Use and provision of ecosystem services in vineyards in the area of Berg en Dal

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Dutch weather conditions at vineyard De Colonjes, just after a herb mixture has been sown between the grapevine rows. The mixture consists of plant species that have the ability to increase soil fertility and quality.

Abstract

As a result of development of new grape varieties the amount of vineyards in the Netherlands is increasing. In the municipality of Berg en Dal six vineyards are located, which mostly use an ecological approach to grow grapes for wine production. In this paper for the first time the ecosystem services (ES) on these vineyards are identified, based on literature and interviews with wine farmers. This research shows that a wide array ES is produced and used in the Berg en Dal vineyards, several of which have not been mentioned in literature. Some important ES produced in the vineyards are biodiversity conservation, soil quality maintenance and erosion prevention. Especially understory plants and biodiversity turn out to be effective components on vineyards to produce ES. The vineyards are important for tourism in Berg en Dal and provide several cultural functions as well. Although the vineyards in Berg en Dal seem to make good use of ES, several improvements are suggested to maximise the benefits from ES. Finally the relevance of vineyards in Berg en Dal with regard to ES conservation is examined.

Contents

1. Introduction

Within ecosystems all kinds of living organisms and a non-living environment interact and lead to a myriad of ecological processes (MA, 2005). Through these processes ecosystems can make contributions to human wellbeing, which are called ecosystem services (ES). ES are often categorised in provisioning services, such as the provision of water and food; regulating services, such as erosion protection or pollination; habitat services, such as refuge area for species; and cultural services, such as recreation or aesthetic of the landscape (De Groot et al, 2010a). Although ecosystems and ES are essential for every living organism, including humans, around 60% of the ES are declining (MA, 2005). As agriculture affects large areas of land and ecosystems, conservation of ES is largely dependent on management within agricultural areas (Sandhu et al, 2012; Viers et al, 2013).

Vineyards are potentially suitable areas to combine the conservation of ES with agricultural production. In vineyards ES are both used (e.g. maintenance of soil quality and water regulation) and produced (e.g. production of grapes for wine production and several cultural ES) (Guerra & Steenwerth, 2011; Winkler & Nicholas, 2016). Most vineyards are located in areas with hot, dry summers and cool, wet winters, although since recent times quality wines can be produced in colder regions as well. This is a result of advancing development of novel grape varieties and, to a lesser extent, global warming (Viers et al, 2013; Van Dinther, 2011). The environment of a vineyard, e.g. the quality of the soil, has direct influence on the quality of the wine, which makes care for the environment an important aspect in wine production. The need for sustainable wine production also arises from recent increase in wine demand (Viers et al, 2013).

In 1998 the first grape varieties suitable for the climate in the Netherlands became available and the selection of suitable grapes has since then increased. These new varieties are, compared to classic varieties, less sensitive to fungal diseases like mildew and ripen earlier (Oude Voshaar & Maas, 2004). While the development of grape varieties continues, the quality of the wines is improving as well, which is one of the reasons Dutch wine farmers can rely on a large market to sell their wines (Van Teeffelen & Oude Voshaar, 2008; Boxma, 2010; Van Dinther, 2011). In 2011 the area occupied by vineyards in the Netherlands had grown to 160 ha and has been increasing further since (Van Dinther, 2011). The municipality of Berg en Dal (the municipality is hereafter referred to as only Berg en Dal), covered with fertile loess soil, accounts for 18.15 ha, divided over 6 vineyards. Although most of the Berg en Dal wine farmers have adopted an ecological approach for producing grapes (see Appendix 1), the ES used and provided in the vineyards have never been identified and thus it is unclear how ES benefit winegrowing in Berg en Dal.

The objective of this paper is to give an overview of the ES that are used and provided by the vineyards in Berg en Dal. By combining data from literature and results from interviews at vineyards in Berg en Dal the state of ES in the Berg en Dal vineyards will be identified, in order to determine whether the use of ES can be increased and whether vineyards are suitable for ES conservation. First the research methods and used concepts will be explained. This is followed by the results section, which includes the literature study, a description of the vineyards in Berg en Dal and an overview of the relevant ES in the researched vineyards.

In the discussion results from the literature study and from the interviews are compared and recommendations for better use of ES in the Berg en Dal vineyards are done. Finally the role the vineyards in Berg en Dal could play in ES conservation is explored.

