South Downs National Park Viticulture Growth Impact Assessment

By

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Foreword

This is the first growth impact assessment conducted on viticulture and wine production in a protected landscape that has ever been carried out in this country. The South Downs National Park Authority (SDNPA) commissioned the research from the consultants Vinescapes as we needed to understand the impact of the rapid increase in viticulture and associated wine production on our cherished landscape. The scale of this growth is indeed impressive with a 90% increase in vineyard coverage in the South Downs National Park (SDNP) since 2016 with approximately five new vineyards planted every year. The scale of this recent growth is, however, dwarfed by potential future growth. Almost a third of farmland in the SDNP, covering almost 40,000 hectares of land, is considered suitable for viticulture if current trends of temperature increases caused by climate change are realised.

The SDNP benefits from the highest level of landscape protection in the country. It has two statutory purposes to, firstly, conserve and enhance the natural beauty, wildlife and cultural heritage of the area and, secondly, promote opportunities for the understanding and enjoyment of the special qualities of the National Park by the public. The National Park Authority also has a duty when carrying out the purposes to seek to foster the economic and social well-being of the local communities within the National Park. The landscape of the South Downs has been shaped by human activity over millennia and it continues to evolve as a dynamic process. The Authority has a key role in helping to manage and guide change to ensure that the special qualities of this landscape remain both respected and cherished.

The purpose of this study is to improve our understanding of the impacts of viticulture and wine production in the South Downs within the context of our purposes and duty. It includes careful analysis of the environmental, socio economic and visual impacts of viticulture and wine production whilst addressing the impact of climate change. There has been extensive work with our local communities through the SDNPA Citizen Panel and a series of interviews with local vineyard managers.

I commend this study to you and would like to thank everyone involved in its production. I hope the study will become a valuable source of evidence for a range of stakeholders for many years to come including existing and prospective vineyard owners and managers, local communities and all those with an interest in our National Park.

Ian Phillips, Chair SDNPA

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Executive summary

The recent significant increase in vineyard area in the UK (>300% between 2005 and 2019) represents one of the most remarkable success stories of rural diversification and enterprise of recent decades. The protected landscapes of the South Downs National Park (SDNP) is witnessing land use change into viticulture (grape growing). There are currently 51 vineyards (covering 436 hectares (ha)) and 11 wineries within the SDNP. They employ 358 people (including seasonal labour), attract 33,000 visitors a year, contribute approximately £24.5 million (directly) to the economy and are attracting international acclaim for their high-quality wines. Although the precise outlook and future growth trajectory of the sector remains unclear, expansion scenarios demonstrate significant wider economic gains. However, these potential benefits notwithstanding, the delicate ecosystems and landscape character of protected landscapes can be harmed by vineyards and winery related infrastructure if not carefully managed.

A South Downs National Park Authority Citizen Panel survey conducted for this study found 69.2% of respondents thought an increase in vineyards in the SDNP would have a positive or no impact on the views and general character of the landscape. Just 11.8% thought increased vineyards would have a negative impact. Most respondents saw an increase in vineyard numbers and wine production as an overall economic positive; nevertheless, many had significant concerns about environmental harm associated with pesticide use, pollution, water use, noise, buildings and infrastructure. Other stakeholders engaged through this study had greater concerns about negative impacts on protected landscape characters, where vineyard and winery location, and their scale, are critical variables in assessing impact risks.

There is a clear desire among Vineyard managers interviewed for this study, to mitigate environmental risks. Much good practice is in evidence. Training and support are key to further enhancements, particularly with regards to promoting ecosystem services through biodiversity, soil quality, and carbon sequestration. Key report recommendations for producers include conserving special views; retaining field patterns, hedges and trees; establishing baseline ecology and soil conditions pre-planting; using non-planted vineyard areas for flora and fauna; using winter cover crops to reduce pre-planting erosion risks; increasing and monitoring biodiversity; encouraging human interaction, wellbeing and education; managing tourism and exploiting opportunities from such; adapting to climate change and embracing sustainable technologies; and working with local communities.

Underpinned by climate change and supported by unique landscapes, heritage, investment and expertise, viticulture and wine production look set to become an increasing presence in the South Downs. Therefore, to further support the viticulture and wine production sectors within the SDNP, we recommend closer engagement between the Authority and producers, including dedicated support through farm clusters and rangers, and support from the Wines of Great Britain (WineGB) sustainability scheme. We also recommend clear guidance is issued to vineyards and wineries that sets out both policy and practical solutions for alignment with the purposes and duty of the National Park. These steps would begin to offer a pathway through which risks can be pre-empted and addressed and positive opportunities maximised.

Acknowledgements

Globally, reports of this nature, regarding viticulture impacts, are extremely scarce. Its inception and execution have therefore not relied on precedents but rather on many individuals and organisations providing valuable time and input to contribute to its development and completion.

