EcoServ-GIS v3.3

Technical Report: “Education and Knowledge Service”

1. Ecosystem Service Definition and Description

Short definition:

Opportunities for young students to develop skills and learn within the natural environment.

Long definition:

Opportunities for young students to develop skills and learn within the natural environment. Greenspace and semi-natural sites provide the opportunity for education benefits. Sites with a greater variety of broad habitats have greater capacity, as these provide more opportunities for gaining knowledge from the natural environment. Demand is mapped based on an assessment of education deprivation scores, population density and the distance to local schools.

Descriptive map text:

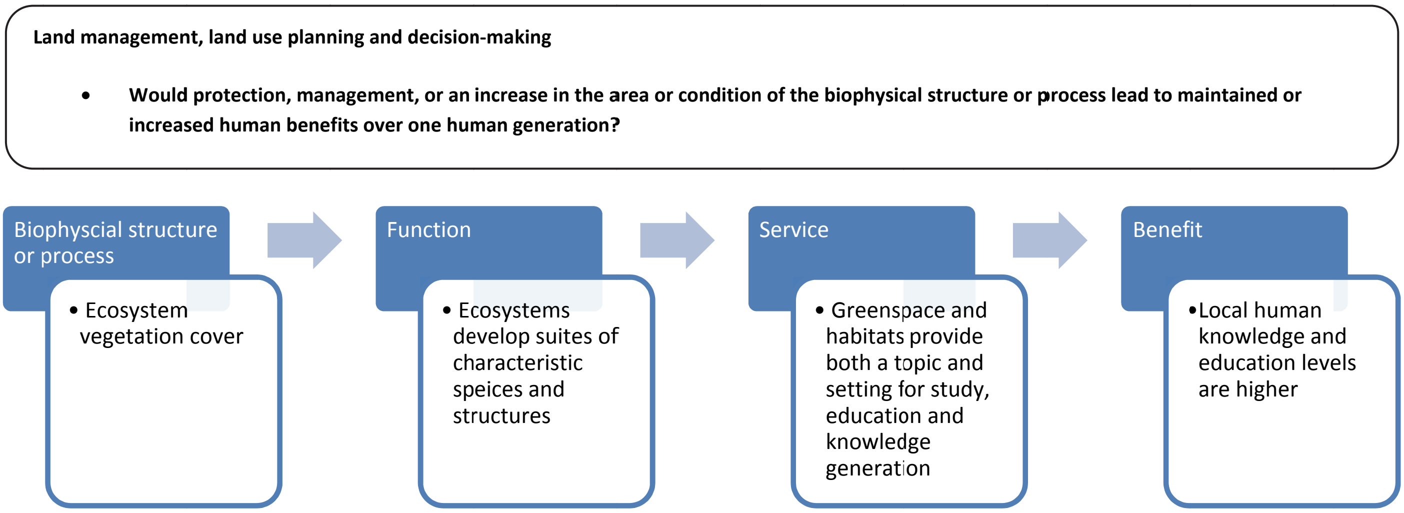
Greenspace and semi-natural habitats provide direct opportunities for education and study via activities such as pond-dipping, botanical surveys, or butterfly transects. Additionally, habitats can provide a location for more general outdoor learning experiences. Areas with more young people, where education levels are currently lower, and that are closer to schools have greater demand for such benefits.

Service benefits description

People may benefit from this service where school activities, or informal learning, occur in a natural environment setting, such as where lessons or activities are conducted outdoors within school grounds, in nearby greenspaces or following visits to reach local nature reserves. The links between the composition and status of the natural environment and the positive impacts on local people's health is likely to be strongest when such activities are frequent and regular. The benefits of existing greenspace and natural habitats, or of increased future cover are assumed to be higher where the levels of educational attainment are currently low, where larger numbers of young people live near to greenspaces, and in areas closer to schools.

2. Service Cascade

As this toolkit is aimed at a county to regional scale the focus of land management and decision making is local. A timescale of one human generation is set within which to consider, assess or measure the impacts of land use planning decisions and management. This is logical in relation to the long-term planning decisions of local authorities, health boards and large infrastructure projects.



3. Literature review

The natural environment provides people with valuable opportunities to gain knowledge and practical skills. This may be informally through play (Fjùrtoft et al. 2000; Browning et al. 2013), or walks, via education events (Kimble 2014) or hobbies outside of school, via promoted or designed "nature trails" (Zimmerman & McClain 2014), via participation in citizen science (Davies et al. 2011), or from formal education within school time, or at residential education centres (Humberstone & Stan 2012; Collado et al. 2013). In addition, although reviewers have noted it is an under-researched area, a recent review of the links between the environment and development in young childhood noted that access and use of greenspaces may be important for children's cognitive and motor development (Christian et al. 2015). Research in school students has found that higher connectedness to nature related to more holistic and innovative cognitive styles (Leong et al. 2014).

