ECOSYSTEM SERVICE MODELLING

RULE-BASE DEVELOPMENT – SUGGESTIONS FOR USER

Contents

Food Provision			
CICES Ecosystem Service Typology			
Section	**Division**	**Group**	**Class**
Provisioning	Nutrition	Biomass	Cultivated crops
Food Provision	Food provision is an important ecosystem service that relies on a range of supporting services provided by a range of types and locations of land (Parikh and James, 2012; Swinton et al., 2007). Agricultural ecosystems are those that are most directly managed by people to meet human needs. Agriculture varies from intensive production of arable crops in lowland areas, extensive permanent grazing regimes on open moorland and intensive small-scale horticultural fruit and vegetable production on allotments and in gardens. Enclosed farmland is managed for food production and underpins the UK agri-food sector, which contributes more than 6% to the UK's GDP (Firbank and Bradbury, 2011).		

Factor 1a - Soil		
Soil Types		Soil type is an important consideration for food production. The most important supporting service for agricultural production is the maintenance of soil fertility, which is fundamental to sustaining agricultural productivity. Soil carbon also plays a major role in soil structure, another major component of soil fertility (Swinton et al., 2007).
Mineral		Mineral soils provide good productivity and afford some of the best soils for food production. The management regime for agricultural production varies across the UK but is generally intensive with substantial inputs to the system. The effect of this intensive management on soils has been substantial (Paustian et al., 1997).
Organo-Mineral		Organo-mineral soils are generally poorer for food production, often associated with acid upland soil and cooler, wetter climatic conditions.
Organic		Organic soils can provide the best food production conditions when adequately drained; as in the Fens of East Anglia. However, they require artificial drainage conditions and agro-chemicals are needed to maintain a neutral pH and high level of nutrients. Generally, organic soils types are located in the north and west of the UK, generally in upland areas where they are associated with poor drainage conditions. They are an important feature often associated with wetland habitats, therefore they are rarely cultivated but they do supply wild food which can be harvested.
Soil Systems		Well drained and nutrient rich brown earth soils require the fewest artificial inputs to allow them to be used for cultivation. However, any intensive use depletes soils of nutrients so rotation or external inputs need adding to the system. Very sandy soils tend to be nutrient poor and are too well drained; subsequently they are ineffective at retaining water and nutrients. Waterlogged systems can require substantial drainage operations to allow them to be suitable for cultivation (Ritzema, 1994).
Factor 1b - Geology		
		The underlying geology is an important determinant of food production capability through its affect on soil type and texture. Underlying geology also affects other features of soil type, such as depth and stone content; both of which have an impact on food production.

Factor 2 - Habitat		
Biophysical Properties of habitats		Generally semi-natural habitats are not important areas for food production and are mostly associated with wild food provision. However, many habitats are maintained by agricultural grazing systems which do contribute to food production, but where maintenance of the habitat is the priority and food production is seen only a secondary factor. Some habitats contribute to wild food production in minor ways, such as bilberries from moorlands or grouse from managed heather moorlands. Other habitats are based on traditional farming systems (such as old orchards), but again the maintenance of the habitat takes precedence over food production.
Below ground physical features	*Root depths*	Below ground physical features can be engineered by machinery and by some specialist grassland types to develop deep rooting systems and an open soil structure. This improves the soil aeration, drainage and nutrient availability to the grasses themselves and for subsequently planted crops, improving growth and yield (Fitter, 1991).

Below ground biological features	*Species richness*	The ecological assemblages of soil fauna and flora can be a significant factor in maintaining soil structure and encouraging strong root systems and therefore more productive crop growth. Earthworm numbers are particularly significant for soil system health and some crops are selectively bred to have a well-developed root system (Fitter, 1991). In some instances the soil is prepared to enhance below ground biodiversity, which encourages crop growth.
Above ground physical features	*Biomass/ Canopy Height*	The canopy height and structure is dependent on the crop type. Often the most significant factor for ecosystem services is the timing of bare soil and harvesting. For example, maize, which is harvested late in the growing season, leaves the soil bare when rainfall is high, which can lead to an increase in pollution incidences. Rotational grasses are sown every couple of years as part of an arable crop rotation and are known as a 'grass ley'. Grass leys are productive in early life and play an important role in a mixed farming system by returning organic matter to an arable rotation (Fullen, 1998).
Above ground biological features	*Species Richness*	Crops are generally monocultures, and therefore low in species richness. However hedgerows, beetle banks and headlands provide a greater abundance of flora species diversity to be present within the intensive agricultural environment. This in turn can support more insects and birds, which provide natural pest control and pollination. Grazing land, and therefore animal condition and yield, is maximised by sowing of specific grassland mixes. These are often dominated by perennial rye grass and clover, meaning they grow rapidly and sustain a lush sward but are species poor. The productivity of the grassland is maintained by inputs of fertiliser and re-seeding but if little management occurs grass lays will reduce in vigour and will revert to more species rich mix; which is less productive and a diminishes grazing resources. (Lichtfouse, 2011).
Other effects (How other data can be used as a proxy indicator)		Management systems are one of the most important factors for food production. Where precision agriculture is practiced inputs and outputs are very carefully balanced to maximise productivity and minimise environmental damage (Watson *et al*, 2002). Land under such management could be deemed more important for the delivery of certain services as there should be less impact on pollinators as the balance of the soil/plant systems are carefully considered. Where land is managed according to a traditional seasonal pattern, with fertiliser applied on a whole field or farm basis, there is much greater possibility for nutrient run off (Withers & Lord, 2002). Any data on management can help assess the effect of the food production systems on ecosystems service provision much more accurately. If no data is available a 'worse case' risk approach is the safest method to adopt when scoring assessments. To get an idea on areas being managed for agricultural activities, broad landscape scale datasets such as Phase 1 and Land Cover Map 2007 can provide an indication of the land use and include categories covering arable and horticulture. They do not include information on crop type or management regimes and more detailed habitat data, such as NVC, is normally confined to protected sites. Supplementary information on crop type would be needed, particularly if the ecosystem service study is at a local scale