This report was primarily made possible by the support of the South Downs National Park Authority (SDNPA), with a specific thank you to Mark Alden (SDNPA Enterprise Development Lead) for his continued engagement and advice throughout the project, and Adam Brown (Research and Evidence Officer) for guidance and the provision of several integral datasets. We also recognise and thank Chris Paterson and team at the SDNPA, whose support in inviting the Parish Council representatives and local community groups to the stakeholder perceptions workshop was invaluable.

Thank you to the Parish Council representatives and local community groups who attended the viticulture growth impact assessment workshop, for their valuable feedback into this study. Also, to the SDNPA Citizen Panel for their input into the stakeholder perceptions survey that provided so much valuable information and insight into how vineyards and wine production is perceived by communities in the SDNP.

A special thank you to the SDNP-based vineyard managers and producers who provided valuable feedback in the Vineyard Survey, which has informed many areas of this study. Also, to the producers in the Kent Downs, Surrey Hills and High Weald Areas of Outstanding Natural Beauty (AONB) and the New Forest National Park Authority for their contributions to the elements of the report that provide a wider context beyond the SDNP.

We also wish to acknowledge the help provided by specialist staff in the SDNPA; Jeremy Burgess (Landscape and Biodiversity Lead), Lucy Howard (Planning Policy Manager) and Roni Craddock (Infrastructure and Environment Strategy Lead) in particular and who provided critical insights in relation to biodiversity and landscape character.

We also received valuable data, information and inputs from Chris Cooper (WineGB technical adviser – pesticides) and Peter Hayes (Global viticulture & wine business strategy advisor).

This report has been a collaboration between experts from numerous fields, and finally we would like to thank our associates for their contributions: Professor Steve Dorling (Weatherquest/University of East Anglia (UEA)); Lionel Fanshawe and team (terra firma landscape architects), Chris Foss (Chair of the WineGB sustainability scheme); Professor Andrew Lovett (UEA); and Lindsey Simpson (Simpson Consulting Ltd).

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The authors' biographies can be found in Appendix A.

4. Introduction

Whilst still relatively small-scale, cool-climate viticulture in England and Wales is rapidly expanding and there is currently more than 3,000 ha of land under vine, an approximate 300% increase in the last 15 years (2005 – 2019; 2020 plantings were not confirmed at the time of writing). Rapid recent expansion in vineyard numbers in the south-east and south-central areas of England, including the South Downs National Park (SDNP) (see Section 5.2), has been underpinned by recent climate change, which has driven warmer growing seasons that in turn facilitate the production of market-friendly grape varieties and a burgeoning international reputation for high-quality world-class wine. Supported by investment, upskilling and structural adaptation (guidance, support and policy from government and representative bodies such as Wines of Great Britain (WineGB)), interest in land use diversification and climate change adaptation in agriculture is significant.

Commercial vineyards have existed within the National Park area since the 1950s, and there is reference to a vineyard in East Meon (Hampshire) much earlier, in 1307 (East Meon Vineyard, 2020). In fact, grapevines were even grown in southern England by the Romans, so whilst there is nothing new about growing vines in the South Downs landscape, the resurgence and rate of increase in scale in recent years is unprecedented. Indeed, rapid sector growth and diversification into grape growing is one of the most extraordinary phenomena to have occurred within UK agriculture in recent decades. Fifty years or so ago, the prospect of grape growing and wine making in the UK, on the scale and to the quality standards now being achieved, would have been hard to imagine. Within the SDNP, the change of land use to viticulture is taking place amongst the unique heritage, landscape, communities, economy and character that make up the National Park. It is therefore not surprising that the increase in the number of new vineyards, expansion of existing plantations, and the construction of wineries, storage facilities and associated infrastructure has raised questions regarding the impact this growth – and further growth – could have on the special qualities of the SDNP and the two purposes for which the National Park is designated.

Those purposes of the National Park are to conserve and enhance the natural beauty, wildlife and cultural heritage of the area and to promote opportunities for the understanding and enjoyment of the special qualities of the National Park by the public. The National Park Authority also has a duty when carrying out the purposes to seek to foster the economic and social well-being of the local communities within the National Park.

The SDNP has an estimated 115,000 people living within its boundary and many more visitors come to enjoy its sense of tranquillity and its unspoilt places. The geology of the South Downs has sculpted the underlying beauty of the National Park, be it the chalk, greensand or clays which are dominant in different areas. Far-reaching panoramic views frame its beauty, where decades of farming or pasture have defined much of its character. Together, these special qualities characterise the National Park's sense of place.