The education opportunities provided by the environment can be gained at any stage of life, but there is suggestion that early childhood experience of access to nature though e.g. play in woodland, can impact the use or likelihood of use of such areas later in life (Milligan & Bingley 2007). Additionally there is concern that reduced access to the outdoors and environmental experiences could impact on children's development and learning styles (Barratt Hacking et al. 2007).

The notion that humans have a propensity for, and benefit from, connection to nature has been proposed (Wilson 1984; Kahn 1997). Recently the potential adverse affects of lack of such nature contact amongst children has been discussed via a potential "Nature Deficit Disorder" (Louv 2010), and this has often gained media and organisation attention (Moss & Young 2012). There is a relative lack of academic research directly examining this area. Research however has shown an association between exposure to the natural environment in children and attitudes to biodiversity and the natural world. Direct contact with nature can increase children's affinity with the natural world and affect later behaviour, such as intentions to further visit natural areas (Collado et al. 2013). Contact with nature in school children has been found to be positively associated with biophilia attitudes to wild species (W. Zhang et al. 2014). The direction of causality is unclear. Exposure to the natural world could lead to greater interest and appreciation, or vice versa. An interesting recent study of the broader psychological benefits of connection to nature found that those "individuals who were more emotionally attuned to natural beauty (i.e., those who perceive nature's beauty) appear to reap the most positive benefits from being connected with nature" (J. W. Zhang, Howell, et al. 2014). Although this is an area of active research it appears that exposure to nature via educational visits has potential to prime behaviours and experience for later life. This may be of increased importance given the concern that informal or recreation based access to nature is declining, for example with increased uptake of other activities or recreation (Pergams & Zaradic 2006).

Informal opportunities for knowledge generation or education occur where local neighbourhoods or nearby parks or greenspaces hold examples of habitats, ecosystems, or component species that might inspire thought, consideration or attention. In developing easily understandable guidance for enhancing wellbeing as part of the foresight project the New Economics Foundation (NEF) produced a report that suggested building the following five actions into our day to day lives: *connect*, *be active*, *take notice*, *keep learning*, and *give* (Aked et al. 2008). Research suggested these are associated with improved well-being, of these *take notice* and *keep learning* have significant potential to be influenced by opportunities in the local environment. Observing the impact of the changing seasons on habitats, viewing migrating wildlife, the opportunity to see and learn about different habitat types, or forms of historical land management all occur during visits to parks or neighbourhood local nature reserves. Many such reserves include display panels or provide leaflets on the history, management or species present within the site, offering learning experiences, whilst guided walks may also be available.

There is a clear interest from sections of the public for participation in collective knowledge generation or biological recording around the natural environment. This can be seen with the success of the Wildlife Trusts' Watch groups, and the RSPB garden and school bird watching initiatives, which involve hundreds of thousands of people each year. Similarly the "citizen science" Open Air Laboratory (OPAL) has worked with over 200,000 people and over 1,000 schools and 1,000 voluntary groups (Davies et al. 2011).

The formal school environment presents many opportunities to incorporate the benefits of nature in learning. Recent reviews have reported benefits to school learning activities in the natural environment, including: increased awareness of environmental issues and natural science skills which may lead to the children adopting more sustainable and environmentally friendly behaviour now and in later life, greater motivation for studying science, improved educational attainment in a range of subjects, improved health and attention levels, better relationships between children, increased reported levels of self-efficacy and self-worth, motivation of otherwise apathetic children, and can help enforce school communities (KCL 2011; Rickinson et al. 2004). Outdoor activities and "fieldwork" can be particularly memorable to students and therefore help with learning and retention of facts (Rickinson et al. 2004). A review for Natural England highlighted several issues relevant to learning outside the classroom in natural environments (KCL 2010). These included that barriers exist to the effective delivery of learning in natural environments, there is a lack of a coordinated approach from the natural environment sector to working with schools at a local level, schools face a fear of accidents, the cost of trips or visits and teachers' confidence in using natural environments. The review recommended that schools be provided with a rationale for the benefits of learning in the natural environment, that staff should be given adequate support and that practices should be developed with providers that reflect local needs and opportunities (KCL 2010).

The exact benefits of the natural environment to learning and education in a formal school setting can be explored further. Reviews indicate that student's and pupil's education are impacted by the classroom and campus environment, both built and natural (Zandvliet 2014). The different situations where the benefits can occur are therefore: the school classroom, school grounds, visits to nearby areas, and residential education centres. In terms of frequency of occurrence, and therefore in likely strength of impact, these decline in this order.

Nature can be brought into the classroom as a topic for learning, but it can also be physically brought into class where specimens, species or vegetation are available from nearby sites for study. Research also indicates that classroom physical and environmental conditions can influence pupil education attainment levels (Barrett et al.

2015), and that students performance can be related to levels of nature exposure from school classroom and cafeteria windows, even after accounting for confounding variables between schools and student composition (Matsuoka 2010).

