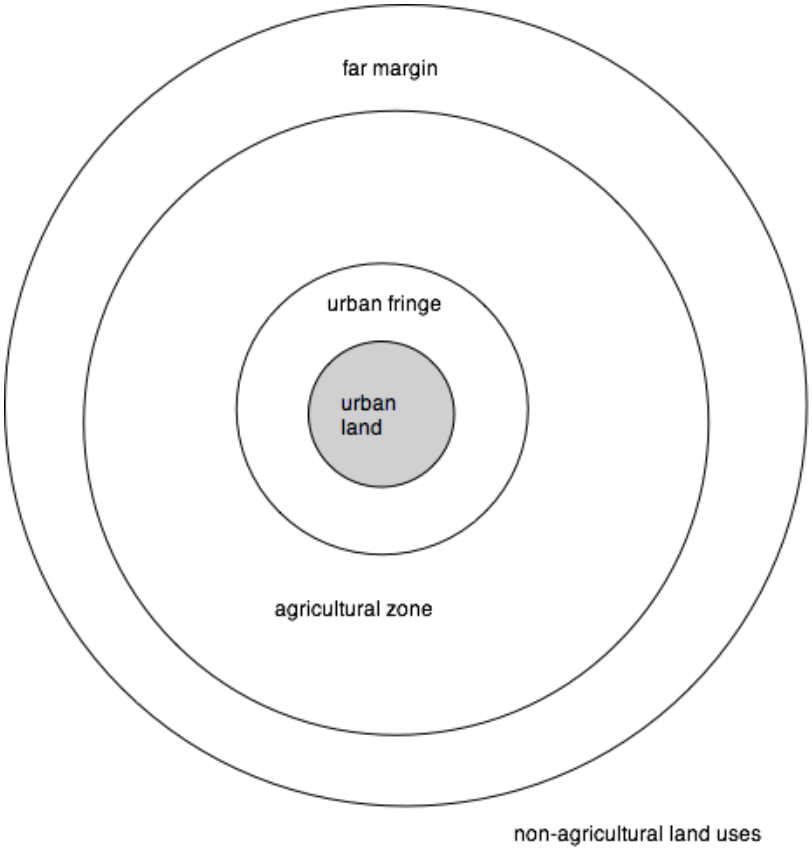
2 The spatial dimension of agricultural land

2.1. The spatial nature of agricultural production

Agriculture is the largest single form of land use in most OECD countries and most land currently used for crop and livestock production is unlikely to change uses substantially in the foreseeable future. But there are parcels of farmland that are susceptible to a change in use. The majority of this land is either adjacent to urban areas, or at the fringe of an inhabited areas where agricultural productivity is limited (Table A. B.1). This leads to a typology of three farmland categories: agricultural zone, urban fringe and far margin (Figure 1). Understanding the nature of land use in each region is a necessary step before assessing the ability of various types of policy to control farmland conversion.

Figure 1. Farmland typology



2.1.1. Urban fringe agriculture

The conventional perspective on agriculture near urban zones is that it will tend to specialise in high-value activities that have relatively high transport costs, with more remote farmland specialising in the production of lower unit value products that have low unit transport costs.[1] This model is predicated on the classic work of von Thunen (Annex A). But is the von Thunen analysis still appropriate?

Von Thunen postulated an isolated state with a single market town and a featureless and uniform agricultural hinterland. In this context, the logic of his model dictates concentric rings or circles around a city with higher-value or perishable commodities produced close to the market point. However, today agricultural production takes place in a more complex world. The most obvious differences are that there is not a single demand point and that farming does not take place in a homogeneous and featureless plain.

The implications of this are important. A farm may serve multiple markets and, where this is the case, standard industrial location methods will lead it to locate at a point that minimises total costs (not the costs of serving any particular market). Further, differences in topography, soil quality and access to a transport network will result in farms having a different spatial pattern from the simple suggested by von Thunen. These, however, are obvious complexities that qualify the underlying model.