This report was commissioned to provide a wide ranging, evidence-based and impartial risk analysis of the impacts of viticulture and wine production on the National Park and its natural capital. It also stands to provide recommendations for sustainable approaches to mitigate negative impacts of viticulture and wine production, recommendations to enhance

opportunities for positive impacts, and to provide knowledge to National Park Authorities and those within or looking to enter the viticulture sector. The South Downs National Park Authority (SDNPA) is the local planning authority for the National Park area and planning is an important constituent in understanding and mitigating impacts, particularly from winery and related infrastructure.

The report focuses on economic, social, environmental and landscape impacts of viticulture and wine production, presently and under both growth and climate change scenarios. Its content is derived from an evaluation of current practices and policies, stakeholder engagement and perspectives, viticulture suitability and climate change modelling, environmental risk assessments, natural capital and asset statements, and landscape character and socio-economic impact assessments. Collectively, these frame key impacts, recommendations and decisions regarding the SDNPA's response to an increasing agro-economic change.

This report sees a collaboration with the Kent Downs, Surrey Hills and High Weald Areas of Outstanding Natural Beauty (AONBs) and the New Forest National Park Authority. As with the SDNP, viticulture is likewise expanding in these sensitive and special areas. The report seeks to determine if any key environmental differences exist between the SDNP and these areas of national importance in relation to viticulture.

4.1. Aims and objectives

The central aim of this Viticulture Growth Impact Assessment is to deliver objective, accessible and robust data; information regarding current and future impacts of viticulture and wine production within the SDNP; and recommendations for enhancing opportunities and mitigating risks. The overarching study objective is to establish an evidence base which includes:

a) Measuring the significance of environmental, economic and social changes brought about by viticulture and wine production within the SDNP, compared with these factors for the types of land use most likely to be lost to or replaced by viticulture.
b) Identifying activities or interventions that could be adopted by vineyards and wineries to reduce negative impacts and enhance positive impacts.

In turn this will:

c) Inform a consistent approach and viewpoint on viticulture growth inside the National Park; tactics; and policy or programming strategies subsequently employed by the SDNPA.
d) Enable the SDNPA to produce, in the future, a planning Technical Advice Note and a Natural Capital Account for Viticulture.
e) Provide the SDNPA with evidence to understand where the impacts are likely to be greatest and to identify which geographical areas, if any, may have greater or lesser potential to accommodate change.

5. Study framework and terms of reference

This study forms an evidence-based discussion document and point of reference from which further questions, research needs and guidance will be generated about how viticulture expansion within the National Park might be viewed and best approached.

There are no UK-based precedents for a study such as this; indeed, even internationally there has been surprisingly little research into the broader impacts of viticulture and wine production sector growth, within a defined geography. In part this may be due to the longer established and 'accepted' nature of viticulture environments, or that the focus on impacts has been limited to specific elements, as needs have arisen. However, in a changing environment, a living and working landscape, and with increasing awareness and concern about how landscapes, the environment and natural capital are protected and managed, this study is a timely exercise from which mitigation and adaptation activities can be informed.

Change relating to viticulture and wine production in the contexts of landscape and land use, a changing environment, and existing policies are set out in Section 5.4. Following these, the scope and themes (Section 5.5) and delimitations (Section 5.6) for this study are provided.

5.1. Landscape and land use within the SDNP

The SDNP is located in southern England (see Figure 1), covering an area of 1,627 km^2 (628 miles^2) and stretching for 146 km (100 miles) from Winchester in the west to Eastbourne in the east, through the counties of Hampshire, West Sussex and East Sussex. The National Park covers the chalk hills of the South Downs (on the English Channel coast these form the white cliffs of the Seven Sisters and Beachy Head) and a substantial part of a separate physiographic region, the western Weald, with its heavily wooded sandstone and clay hills and vales. The SDNP is England's newest National Park, which was established in 2010 and became the local planning authority on 1 April 2011.

Figure 1. Location of the SDNP in southern England from the Local Plan (SDNPA, 2019).

The purposes and duty of the SDNPA are set out in Figure 2.