The presence of nature, habitats and vegetation within school grounds can also be important for education. Woodland, wildflower meadows and ponds offer obvious opportunities for learning about habitat and species identification, when available within school grounds. However, such habitats, if easily accessible to students, also offer opportunities for interaction with nature during free time, breaks or in lunch hour. Such interaction may then have benefits to educational outcomes at other times of the day. Research has shown that the volume of vegetation in school grounds can significantly influence the perceived restorativeness of play by students (Bagot et al. 2015). This impact of such stress reduction may then have a number of positive influences linked to behaviour, attention and learning, even some time after the exposure to nature. These further benefits are in common with those experienced from short trips to nearby sites, discussed below. Interestingly school ground vegetation composition can also relate to children's activity levels, during which such benefits can occur. In America a study has shown that presence of trees in schools grounds was positively correlated with amount of time allocated for recreation during school breaks (Arbogast et al. 2009).

Access to nature at nearby greenspace sites, nature reserves or country parks can be used by schools to provide education opportunities not otherwise available within school. Such trips may be by foot or via short coach journeys. The availability of access to habitats such as woodland, rivers or meadows allows practical examples of such areas to be seen and experienced by students rather than learning through verbal lessons or media presentations. In examining different biodiversity learning environments in London a nature reserve visit was associated with considerable motivation experience for the children and allowed students to show a range of skills such as in species identification (Kimble 2014). The benefits of active learning in outdoor environments, and also the after effects of such exposure are becoming more fully appreciated. Research indicates that exposure to the natural environment can be beneficial for mental health and cognition (Bratman et al. 2015), thus fostering a positive learning environment. Some of these benefits are exemplified by the "Forest School" movement. These activities involve learning experiences centred around school woodlands or after short visits to nearby woodland sites, and have been reported to have positive impacts on education and behaviour, especially for some learning styles or personalities (O'Brien & Murray 2007). Research from a small cohort of Scottish school pupils showed that a Forest School (outdoor) environment was more restorative compared to indoor classroom settings (Roe & Aspinall 2011), additionally those students with the poorest behaviour initially were seen to benefit the most from the Forest Schools experience. This finding follows work that the use of natural settings for education activities can help to manage the behaviour of difficult children (Roe & Aspinall 2011). Interestingly, some of the associated activities occurring on school visits may also have positive impacts on children, that may impact educational attainment. For example the act of walking itself, in groups and away from normal environmental settings can be therapeutic and can help with socialising compared to walking in day to day or urban settings (Doughty 2013). Exposure to nature can also impact behavioural attitudes such as pro-sociability (J. W. Zhang, Piff, et al. 2014), which have potential to impact on teamwork activity and learning behaviour when in an education setting. Similarly access to nature can also have a positive influence on creativity (Plambech & Bosch 2015), which may be important for knowledge building or certain education projects.

Taken together, the body of work regarding formal education settings, indicates some interesting links between the natural environment and education and knowledge generation. It is difficult to quantify the exact benefits but due to the influence of access to the natural environment on attention, learning, memory and stress reduction that there are positive uses to be made of outdoor learning experiences, both formally by schools, and informally, where they occur in the immediate living environment. Several studies indicate that such benefits may be highest for those students with currently lower attainment levels, for example due to stress, attention deficit or anger issues. Additionally interesting research suggests that lower quality school built environments, e.g. with poor natural light and poor building stock could also benefit from access to good quality outdoor environments, at least during times of favourable outdoor climate conditions. Therefore the benefits experienced are unlikely to be the same for different schools, school populations, or pupils, for example varying with socioeconomic group or age.

Outside of a formal education setting, there are also a number of studies which suggest how access to nature and the use of outdoor spaces may affect childhood cognitive development and mental health (Christian et al. 2015), factors which in turn might be expected to impact on educational attainment and knowledge in later life. There are therefore further indirect links between the natural environment and education. A recent cohort study in England found that poorer children (age: 3 to 5) in neighbourhoods with a higher cover of greenspace had fewer emotional problems, compared to less green neighbourhoods (Flouri et al. 2014). Research in rural America found that access to nearby nature or natural features was associated with the moderation of stressful life events in children (Wells & Evans 2003).

In summary, although a number of positive benefits to education and knowledge generation of the natural environment have been presented, there appears a surprising lack of research in this area compared to the levels of research, for example of childhood exposure to different levels of environmental pollution and the resultant health and learning impacts. Further work is required on: levels of greenspace or habitat diversity required to give the benefits of contact with nature during outdoor learning, the most effective frequency or length of visits, and any effects of age, group size or the extent of adult direction or active student participation in the event activity, on the benefits received. Long-term studies are required to assess the longevity of the positive impacts. Although the focus here is on the use of the natural environment for education, the positive impact of community gardens for environmental education has also been highlighted in the literature (Bendt et al. 2013), whilst studies have noted the benefit of green areas within school ground as also contributing to local ecological networks (Iojă et al. 2014).

Few directly comparable mapping studies of the education ecosystem service were found during the review. However interesting work in the East Midlands, under the public benefits mapping system developed an education score based on the number of local schools and the index of deprivation education score (East Midlands Regional Assembly & Partners 2006b).

