EcoServ-GIS v3.3

Technical Report: "Green Travel Routes Service"

1. Ecosystem Service Definition and Description

<u>Short definition</u>:

Areas where greenspace and the natural environment provide a safe, relaxing or encouraging travel route option within urban areas

<u>Long definition</u>:

Green travel routes and corridors occur within urban areas where people benefit from a range of positive features of habitats and vegetation cover. Benefits may include: encouraging more frequent active travel behaviour, safer traffic-free routes, calm, relaxing and inspiring locations, and buffer zones away from traffic related pollution. The capacity of the natural environment to provide green travel routes is mapped by assigning perceived naturalness scores to habitats along different types of travel corridors. Societal demand (need) for these routes is identified by mapping the location of key travel destinations or starting points. These include schools, towns centres and train stations. Least cost modelling is used to determine those corridors most connected to the key travel destinations.

<u>Descriptive map text</u>:

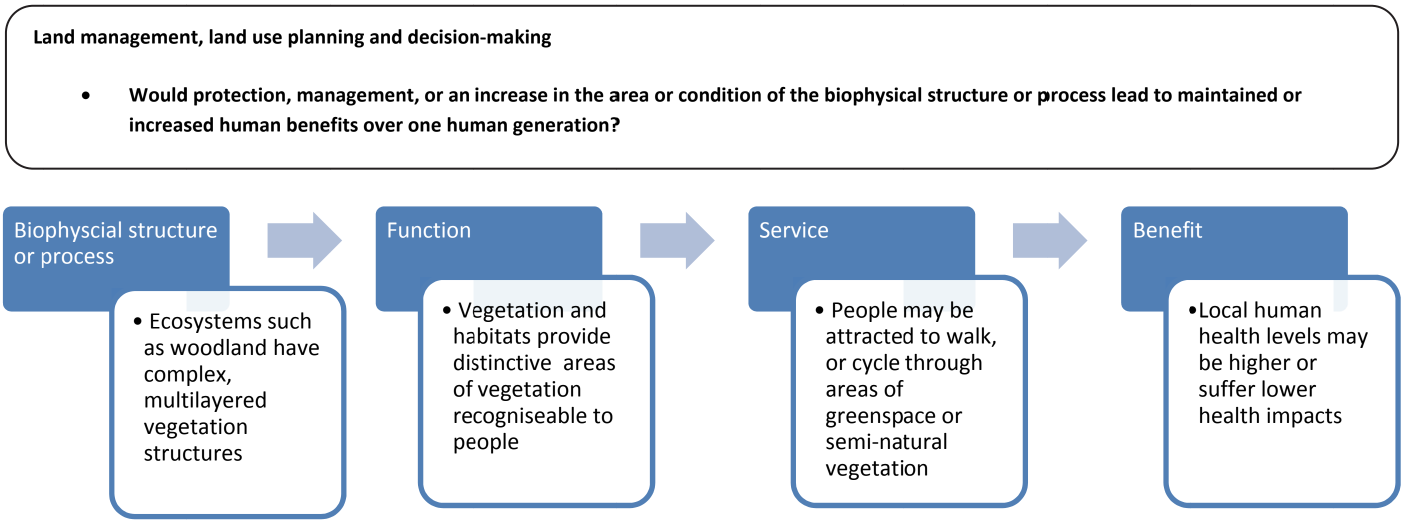
Greenspaces along travel routes help to encourage more active travel use, buffer commuters from traffic pollution and provide a safer, more attractive travel route, compared to road use

<u>Service benefits description</u>

People may benefit from this service where green travel routes occur close to their homes, or along part of their commuting route. The benefits are likely to be higher in situations of frequent use such as commuting to school or work. The link between the composition and status of the natural environment and positive impacts on local people's health is complex, due to the differing potential causal links. Greenspace naturalness, type, patch size and width are all likely to be important. The benefits of existing vegetation cover, or of increased future cover are assumed to be higher where travel routes occur in locations that are most likely to be used frequently by the most people. Because the benefits arise to people using the route, and not necessarily living near to the route, proximity rather than population density is used to indicate demand.