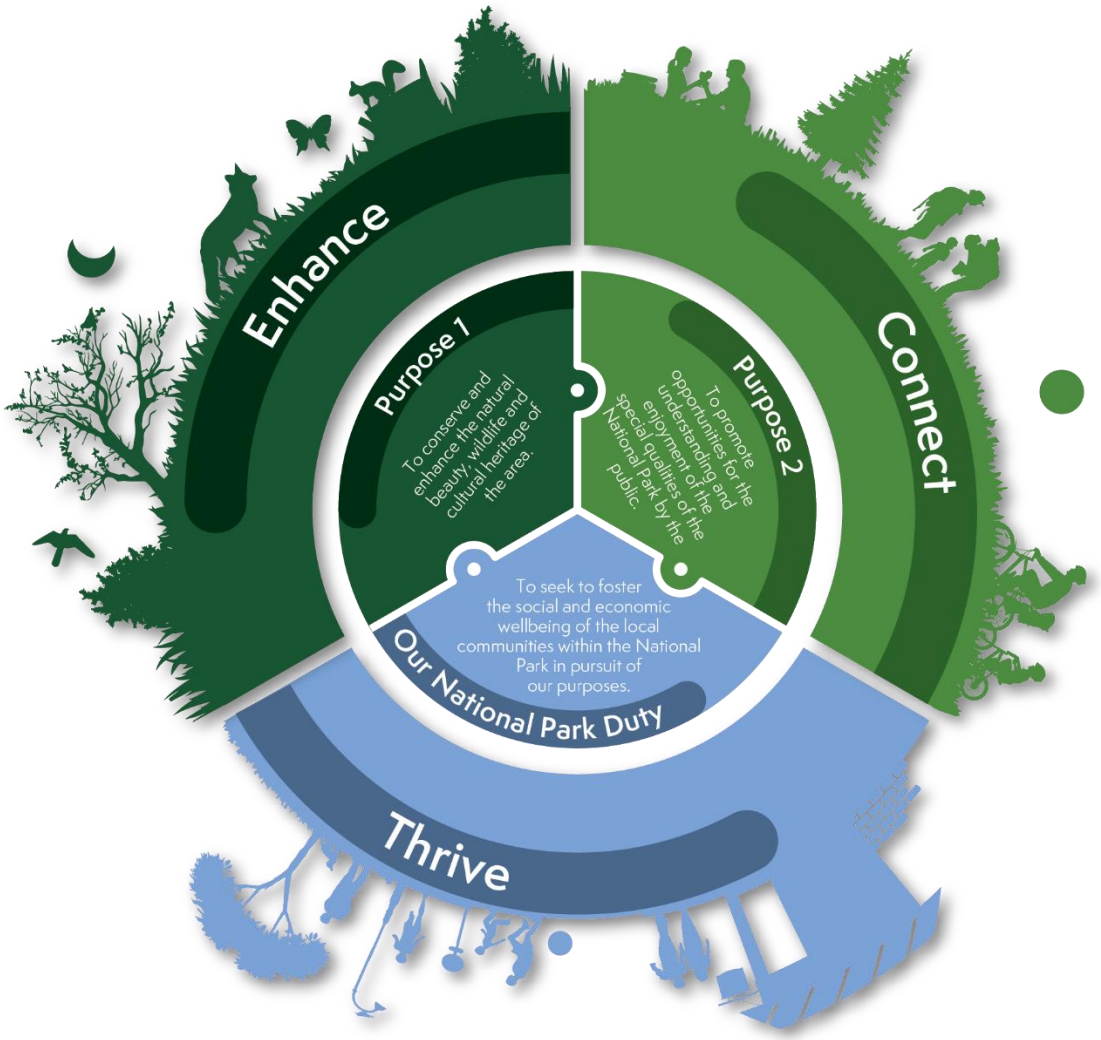


Figure 2. SDNPA purposes and duty
(SDNPA, Partnership Management Plan 2020-2025, 2020a).

The South Downs National Park has seven special qualities (Figure 3) (SDNPA, Local Plan, 2019), which are set out in figure 3.