2. Methodology

2.1. Concepts

ES originate from ecosystem functions, which are the underlying ecological processes that lead to ES. This will be clarified by examples of ecosystem functions and ES in each of the already introduced categories. Provisioning ES, e.g. the output of food and plant materials, are the result of the conversion of nutrients, sunlight, water and CO_2 to biomass. The capability of the ecosystem to do so is the ecosystem function (De Groot et al, 2010a). Ecosystems regulate and maintain important processes on earth that support life through regulating ecosystem functions (De Groot, 2002). Plants from the Leguminosae family, for example, can fix atmospheric nitrogen (the ecosystem function) and thereby make nitrogen available for plant growth (the ES) (Guerra & Steenwerth, 2012). Habitat ecosystem functions are the ways by which ecosystems provide habitat to organisms for refuge and reproduction. This leads to conservation of biodiversity and genetic diversity. Finally there are cultural ecosystem functions, which are the capabilities of ecosystems to educate, inspire and recreate people or otherwise affect people's personal state (De Groot et al, 2002; Winkler & Nicholas, 2016). In this paper the ES of vineyards are divided in these four categories.

2.2. Literature review

By using data from literature I identified the possible ES at vineyards in general. Most literature about ecosystem functioning in vineyards consists of case studies, which most of the times do not speak in terms of ES. By using the ES overview in De Groot et al (2002) and the overview of major ES in agriculture in Zhang et al (2007), I was able to identify the relevant ecosystem functions and ES in vineyards as described in the case studies.

2.3. Interviews

Beside the literature study I collected data by visiting three vineyards in Berg en Dal to interview the wine farmers and to gain an impression of the landscape. The interviews were held at vineyards *De Plack* and *De Colonjes* on 25 May 2016 and at *De Holdeurn* on 26 May 2016. The interviews were set up semi-structured in order to let the wine farmers paint a picture of agriculture and winemaking in the area. I started each interview with a short introduction to ecosystem functions and ES and gave some examples of ES at vineyards. Then I asked some general questions about Berg en Dal, the background of the vineyard and about winemaking, after which usually topics related to ES came up spontaneously. I for example asked the wine farmers by which ways they use the ecosystem and by which ways vineyards influence the surrounding areas. Furthermore I made sure to get a good impression of the cultural ES in the area (e.g. tourism and education) as I expected the perception of cultural ES would be rather location-specific. During the interviews I wrote down all relevant information, which I wrote out in a short report, enclosed in Appendix 1. In order to sufficiently describe the vineyards and the surroundings I included observations I did in the report, for example of the kinds of insects present.

2.4. Analysis

To be able to apply the data from literature to the vineyards in Berg en Dal I combined the data acquired from literature with data from the interviews. The literature study made clear that most ES are delivered by ecological components, such as understory plants. Based on my observations done at the vineyards I determined whether those ecological components were sufficiently present to produce the related ES. Furthermore the description of ES in literature (e.g. De Groot et al, 2002 and Zhang et al, 2007) provided a suitable framework to identify ES based on information given by the farmers.

3. Results

3.1. Results from literature study

As vineyards can have different characteristics, the ES identified in this section might not be relevant to all vineyards. The actual ES in a vineyard are determined by a plethora of factors, e.g. the biodiversity and the way the soil is treated by a wine farmer. The ES identified in this section are in italics.

3.1.1. Provisioning ecosystem functions

In vineyards the ES from this category of functions is *production of wine*; other outputs are negligible. As a result of photosynthesis and uptake of nutrients grapevines convert solar energy, nutrients, carbon dioxide and groundwater into grapes, which can then be made into wine (cf. De Groot et al, 2002). Dependent on the regulating ES within vineyards, the amount and quality of grapes harvested van vary.

3.1.2. Habitat ecosystem functions

Vineyards are monocultures that can simplify landscapes and degrade habitat quality and thereby can be drivers of biodiversity reduction (Viers et al, 2013). Enhancing the landscape diversity of vineyards, taking into account the natural surrounding habitat, can increase the biodiversity of vineyard ecosystems. For example establishing an ecological corridor, planting hedgerows, trees or understory plants have a positive influence on the biodiversity (Viers et al, 2013). Minimising use of insecticides is essential for retaining a diversity of insect or spider species (Zhang et al, 2007). When taking into account the properties and diversity of ecosystems surrounding vineyards, vineyards can act as *refuge and nursery habitats for biodiversity conservation* (De Groot et al. 2002). Some regulating ecosystem functions can positively influence biodiversity as well, which will become clear in the section below.