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 (20 to 30 yrs) 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 planning projects.



3. Literature review

Active travel, such as walking or cycling, is beneficial to health. There has been a decrease in physical activity levels over recent decades, e.g. with children more frequently being driven to school than walking or cycling (Mackett 2013). Active travel can potentially allow a large proportion of the population to meet the recommended targets for physical activity (Buehler et al. 2011). Comparison between countries suggests that there would be significant health benefit to people in England and Wales if physical activity increased to levels seen in countries such as Switzerland and the Netherlands (Götschi et al. 2015). Economic analysis has also indicated that there would be benefits to the NHS in England and Wales from increased walking and cycling by people in urban areas (Jarrett et al. 2012). In addition to the emphasis on physical health research also indicates that active travel is significantly associated with mental well-being compared to car travel, walking or driving (Martin et al. 2014).

The Marmot review recommends that action to reduce health inequalities occur across all determinants of health and that this includes a policy objective to “create and develop healthy and sustainable places and communities” (Marmot et al. 2010). These objectives fit well with the scope of green travel route creation.

It is widely acknowledged that policies to encourage further active travel are likely to be positive for community health (De Nazelle et al. 2011). However there may be occasional risk trade-offs, where for example there may be areas with potentially increased exposure to urban pollutants or accidents (De Nazelle et al. 2011). The relative exposure level experienced under different types of commuting are complex. Perhaps in contrast to expectations car commuting exposes commuters to high pollution loads (Karanasiou et al. 2014). This can be considered an argument for the uptake of green travel routes to allow active travel in locations away from roads and vehicles. Research has indicated that green travel routes will benefit from buffer zones between the route and roads, for example of woodland or trees, and that they should be between 5.8 and 14.2 m wide to reduce pollutants (Grange et al. 2014). Many of the health and well-being benefits of greenspace and parks (Forest Research 2010; Greenspace Scotland 2008) would be expected to also occur in green travel routes. Green travel or active travel route use is one of many benefits of areas managed as conservation buffers in the landscape (Bentrup 2008).

The exact relationship between features in the environment such as safe green travel routes and active uptake and use of such features by the local population can be difficult to predict, and may be complicated by for example the occurrence of efficient and easily available public transport systems (Broberg & Sarjala 2015). Relationships may also be more complex in rural areas due to the longer travel distances (Dalton et al. 2011). Therefore in this current work only urban areas are considered. Travel behaviour of British urban residents can differ between traditional urban and suburban neighbourhoods, and is strongly affected by residents attitudes (Aditjandra et al. 2013). Research suggests that creating more walkable local environments may result in higher activity and lower car use (Frank et al. 2007). Targeting behaviour of increased active travel to schools can be effective, and can have other benefits such as reduced CO^2 levels caused by school run transport (Bearman & Singleton 2014). Available studies suggest that often intervention and encouragements may be needed to ensure people undertake active travel choice options (Norwood et al. 2014).

When regular active travel is practised, use levels are likely to be higher where travel distances are shorter. Recent research in England indicates that active travel to school drops rapidly to almost 0% (walking or cycling) when the distance from school approaches 2 to 2.5 km (primary school) and 4 to 4.5 km (secondary schools) (Bearman & Singleton 2014). Mean distances were: walking 0.8 km (primary schools), 1.5 km (secondary schools) and for cycling 1.05 km (primary schools) and 2.08 km (secondary schools) (Bearman & Singleton 2014).

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

Capacity

- The design or characteristics of local neighbourhood environment can encourage more active use, although use levels are also be impacted by socioeconomic conditions and community characteristics (Aditjandra et al. 2013; Frank et al. 2007).

Demand

- Studies have used least cost analysis to examine connectivity and use of greenspaces (Moseley et al. 2013).
- Children who have freedom to play outdoors and undertake active travel undertake more physical activity than those who do not (Schoeppe et al. 2013).
- Benefits of active travel in children are not just limited to school travel destinations (Smith et al. 2012).
- Much active travel use is over relatively short distances of 1 to 2 km (Bearman & Singleton 2014).
- Commuting to school is a significant opportunity for active travel (Bearman & Singleton 2014).