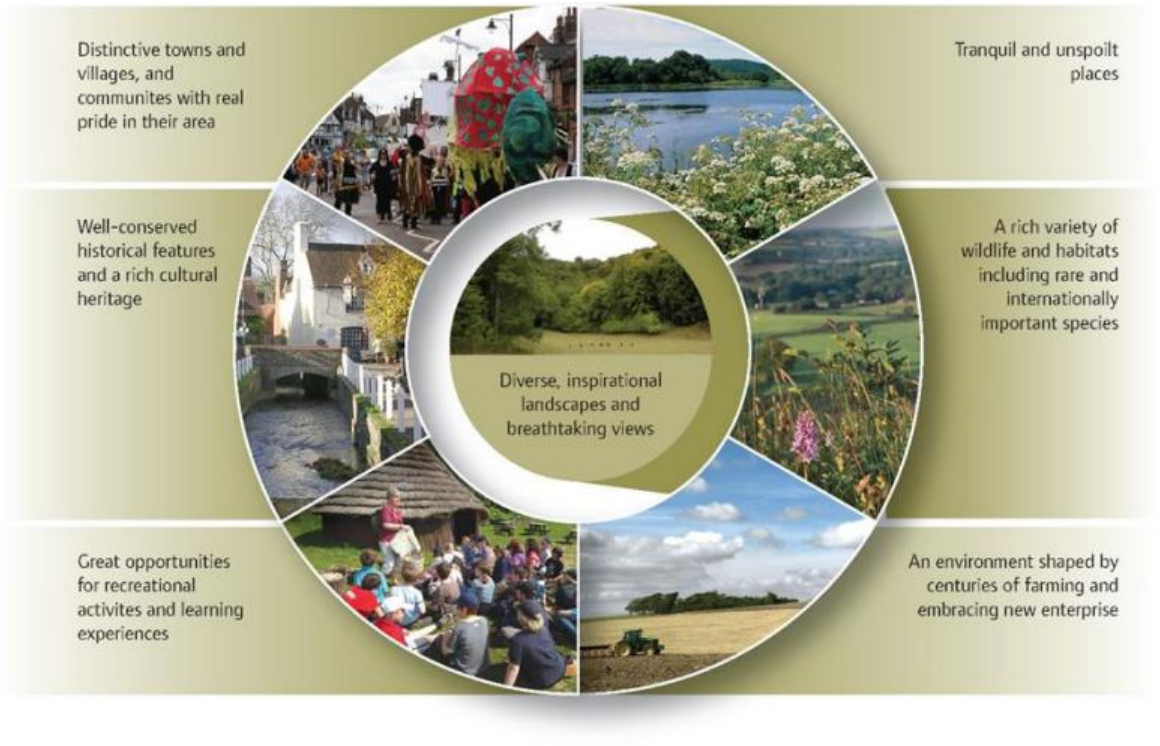


Figure 3. The seven special qualities of the SDNP (SDNPA, Local Plan, 2019).

5.2. Growth of viticulture and wine production in the UK and SDNP

Evidence points to the existence of vineyards in southern England during the Medieval Warm Period (Gladstones, 1992; Selley, 2004) and to their potential existence in Roman Britain (Selley, 2004). The Domesday Book refers to more than 42 vineyards in southern England at the end of the 11th Century, and in Section 4 of this report we have noted the existence of vineyards in the South Downs National Park area for millennia. Between the 1950s and the 1990s they were established on a more commercial basis (for example Hambledon and Breaky Bottom), increasing to 51 vineyards in the SDNP today (Figure 4). Vineyard numbers have also increased in the Kent Downs (36 vineyards covering approximately 680 ha; based on 2019 planted area) and Surrey Hills (11 vineyards covering approximately 120 ha) AONBs.

The presence of commercial vineyards in England and Wales today is mainly attributed to suitable climatic conditions, in particular to growing season air temperatures; indeed, during a period of lower temperature, known as the Little Ice Age (from the 16th to the 19th centuries), the number of vineyards in the UK declined. The subsequent revival of UK viticulture began in the early 1950s and, up until 1993, the volume and spatial distribution of UK vineyards continued to increase (Figure 5). From 1993 to 2004, however, both vineyard area (total area) and numbers declined by 29%, which has been attributed to a combination of factors, including sub-optimal varieties for the climatic conditions, poor vineyard site

selection, poor winemaking, poor quality, high costs, low yield, strong international competition and marketing difficulties. Since then, however, a significant increase in the area under vine to approximately 3000 ha has been accompanied by an increase in vineyard numbers to more than 750 in 2019 (Figure 5). This turnaround was primarily triggered by the production of award-winning sparkling wine from Nyetimber and the associated realisation that high-quality wines could be made in England using the classic Champagne varieties of Chardonnay, Pinot Noir and Meunier.

Recent vineyard plantings have predominantly occurred in southern England (50 – 52^{o}N), with vineyards in south-east (East and West Sussex, Kent, and Surrey) and south-central (Berkshire, Hampshire, the Isle of Wight, and Wiltshire) England accounting for around 70% of the UK total. Most large commercial vineyards are located within south-east and south-central England.

Data from the UK Vineyard Register (Food Standards Agency, 2019) shows that the average vineyard size in the UK has increased from 1.98 ha in 1989 to 3.41 ha in 2018. Total UK vineyard area is greater than that of another emerging cool-climate sparkling wine-producing region, Tasmania (approximately 2000 ha) (Wine Tasmania, 2019), but significantly smaller than another closer and long-established producing region, Champagne in France, which extends over 35,000 ha, growing predominantly the same varieties as in the UK (Comité Champagne, Champagne Industry, 2020).

English sparkling wine in particular has received significant national and international acclaim for its quality. Whilst not all English sparkling wine is of an exceptional standard, those that are have been heralded by wine critics, competition judges, the wine (and other) media and customers as prestigious. Indeed, increasing recognition for its quality and associated awards were contributing reasons cited by English wine producers (in a 2015 survey) as drivers for recent growth of the sector (Nesbitt, Kemp, Steele, Lovett, & Dorling, 2016).