Several insights from the following research were used to help construct the current GIS model:

Capacity

- A study in Norway illustrated that different habitat types were used differently for play by children in a natural setting (Fjùrtoft et al. 2000), illustrating that more diverse sites might offer more capacity for play experience and the knowledge and education benefits that derive from these.
- An American study of young adults examined access to the natural environment (urban greenspace) compared to urban street environments (via a 50 min walk) led to improvements in mental health such as decreased anxiety, maintenance of positive affects and increased cognitive ability, such as attention span (Bratman et al. 2015). This shows the positive impacts of access to nature, although the authors noted the relationship was stronger for the stress reduction mental health benefits, and there was more mixed evidence for the cognitive benefits.
- A study in Michigan, America found that measures of students performance were related to levels of nature exposure from school classroom and cafeteria windows, even after accounting for confounding variables between schools and student composition (Matsuoka 2010).
- Forest School learning experiences centred around school woodlands or after short visits to nearby woodland sites, have been reported to have positive impacts on education and behaviour, especially for some learning styles or personalities (O'Brien & Murray 2007).

- School grounds and playgrounds can help provide a restorative setting for pupils and research has shown that the volume of vegetation in grounds can significantly influence the perceived restorativeness of play (Bagot et al. 2015).
- The conditions within primary school classrooms can influence pupil education attainment levels (Barrett et al. 2015). Significant positive features were natural light, air quality / ventilation and stimulation levels (colour, complexity) of the room. The environment factors of light and air quality accounted for over 50% of the impact on learning. This can be taken as evidence that the environmental setting of learning is important and by extension that education in positive outdoor setting could lead to positive education benefits, perhaps especially in areas where the school classroom has poor environmental quality, that could be hampering educational attainment.

Demand

- A wide range of support exists for the positive benefits of learning in natural environment settings but often these have not yet been effectively presented to decision makers (KCL 2011).
- Research from a small cohort of Scottish school pupils showed that a Forest School (outdoor) environment was more restorative compared to indoor classroom settings (Roe & Aspinall 2011), additionally those students with the poorest behaviour initially were seen to benefit the most from the forest schools experience.
- School location and multiple index of deprivation scores can be used to indicate demand for education benefits (East Midlands Regional Assembly & Partners 2006a).
- In a review of the links between the environment and development in young childhood a recent review noted that greenspaces may be important for children's cognitive and motor development, for example when comparing between neighbourhood or local landscape availability of natural play space (Christian et al. 2015).
- There is some indication that the impact of exposure to nature on children may influence behaviour more in urban than rural areas (Collado et al. 2015), suggesting demand increases with urbanisation.

4. Summary of constructing the GIS mapping service model

Sufficient information was available in the literature and sufficient detailed GIS data was available to build a logic based model of the service, however a number of approximations and assumptions had to be made. The following insights from the literature were used to build the models:

Capacity

- Accessible nature (greenspace, habitat, parks, school grounds) can be used for direct study, or as a location or setting for outdoor learning experiences.
- A more diverse local neighbourhood environment (both built and natural) offers more opportunity to learn and take notice, compared to more uniform local environment.
- Presence of greenspace and natural vegetation within school grounds may have particular benefits, especially where visible to students from within classrooms, or where accessible for use during play time.
- In the absence of strong guidance from the literature, number of broad habitats can be used as a proxy for site capacity. Site naturalness or site size could be alternative indicators of capacity.

Demand

- Education and knowledge generation can be formal e.g. through schools, or more informally through general observation and experience in the natural environment, or via nature trails and walks.
- Use and exposure to the natural environment by children, e.g. via education visits, may help prime them for the positive benefits of use, later in life.
- Use of the outdoor and natural environment for education activities can have positive benefit to people, these may last beyond the site visit itself, and these may be more important for certain groups of society.

- Beneficial sub groups include those with behavioural issues impacting on learning, those who tend to have less access to, or who use greenspace less, such as lower socio economic groups. However much additional research is required in this area.
- Cost and fear of accidents may deter schools from undertaking visits to the natural environment.
- Distance to greenspace and semi-natural sites from schools may be considered a suitable correlate for cost of access and frequency of use for formal school education visits.
- Number of young people (<15) can be used as a proxy for the population with highest demand.
- Socioeconomic groups (e.g. IMD / SIMD) can be used to indicate those groups who have highest demand.

Service Flow / benefits

- A more coordinated approach is required from the environmental sector on working with schools and illustrating the many benefits of access to nature.