Flow / Benefits

- Although green travel routes may be associated with various benefits the main benefits to people are likely to be due to increased physical activity levels in areas where such routes are used frequently.

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 large number of approximations and assumptions had to be made.

The main literature inspired rules used to build the models were:

- Green Travel Routes provide many benefits to people, the most important of which are likely to be increased physical exercise although many other linked positive benefits can occur.
- Little literature exists on which to assess capacity for this service, therefore an assumption is made that more natural and wider or larger areas of greenspace along travel routes will be more attractive to use by people.
- The service is more relevant to urban areas.

- The service will occur most where people undertaken frequent regular journeys such as commuting to work, school or into town centres.

Capacity is mapped by identifying potential travel routes (pavements, paths, cycle routes) and creating a route corridor map linking these. Analysis is carried out to select the longer linear routes (e.g. > 2 km) so that only the larger areas of well-connected routes are examined. These broad routes are buffered and mapped as potential Green Travel Access areas. These are defined as interconnected travel routes containing significant areas of greenspace or vegetation cover. Areas of greenspace above a site based threshold are then analysed in terms of perceived naturalness scores. A site based and a local based score are summed and used to represent naturalness at each focal cell. Route area thresholds are applied to remove isolated areas. Given that linear routes are buffered by 40 m, the default area threshold of 1,000 m^2 approximates to a minimum green travel route segment length of 25 m.

Capacity parameters are:

- Minimum route length — Default: 2000 m
- Minimum green travel route area — Default: 1,000 m^2 (0.1 ha)
- Focal distance for local mean naturalness score — Default: 300 m

Demand is mapped by examining travel destination and origin locations within urban areas. Urban areas are mapped and buffered using a method that allows nearby urban areas to merge along close borders, in areas where travel between such areas might be expected. Destination points of town centres, schools and train stations are then used to model travel paths. The points are buffered then linked to the travel networks previously mapped in the capacity model. Least cost analysis is used to model travel along this route, with a user defined maximum travel distance. The default distance is set from research of cycle travel to English secondary schools: 4.5 km (Bearman & Singleton 2014). The travel cost score is then standardised and used to map Demand for Green Travel Routes.

Demand parameters are:

- Maximum travel distance — Default: 4,500 m

5. Spatial occurrence and service flows

This service is provided by areas of natural or semi-natural habitat or greenspace, where these occur along travel routes. The flow of the service is considered to be both in-situ within each area, and also along the travel network route as a whole. The benefits would be experienced where people are walking, cycling or jogging along these routes. The model examines areas likely to be accessible or frequently used by people but also includes buffered areas where greenspace occurs adjacent to such areas.

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 and 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 service the following information would be required:

Capacity

- The type, location, extent, condition, quality and management status of greenspace.
- The location, extent and condition of urban travel routes.
- The extent to which greenspace encourages use of travel routes by people.

Demand

- The origin and destination points of frequent urban journeys.
- The number of people who travel along particular routes, for how long and with what frequency.
- The age, socio economic group and health status of the travellers.
- The relative levels of physical exercise experienced by typical travel uses.

Service Flows and benefits

- The long term activity levels and health benefits of users of green travel routes compared to other similar areas without Greenspace or vegetation cover.

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, 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 location, extent and condition of urban travel routes.
  - *Location and extent*: Determined from combined analysis of available data on pavements, Sustrans cycle routes and PROW / Core paths.
  - *Condition / management*: no information available .
- The extent to which greenspace encourages use of travel routes by people.
  - No information was available. Perceived naturalness score were used as a proxy to represent the potential attraction of sites.

Demand

- The origin and destination points of frequent urban journeys.
  - Point location data on schools, train stations and town centres was used to map likely travel origin and destination points.
- The number of people who travel along particular routes, for how long and with what frequency.
  - No information was available. Number of users and use frequency was simply estimated based on distance to origin or destination points.
- The age, socio economic group and health status of the travellers.
  - No information available.
- The relative levels of physical exercise experienced by typical travel uses.
  - No information available.

