

Additional baseline information

During a detailed climate assessment, practitioners may gather additional baseline information to strengthen how climate risks to BNG habitats are identified - think of it as adding puzzle pieces that make the whole picture clearer. For major infrastructure projects, this information may already exist for the project's climate change risk assessment. In these cases, the task is to make accessible the relevant data for assessing climate risks to BNG habitats.

Examples of such baseline data are outlined in Table 4.4.

Table 4.4: Additional baseline data sources for the detailed climate assessment

Data source	Description	Why it is useful for a detailed climate assessment
Environment Agency flood risk maps	Maps showing current and future flood risks from rivers, sea, and surface water	Identifies flood-prone areas to inform BNG habitat placement and long-term viability
Environment Agency Climate Change Allowances for peak flow, peak rainfall and sea level	Guidance on peak flow, rainfall, and sea level rise under future climate scenarios	Supports design of resilience measures for BNG habitats
Outputs of the Enhanced Future Flows and Groundwater (eFLAG) project	Future projections of river flows and groundwater levels under climate change	Assesses water availability and stress for aquatic and riparian BNG habitats
Natural England National Climate Change Vulnerability Model (NCCVM)	Spatial model showing habitat vulnerability to climate change across England	Helps prioritise habitat types and locations for BNG based on climate sensitivity
Soil type and soil health – based on Cranfield University Soilscales data (soil texture, drainage capacity) and UK Soil Observatory data	Soil data including texture, drainage, and health indicators	Informs habitat suitability, planting schemes, and restoration potential
British Geological Survey - Geology	Geological maps and data on substrate composition and stability	Supports understanding of ground conditions for BNG habitats

4.2.2 Assess climate risks for BNG habitats

Once climate data has been obtained, practitioners can assess what those future conditions actually mean for BNG habitats over the minimum 30-year period for BNG. A useful way to start is by examining the climate risks associated with specific future climate conditions. For example, over the 21st century, the UK is expected to experience hotter, drier summers. These conditions can expose BNG habitats to significant heat and drought stress, increasing the likelihood of habitat decline and degradation. At the same time, warmer, wetter winters are projected. These create ideal conditions for pests and diseases and increase risk of flooding, which can damage or degrade habitats.



Examples of climate risks to BNG habitats are shown in Figure 4.1. Appendix A describes potential climate risks to BNG habitats in more detail.

4.2.3 Identify resilience measures

With the climate risks to BNG habitats understood, practitioners can identify resilience measures that help habitats withstand the changing conditions. These measures typically focus on three key areas:



○ BNG habitat and landscape design

This includes design elements that buffer the severity of climate risks. For example, systems to store water during summer droughts and enable the flow of water during winter rains. Careful placing of habitats, landscape features that protect BNG habitats from extreme weather, and mosaic habitats are other elements that integrate resilience within designs.

○ **Landscape aftercare**

Aftercare should include plans to prepare for, and respond to, extreme weather. This could involve plans for preparing for and responding to heatwaves, droughts, heavy rainfall or storms. These plans are especially important to support newly created or enhanced habitats through the most vulnerable stages of establishment

○ **Long-term management and monitoring plans**

Over the 30-year BNG period, practitioners should monitor how well resilience measures are performing and how BNG habitats are establishing under changing climate conditions. This helps identify when additional resilience measures are needed to keep BNG habitats on track to reach their target type and condition.

With a detailed climate assessment, resilience measures should be included within design specifications, landscape aftercare plans and Habitat Management and Monitoring Plans (HMMPs). Appendix B provides examples of practical resilience measures and Box 4.1 highlights resilience considerations for construction and maintenance teams involved with implementing the BNG design and HMMP. Figure 4.1 illustrates the combination of resilience measures for BNG designs, landscape aftercare and long-term maintenance and monitoring.