Capacity

To map capacity, areas of the natural environment are assumed to provide the opportunity to learn and gain skills. Areas of the BaseMap which are unclassified or uncertain are excluded. Arable land, and roads and rail verges are also excluded. All remaining habitat types are assumed to provide equal opportunities for education. Research suggests that sites with a variety of habitat types are better for play experience (Fjùrtoft et al. 2000). Diverse sites with more habitat types are logically considered to offer more opportunities for education than less diverse sites. Sites are therefore graded according to the variety of habitat types within an area that would be typically expected to be covered by a short local walk within the site (default 300 m). The greater the variety, the greater the capacity to provide education. A threshold is applied in order to aid the differentiation of sites, only areas with two or more habitat types within the search distance are considered to have capacity. Education is a service which occurs in situ; to gain knowledge from nature, children must be able to access a site. As such, capacity does not extend beyond the perimeter of accessible sites. A threshold is applied to identify sites which may be too small to support site visits or any level of education benefit use (default 1 ha).

Both restricted and unrestricted capacity areas are identified. Accessible areas are mapped in relation to a range of data sources used to identify legally accessible (England and Wales) or those sites more likely to be used (Scotland). The following data sources were used:

- 20 m either side of a Public Right of Way or Core Path, or pavement, or Sustrans National Cycle Network.
- Areas with Countryside Rights of Way access (England and Wales).
- Beaches and a 100 m swim distance from these.
- Local Nature Reserves and National Nature Reserves.
- Playgrounds, general amenity greenspace, cemeteries, parks and public gardens.
- Accessible woodlands (“Woodlands for People”) mapped by the Woodland Trust.

Demand

This model takes into account two broad areas: the need for green education sites for educational institutions and the need for green education sites for children to learn informally as part of their everyday lives. Indicators have been selected and weighted to reflect insights from the literature, but users can alter the weighting for example if only formal education use, or informal community use were of more interest.

The main indicators selected for use were:

- Number of young people in the local population (default <15).

- Education scores of the local population (IMD / SIMD).
- Travel distance from schools (buffer, Euclidean) (relative to a maximum travel distance, default 8 km).

These indicators are created as follows. The number of young people is calculated based on first calculating the local population size from the "House-pop" field in the "Popsocioec" point dataset created by the BaseMap models. The local population size is then multiplied by data representing the proportion of the local population that is under a certain age. The default is under 15, "unprop15" field in the "Popsocioec" point data. Other age ranges can also be analysed. The education scores are calculated from the relevant score in the Index of Multiple Deprivation (IMD / SIMD). Travel distance is based on the minimum Euclidean distance to the nearest school from the OSEducationFacilities dataset created by the BaseMaps. The score is inverted so that high scores represent the nearest distances. The scores are calculated based on a maximum travel distance. Therefore the travel distance scores have greater impact at the region and landscape, rather than local scales (see below for explanation of scales analysis). For each indicator type higher scores are representative of higher demand (higher number of young people, higher levels of education deprivation, closer distance to schools).

The overall level of demand is assumed to be higher at short distances closer to where young people live, and to schools. However it is noted that both family trips or school trips can offer significant educational benefits, but that the typical distance and frequency of both will tend to decline with distance from school or home. The analysis is therefore repeated at three spatial scales, and weighted by predicted impact on total demand.

The likelihood of trips occurring at the longer distances is assumed to be linked to the strength of attraction of the destination feature. Therefore at each scale the creation of each indicator analysis is "masked" to only return data for greenspace sites that fall within the following site-scale thresholds:

- Local scale greenspace sites - default > 1 ha.
- Landscape scale greenspace sites - default > 10 ha.
- Region scale greenspace sites - default > 100 ha.

At each of the three scales: local, landscape and region, the indicators are first combined to create a single scale-specific score. The scores are given equal weight, although this can be altered by users. Indicators cannot be given a weight of 0.

The scores from the three scales are then combined to give a final score to each area of greenspace. This assumes that the value of the site at different scales is cumulative. If a site scores highly at both local and landscape scales it shows more demand than a site with just local high scores. This reflects its importance for local education use but also that it has a value for users who may travel there from more distant areas. In combining the three spatial scales more importance is given to local scores. The spatial scale weights can be altered by users. These weights can include 0, which would remove one of the spatial scales from the analysis, for example where only local scale or regional scale analysis was of interest. The default weight can be altered by users.

- Local scale (default 600 m) Importance weighting = 0.5.
- Landscape scale (default 3 km) Importance weighting = 0.4.
- Region scale (default 8 km) Importance weighting = 0.1.

The default settings have been informed following examination of the literature and are intended to reflect the decreasing likelihood to travel to more distant sites but the greater attraction of larger greenspace sites. Because frequency of visits is assumed to be important for this service local sites have been given a higher importance weighting.

5. Spatial occurrence and service flows

This service is provided by areas of natural or semi-natural habitat or greenspace. The flow of the service is in-situ. The benefits are experienced therefore where people are present within an area of greenspace. The model separately analyses all areas, and also those areas more likely to be used or accessed by the public .

6. Ideal Data

The ideal data with which to map the service would be locally collected site measurements, at a relevant local spatial scale, compared to reference measures at a national scale. Data would be recently collected and updated regularly. Scientific research would be available which measures the impact of marginal changes in the extent, composition or condition of the natural capital asset on the level of the service delivered to people, and the benefits experienced. There would be detailed data on the number per socio-economic category, age or other suitable classification category of people who could benefit from the service, along with research on how changes in these social characteristics alter their relative levels of service demand over time. Finally there would be data on how levels of human use impact ecosystem condition.