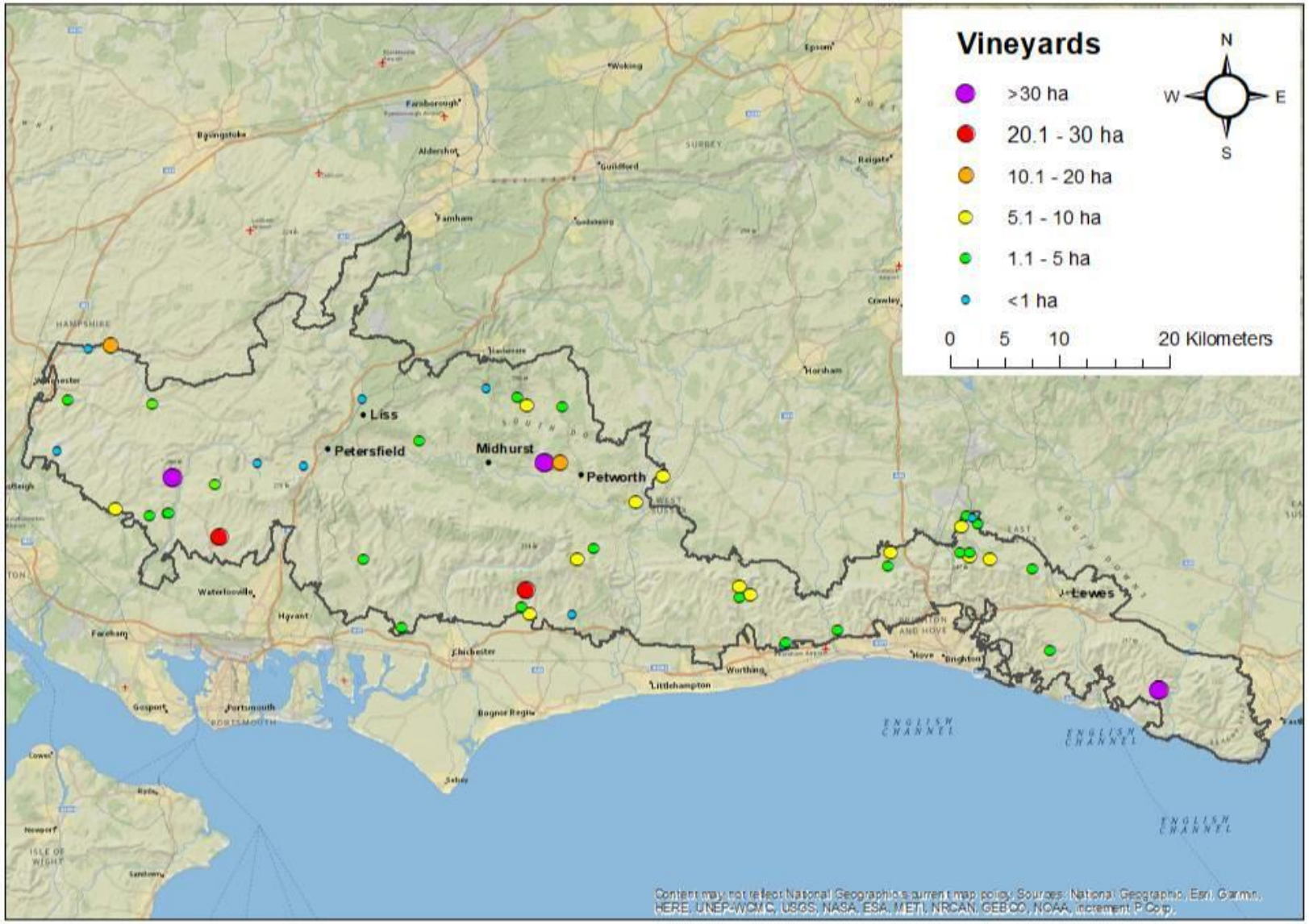


Figure 4. Vineyards within the SDNP (2020), classified by scale (ha).

The recent rapid expansion of viticulture in England and Wales is predicted to continue, with a potential 40 million bottles of English wine being produced annually by 2040 and a potential retail value of £1bn or more (Wine GB, Looking to the future, 2018).