3.1.3. Regulating ecosystem functions

Regulating ES within vineyards may be used by the vineyard itself as well as provided by vineyards. As regulating ES are mostly delivered by ecosystem elements on the vineyard, the advantages and disadvantages with regard to ES of several ecosystem elements are discussed.

Regulating ES provided by understory plants

An understory of plants in vineyards can potentially have disadvantages, e.g. competition with grapevines for water and nutrients or damage due to increased amounts of rodents. The amount of grapes harvested can decrease as well. However, cover crops have several benefits, which is why they are considered as a desired element in vineyards. Cover crops

can *improve the soil structure*, for example by strengthening soft soils (Guerra & Steenwerth, 2011). Cover crops increase the total biomass in vineyards, which increases the amount of soil organic matter. This is beneficial for *microbial activity* (e.g. amount of beneficial nematodes) and *soil quality* (McGourty et al, 2008; Guerra & Steenwerth, 2011). Improved soil structure and quality can improve the quality and quantity of yield from vineyards (Zhang et al, 2007). Other functions are *management of water content*, *weed suppression* and *reduction of soil erosion*. By slowing down growth of grapevines, leading to a more open canopy, cover crops could *decrease* Botrytis *infection of grapevines* (Guerra & Steenwerth, 2011; Tompkins, 2010). Several understory plant species, like Leguminosae, possess nitrogen-fixing bacteria, so *the amount of nitrogen in the soil is regulated* (Zhang et al, 2007). An understory of native plant species can lead to *a preservation or increase of (soil) biodiversity* (Tompkins, 2010; Guerra & Steenwerth, 2011). For example understory plant species can provide in nectar, pollen, sap and seeds, which are necessary resources for different kinds of insects or birds (Zhang et al, 2007). In a case in Australian and New Zealand vineyards, a pest was sufficiently reduced this way: the natural predator of the pest was attracted by sowing a particular species of plant, providing food and habitat for the predator (Sandhu et al, 2010).

Regulating ES provided by biodiversity

Although increased biodiversity is an ES itself as a result of ecosystem functions, it offers many ES as well, as illustrated by Zhang et al, 2007. For example, soil organisms can *improve soil structure and quality* by creating burrows. Soil organisms can as well *retain organic matter in the soil*, by *decomposing organic waste*. Bacteria and fungi perform this function as well, which is beneficial for *waste management* as well as *nutrient cycling*. Insects are *pollinators*; this is an essential function for natural ecosystems and agriculture. Grapevines are self-pollinating, so this service is not useful in vineyards (see Appendix 1). By stabilising the ecosystem, increased biodiversity results in *pest control or reduction* (Guerra & Steenwerth, 2011). Predator and parasitic species of e.g. insects, spiders or birds are important for *natural pest control* (Zhang et al, 2007). Increased biodiversity can as well positively influence several cultural ecosystem services, like *recreation and aesthetic* (Sandhu et al, 2010). These cultural ecosystems are further explored in the next section.

3.1.4. Cultural ecosystem functions

A study by Sandhu et al (2012), based on interviews with experts, showed that vineyards, along with other agricultural land uses, are associated with positive impact on aesthetic, recreational, cultural, artistic, spiritual, historic, scientific and educational ES. However, the association of cultural ES with vineyards is subjective. A study by Winkler & Nicholas (2016) to examine cultural ES in vineyards therefore distinguished four perspectives: Science and Experience, represented by wine producers, and Conservation and Wine Culture, represented by residents of the area. The following cultural ES are derived from this study, which was done in Southeast England. Participants of the study from the Science perspective are mostly wine experts, who do not experience emotional connections with vineyards. They find *scientific and educational* ES most important, while other cultural ES were not important at all for them. They feel responsibility to conserve natural resources. The participants within the Experience perspective regard wine production as most important function of a vineyard, while cultural and symbolic ES are not important to them. They think vineyards are *beautiful*, probably even more than the natural landscape of the area and are not really concerned with loss of natural resources or natural heritage.

Participants from the Conservation perspective, the first group of residents of areas close to vineyards, do not feel emotionally connected to vineyards, but are mostly concerned with loss of natural resources and loss of identity and heritage due to vineyard establishment. Finally there are participants from the Wine Culture perspective, the second group of residents within areas close to vineyards, who are more positive about vineyards. They appreciate vineyards for the ES *entertainment, aesthetic, inspiration, recreation* (activities in the vineyard, special food production). They think *nature heritage* is important, they are not afraid of land use change. Spiritual ES are not regarded as important (Winkler & Nicholas, 2016).