However, there are other factors that affect the spatial distribution of production that are also important, although less obvious. Rather than simply qualifying the von Thunen model, they fundamentally alter its basic assumptions to a point that it is less germane. These are most important in the urban fringe, where farmland has a significant opportunity cost.

In particular, the anticipated time-scale for land conversion is a crucial factor. If the planning horizon is short, then farm operators are likely to avoid using land to produce commodities that involve large fixed capital investments that are immobile. For example, construction of a dairy barn or milking parlour involves a large capital investment cost that can only be recovered over an extended time interval. Even though dairy may generate a high rate of return per unit of output and involve high transport costs, it may not be competitive with field crops on land that has only a brief time-interval before conversion. In addition, while field crops may also involve large capital costs for equipment, these investments are mobile and can be easily relocated to a different site.

If developers purchase farmland well before there is any discernable pressure for conversion, similar effects on farmland use can occur. Once the land is purchased, it is typically leased to farmers until it can be developed. But in this circumstance neither the farmer nor the developer has any incentive to invest in long-term improvements − the developer, because he/she plans to use the land for another purpose; the farmer, because he/she has only a short-term right to use the land. Indeed, this process may lead to the rational decision to adopt farming practices that maximise short-term profit, but are not sustainable over an extended period of time.

Similarly, in the situation where agriculture has become only one of several types of land use, the interspersion of the other forms of land-use may lead to restrictions on farm management practices. Following von Thunen's analysis, more intensive land uses would be expected the closer the proximity to urban areas, because of the high cost of land. However, if higher-value intensive production requires farm practices that impose burdens on other neighbouring parcels of non-agricultural land, then it may not be possible to adopt that form of production.

To take an example: a producer of tree fruit on a small land base has a high-value perishable crop and, in a von Thunen world, might be expected to be located near urban areas. However, if the farmer uses pesticide sprays and noise-makers to prevent damage from birds, adverse responses from neighbouring private residents may result. Should these management practices consequently be prohibited, then returns from tree fruit production could be lowered to such a point that it ceases to be a viable activity. In this case, a lower-value activity, such as row crops, which involves fewer management practices that are incompatible with adjoining land uses, may be adopted.

A third complicating factor outside the von Thunen model is the potential for part-time farm enterprises. A consequence of having higher-value farmland in close proximity to urban areas is the much larger investment necessary to assemble sufficient land to support full-time farming. Moreover, opportunities for off-farm employment are typically greater the closer a farm is to an urban area. These two factors would suggest the existence of more small farms capable of providing only a portion of household income. In this context, the choice of farm enterprises is conditioned by other opportunities for labour and capital. Consequently, one can imagine that such a farm would be used to produce commodities (e.g. beef cattle), which would not be those predicted by the standard von Thunen model.

Finally, von Thunen did not include environmental services in his analysis. Farms can produce positive amenity benefits, both to neighbours and to wider society. If farmers are able to capture some of this value, either through direct payments or through tax expenditures, then the returns from farming will be increased. However, some farming management practices generate higher amenity benefits than others and it would be rational for governments to provide additional financial incentives for promoting the adoption of amenity-enhancing farming practices. As a result, if a farmer considers the total return from commodity and non-commodity production, one might observe a different spatial pattern of land uses than is the case if only the returns from standard commodity production are considered.

2.1.2. The agricultural core zone

The von Thunen model suggests that in the agricultural core zone there will be concentric rings of specialised production around the urban centre, which serves as the market point. A combination of differential transport costs and different demand levels for the various outputs will determine the order of products to be produced and the relative size of each ring.

In the modern agricultural core zone, most of the von Thunen analysis still holds in a general sense but with some significant variations, stemming from the following influences: first, farms may tend not to specialise in producing a single commodity as a part of a risk-mitigation strategy. Thus, mixed farms combining multiple crop and livestock enterprises are frequently found, even though this practice may lower the aggregate net return. If farms have access to government programmes that reduce enterprise risk it may be more likely to find a spatial distribution that involves a higher share of specialised farms.

