Forest Research

BPG

NOTE 21

Best Practice Guidance for Land Regeneration

CLIMATE CHANGE AND LAND REGENERATION

Andy J. Moffat

Introduction

Authoritative reviews of weather data over the past 40 years show that Britain's climate has been changing, in some regions markedly. There has been a clear trend towards warmer conditions, and increased winter and reduced summer rainfall. In tandem, storminess has increased in frequency and intensity (Jenkins *et al*., 2008; Figure 1). These trends are expected to continue into this century – by 2080 UK climate projections from UKCP09 (see Useful links section) show a likely increase in mean summer temperature of between 2.5 and 4.2°C and a decrease in summer rainfall of up to 40% in southern England. In contrast, an increase in winter precipitation of up to 33% is expected in the west of Britain. Climate change is being taken seriously by the UK Government and its devolved administrations, and there are now significant policies both to reduce further global warming, and to ensure effective adaptation of existing systems and services.

Figure 1 Storms are likely to become increasingly frequent as a result of climate change.

Climate change of the magnitude suggested above will affect the establishment of greenspace on former brownfield and contaminated land in many ways. It is thus vital that those planning or executing the regeneration[1] of land for green infrastructure take climate change into account. The consequences of not doing so could be harmful to human and ecosystem health, or costly (e.g. if engineered structures need repair). This BPG Note summarises important aspects of a changing climate on regeneration practice and suggests processes and mechanisms that can be used to ensure that climate change is factored into operational activities.

Climate impacts on reclamation technologies

Climate is already taken into account during the planning of a range of brownfield solutions. The Source–Pathway–Receptor model is at the heart of decision-making regarding the treatment and management of contaminated land and it continues to form a good basis for considering future climate across the breadth of brownfield site types. The Environment Agency (2010) provides the most up-to-date guidance on the regulatory regime concerning land regeneration. It includes specific information on climate change issues too. Reference to this report is highly recommended.

Managing rainfall is an important consideration for all sites, and design of surface water features should take into account the certainty of above-average (e.g. 1 in 30 year[2]) rainfall events. It is also vital that projections of future rainfall regimes be considered (DCLG, 2012). Flooding can create new receptors for pollutants and so flood risk assessments are usually required as part of brownfield development.[3] For sites that have already undergone development, a flood plan should be prepared if there is a risk of pollution, and flood

[1] The term **regeneration** comprises **reclamation** (ground engineering works undertaken for the provision of a growing medium) and **aftercare** (the treatment of the reclaimed land in order to grow vegetation). It also includes **remediation** (the clean-up of contamination where necessary).

[2] See, for example, the range of flood return periods in Table 6.1 of www.standardsforhighways.co.uk/dmrb/vol4/section2/ha10704.pdf.

[3] A site-specific flood risk assessment is required for development proposals of 1 hectare or greater in Flood Zone 1; all proposals for new development in Flood Zones 2 and 3, or in an area within Flood Zone 1 which has critical drainage problems (as notified to the local planning authority by the Environment Agency); and where proposed development or a change of use to a more vulnerable class may be subject to other sources of flooding (from DCLG, 2012).

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AJ Moffat & ASSOCIATES

protection measures such as berms should be considered. Likely reduction in summer rainfall can be mitigated by capture and storage of excess winter rainfall in ponds and lagoons on site for recirculation and irrigation during the summer.

On landfills and other sites where contaminants are contained through the use of an engineered cover system (often made of compact clay), increased drought in the future may threaten cap integrity if it induces desiccation cracking (Al-Tabbaa *et al*., 2007). Such cracks may lead to the release of contaminant-laden leachate and increase the risk of leakage of methane and other gases, especially through 'barometric pumping' when atmospheric pressure is low. Indeed, the lowest pressure for 127 years was recorded in Scotland in 2014 and low pressure systems are expected to become more common in the future. Higher temperatures may also increase the risk of volatilisation of some organic contaminants and mercury. Hence, regeneration will need to plan for these possibilities through enhanced cover design and adequate soil cover to prevent desiccation where a mineral cap is employed.