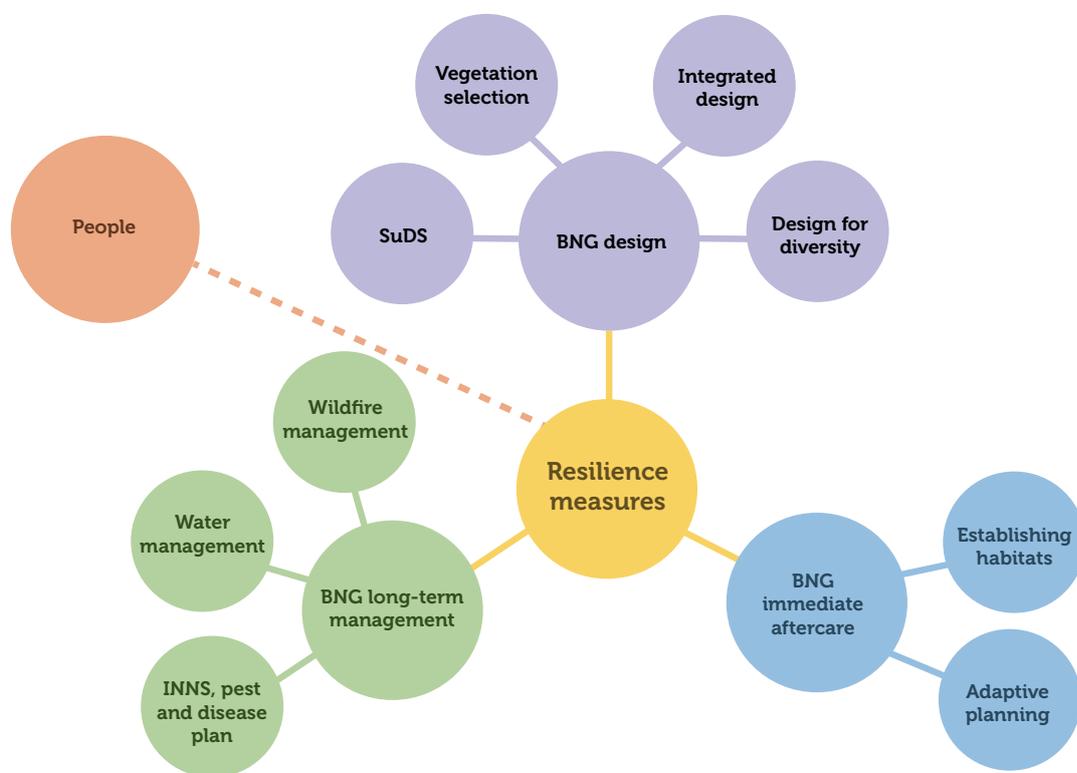
Box 4.1 Resilience considerations for construction and maintenance teams involved with implementing the BNG design and HMMP

Maintenance staff, contractors, and land managers working on BNG sites are increasingly exposed to climate risks, including extreme heat, heavy rainfall, flooding, and severe storms. Integrating resilience measures into site planning and day-to-day operations is essential to safeguard their wellbeing and reduce health and safety risks. Simple steps like monitoring weather forecasts for safe work scheduling can make a significant difference.

BNG practitioners should highlight the importance of climate resilience measures for site-based teams. Practical examples of resilience measures for these teams include:

Climate risk	Examples of resilience measure
Extreme heat	Adjust work schedules to cooler parts of the day Provide shaded rest areas and hydration stations Train staff on heat stress symptoms and response protocols
Extreme rainfall / flooding	Safe access routes and drainage on site Provide waterproof PPE and shelter options Develop emergency response plans for flash flooding
Extreme storms	Schedule work to avoid high wind forecasts
Cold snaps	Supply thermal PPE and warm rest areas Adjust work schedules to avoid dangerous conditions associated with ice and snow

Figure 4.1 The combination of resilience measures for BNG designs, landscape aftercare and long-term management and monitoring. SuDS = Sustainable Urban Drainage Systems; INNS = Invasive Non-Native Species.



4.3 Identify opportunities for wider resilience and co-benefits

Integrating climate resilience with BNG can provide wider resilience benefits for people, infrastructure and landscapes. When designed and managed effectively, these habitats can help to strengthen resilience against climate risks, which include:



	Flooding – by slowing or storing as part of a wider catchment-based natural flood management approach
	Extreme temperatures – through natural cooling and shading
	Storm events – protection from damage e.g. soil stabilisation, and reducing wind impacts
	Catchment-scale risks – by improving water management

To maximise wider resilience benefits from BNG habitats, it is important to look beyond the habitats themselves and understand the broader climate risks facing the proposed development, its locality and surrounding communities. This means exploring how climate-related hazards could affect operational performance, critical infrastructure, and people.

The earlier these wider risks can be explored, the more opportunities to design BNG to support both nature's recovery and long-term climate adaptation.

How these wider resilience opportunities are identified depends on the depth of the climate assessment:

○ **High-level climate assessment**

For high-level climate assessments, the aim is to flag broad opportunities where resilience measures for BNG habitats could also enhance the resilience of people, infrastructure, and ecosystems. This helps shape early design thinking and informs BNG feasibility assessments.