In order to reliably map the Education service the following information would be required:

Capacity

- The type, location, extent, condition, quality and management status of greenspace and semi-natural areas.
- The education and knowledge capacity of particular habitat types and sites.

Demand

- The number of people who visit each site, for how long and with what frequency.
- The age, socio economic group and education status of the visitors.
- The number of school visits made to each site, frequency and duration of visits.

Service Flows and benefits

- The long term education and knowledge generation levels in the local population compared to the levels that would be expected in other similar areas without vegetation cover or available greenspace.

7. Proxies for ideal data

In the absence of the full range of ideal data to map the service, assumptions have been made, and additionally proxies have been used to represent selected elements of the ideal set of data.

Capacity

- The type, location, extent, condition, quality and management status of greenspace.
    - Type, location, extent: BaseMap: A combination of local data and several (optional) national datasets including: priority BAP habitats, LCM 2007, local and national nature reserves, combined with Local Authority Open Space Survey / Green Infrastructure Survey (or equivalent).
    - Condition, quality and management: No consistent, reliable information.
- The education and knowledge capacity of particular habitat types and / or site areas.
    - Analysis is conducted to examine the diversity of broad habitats. All broad habitats are assumed to have equal potential for education and knowledge generation, but in order to prioritise sites only those areas with a richness >= two are mapped. Analysis examines the richness within a short distance typical of a 5 min walk within a site (default 300 m).

Demand

- The number of people who visit each site, for how long and with what frequency.
  - Number of young people (default < 15) within each spatial scale (local, landscape, region).
- The age, socio economic group and education status of the visitors.
  - The age range is set by the number of young people indicator.
  - Education score (SIMD / IMD) (mean) of people within each spatial scale (local, landscape, region).
- The number of school visits made to each site, frequency and duration of visits.
  - A score represents the inverse distance to the nearest school at each scale (high scores indicate close distance). This is used to represent a combination of likelihood of visitation and frequency of visitation.

Service Flows and benefits

- The long term benefits of the education use of sites compared to education in other similar areas without, or with less, Greenspace.
  - Spatial overlay of capacity and demand is used to indicate potential flow and benefits of the service.
  - Ranking by quintiles is used to identify areas of relative high priority, improvement areas and gaps.

8. Limitations to the model and potential future improvement (where relevant)

Limitation	Impact
Source data	Habitat mapping is often only available at the broadest level. Fine scale variations in population demographics are masked. Education facilities are mapped as a single category, some may be universities, which are not a target of this service model. Education deprivation scores are broad, a narrower focus on particular conditions may be beneficial
Literature	A variety of literature indicates the general education benefits of the natural environment. No literature exists to fully inform the demand visitation distances model.
Mapping rules transferability	Spatial scales and distance categories are indicative and remain largely arbitrary. More detail on likely travel distances and site use would be beneficial.
Study area extent	Very small study areas may not contain education facilities.
Landscape composition	N/A
Buffer zone impacts	N/A
Landscape pattern	N/A
Topography	In rare cases topography will impact on the likelihood of site use for education. e.g. steep slopes being dangerous or inaccessible.

9. Final List of Indicators

Indicators with a suffix of _IndC or _IndD are saved in the Indicators Geodatabase.

Indicator Name	Type	Description
Accessible_IndC	Capacity	Sites likely to be used by the public (Scotland), or legally accessible areas (England, Wales)
AllGESHabVariety_IndC	Capacity	Habitat richness / variety within local search distance (default = 300m)
AllGESHabVariety2_IndC	Capacity	Habitat richness / variety within local search distance (default = 300m) (cut to only Accessible areas)
DistancetoSchools_region_IndD	Demand	Distance to the nearest school (m) - region scale
DistancetoSchools_landscape_IndD	Demand	Distance to the nearest school (m) - landscape scale
DistancetoSchools_local_IndD	Demand	Distance to the nearest school (m) - local scale
EducationScores_Landscape_IndD	Demand	Mean education score from the IMD / SIMD (units as per source data) - Landscape scale
EducationScores_Local_IndD	Demand	Mean education score from the IMD / SIMD (units as per source data) - Local scale
EducationScores_Region_IndD	Demand	Mean education score from the IMD / SIMD (units as per source data) - Region scale
GE_Nat_Sites_IndC	Capacity	Greenspace greater than minimum site threshold, coded by broad