These results show that people's perceptions about cultural ES within vineyards are divided. Winkler and Nicholas did a similar study in Sonoma and Napa. Results in this study were divided as well. Taking both studies into consideration, cultural ES that generally were regarded as important are *heritage* and *entertainment*, while *symbolic value* was intermediately valued and spiritual value was not regarded as important at all. For the other cultural ES no overall statement can be made (Winkler & Nicholas, 2016).

The presence of cultural ES on vineyards can be enhanced if a wine farmer decides to broaden his scope to more than only wine production. For example in Waipara Valley, a wine growing area in New Zealand, a project called 'Greening Waipara' is running. 'Greening Waipara' is aimed at measuring and developing ES of vineyards in the region (BPRC, 2016). Several vineyards that are part of that project have established biodiversity trails, which show the natural landscape of the area. Such initiatives are important for ES like education and recreation (Sandhu et al, 2010).

3.2. Results from visits to vineyards

The interviewed wine farmers in the area were not familiar with the term ES, although, after a short explanation, they were able to identify some ES on their vineyards. The wine farmers' explanations about the ecological processes on their vineyards and them allowing me to take a look around the vineyards gave a sufficient image of winemaking in Berg en Dal. I wrote down all relevant information acquired from each visit in a report, which can be found in Appendix 1. In the report also more information about the data and the vineyards can be found.

All three vineyards are surrounded by trees and have a diverse understory of plants and flowers. In one vineyard the understory consists of mostly grasses and some species of native herbaceous plant species. In the others vineyards a mixture of Leguminosae especially developed for vineyards is sown as understory. The wine farmers point out that Leguminosae fix atmospheric nitrogen and thereby make fertilising unnecessary. One of the wine farmers even sometimes mows parts of the understory (cuttings disposed) to prevent eutrophication. The farmers consciously maintain the understory in the vineyards for *N-fixation, maintaining a healthy humus layer, improving the soil structure, biodiversity conservation and soil organism activity.* The other ES, which are described in the literature study, were not specifically mentioned during the interviews.

The understory flowers clearly attracted a diversity of insects, like bees, ladybugs, butterflies and hoverflies. At one vineyard, located in a more woody area, some *Eucera longicornis* bees were present, a rare species in the Netherlands. Birds (e.g. starlings, sparrows, blackbirds) flew around in the vineyard, probably feeding on insects and worms. The understory flowers and the variety of animals on the vineyards *positively affect the aesthetic value* of the vineyard. Wine farmers pointed out the effectiveness of biodiversity for *natural pest control* and for *pollination* of plants and crops in ecosystems and other agricultural practices. The farmers told grapevines are self-pollinating, so they do not profit from pollination themselves.

To *maintain soil biodiversity and quality*, the farmers do not plough the space between the grapevines. Any machinery used is as small as possible, to prevent the soil from crushing. The farmers indicated the presence of worms and other soil organisms, which also positively influence the quality of the soil. Furthermore *soil erosion is prevented* due to the solid root system of grapevines, which remains intact throughout the year. Soil erosion caused by water is a problem in Berg en Dal, as the weak structure and low organic matter content make loess soils sensitive to erosion. The large scale of agriculture on these soils amplifies the sensitivity to erosion (De Knegt, 2014). Vineyards therefore provide an important ES by preventing erosion.

The three wine farmers all spoke about the difficulties they have to prevent damage caused by *Drosophila suzukii*. *D. suzukii* is a species of vinegar fly that is a pest on soft- and thin-skinned fruit. *D. suzukii,* as one of very few vinegar fly species, attacks healthy, ripening fruit and can therefore be a serious economic threat to the wine farmers. The species began to spread from eastern and south-eastern Asia to the Western world in 2008 (Walsh et al, 2011). *D. suzukii* recently started to occur in Berg en Dal as well, presenting challenges for the wine farmers to minimise loss of grape yield. On one of the vineyards, which used to be organically certified, insecticides are used to fight the fly, resulting in the vineyard losing its organic certification. In this vineyard still a wide variety of insect species was present at the time of the visit, although the insect population is probably negatively affected. The wine maker with the largest vineyard in the area is fully dependent on winemaking for income and does not want to lose the organic certification. He decided to plant more white grape varieties, as those are hardly affected by *D. suzukii.* He also explained *D. suzukii* propagates in tall herb vegetation of e.g. brambles and nettles. Tall herb vegetation in and near his vineyards is carefully cut, which does result in a reduction of the pest. The third wine farmer, for whom the vineyard is not an essential source of income, told he would likely continue with white grape varieties only.