○ **Detailed climate assessment**

A detailed assessment goes further by examining these opportunities in depth and determining how the resilience contribution of BNG habitats can be realised. Depending on the scale of the development project, a Climate Change Risk Assessment (CCRA) may already be underway and can help highlight the most significant hazards.

By weaving wider climate resilience into BNG design from the outset, projects can deliver habitats that establish under future climate conditions and bring meaningful, long-term benefits to the surrounding communities and landscapes.

Appendix A: Examples of climate risks to BNG habitats

This appendix provides examples of climate risks that could damage, degrade, or lead to the loss of BNG habitats. These examples are illustrative only and not intended to be a comprehensive list. The purpose is to help practitioners identify the climate risks most relevant to their site, based on local climate projections and the habitats proposed for BNG.

This appendix starts by describing risks linked to seasonal climate variables, such as rising summer temperatures and more extreme summer heatwaves. It then illustrates how multiple climate factors can interact across seasons and how this combination of climate stressors can affect BNG habitats. For example, higher summer temperatures occurring alongside more frequent heatwaves and droughts could place BNG habitats under heat and drought stress. Then more intense summer downpours cause erosion of the drier soils, and it is this combination of climate stressors that results in the degradation and loss of BNG habitats.

To fully assess climate risks to BNG habitats, practitioners need to consider both the impacts of seasonal climate variables, and the cumulative pressures created when several climate factors occur across different seasons.

A.1 Seasonal climate variables

Hotter, drier summers

Across the UK, climate projections indicate that average summer temperatures will rise, accompanied by more frequent, longer, and more intense heatwaves. These conditions are also expected to occur with reduced summer rainfall and a higher likelihood of drought. Under these conditions, BNG habitats may be exposed to the following that could damage or degrade the habitats, and ultimately lead to their loss:

- **Increased vegetation stress and dieback**

Heat and drought can cause wilting, reduced growth, or mortality. Newly created habitats are especially vulnerable before their roots establish.

- **Reduced habitat quality and structure**

Prolonged dryness may reduce flowering, seed production and vegetation growth. Grassland swards for example, may become sparse or appear 'brown', which can affect long-term establishment.

- **Failure of habitat creation or enhancement**

Habitats that are planted during winter and then, during the following spring, exposed to drought, may fail under hotter, drier conditions.

- **Decline in water-dependent habitats**

Creation of wetland features may be compromised if groundwater levels fall or water sources dry out. For example, lower water tables can affect wet grasslands and wet woodlands, and cause ponds, marshes, and ditches to dry out. For ponds and similar habitats, water temperature increases can reduce oxygen, affecting aquatic plants.

- **Increased pest, disease, and invasive species pressures**

BNG habitats experiencing heat and drought stress can be more susceptible to pests and diseases. In addition, invasive species that are more heat- or drought-tolerant may outcompete native plants.

- **Increased wildfire risk**

Dry vegetation can increase the likelihood of wildfires occurring and spreading, and such fires can destroy large areas of BNG habitats.

Warmer, wetter winters

The UK's climate projections indicate that average winter temperatures will rise, accompanied by more rainfall and flooding events. Under these conditions, BNG habitats may be exposed to the following that could damage or degrade the habitats, and ultimately lead to their loss

○ Prolonged soil saturation and waterlogging

Reduced oxygen availability in soils can lead to root stress and reduced growth, especially for habitats not adapted to saturated conditions. In addition, waterlogging can delay the establishment of newly created habitats.

○ Increased risk of pests, diseases and invasive species

Wet, mild winters can create favourable conditions for pathogens, which can increase the occurrence, duration and diversity of pests and diseases. Warmer winters can also increase overwinter survival of invasive plants, and floodwaters can transport seeds of invasive species such as Himalayan balsam or giant hogweed.

○ Nutrient leaching, altered hydrology and soil erosion

Floodwaters can wash away soils and affect soil nutrient composition, which in turn can affect the establishment of BNG habitats. Flooding can physically damage habitats, and deposit debris, leading to degradation. Soil erosion can expose roots of habitats, leaving them more vulnerable, whereas increased turbidity can affect aquatic plant establishment.

Extreme weather events

Across the UK, extreme rainfall is becoming more frequent and intense, with winters now wetter and heavy downpours causing longer-lasting floods across wider areas. Severe storms are projected to grow in strength, with more powerful autumn and winter systems expected to cross the UK. Extreme heat events are also increasingly common, and, along the coast, rising sea levels are magnifying flood risks.