Second, von Thunen assumed a uniform homogeneous plain. In reality, soil quality can vary considerably over a relatively small area and this can make certain crops more or less viable, irrespective of their distance from a market. Further, topography can also vary and this, too, will alter the spatial distribution of farm products. The existence of spatial variability in the productive capacity of farmland is the basis of Ricardian rents and provides a different perspective on the extensive margin (Box 1). Ricardo recognised that within the agricultural core zone the quality of land will vary and will command different prices. If commodity prices fall then it is possible that inferior land leaves production because it can no longer generate enough output to cover costs. This means that even within the agricultural core zone there may be pockets of land that are too unproductive to be farmed. It also means that in many regions the mix of commodities produced varies considerably from the regular rings described by von Thunen.

Within the agricultural core zone, land that is at the extensive margin in the Ricardian sense can be divided into two categories. Some of this land does not form part of a farm and is generally not bought and sold by farmers as commodity prices change. For the most part, this land is not farmland in any sense. The second category of land consists of those parts of a farm that are marginally arable or marginally useful for permanent pasture. Whether this land is used for commodity production depends on prevailing prices and on prevailing policy.

Box 1. Concepts of the extensive margin

The concept of the extensive margin is important in agricultural economics, including analysis of the environmental effects of agricultural land-use change (Lubowski et al. 2006). It describes land where profitability in agricultural use ceases. But there are two concepts of the extensive margin, and each approaches the idea from a different perspective. The original concept comes from Ricardo's analysis of land rent. Ricardo recognised that land of different quality, when applied to the production of the same commodity, will generate different yields. These yield differences may be accompanied by differences in cost of production with the result that the unit cost of production varies from one parcel of land to another. However, all units of output have the same price. This results in competition and higher rents for the better land. For Ricardo, the extensive margin is defined as land of sufficiently low quality that its output just covers the opportunity cost of undertaking production. If we assume farmland has no opportunity cost, then the rent for this land will be zero since all revenue will be consumed by inputs that do have an opportunity cost.

The second approach to the extensive margin comes from von Thunen. While the definition of the margin is the same – farmland that only covers the opportunity cost of other factors and earns no return for itself, the cause of differential land rents is different. Land rent for von Thunen is determined by differences in transport cost. Farms further from the central market incur higher transport costs to ship their goods, but all have the same price. The extensive margin here is defined by the furthest distance a good can be shipped and still cover its opportunity cost of production.

Ricardo assumes farmland has different quality, but ignores transport cost. Conversely, von Thunen assumes transport cost, but assumes land of homogeneous quality. In reality, farmers face both factors. This means that both quality and distance will alter returns and land rents. While every farm has a mixture of higher and lower quality, the main policy interest in the extensive margin comes from the existence of large blocks of land that are vulnerable to leaving production collectively. Two reasons underlie this focus. The first is that a local economy is more affected if the majority of the farms in its territory are at risk of ceasing production than if marginal land is uniformly distributed across all farms, nationwide. The second reason is the importance of marginal land for environmental purposes. Because marginal land is less intensively managed it offers greater habitat value, but because it is more susceptible to erosion and other harmful management practices it is more likely to be associated with adverse environmental effects. Once again, the concentration of environmental impacts in a small area can imply a larger concern than would occur if the effects were uniformly distributed.

The two ideas lead to different sets of policy concerns. In some countries, the extensive margin mainly reflects a concern with Less-favoured Areas (LFAs) that are remote from population centres. These are often on hilly land, where the combination of low productivity and distance makes farming marginal, but also has the effect of limiting alternative economic activity. However, the habitat value of this land is often high if it remains in farming. In other countries, most truly remote land has been permanently withdrawn from farming, so the term "extensive margin" mainly refers to blocks of land within the core agricultural zone that are of limited productivity. On this land there may be better opportunities for other activities and its habitat value is often not as significant as land in LFAs because it is embedded in a larger agricultural zone.