An important aspect of winemaking in Berg en Dal is choosing the right grape varieties, because this makes profitable winemaking possible in the first place. Finding and optimising suitable varieties was successful partly due to testing on Dutch vineyards (Oude Voshaar & Maas, 2004). The vineyards in Berg en Dal all use recently developed grape varieties and thereby *contribute to knowledge about new grape varieties.*

The vineyards are effective and important *attractors of tourism* in Berg en Dal, with at least 16,000 visitors each year. There are walking and cycling routes on the vineyards and a 'wine route', which is a tour along the vineyards in the area. The three vineyards visited all take

part in the wine route and allow visitors to taste wines from the vineyards. In the summer there are several wine festivals as well. These activities are promoted and subsidised by the municipality and regional tourist organisations. The vineyards thus allow for *recreation* in the area.

The wine farmers all think their vineyards *enhance the beauty of the landscape*. This thought partly comes from the idea that the area occupied by the vineyard would otherwise be used for more common crops, like potatoes or sugar beet. The wine farmers also think that the vineyards and surroundings allow people to experience *greenness, silence and tranquillity*, which they think become more and more inaccessible due to urbanisation of the society. One of the wine farmers, whose primary source of income is his holiday farm, actively manages the surroundings of the farm to allow people to experience these cultural ES. He said that his visitors, mostly from urban areas, really appreciate the place for it. An important incentive for establishing the vineyard was to enhance the green image of the holiday farm.

Finally the vineyards have a *social function*: when the grapes need to be picked, people from the area are invited to help. One vineyard acts as a *social working facility* by allowing for example youth delinquents and mentally disabled people to help with harvesting the grapes.

In Table 1 an overview of the ES at the Berg en Dal vineyards is given, identified from the results of the field visits and the literature study.

Table 1. Results of the literature study and field visits resulted in the following overview of ES in vineyards in Berg en Dal

ES category	Ecosystem services	Ecological components
Food	Production of grapes for wine	Presence of grapevines
Biodiversity conservation	Refuge and reproduction habitat for animals	Presence of trees, plants and a diverse landscape
Soil retention	Prevention of soil erosion	Roots of grapevines and understory
Soil structure and quality	Improvement of soil structure	Presence of cover crops and soil organisms
	Maintaining healthy humus layer	
	Maintaining microbial activity in the soil	Presence of cover crops and biomass
	Water content management	Presence of cover crops
Nutrient regulation	N-fixation	Presence of cover crops (especially Leguminosae)
	Organic matter cycling	Presence of cover crops, soil organisms, bacteria and fungi
Waste treatment	Decomposition of organic waste	Presence of soil organisms, bacteria and fungi
Pollination	Pollination for ecosystems and agriculture	Presence of pollinating insects

Biological control	Control of pest species	Presence of cover crops and natural predator species
	Control of vine diseases	Presence of cover crops
	Weed suppression	Presence of cover crops
Aesthetic information	Enhancement of scenery and beauty of the landscape	The vineyard itself and biodiversity on the vineyard
Recreation	Making Berg en Dal attractive for tourists and recreationists	Activities on vineyard, walking and cycling routes on vineyard, wine festivals
Cultural and artistic information	Allowing people to become acquainted with wine culture	Wine tasting
Science and education	Development and testing of new grape varieties	Use of new grape varieties
	Vineyard as social work facility	Wine picking as part of rehabilitation and reintegration projects

4. Discussion

4.1. Comparison of results from literature study and field visit

Data about vineyards from literature is based on case studies done in typical winegrowing areas, which are in hotter and drier areas than Dutch vineyards (e.g. Guerra & Steenwerth, 2011; Viers et al, 2013). Moreover these vineyards are usually of larger scale than those in Berg en Dal. The data acquired from literature might thus not be accurate for the vineyards examined in this study. The functions of understory plants and biodiversity might be slightly different in the Berg en Dal vineyards. However, most ES of understory plants and biodiversity will likely be applicable in Berg en Dal as well, as those services are not dependent on climatic conditions. Examples are improvement of nutrient cycling, soil structure or control of pest species.