As these extreme weather events intensify, so does the risk that a single event could destroy or severely damage BNG habitats, for example:

- Intense rainfall and flooding can trigger landslides and wash away newly created habitats.
- Severe storms and high winds can uproot trees and damage other habitat types.
- Droughts and heatwaves increase plant stress; if prolonged, this can lead to widespread habitat degradation.

In short, more frequent and severe extreme weather events means that BNG habitats are facing greater exposure and vulnerability to climate risks.

Multiple climate stressors acting together

Seasonal climate stressors and extreme weather events affect BNG habitats throughout the year. It is this combination of multiple climate stressors acting together that can push BNG habitats into decline.

For example:

- Summer drought combined with intense downpours: prolonged drought can weaken BNG habitats, reducing root growth, and drying out soils. When intense rainfall follows, soils erode more easily, which can damage seed banks and BNG habitats themselves.
- Summer heatwaves combined with winter flooding: heatwaves can stress BNG habitats, and subsequent flooding can further damage weakened habitats and their environment, for example by landslides and prolonged waterlogging.
- Winter storms followed by spring droughts: storms can break or uproot trees, hedgerows and other habitats, leaving gaps that are re-stocked with saplings or seedlings. If a drought follows, establishment of newly planted habitats is slowed or disrupted.
- Successive extremes with little recovery time: BNG habitats can experience repeated cycles of extreme weather, for example flooding during milder winter, heatwaves and drought during spring and summer. This cumulative stress with limited recovery disrupts establishment, prevents stable succession, and ultimately leads to long-term decline.

Appendix B: Examples of resilience measures for BNG design, landscape aftercare and long-term management and monitoring plans

This appendix sets out examples of climate resilience measures that can be incorporated into BNG habitat designs, landscaping aftercare plans, and long-term BNG habitat management and monitoring plans.

These examples are illustrative, not exhaustive. Their purpose is to help practitioners recommend, or identify, resilience measures that are most relevant to their BNG proposals (Box B2). This should be based on all climate risks facing each habitat, as well as the ecological, hydrological and environmental conditions of the site and surrounds. This appendix highlights resilience measures that act as buffers, reducing the severity of climate impacts on BNG habitats to enable habitats withstand a wide range of climate stressors. Equally important is monitoring how well the resilience measures perform over time, and how BNG habitats themselves respond to changing conditions. This allows practitioners to identify when additional or alternative resilience measures may be needed. For example, modifying management practices, as well as reviewing species selection, such as re-stocking with drought-tolerant species.

When selecting resilience measures, a helpful starting point is to identify the outcome and then consider the practical measures that could deliver it. For example, in hotter, drier summers with more intense downpours, it can be essential to keep soils cool, damp, and protected from erosion. Resilience measures that achieve this might include applying organic mulch to soils with newly planted habitats and creating shallow ditches to gently divert rainfall, preventing erosion and safeguarding BNG habitats.

All resilience measures should be feasible and practical to manage and maintain. While the examples in this appendix are listed according to the design, aftercare or long-term management stages of BNG, they might be prepared in a different phase. For example, the design stage might include drafting an Extreme Weather Response Plan that is then implemented during the aftercare and management stages.

Box B2. Supporting practitioners

This guide is designed to support BNG practitioners, whether working independently or as part of a larger team, by providing practical steps for selecting and recommending climate resilience measures at any project stage. For practitioners involved with reporting only and not design, this list provides example resilience measures to include in reports as recommendations when appropriate to do so. Whereas practitioners involved with the design stage could use this list to engage design teams, landscape architects and drainage engineers on specific resilience measures. For those joining a project later, this list can help to recommend measures to strengthen habitat resilience.

Examples of climate resilience measures for BNG habitat designs

Keep soils damp, cool and protected from erosion

- Apply organic mulch (e.g. woodchip, leaf litter, composted bark) on soils around new planting with the aim to reduce evaporation and regulate soil temperature.
- Consider using coarse woody material (logs, brash, branches etc) to protect soils and newly establishing BNG habitats if the material can be secured.
- Establish fast-growing nurse vegetation to provide temporary shade and soil protection, for example sowing with a grassland mix that grows quickly and provides soil protection while tree saplings become established.
- Shape the landform to include gentle depressions where moisture can collect, e.g. with use of ponds and scrapes.