Figure 2 Soil cracking and mortality in trees planted on clay soils subject to drought.

Brownfield remediation and reclamation are processes that generate atmospheric carbon dioxide and thus contribute to climate change. Some technologies, such as 'dig and haul', use very large amounts of fossil fuel. Techniques such as life cycle analysis can be used to inform on choice of technology. The overall environmental sustainability of land regeneration is an increasingly important consideration (Bardos *et al*., 2011), and in the face of large financial and carbon costs some techniques may be increasingly unacceptable.

Provision of an adequate quantity of soil or soil-forming material (see BPG Note 5) to sustain plant water needs during summer months is an important aspect of land reclamation. Climate projections suggest that many areas in Britain will experience a reduction in summer rainfall so vegetation will be increasingly reliant on moisture stored in the soil. For landfill sites, the Forestry Commission has recommended a minimum rootable soil thickness of 1.5 m (see BPG Note 5). It is also recommended that this should be reviewed in areas of current or projected low summer rainfall and according to the nature of the soil cover, including for example soil texture and stoniness. Clay soils, in particular, can be prone to cracking and drought (Figure 2). Choice of vegetation should be made after soil provision has been finalised, and modified according to expected moisture supply (Moffat, 2011). It is important to remember that annual and summer rainfall amounts can vary considerably from year to year so calculations should err on the side of caution.

Predicted increases in the amount of winter rainfall and the number of rainy days over much of the western part of Britain mean that days when soil materials can be stripped, stored or replaced will be reduced. In some regions this will seriously compromise quality reclamation unless the delivery timetable can be extended to accommodate this constraint. Likewise, prospects for effective cultivation, for example using winged tines to alleviate soil compaction (see BPG Note 19), may be reduced to zero in some years. This reinforces the need for best practice in soil handling and placement, and the need to keep vehicle movements to a minimum after placement to reduce the risk of soil compaction.

Climate impacts on aftercare

Climate projections should be used to explore likely temperature and rainfall conditions that the regenerated site will experience. Choice of vegetation should take account of future as well as current climate as far as possible. For trees, Forest Research's Ecological Site Classification (ESC) decision support tool (see Useful links section) uses climate projections to suggest suitable species depending on location. The Right Trees for Changing Climate Database (see Useful links section) can also be used to investigate species choice, especially for urban areas, and BPG Note 20 provides guidance on selecting drought-tolerant tree species for land regeneration. Given the uncertainty associated with future climates, it is important to select as wide a range as possible in plant species suited to the target future land use to build resilience in the chosen vegetation type. Use of species diversity is important in new greenspace projects, though it adds complexity to planning, planting and maintenance, and may cost more than using restricted species mixtures.

The type of greenspace to be created and its constituent vegetation species should also be considered more critically for the benefits it is expected to provide, now and in the future under a new climate. In towns and cities, green infrastructure is expected to play increasingly important roles in providing shade and cooling, but these services will require forward planning, for example with choice of tree species that reach appropriate heights. Greenspace on reclaimed brownfield land is expected to be increasingly valued for recreational opportunities during hot weather, given the proximity of many of these sites to centres of population. Provision of temporary or permanent water storage features in these circumstances can also significantly improve amenity value (Figure 3), and may serve in sustainable drainage systems (SuDS, see Useful links section).

Climate change is likely to significantly affect current communities of fauna and flora and the overall biodiversity that a reclaimed site can sustain. Indeed, such is the expected rate of climate change in the next few decades that it will be necessary to reconsider these concepts and their relevance for reclamation practice. Habitat for wildlife will remain one of several services that greenspace on reclaimed brownfield land can provide, though it is currently difficult to predict or plan for the type of wildlife community that will eventually occur. The 'right plant, right place' and diversity principles help us understand the need to match species to soil, site and future climate rather than to seek to plant vegetation (e.g. of native species) that may struggle under these conditions. Using suitable plants will maximise the chance of vegetation survival, growth and consequent support for wildlife. Nevertheless, greenspace managers should be prepared for the likelihood that vegetation will continue to change, reflecting the nature of the changing climate at the site. A flexible approach will be necessary.