Although in literature (Zhang et al, 2007; Guerra & Steenwerth, 2011) some more benefits of understory plants and biodiversity are described than the farmers are aware of, the farmers consciously maintain understory and biodiversity. They do have scientific knowledge, for example about the capability of Leguminosae to fix atmospheric nitrogen, but also rely on their feeling that an ecologically managed vineyard must be advantageous to them as farmers as well as the environment. This consciousness actually results in a manner of treating their land that meets many recommendations done in literature to increase ES use and provision.

In the vineyards in Berg en Dal several ES could be identified which were not identified in the literature study. The ES of grapevine roots to prevent soil erosion was not mentioned in the articles, while understory plants were attributed this ES. A reason for this could be that authors do not consider grapevines to be a part of the ecosystem they described. In this paper, however, vineyards are considered modified ecosystems, of which grapevines are a part: production of grapes is considered an ES as well. Besides erosion prevention, social functions of a vineyard, e.g. the possible function of a social work facility, were not described

in literature. This can be the result of the subjectivity that the experience of cultural ES is subject to: in the Netherlands such functions might be acclaimed, while they are not considered important in other countries or cultures. Comparably, the wine farmers that were interviewed did not fit well in the described wine producers' perspectives of cultural ES, but had more characteristics of the Wine Culture perspective (Winkler & Nicholas, 2016). The owner of the holiday farm, for whom production was actually not a determining incentive to establish a vineyard, illustrates this. The owner of the largest vineyard is keen on wine production and quality, but clearly stated to attribute value as well to greenness, aesthetic, education, nature conservation and especially recreation. Clearly the wine growers in Berg en Dal have a different vision than the wine growers described in the case study of Winkler and Nicholas (2016).

4.2. Recommendations for wine farmers in Berg en Dal

Although special vineyard plant mixtures are already used in two of the vineyards, the composition of understory plant species probably is the component in the vineyards that has the most potential to increase ES use. Now the mixtures sown mainly contain Leguminosae, which are effective for nitrogen fixation and maintaining a healthy humus layer, but there is a wide array of other functions that understory plants van perform. Particular species can be useful for weed suppression, disease reduction, increase of biomass or erosion protection (Guerra & Steenwerth, 2011). An interesting study would be to research the ES that understory plants, suitable for Dutch climate, can provide, in order to maximise the functioning of understories in vineyards.

Understory plants in some cases have also shown to be potentially successful pest regulators by attracting predators of pest species. Although *D. suzukii* is an exotic pest species, there are several species of native predators and parasitoids, which attack *Drosophila* species and might therefore also affect *D. suzukii*. For example parasitoid wasp species and bugs are potential biocontrol agents of *D. suzukii* (Walsh et al, 2011). To find predators of *D. suzukii* in the Netherlands and species of understory plants, which attract those predators, probably a difficult search is required. The potential economic benefits are considerable, however, not only for vineyards, but for lots of fruit producers as well.

4.3. Vineyards and ES conservation

It became clear which ES are used and provided by vineyards in Berg en Dal. Although this information is probably useful for wine farmers to better understand how the ecosystem at a vineyard can support winegrowing, it would be too simplistic to consider vineyards as suitable places for conservation of the provided ES based on these results. The establishment of vineyards usually leads to loss of the natural ecosystem and thereby to loss of ES or generation of ecosystem disservices (Sandhu et al, 2012; Viers et al, 2013). One of the identified ES on vineyards, for example, is biodiversity conservation, but it is unlikely that a vineyard is a more suitable place for biodiversity conservation than the natural ecosystem. On the other hand a natural ecosystem does not provide us with food. But other types of agriculture might then be more efficient to conserve certain ES than a vineyard, while providing in food as well.

However, in this paper became clear that most ES in vineyards are provided by ecological components such as understory plants and biodiversity, while only very few ES were

provided by the grapevines, the producing crops. In Berg en Dal most fertile loess soil is actually used for intensive agriculture, with crops like potato and sugar beet (De Knegt, 2014). Components that produce ES such as on vineyards are not present in this type of agriculture, so expectedly vineyards are more useful for ES conservation. Moreover the vineyards in Berg en Dal do not occupy large areas of land, which implies a negative effect on ES conservation due to the vineyards is not likely. The vineyards could actually increase the variation of the landscape and thereby positively influence the provision of ES, even when compared to the natural landscape.

ES provide ecological, socio-cultural and economic values; a trade-off between these values is needed to determine the value of the ES that are provided and to determine which land use is desired to conserve ES. The identification of ES is the first step in this ecosystem assessment (De Groot et al, 2010b). To exactly determine the importance of vineyards for ES conservation the ES need to be quantified and a comparison must be made with competing forms of land use, before assessing the trade-offs.