In some cases, policy and prices reinforce each other in moving the land in or out of production, while in other cases they act at cross purposes. For example, the Conservation Reserve Program (CRP) in the United States has taken a considerable quantity of farmland out of production. When commodity prices were low, the policy and market signals were reinforcing. Nevertheless, when commodity prices were high in 2007-08,

although a large amount of this land would have been expected to be brought back into production, the CRP contracts prevented this from happening.

Third, there is the influence of multiple markets. In most regions the majority of production is not sold for consumption in the local urban centre. Consequently, the relevant transport costs are far more complex, and points more remote from the nearest urban centre may actually have lower transport costs to external markets than do points closer to the city. More importantly, the existence of multiple markets can lead to specialisation of production. A region may produce far more of some commodities than can be consumed locally and no other commodities. In this case the mix of production is not determined by the process described by von Thunen –here, production is determined by larger market forces, not local markets.

2.1.3. The far, or extensive, margin

The typical problem of rural development involves a region with declining income and employment and a falling population. In these areas, the main concern is how to stimulate growth in the rural economy and attract new sources of income and population to prevent stagnation and possibly decline to the point that abandonment results.

Land at the far margin is marginally profitable and continually faces the possibility of being withdrawn from production. From a spatial perspective, a major impediment for the viability of farms in this zone is the high transport costs. However, it is also typical that land at the far margin is also of inferior quality. LFAs typically are found in remote rural regions, so they are far from markets, but also commonly experience some combination of infertile soils, steep topography and poor climatic conditions.

While von Thunen postulated a sharp edge between farmland and land too inferior for farming, in reality there is a transition zone similar to the urban fringe. Within this zone, there will be a mix of farmland and land used for less profitable purposes. The key distinction between the near and far margins is that farming is a low-value activity in the former and a high-value activity in the latter case. The common aspect is that opportunity costs are the determining factor in establishing land use.

At the far margin, both market forces and policy influence land use. Higher or lower output prices lead to land being brought into, or taken out, production. Unlike marginal land in the agricultural zone, price changes at the far margin may lead to changes in ownership and use of marginal land. Low prices can lead to farms being sold as holidays homes, or even abandoned if no buyer comes forward. In many countries policy for LFAs provides supplemental revenue to farms that would otherwise be unprofitable and cease production.

A central argument for this support is that farms in LFAs may provide significant environmental services from agriculture, especially when the land has been in production for an extended period of time and the ecosystem has been converted from one based on natural processes to one that reflects significant human management. In this situation, species have long adapted to the managed environment and may no longer be suited to an environment that does not include agriculture. Thus, a major justification for LFA programmes is social pressure to preserve particular kinds of species habitat and landscapes.

2.2. The amenity value of agricultural land

2.2.1. What are the farmland amenities?

Provision of amenities in rural areas primarily entails control over the use of rural land, at either the extensive margin of production (e.g. what land is used for farming) or at the intensive margin (e.g. how is the land is used?) (Heimlich, 2000). Agricultural land is one of several types of rural land that produces amenities. As agricultural activities cover a high proportion of the land in rural areas, the relationship between agricultural land use and the environment is often central to the provision of rural amenities. Nonetheless, the relationship between the use of agricultural land and the amenities provided is not straightforward.

Rural amenities associated with the use of land include the provision of services, such as landscapes, biodiversity, ecosystem functions and community support (Hodge, 2000). Farmland-specific amenities are attributes of farmland that are uniquely provided by farmed land. Examples include the scenic beauty of rolling pasture and the cultural value of farming as a way of live. Farmland also produces rural non-farm amenities, such as open space, wildlife habitats, groundwater recharge and preventing urban sprawl. These rural amenities may be provided by other types of rural lands.