Use natural forms to shelter habitats from extreme weather

- Create habitats that form windbreaks such as staggered belts of double-hedgerows and lines of trees.
- Provide natural sheltering for BNG habitats, e.g. design naturalistic landforms that deflect wind and reduce exposure to storms; position planting in clusters and curves; avoid straight boundaries of BNG habitats and avoid 'hard' edges between BNG habitats.
- Use nurse trees to shield young habitats while they establish.
- Plant BNG habitats around existing natural features (e.g. banks, trees, hedgerows) that provide protection from climate extremes.

Design BNG habitats with diversity, ecotones and habitat mosaics

- Use gradual transitional planting, where one habitat blends into the next through a series of intermediate plant communities, creating a natural gradient of height, structure and species composition.
- Incorporate habitat mosaics to create a patchwork of different habitats (such as grassland, woodland edges, and tall-herb areas) arranged in small, varied patches, creating a mix of structures and microenvironments rather than one continuous habitat.
- Include features to introduce diversity around the edges and along the boundaries of BNG habitats, e.g. tussock patches, bare ground pockets, miniscrapes, log piles.
- Integrate ecotones⁶ within BNG habitat designs to increase diversity, especially through edge effects, which can help strengthen resilience.
- Use undulating, natural curves to increase structural variation instead of 'straight-line' boundaries of BNG habitats.
- Plant edges with mixed height classes to establish natural transition zones.

⁶ The term ecotone refers to a zone of junction, or transition area, that exists between two distinct ecological communities or biomes. Ecotones are areas where ecological communities, ecosystems or biotic regions coincide.

Gentle, shallow drainage to mitigate flash flooding and waterlogging

- Include shallow, long-profile swales that disperse flow across the site.
- Use microchannels or naturalistic rills that slow, spreads and guides water across a site.
- Consider features that provide for safe overflow during intense storms.

Managing water

- Integrate seasonal ponds, scrapes, and other such features specifically to retain moisture during dry months while also providing micro-habitats.
- Consider 'two-stage' ditches: the first stage is the lower main channel that carries water during normal flows, and the second stage comprises shallow terraces either side that carry water during high flows or heavy rainfall.
- In areas prone to heavy rainfalls, consider small woody debris structures in ditches or minor channels to slow flow, if these can be safely secured.
- Integrate soil bunding to retain water on slopes and direct water flows.
- Review options for rainwater harvesting systems.

Adding wildfire breaks

- Plan for wildfire breaks along site boundaries or within large areas of BNG habitats.
- Use bareground or sparsely vegetated corridors as firebreaks that also provide habitat for invertebrates and pioneer species.
- Incorporate pockets of wet habitat types or features to break continuity if wildfires were to spread.
- Avoid creating wildfire risks through a BNG habitat design, e.g. large, continuous grasslands in areas prone to summer heatwaves with a history of wildfire.

Increase structural diversity through varied planting layouts and staggered planting programmes

- Set planting layouts as staggered spacings rather than uniform grids.
- Introduce multiple height layers within areas of a single habitat type through the species mix, planting layout and planting programme.
- Mix early, mid, and late successional species.

Examples of resilience measures for landscaping aftercare

Plan for extreme weather

- Implement a plan to prepare for, and respond to, extreme weather.
- This plan should include regular checks of weather forecasts in order to prepare the site for minimal disruption when extreme weather is predicted (for example removing debris, loose materials etc). Also post the event and when safe to do so, visiting the site to identify and undertake any remediation works promptly. Acting promptly can minimise risk of on-going damage and deterioration.
- While extreme weather plans should cover all types of events, it can be useful to implement weather-specific plans, for example:

Drought Plans

- Drought Plans should be considered for locations forecast to experience summer heatwaves and drought.
- The plans should include monitoring newly created or enhanced BNG habitats for signs of drought stress, in order to identify additional watering needs.
- The plans should also include clearly identified sources for additional watering (and how the water will be transported to site) in case these are required, together with other measures such as slow-release water bags or rainwater harvesting systems.