5. Conclusion

There is a wide array of ES that can be used as well as provided by vineyards. Important features on a vineyard that deliver multiple ES are understory plants and biodiversity. In the vineyards in Berg en Dal these features are present and are of benefit for sustainable production of wine. Besides wine production the vineyards in the area are important for tourism and recreation and deliver an array of cultural ES. The vineyards are able to reduce soil erosion as well and thereby provide a solution to the serious threat of erosion of loess soils in Berg en Dal. Vineyards are possibly suitable for ES conservation in Berg en Dal, although more research is needed to determine whether this truly is the case. Yet knowledge about ES is useful for the wine farmers to produce wine in a sustainable way and offers possibilities to maximise the benefits of ES in the future, for the farmers as well as the people living in Berg en Dal.

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Appendix 1: report of the interviews with three wine farmers

The wine farmers all granted permission to publish the interview in this paper accompanied with their names and the names of the vineyards.

Wijngaard De Plack
Contact: John Grutters
Date of visit: 25 May 2016

Vineyard De Plack (started in 2006) is located near De Horst, a village near Groesbeek on the eastern borders of the Netherlands. The vineyard is 1 ha and besides viticulture there is a poultry farm on De Plack. The vineyard used to be organic, but the owners decided around 2 years ago to use insecticides to fight *Drosophila suzukii*, a species of vinegar fly that recently started to occur in Dutch viticulture. *D. suzukii* is a pest in soft summer fruits, like cherries, blue grapes and, to a lesser extent, white grapes and is a threat to viticulture in the Groesbeek vineyards. In 2011 the vineyard was certified as climate neutral and still is climate neutral today. I asked to what extent sustainability is important for marketing the wine. Although visitors on the vineyard are often interested in sustainability, John does not think that sustainability is essential for marketing the wine.

The floor of the vineyard is full of herbaceous plants, which are partly sown and partly came up naturally. Lots of insects and birds are present, e.g. bumblebees, ladybugs, ants, starlings and sparrows. John told there are lots of worms in the soil as well. He also pointed out that grapevines are self-pollinating. Usually the floor of the vineyard is not mown, only sometimes when a specific area is suspectedly becoming eutrophic. In that case he disposes the cuttings. The products used to increase the growth and quality of the grapevines are sulphur (to prevent mildew), leaf strengtheners (to increase overall strength and resistance against pests), calcium and magnesium salts (to increase growth) and insecticides to fight *D. suzukii*. Furthermore groundwater is regularly sprayed over the vineyard during spring to protect the grapevines from night frost. The root system of the grapevines remains intact throughout the year, so the soil profits from sustained solidity.

De Plack participates in the *Wijnroute*, a bicycle route for tourists past some of the vineyards near Groesbeek. John says the *Wijnroute* is important for the marketing of the wine, as a lot of people become acquainted with the vineyard and its products. To make the vineyard more attractive for recreation a small terrace was opened on the farm and an old growth orchard and hedges were planted. Citizens from the region of Nijmegen regularly help at the vineyard, for example by picking grapes. Furthermore there are guided tours on the vineyard. A walking route was laid to make the vineyard accessible for people who would visit the area by foot, although the path is not accessible now for everyone due to complaints by neighbours of the vineyard.

When I asked about policies that might support or impede the use and provision of natural assets it became clear that the local government is little involved in viticulture in the Berg en Dal area. Events that are in support of tourism in the region, like wine festivals and the

Wijnroute, are being promoted by the municipality, by Dutch tourist organisation VVV and by regional tourist organistion RBT KAN. The wine growers I interviewed all stated that there are no other policies that are directly in support or hindrance of the ecosystem services on the vineyard and were not aware of policies that might indirectly do so. John did mention that he thinks it is important to research possible strategies for collaborative landscape governance.

John mentioned one grapevine produces approximately 1.3 kg in vineyard De Plack and that 1 ha of vineyard produces approximately 3000 kg of grapes.

Wijnhoeve de Colonjes
Contact: Freek Verhoeven
Date of visit: 25 May 2016
Information from the interview at de Colonjes is left out in case this information is the same as in the previous interview (this is the case mostly for general information about viticulture).