Amenities associated with the use of farmland tend to arise from both negative and positive externalities associated with primary use of farmland as an input to agricultural production (Johnston and Swallow, 2006; Hellerstein et al., 2002; Heimlich, 2000; Hodge, 2000). The treatment of these externalities depends heavily of the prevailing property rights and their enforcement as well as of policies affecting all land-use sectors (Hodge, 2000).

Some farmland amenities, such as recreation activities, may be marketed as private goods.[2] However, as farmland amenities have, in general, public-good characteristics – they are non-rival (because at least some of the benefits they provide are available to all) and non-excludable (one person's consumption does not reduce another person's consumption) − there is a potential for under-production of amenity benefits (OECD, 2000). Research has shown that individuals from many societies tend to prefer the same sort of scenery, involving a combination of small fields, fences or hedgerows, a mix of vegetative cover and the presence of grazing farm animals (Hodge, 2008; McGranahan and Thomson, 2008). As a result, various farmland preservation programmes have been implemented by national and local governments, trusts, and non-profit organisations across the OECD countries. The study undertaken by the Economic Research Service in the United States found that provision of rural amenities in the country is a key reason for the increasing importance of farmland preservation programmes, both at the Federal and State level (Hellerstein et al., 2002).[3]

The amenity value of agriculture also provides a partial explanation for why ex-urban development takes place. Those individuals who place a high value on living in open spaces will be prepared to absorb the high commuting costs associated with a home in the country. Even if prospects for future capital gains from urban expansion are not great, there will still be individuals who prefer an ex-urban life style. Moreover, these individuals may be strong opponents of additional development once they have moved to the countryside because any additional farmland conversion would reduce their amenity benefits.

2.2.2. Valuing farmland amenities

The amenity value of agriculture is widely recognised (OECD, 2000, 2008b). This shift in relative importance of private commodities versus public environmental services has important implications for valuing farmland. The standard way of valuing agricultural land is to estimate the discounted present value of the future stream of net revenues generated by the sale of agricultural commodities (OECD, 2008a), except when land market prices are regulated. Rivalrous and excludable goods that were sold in private markets generated an income stream that was used to purchase another good farmland that was also rivalrous and excludable. If one person owns a parcel of farmland that means no one else can own it and legal and social conventions in all OECD countries preclude others from using that person's land without their permission.

Historically, this has provided a measure of the relative productivity of land and any benefits accruing from agricultural support. For example, for land in the agricultural zone, where opportunity costs are low and non-commodity benefits are less important, this approach remains satisfactory. However, for land at either margin other influences play a role in determining the full value of farmland.

When the social value of farmland stems from the production of both private and public goods, the underlying calculus of value and return to land ownership becomes more complex. In principle, the value of farmland becomes the discounted value of the stream of future returns from both the commodity and environmental

services from agricultures. But if the environmental services have no price, how is their value computed and how does the landowner receive benefits?

Moreover, any particular price that is established by the landowner is likely to lead to underproduction of the public good outputs because they are non-rivalrous in consumption. Private ownership of land leads to owners making decisions on land use that are driven by comparing alternative income streams from various land uses. In particular, for farmers, the future stream of agricultural income is compared to the lump sum that becomes available on selling to a property developer. The farmer has no reason to consider the value of environmental services associated with farming in this decision if the farmer receives no payment for producing these outputs.

Where environmental services have low value, because either demand is low or there are numerous alternative sources of equivalent output, decisions based solely on income streams are relatively efficient. But in cases where environmental services generate a large share of value, ignoring their existence will lead to farmland losses that are socially undesirable. Obviously, if farmers are paid the social value of non-commodity outputs the externality is internalised, and land is more likely to remain in farming. Alternatively, farmers can be prohibited from selling their land for alternative uses. Either option has the same outcome, but the distribution of costs and benefits is different.

In the first case, individuals implicitly pay the farmer for environmental services through a tax that is imposed on them and used as a recompense for the provision of these amenities. Alternatively, a tax expenditure, such as use value assessment, can be employed. This approach is consistent with a philosophy that prices generally provide appropriate signals for allocating resources, and with property owners being able to hold all rights associated with land.