Flood Plans

- Flood Plans should be considered for locations currently experiencing flooding, and/or forecast to experience worsening flood events.
- The plans should include regular checks of weather forecasts in order to prepare the site for minimal disruption when flooding is predicted. For example, checking that drainage features are functioning and removing any blockage, stabilising areas vulnerable to erosion e.g. with biodegradable mats, securing equipment and materials, and notifying all relevant stakeholders.
- The plans should include, when safe to do so, inspecting habitats for damage, sediment deposits and erosion, checking drainage features e.g. removing debris, and stabilising soils if required. Taking machinery onto water-logged ground should be avoided. In the event of soil erosion and other forms of site damage, areas requiring urgent stabilisation should be identified and marked for action as a priority (when safe to do so).
- Post-flooding, remediation measures might include repairing or reinstating drainage features, rebuilding soil profiles (avoiding compaction), repairing access tracks, removing silt and debris blocking drainage features, and re-seeding or re-planting bare areas in the event of habitat loss. Regular inspections should be undertaken to check the remediation measures are holding.
- A Flood Plan should also include monitoring the effectiveness of measures to reduce flood risk. This enables site teams to act quickly, safely and promptly if new or additional measures to reduce flood risk to BNG habitats are required.

Detect, manage and control pests, diseases and invasive species

- Implementing plans to monitor for pests, diseases and invasive species can be essential, given the likelihood that these will increase in occurrence and variety under climate change. Such monitoring

should include use of the latest technologies to detect, manage and control pests, diseases and invasive species during the aftercare and long-term management phases.

- Detecting, managing and controlling pests, diseases and invasive species should be based on the latest good practice, Health and Safety requirements and legal requirements.

Reduce stress on newly created or enhanced habitats

- Replace failed plants quickly (at the appropriate time) to prevent exposed soils drying and destabilising.
- Apply protective guards and shelters (tree shelters, windbreak netting) in areas vulnerable to high winds, with a programme for their removal.
- Consider biodegradable erosion control (such as matting) to slow water runoff, retain sediment and promote habitat establishment.

Inspect drainage and water management features

- Regularly inspect drainage and water management features to check they can function effectively. For example, inspecting that swales, shallow ditches, scrapes, overflows and rainwater harvesting systems are functioning.

Manage wildfire risks

- Maintain the 'low-fuel' strips that act as temporary firebreaks.
- If there is a risk of wildfire and if safe to do so, consider targeted watering of buffer zones around high-value habitats.

Monitor and respond promptly

- Monitor how well the resilience measures are performing to act promptly if more or additional measures are required.
- Monitor how well BNG habitats are responding to climate change, for example checking for early signs of stress (wilting, leaf scorch, soil cracking, waterlogging) to act promptly if more or additional measures are required.

Examples of resilience measures for long-term BNG Habitat Management and Monitoring Plans

The management and monitoring period for BNG requires ongoing, careful observation of how the site and BNG habitats are responding to climate change, so that resilience measures can be adapted and improved over time. The aim is for BNG habitats to withstand repeated climate shocks over the minimum 30-year maintenance duration.

During the management and monitoring period, many of the resilience measures during the aftercare period should be implemented. For example:

- Extreme weather plans should be implemented and effective in minimising damage from such events and enabling prompt action if remediation is needed.
- Plans to detect, manage and control pests, diseases and invasive species should enable use of the latest technologies.

- Resilience measures themselves should be monitored to understand how well they are working. For example: Are measures designed to retain water during summer months performing as intended? Are shallow drainage channels reducing damage from heavier summer downpours?
- Monitoring the effectiveness of resilience measures, alongside how the site and BNG habitats are responding to climate change, builds the evidence base needed for informed decision-making.

Significant decisions for practitioners include, firstly, assessing whether habitats are simply taking time to establish naturally, or whether they are suffering from climate-driven impacts and require resilience interventions. This relies on knowledge of the locality, for example, are similar habitats nearby also failing. It also relies on monitoring, as described above, both the effectiveness of the resilience measures and the responses of the BNG habitats to climate change.

Second, practitioners need to determine whether habitats that repeatedly fail to establish would benefit from restocking with a different species mix. For example, more drought-tolerant, heat-resilient, or flood-resistant species, or adjusting proportions within a mix to favour those more likely to thrive under new climate pressures.

The species mix for BNG habitats under climate change is a critical decision and one with many considerations. For example, there are unknowns as to the ecological impacts of such decisions or whether BNG habitats will themselves adapt and survive. Also, BNG habitats would likely still need protection from multiple climate stressors (i.e. the resilience measures listed in this appendix). However, species mix for BNG habitats is critical and should be informed by monitoring, site evidence, and emerging ecological knowledge.

Effective communication between all stakeholders involved in BNG is critical. This includes actively sharing emerging knowledge on habitat restoration under a changing climate, and collaborating to gather insights that inform proposals to adapt and strengthen resilience measures over time. Consistent, open communication means that the management of BNG habitats benefits from collective expertise and continuous improvement as climate pressures evolve.

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