		habitat
GE_Nat_Sites2_IndC	Capacity	Greenspace greater than minimum site threshold, coded by broad habitat (cut to only Accessible areas)
GreenEducationSites_IndC	Capacity	Green education sites greater than minimum site threshold
GreenEducationSites2_IndC	Capacity	Green education sites greater than minimum site threshold (cut to only Accessible areas)
Greenspace_landscape_IndD	Demand	Greenspace sites for demand mapping > landscape site size threshold
Greenspace_local_IndD	Demand	Greenspace sites for demand mapping > local site size threshold
Greenspace_region_IndD	Demand	Greenspace sites for demand mapping > region site size threshold
GS_Education_Scores_Landscape_IndD	Demand	Mean education score from the IMD / SIMD (units as per source data) - Landscape scale (cut to only Accessible areas)
GS_Education_Scores_Local_IndD	Demand	Mean education score from the IMD / SIMD (units as per source data) - Local scale (cut to only Accessible areas)
GS_Education_Scores_Region_IndD	Demand	Mean education score from the IMD / SIMD (units as per source data) - Region scale (cut to only Accessible areas)
GS_NumberYngPeople_Landscape_InD	Demand	Number of Young People (<default age threshold) within landscape scale buffer (cut to only Accessible areas)
GS_NumberYngPeople_local_InD	Demand	Number of Young People (<default age threshold) within local scale buffer (cut to only Accessible areas)
GS_NumberYngPeople_region_InD	Demand	Number of Young People (<default age threshold) within region scale buffer (cut to only Accessible areas)
Min_Distance_Landscape_Schools_Inv_Score_IndD	Demand	Distance to the nearest school - inverse score - landscape buffer scale (1 to 100)
Min_Distance_Local_Schools_Inv_Score_IndD	Demand	Distance to the nearest school - inverse score - local buffer scale (1 to 100)
Min_Distance_Region_Schools_Inv_Score_IndD	Demand	Distance to the nearest school - inverse score - region buffer scale (1 to 100)
NumberYoungPeople_Landscape_IndD	Demand	Number of Young People (<default age threshold) within landscape scale buffer
NumberYoungPeople_Local_IndD	Demand	Number of Young People (<default age threshold) within local scale buffer
NumberYoungPeople_Region_IndD	Demand	Number of Young People (<default age threshold) within region scale buffer
Schools_Landscape_IndD	Demand	Number of schools within the landscape scale buffer
Schools_Local_IndD	Demand	Number of schools within the local scale buffer
Schools_Region_IndD	Demand	Number of schools within the region scale buffer

Detailed GIS Analysis steps

Model: ES1 Education Capacity

Models the availability of semi-natural areas that are suitable for education activities and informal learning. These sites are graded according to the variety of nearby broad habitat types, from which children could learn.

- Defaults are set for cell size and extent, but can be altered by the user.
- Sub models delete all previously run data from Scratch, Outputs, Indicators, Shapefiles geo database and folders (mainly required during model testing rather than the final models).
- Sub model runs to collate all the optional available separate data sources relating to likely site use or accessibility. These are combined to create a single data layer of accessible sites .
- Indicator is created "Accessible_IndC".
- The accessibility indicator is used to clip the BaseMap to create a dataset of accessible areas.
- A sub model runs, using the BaseMap_FINAL data.
- Selected habitats that are unlikely to have education use are removed. These are railways and road verge areas, gardens, arable land and areas of uncertain habitat or that are unclassified.
- Analysis dissolves polygons and identifies mapped "sites", after accounting for small features such as streams or paths that could occur and split polygons.
- The minimum site threshold is applied, GreenEducationSites_IndC is produced (vector polygons).
- A raster dataset representing the broad habitat of each polygon is mapped.
- The GENatSites_IndC is produced (raster).
- Analysis at the selected neighbourhood size (default 300 m) is conducted to return the variety of habitats.
- A threshold for minimum habitat variety is applied (default 2).
- The AllGESHabitatVariety_IndC is produced.
- Extract by mask is applied (default Study Area buffer).
- Values are re-scaled onto a 1 to 100 scale.
- A version of the dataset with No Data replaced by 0 is created.
- Datasets (raster) saved as Education_Capacity and Education_Capacity_0_100.
- A sub model converts the raster data to vector shapefiles. The values are grouped into simplified categories, e.g. 1-10 (10), 10-20 (20), 20-30 (30) etc.
- A sub model conducts similar analysis using the accessible areas of the BaseMap.
- Selected habitats that are unlikely to have education use are removed. These are railways and road verge areas, gardens, arable land and areas of uncertain habitat or that are unclassified.
- Analysis dissolves polygons and identifies mapped "sites", after accounting for small features such as streams or paths that could occur and split polygons.
- The minimum site threshold is applied, GreenEducationSites2_IndC is produced (vector polygon).
- A raster dataset representing the broad habitat of each polygon is mapped.
- The GENatSites2_IndC is produced (raster).
- Analysis at the selected neighbourhood size (default 300 m) is conducted to return the variety of habitats.
- A threshold for minimum habitat variety is applied (default 2).
- The AllGESHabitatVariety2_IndC is produced (raster).
- Extract by mask is applied (default Study Area buffer).
- Values are re-scaled onto a 1 to 100 scale.
- A version of the dataset with No Data replaced by 0 is created.
- Datasets (raster) saved as Education_CapacityUnrestricted and Education_CapacityUnrestricted_0_100.