In the second case, it is assumed that the right to alter land uses is severed from the property owner and reserved to the state. Property owners only have those specific rights explicitly granted to them and any residual value rests with the state. The argument for this approach is that the property owner usually does not bring about the increase in value associated with a change in land use. Therefore any increase in property value is a windfall to the farmer that may appropriately be kept by society, since it was society that generated the increase in value. Further, if the farmer incurs no, direct costs in generating environmental services there is no obvious reason to pay for them.

There are divergent views on whether the presence of at least some agricultural production is necessary for the provision of certain farmland-based environmental services in rural areas, such as landscape or flood control (OECD, 2003a; 2003b; 2008b). The OECD work on multifunctionality has shown that non-commodity outputs (NCOs) provided directly by the use of fixed factors in agriculture (land) are more typically related to commodity outputs by a relationship of technical interdependency than because they use the same allocable fixed factor. The typical case is of a fixed input that generates a NCO simultaneously with a commodity output, and not of commodity and non-commodity outputs competing for the rival use of a fixed input. However, it depends on the particular case as to whether this technical interdependency operates at the margin (*i.e.* the more commodity output is generated by the fixed factor, the higher (lower) the level of the non-commodity output) or whether the provision of the non-commodity output requires simply that the fixed factor should be used to produce a particular agricultural commodity, regardless of the intensity of use. Thus, if commodity price changes alter the *intensity* of use of the fixed factor it is not always clear what the impact on non-commodity output would be (Burrell, 2001).

In some cases, commodity outputs are complementary with farmland-based environmental services, but competing in others. For example, grassland biodiversity can depend on farming intensity (Havlik, 2008). That is, at low levels of intensity, agricultural production can be complementary to grassland biodiversity by preventing land from reverting to forest. At high levels of intensity, excess nutrients from livestock or crop production can jeopardise nearby grasslands. Moreover, there may be regions of complementarity and regions of competition between commodity, environmental services from agriculture and non-agricultural

rural activities (e.g. rural tourism), again depending on production intensity (Hodge, 2000, 2008; OECD, 2006b).

Some farmland-based environmental services are complementary with each other, but there are competing relationships in other cases, depending primarily on: i) farm characteristics that facilitate provision of one environmental service may facilitate provision of the others (such as more land area per farmer and more woods and hedges on a farm); and ii) a farm's previous experience in seeking out information about agri-environmental programmes may lower its transaction costs with respect to committing to supply environmental services (Dulpaz, 2008; Ollikainen and Lankoski, 2008). Moreover, biodiversity protection requires particular types of land use, not just a certain amount of land in agriculture irrespective of what is being produced on it. Thus, unless the amenity values that matter the most are evaluated, how to provide farmland amenities most efficiently remains an open question.

The relative value of farmland amenities varies from region to region and depends on several factors, including the total amount of farmland available in the region, availability of other rural land offering similar amenities (e.g. forest, parks) and the socio-economic characteristics of people living in the region. For example, as a region's population, incomes and education levels increases, demand for a broader array of farmland amenities will also increase, especially in sub-urban and urban-rural fringe settings versus rural settings (Nickerson and Hellerstein, 2003; Wu et al., 2004). The geographic distribution of population also matters. On one hand, too many houses in a farm landscape could diminish its visual benefits, but on the other, the more people living within close proximity to the farmland, the more valued the scenic amenities may be.

2.2.3. Implications for farmland preservation policies

Reflecting heightened policy concerns over the environmental performance of agriculture, programmes for the environmentally sustainable use of farmland are now receiving greater prominence among policy makers in several OECD countries. Countries across the OECD area have, to an increasing extent, made support payments to farmers subject to environmental conditions (cross compliance) (OECD, 2005). In the European Union and Switzerland farmers are obliged, *inter alia*, comply with specific environmental standards and land-management practice requirements in order to receive most forms of farm-support payments. Japan and Korea have also attached environmental conditions to their newly implemented system of direct payments.