Factor 3 - Landform	
	Landform has an important influence on food production. Intensive agricultural production is limited to flat or gently sloping ground (Spencer, 1978). Steeper land is generally suitable for extensive grazing and very steep land is often only used for woodland production. Cut-offs for the effect of slope on agriculture are generally recognised as: • 7° - limit for trailed machinery (and intensive food production) • 11° - limit for any machinery (above which only extensive grazing possible)

Factor 4 - How it is managed	
Negative Management	Agricultural practices have an impact on a wide range of ecosystem services, including water quality, pollination, nutrient cycling, soil retention, carbon sequestration, and biodiversity conservation (Davari et al., 2010). Conservation management on farmland can be seen as reducing inputs, particularly on grassland based systems. This has the effect of lowering productivity and therefore food production (Lichtfouse, 2011).
Positive Management	Management of land for food production is a key priority across the majority of the rural countryside of the UK. Key management practices include: • Regular cultivation involving ploughing and cropping • Regular grassland management including grazing and grass conservation through silage or hay-making (Morris & Potter, 1995) • Artificial drainage and drain maintenance in areas liable to flooding or high groundwater • Regular use of irrigation in areas subject to drought stress • Regular use of chemical treatments against pests and diseases • Intensive small-scale management for fruit and vegetables in allotments and gardens (Colding *et al*, 2006) • Monitoring of fertiliser application

References

Colding, J., Lundberg, J., & Folke, C. (2006). Incorporating green-area user groups in urban ecosystem management. *AMBIO: A Journal of the Human Environment*, *35*(5), 237-244.

Davari, M, R., Moola Ram, J., Tewari, C., Kaushish, S (2010) Impact of agricultural practice on ecosystem services. *International journal of Agronomy and Plant Production,* **1**, 11-23.

Fitter, A. H (1991). Characteristics and functions of root systems. *Plant roots: the hidden half,* 2, 1-29

Fullen, M. A. (1998). Effects of grass ley set-aside on runoff, erosion and organic matter levels in sandy soils in east Shropshire, UK. *Soil and Tillage Research*, *46*(1), 41-49.

Morris, C., & Potter, C. (1995). Recruiting the new conservationists: farmers' adoption of agri-environmental schemes in the UK. *Journal of rural studies*,*11*(1), 51-63.

Paustian, K. A. O. J. H., Andrén, O., Janzen, H. H., Lal, R., Smith, P., Tian, G., Tiessen, H., Van Noordwijk, M, & Woomer, P. L. (1997). Agricultural soils as a sink to mitigate CO_2 emissions. *Soil use and management*, *13*(s4), 230-244.

Parikh, S. J. & James, B. R. (2012) Soil: The Foundation of Agriculture. Nature Education Knowledge 3(10):2

Ritzema, H. P. (1994). *Drainage principles and applications*.

Spencer, H. B. (1978). Stability and control of two-wheel drive tractors and machinery on sloping ground. *Journal of Agricultural Engineering Research*,*23*(2), 169-188.

Swinton, S, M., Lupi, F., Robertson, P, G., Hamilton, S, K (2007) Ecosystem services and agriculture: Cultivating agricultural ecosystems for diverse benefits. *Ecological economics*, **64**, 245-252.

Watson, C. A., Bengtsson, H., Ebbesvik, M., Løes, A. K., Myrbeck, A., Salomon, E., Schroder, J & Stockdale, E. A. (2002). A review of farm-scale nutrient budgets for organic farms as a tool for management of soil fertility. *Soil Use and Management*, *18*(s1), 264-273.

Withers, P. J., & Lord, E. I. (2002). Agricultural nutrient inputs to rivers and groundwaters in the UK: policy, environmental management and research needs. *Science of the Total Environment*, *282*, 9-24.