Model: ES2 Education Demand

Estimates the societal demand for opportunities to access natural areas for education and skill learning. It estimates the likelihood of people travelling to an area from an education establishment as well as the general need for education from the local and landscape scale population based on the number of children.

- Defaults are set for cell size and extent, but can be altered by the user.
- Sub models delete all previously run data from Scratch, Outputs, Indicators, Shapefiles geo database and folders (mainly required during model testing rather than the final models).

- Sub model creates population based indicators.
- Pop socioec points dataset is analysed.
- Field "House pop" is used to create a population dataset.
- Field "unprop15" is used to create a dataset of the proportion of the population under 15.
- Local, landscape and region scale distance fields are used to conduct point statistics (defaults: 600 m, and 3000 m, 8,000 m).
- Thresholds of population are applied (defaults: local >50, landscape >500, region >1,000).
- The population raster data (population density) and the proportion of young people dataset are multiplied to return an estimate of the population density of young people.
- Indicators are saved: NumberYoungPeople_%scale%_IndD.

- Sub model creates school related datasets.
- The numbers of schools present within each landscape scale are saved as indicators. These are no longer used in the model calculations but have been retained as the indicator data may be of interest.
- OS Education Facilities data is buffered by 150m.
- Distance analysis is conducted, with maximum distance set at each of the three analysis scales. These are then re-scaled to 1 - 100 and inverted to create a score where high scores reflect close proximity to schools.
- Indicators are saved: Min distance %scale% schools inv score _IndD.

- Sub model creates education score datasets .
- Pop socioec points dataset is analysed. Field "EducatScor" is used to create a dataset.
- Local, landscape and region scale distance fields are used to conduct point statistics, returning MEAN values (defaults: 600 m, and 3000 m, 8,000 m).
- Data is masked to reflect the areas of population thresholds, so that scores are not used in areas of very sparse population.
- Indicators are saved: Education scores %scale% _IndD.

- Analysis is conducted at each spatial scale to create a composite score from number of young people, education scores and distance to schools. These can be weighted, but the weight to any indicators must be greater than 0.
- The scores for each spatial scale are then summed together to create a single score to represent total demand. At this stage a user defined weighting can be applied. The weighting can include a weight of 0, which would cause one of the spatial scales to be ignored.
- Extract by mask is applied (default Study Area buffer).
- Values are re-scaled onto a 1 to 100 scale.
- Datasets (raster) saved as Education_Demand.
- A sub model converts the raster data to vector shapefiles. The values are grouped into simplified categories, e.g. 1-10 (10), 10-20 (20), 20-30 (30) etc.

Model: ES3EducationFlows

The capacity and demand data are converted to quintiles and overlaid to identify benefitting areas and gaps

<u>The service flow model is the same for each service</u>

- Defaults are set for cell size and extent, but can be altered by the user.
- Sub models delete all previously run data from Scratch, Outputs, Indicators, Shapefiles Geodatabase and folders (mainly required during model testing rather than the final models).
- Sub model takes the separate capacity and demand datasets and produces the following datasets for either the Study Area of the Study Area plus buffer.
    - Capacity quintiles based on area and value.
    - Demand quintiles based on area and value.
    - All areas where there is some level of demand.
    - When the quintiles are calculated for capacity these are only created for areas with Demand > 0.
- The service occurrence, demand and quintiles data are combined to create two sets of benefitting area data:
    - Ecosystem Service Benefiting Areas (ESBA) and gaps.
    - Ecosystem Service Benefiting Areas (ESBA) and gaps - prioritised.
- Ecosystem Service Benefiting Areas occur where Demand > 0 and Capacity > 0.
- Service Gaps occur where Demand > 0 and Capacity = 0.
- The prioritised data are defined by selecting the highest quintile (5) as high demand or high capacity, this allows the following categories to be produced:
    - A1 - Service Benefiting Area - High Demand (Q=5) and High Capacity (Q=5).
    - A2 - Service Benefiting Area - High Demand (Q=5) and Low Capacity (Q=1).
    - A - Service Benefiting Area - other (Demand Q>0<5 and Capacity Q>0).
    - B1 - Service Gap - High Demand (Demand Q=5 and Capacity Q=0).
    - B - Service Gap (Demand Q>0<5 and Capacity Q=0).
    - C1 - Restricted Service - High Demand (Demand (Q=5) and Capacity (Q>0 but restricted).
    - C - Restricted Service - other (Demand (Q>0<5) and Capacity (Q>0 but restricted).
- The ESBA and ESBA - prioritised datasets are each comprised of a single dataset to facilitate their use in later zonal statistics analysis.
- A sub model identifies "GI assets" by masking the service capacity maps to illustrate only those areas where there is a level of demand.
- A sub model exports the raster files to shapefiles. An optional patch area threshold allows small areas to be removed during the conversion process (default shape area > 200 m^2).

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