In several OECD countries, especially the United States, measures to achieve the environmentally sustainable use of farmland include specific voluntary incentive programmes, such as cost-share programmes; payments for land retirement; purchase/transfer of development rights; zoning; and tax programmes (Hellerstein, et al., 2002; Heimlich, 2000).

In the European Union, one of the three core policy objectives of the Rural Development Policy 2007-13 (RDP) is to improve the environment and support land management. Farmers receive compensation when they voluntarily cultivate farmland according to management and maintenance agreements that recognize clearly defined nature and landscape values. More specifically, two types of support exist under *Axis 2 - Environment and land management* of the 2007-13 RDP:

- *Measures targeting the sustainable use of agricultural land* through payments to farmers in areas with natural handicaps; NATURA 2000 payments; agri-environment and animal welfare payments; and support for non-productive investments;
- *Measures targeting the sustainable use of forested areas* through afforestation of agricultural and non-agricultural land; NATURA 2000; forest-environment payments; and support for non-productive investments.

Environmental and land management measures comprising programmes designed to enable the continuation of farming in disadvantaged areas, despite permanent natural handicaps, are also implemented in other OECD countries, particularly in Japan, Norway and Switzerland. Such schemes for farming in mountainous and less-favoured areas are implemented – not to facilitate adjustment or modernisation of the agricultural sector – but rather to enable farmers to cope with these conditions and thus avert land abandonment.

In Australia, Canada and New Zealand, the emphasis is on community-based approaches (i.e. Landcare groups) for resource management in rural regions, with the purpose of mobilising and motivating citizens to take on greater responsibility for addressing environmental issues. The use of regulations is also widespread across the OECD area. Further, several countries, at the national and sub-national level, protect farmland by purchasing development rights or by providing tax breaks that encourage farmers to continue farming the land in a specific geographical area. Zoning rules and taxation are particularly important in urban fringe areas where rural land is being developed for residential or commercial purposes (OECD, 2008*a*).

In general, the land-preservation policy approach is most common when there are perceptions of a high value from the environmental services from agriculture and there is a considerable likelihood that a significant portion of farmland will be converted to some other use that will eliminate the provision of these services. Thus, in cases where farmland has low opportunity costs there is little pressure for land use controls even if levels of environmental services from agriculture are high. There may, however, be pressures for the adoption of specific farm management practices in order to ensure continued non-commodity production. For example, in Scotland extensive cattle production is encouraged in remote areas to provide nesting and feeding habitat for birds. Similarly, in the migratory fly-paths of North America, farmers are encouraged to maintain wet areas or potholes in fields in order to provide habitat for ducks and geese.

The specific approach adopted by a country reflects many factors, including the underlying structure of its legal system, land tenure rules, relative importance of individual and collective property rights, the relative scarcity of open land near cities, and the degree of urbanization. Clearly, schemes where farmers are paid for the production of environmental services are preferred by farmers, while schemes that preclude farmland conversion without public compensation are preferred by urban dwellers.

Overall, identifying the optimal amount, mix, and geographic arrangement of farmland amenities is a complex task for several reasons. First, farmland amenity values are likely to vary over time—thus studies at one point in time reveal little about changes in these values. Second, amenities provided by changes in other rural lands may substitute for farmland amenities, making the optimal amount and pattern of farmland amenities dependent on changes in the pattern of other rural land uses. Finally, competing effects make identifying the optimal spatial pattern of farmland difficult. Working farmland may exhibit economies, making preservation most efficient when done in large, contiguous blocks. Preserving large blocks of farmland also enhances certain rural amenities, such as wildlife habitat. However, this geographic concentration could reduce the accessibility of farmland amenities to more people. Visual farmland amenities might be enhanced by preserving smaller tracts of more widely distributed farmland or by concentrating preserved farmland in more densely populated areas.