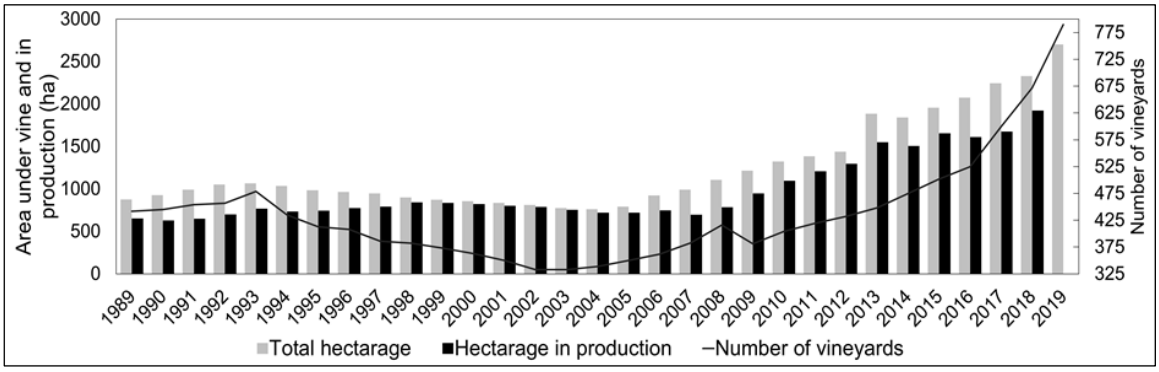


Figure 5. UK hectarage under vine and vineyard numbers (1989 – 2019). Data source: (Food Standards Agency (FSA), 2019) and our team's own research.

The UK's 5-year average bottle production between 2014 and 2018 was 6.92 million/year, although 2018 was an exceptional year in which 13.2 million bottles were produced (Wine GB, 2019). WineGB's chairman has stated: '*English and Welsh wine is seeing growth far exceeding any industry forecasts and the sector is the bright light in UK agriculture with vineyards being planted across the breadth and depth of our island*' (Wine GB, An Industry Coming of Age, 2019). WineGB's research suggests that there is now the equivalent of approximately 2,100 full-time employees involved in the UK wine production sector and that by 2040 this employment level could grow to approximately 30,000. However, despite English sparkling wine in particular receiving significant acclaim and winning international recognition for its exceptional quality (Wine GB, Other competitions, 2020a), doubts have recently been raised about the market viability of immediate and sustained rapid sector growth (Wine GB, Business and Marketing Conference, 2020b), particularly in light of global reductions in alcohol consumption. Therefore, despite the predictions of expansion, it should be noted that the precise growth trajectory for viticulture in England and Wales remains uncertain.

Within these wider national trends, the SDNP has also seen vineyard numbers increase by 90% in the last 5 years (from 27 in 2016 to 51 in 2020). As of April 2020, 436 ha of vines have been established within the SDNP (0.26% of the SDNP area) across 51 vineyards ranging in size from 0.15 to 91 ha. The mean area of vineyards within the SDNP is 8.55 ha, although 32 of the 51 vineyards are less than 5 ha in size (Figure 4). Eleven of the vineyards have an on-site winery, and some of these wineries service more than one vineyard (by providing winemaking facilities/functions), which may be located within or outside of the SDNP, or both.

Note: For this study, individual vineyards are classified as being physically separated when more than 100 m apart. Where two to three vineyards have different names, but which belong to the same business/owner and are within just a few metres of each other, they have been classified as one vineyard entity. Conversely, where two to three vineyards have the same name and belong to the same business/owner but are more than 100 m apart, they have been classified, in this study, as individual vineyards.

The SDNPA is aware of the recent growth in viticulture, as exemplified by Figure 6, showing a display at SDNPA headquarters Midhurst, featuring the English wine sector centre stage. However, a deeper understanding of viticulture and wine production is required (see Section 7), in terms of their associated activities, impacts, potential mitigants and opportunities, to inform decision-making around policy and actions which the National Park Authority may choose to develop and implement.

Figure 6. Display at SDNPA headquarters, Midhurst, featuring the English wine industry centre stage.