Service Flows and benefits

- The long term activity levels and health benefits of users of green travel routes compared to other similar areas without greenspace or vegetation cover
  - 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	Access routes may not all be accurately mapped.
Literature	There were relatively few published sources on which to base the mapping rules.
Mapping rules transferability	Further information on typical travel distances along urban routes would be useful, together with literature on which to base demand modelling.
Study area extent	Very small study area may not contain green travel routes
Landscape composition	In rare cases of upland or entirely arable landscapes there may be no areas of mapped capacity.
Buffer zone impacts	N/A
Landscape pattern	N/A
Topography	Topography will impact on travel route demand due to its influence on likely frequency of certain route use, but it is not currently included in the models.

9. Final List of Indicators

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

Indicator Name	Type	Description
GreenTravelAccess_IndC	Capacity	All buffered access routes
GreenTravelAccessBM_IndC	Capacity	Areas of greenspace present within the buffered access routes
Site_plus_local_naturalness_mean_Unr_IndC	Capacity	Naturalness score created from site score plus focal search score
Travel_points_IndD	Demand	Location of travel origin and destination points

Detailed GIS Analysis steps

Model: ES1GreenTravelRoutes Capacity

Estimates capacity of green travel routes to provide benefits to people

- 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).
- Submodel – All_greenTravel_v9.
- This creates two main outputs: GreenTravelAccesBM_IndD and GreenTravelAccess_IndD.
- Submodel runs – green travel restrictions – selects all locally relevant access files (Sustrans, PROW, Core Paths, pavements, etc).
- Submodel runs – collect green travel routes – this collects all access routes present in the study area, merges the files, the data is then dissolved.
- Lines longer than 10 m are selected, all lines are extended by 10 m, data is dissolved, buffered by 20 m.
- Features selected Shape_area > 2000. Converted to raster and back in order to explode polygons.
- Features selected Shape_area > 1500. Field LngthEst created and populated from Shape_area.
- User selected sites greater than route length threshold. Default = > 2,000 m.
- Greenspace from the BaseMap is then clipped by this layer to give a new layer showing areas of greenspace that occur along green travel routes. This creates many smaller fragmented sections of the route than initially mapped. All features Shape area > 50 are then selected to remove small slivers.
- Submodel Indicator Naturalness Unrestricted runs: This uses the Naturalness score within the BaseMap to create a cell based and focal search distance mean naturalness score.
- Local search distance set to 300 m but can be altered by users.
- The score is calculated from the combined site and local search distance mean value.
- Collect and then merge all access related files.
- Conversion to raster, to feature and back to raster using a site area threshold allows smaller fragmented areas to be removed. A default size of 1,000 m^2 (0.1 ha). This approximates to a 25 m linear route (buffered by 40 m).
- 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 Green_Travel_Capacity and Green_Travel_Capacity_0_100.
- A submodel 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: ES2GreenTravelRoutes Demand

Estimates the societal demand for Green Travel routes

- 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).
- Analysis is applied to urban areas. Urban_GB data is analysed to buffer the area to dissolve small distance between nearby urban area, leaving and expanded 100 m buffer.
- Cities and Towns, OSRailStations and OSEducationFacilities are identified as destination and origin points. These are combined and buffered by 150 m to create TravelPoints_IndD.
- GreenTravelAccess_IndC from the capacity model is used to identify potential travel routes.
- The Travel Points within the travel network are identified.

- A raster version of the travel network is created and cost distance is calculated to the nearest Travel Points feature.
- A maximum cost distance is set. Default: 4,500 m.
- The cost distance is converted to a 1 to 100 scale and inverted.
- 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 NoData replaced by 0 is created.
- Datasets (raster) saved as Green_Travel_Demand and Green_Travel_Demand_0_100.
- A submodel 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: ES3GreenTravelRouteFlows

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

The service flow model is the same for each service

- 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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