Figure 3 Lakes can add to the amenity value of reclamation sites as well as helping to regulate flooding.

Greenspace management

In addition to progressive changes in climate (e.g. in annual temperature and rainfall) extreme climatic events such as flooding are likely to become more common. For sites with no risk of chemical contamination, flooding may be planned for as part of a SuDS scheme, as mentioned above. However, vegetation will need to be able to tolerate temporary waterlogging and anaerobic soil conditions. In contrast, likely reductions in future summer rainfall should encourage the selection of drought-tolerant or deeply rooting species, or both. Irrigation is likely to become more commonplace for establishing green infrastructure, including street trees. 'Grey' water sources, such as run-off from hard infrastructure, should be used for this purpose wherever possible.

The possibility of wildfire is also likely to be of increasing importance in greenspace management, especially where the vegetation is informal and supported by woody shrubs and trees. Wildfires are now commonplace at the urban/rural interface and are predicted to increase with the hotter and drier conditions expected in future decades. On medium and large sized sites, wildfire risk should be considered and management planning put in place to reduce risk.

Contingency plans should also be prepared for when climatically caused emergencies do take place, whether from wildfire, storm damage or flooding. It is difficult to predict when such events will take place but, as it is reasonably certain that they will happen, it is important to be prepared.

Conclusions

Overall, while there is still considerable uncertainty about the nature of the future climate it is evident that we need to take it into account now when designing and implementing brownfield regeneration projects. This may increase project cost and complexity, but not to do so could result in danger to human health, delivery failure, expensive repair and litigation. Guidance from appropriate professional companies, institutions or consultancies is recommended for anyone considering how to climate-proof a brownfield site during its redevelopment.

References

Al-Tabbaa, A., Smith, S.E., Duru, U.E., Iyengar, S.R., De Munck, C., Moffat, A.J., Hutchings, T.R., Dixon, T., Doak, J., Garvin, S.L., Ridal, J., Raco, M. and Henderson, S. (2007). *Climate change, pollutant linkage and brownfield regeneration.* CL:AIRE subr:im bulletin SUB 3. Available from: www.claire.co.uk/index.hp?option=com_phocadownload&view=category&download=30:subrimbulletin03&id=15:subr-im-bulletins

Bardos, P., Bone, B., Boyle, R., Ellis, D., Evans, F., Harries, N.D. and Smith, J.W.N. (2011). Applying sustainable development principles to contaminated land management using the SuRF-UK framework. *Remediation Journal* 21, 77–100.

DCLG (2012). *National Planning Policy Framework*. Available from: www.gov.uk/government/uploads/system/uploads/attachment_data/file/6077/2116950.pdf

Environment Agency (2010). *GPLC2 – FAQs, technical information, detailed advice and references.* Available from: www.gov.uk/government/uploads/system/uploads/attachment_data/file/297454/geho1109brgz-e-e.pdf

Jenkins, G.J., Perry, M.C. and Prior, M.J. (2008). *The climate of the United Kingdom and recent trends.* Met Office Hadley Centre, Exeter. Available from: www.ukcip.org.uk/wordpress/wp-content/PDFs/UKCP09_Trends.pdf

Moffat, A.J. (2011). Restoration for a changing climate. *Mineral Planning* 136, 6.

Useful links

Best Practice Guidance (BPG) Notes for Land Regeneration
www.forestry.gov.uk/fr/bpgn

Forest Research's Ecological Site Classification (ESC) decision support tool
www.forestdss.org.uk/geoforestdss/esc4.jsp

susdrain (information on SuDS)
www.susdrain.org

The Right Trees for Changing Climate Database
www.righttrees4cc.org.uk

UK Climate Projections – UKCP09
http://ukclimateprojections.metoffice.gov.uk

FR(JD-KD)/GG-PDF/Dec15/0055

The Land Regeneration and Urban Greenspace Research Group
Forest Research, Alice Holt Lodge, Farnham, Surrey GU10 4LH
Phone: +44 (0) 1420 22255 Fax: +44 (0) 1420 520180
www.forestry.gov.uk/forestresearch

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