Wine farm de Colonjes comprises three organic vineyards in the vicinity of Groesbeek with a total area of 13 ha. De Colonjes started in 2001 as the first wine farm in the Berg en Dal area and is the only wine farm in the area that fully focuses on winery. This makes de Colonjes important for viticulture in the Berg en Dal area, as they are keen to try new grape varieties and to innovate with (organic) Dutch winery. They also produce most wines from grapes from the different vineyards in the area. Only recently, Freek told, have grape varieties been developed that are suitable for the Dutch climate that actually produce wines of decent quality.

To improve the quality of the soil in the vineyards mixtures of herbs are sown. The *Evangelische Mischung* is sown a year before the grapevines are planted to prepare the soil. Then each year the *Wolff Mischung* is sown, a mixture of Leguminosae to maintain the quality of the soil. According to Freek the herb mixtures fixate nitrogen in the soil, favour biodiversity (e.g. there are lots of butterflies and bees) and are important to form a healthy humus layer. Small agricultural machinery is used to minimise crushing of the soil. A 0.16% sulphur dilution is sprayed over the grapevines to prevent mildew and black spot disease (probably *Guignardia bidwellii*). Freek points out the 0.16% dilution allows the conservation of insects in the vineyard. Leaf strengtheners are used as well. In colder climatic regions like the Netherlands new grape varieties are used that are less sensitive to fungus diseases than traditional varieties. Therefore these new varieties allow organic viticulture in colder regions and also resulted in higher amounts of vineyards in these regions. The increase of vineyards in colder regions is a result from global warming as well.

The new varieties are not protected from *D. suzukii*, however; fighting this pest is a challenge for organic wine growers. Freek told that preventing the growth of tall herb vegetation (e.g. brambles and nettles) significantly decreased the damage done by *D. suzukii*. Since the appearance of *D. suzukii* de Colonjes has to invest in careful maintenance to minimise the amount of tall herb vegetation. As mostly blue grapes are affected they decided to decrease the amount of blue grapes as well. As a result of such measures organic wine production is subject to significantly more labour, according to Freek, which makes it more costly and complex. As he thinks organic wine production has a positive effect on the quality of the soil

and the image of the landscape, he expects supporting policies like subsidies would give a positive impulse to natural values as well as recreational and social features of the area.

De Colonjes is involved in the organisation of wine festivals in the area and participates in the *Wijnroute*. There are approximately 16000 visitors on de Colonjes each year who come to taste wine, to participate in tours on the vineyard and in the wine cellar and to enjoy the landscape. De Colonjes acts as a social work facility as well; for example juvenile delinquents and mentally disabled people regularly work on the vineyard.

Vakantieboerderij en Wijngaard De Holdeurn
Contact: Sjacco Jaspers
Date of visit: 26 May 2016
Information from the interview at De Holdeurn is left out in case this information is the same as in one of the previous interviews (this is the case mostly for general information about viticulture).

The vineyard of De Holdeurn is located to the east of the village Berg en Dal and comprises 0.4 ha of grapevines. The main source of income of De Holdeurn is the holiday farm and apart from the vineyard also vegetables are grown. The grapes and vegetables are grown organically, however are not certifed as organic. As yields are small, certification is too expensive and would not offer advantages, according to Sjacco. He tells organic agriculture and viticulture are more labour-intensive, but also result in a better quality of the soil and therefore are not necessarily more costly. Sjacco for example does his best to prevent nitrogen mineralisation in the soil by loosening and turning over the soil and sows Leguminosae for nitrogen fixation. To prevent the grapes from being affected by *D. suzukii* he is planning to continue with white grapes only.

The local government is enthusiastic about the vineyard as it enhances the scenery and attracts tourists. Promotion of De Holdeurn, for example via the *Wijnroute*, is helpful for selling wine and for gaining publicity of the holiday farm. As agriculture and viticulture are only small sources of income at De Holdeurn, Sjacco does not need subsidies. He thinks he then would need to conform to rules and guidelines, while his advantage would not be substantial. Sjacco actually mostly sees the vineyard as addition to the holiday farm: the visitors like it and it looks nice in the landscape. He thinks the most important ES of his vineyard is its aesthetic value.

The area of the holiday farm is green, with large, old trees and flowers. There are many birds and insects flying around, for instance a rare bee species: *Eucera longicornis*. Sjacco tells the visitors of the holiday farm, who usually live in cities, come for the tranquillity, greenness and silence. In the area close to the farm there are bicycle routes and footpaths; the vineyard is also accessible for recreationists via a footpath. When the grapes need to be harvested, volunteers from the area of Berg en Dal visit the vineyard to help.