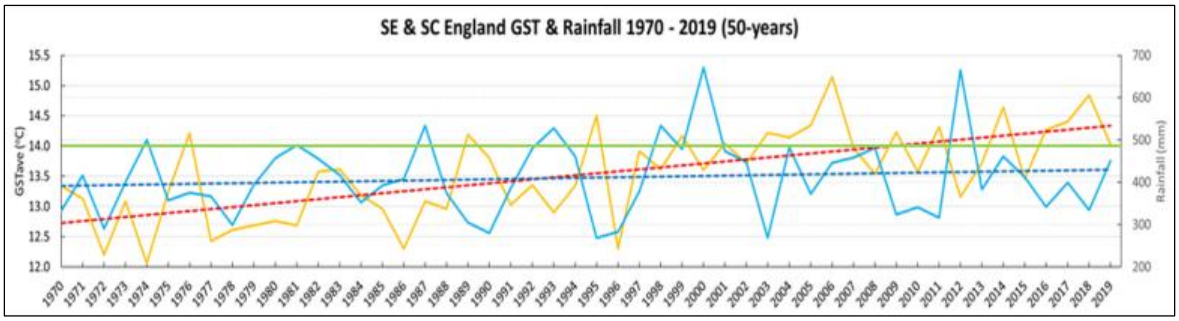
5.3. Climate change context

South-east, south-central and eastern England have seen a trend towards suitable cool-climate viticulture conditions over the last 20 years or so. Although there is much variability in growing conditions from one growing season to another, resulting in significant inter-annual yield variability (Nesbitt, Kemp, Steele, Lovett, & Dorling, 2016), and production is still somewhat 'marginal' in terms of viability by comparison with more established areas such as the Champagne region in France, warming temperatures (see Figure 7) have enabled the growing to commercial standards of the now dominant grape varieties of Pinot Noir, Chardonnay and Bacchus. These and other varieties suitable for high-quality sparkling wine, and to a lesser degree still wine, in cool-climate viticulture conditions, are the main ones grown in the SDNP. Climate change, from which English wine production is a rare benefactor (Nesbitt, Dorling, & Lovett, 2018; Fraga, Malheiro, Moutinho-Pereira, & Santos, 2013; Kenny

& Harrison, 1992) has, alongside other enabling factors, led to increased interest from investors in identifying low-risk, viticulturally suitable land, as well as attention from estates, landowners and farmers looking for business diversification opportunities such as the subsequent establishment of vineyards and, to a lesser degree, wine production ventures.

In 2013, the Intergovernmental Panel on Climate Change (IPCC) first concluded that warming of the world's climate system was unequivocal (IPCC, Inter-Governmental Panel on Climate Change, 2013). Since 1960, the UK has seen warming occur faster than the global average (0.23 and 0.28°C per decade, in winter and summer respectively) (Met Office, 2014), and records show that all of the UK's ten warmest years on record have occurred since 2002. Whilst wine grapes (predominantly *Vitis vinifera* L.) are generally suited to specific climatic conditions, historically found in narrow latitudinal bands (30 – 50°N and 30 – 40°S) in which growing season conditions are often characterised by a lack of extreme heat and cold (White, Diffenbaugh, Jones, Pal, & Giorgi, 2006), recent research suggests that under future climate change higher-latitude regions may have increasing viticulture (Etien, et al., 2008; Schultz & Jones, 2010); this includes the UK (Kenny & Harrison, 1992; Fraga, Malheiro, Moutinho-Pereira, & Santos, 2013).

Using Met Office monthly average temperature data to compute the April–October growing season average temperature (GST) and rainfall (1970 – 2019) in south-east and south-central England, we can see in Figure 7 the marked warming of temperatures over the last 50 years, critically important for grape growing and the ripening of cool-climate varieties to commercially acceptable levels. Over the last 20 years or so, GSTs have more often than not been more than the required bioclimatic GST threshold (14°C) for the now dominantly grown varieties. See Sections 8 and 9 for further information on viticulture–climate suitability and climate change.



GST (–), growing season rainfall (–), GST threshold of 14°C (–), linear trends for GST (--) and rainfall (--).

Figure 7. Average growing season temperature (GST) and growing season rainfall for south-east and south-central United Kingdom (1970 – 2019)

Whilst there is little sustained evidence of growing season rainfall patterns having changed in the last 50 years (see blue trend line in Figure 7), temperature increases and heatwaves like that of summer 2018 (which lead to bumper harvests in UK vineyards) are now 30 times more likely to happen than would have been the case without anthropogenic climate change, according to the Met Office (Met Office, Effects of Climate Change, 2020b). These changing conditions are likely to affect agro-economic activity both temporally and spatially, beyond their existing impacts, and indeed beyond viticulture.

5.4. Planning policy context

The impacts of vineyards, wine production facilities and related infrastructure, for example buildings, utilities and access tracks, must be viewed within national, regional and local planning policy contexts.

It is clear from subsequent Sections of this report that, as with most other crop choices, if land is currently in agricultural use, planning permission is not required to cultivate the land, plant grapes, grow grapes or install trellising. The exceptions are if land has been uncultivated for the last 15 years; is in a semi-natural area (this includes priority habitats, heritage or archaeological features, and protected landscapes); or has not been intensively farmed, such as unimproved grassland or lowland heath, and is 2 ha or more. Under these circumstances an environmental impact assessment screening process and decision is required by Natural England. This Section is therefore only relevant to vineyard- and wine production-related developments that require planning permission.

It is not within the scope of this study to scrutinise all planning policy implications for vineyard- and wine production-related infrastructure. However, here we provide a synopsis of key relevant policies and plans at a national and then a local level, because these also provide the context for framing the impacts, mitigants, opportunities, recommendations and subsequent activities emanating from this study.

5.4.1. National Planning Policy Framework

The National Planning Policy Framework (NPPF) (Ministry of Housing Communities and Local Govt, 2019) confirms that the purpose of planning is to help achieve sustainable development and that there should be a presumption in favour of sustainable development. In paragraph 172 the NPPF states that:

- *'Great weight should be given to conserving and enhancing landscape and scenic beauty in National Parks, the Broads and Areas of Outstanding Natural Beauty, which have the highest status of protection in relation to these issues. The conservation and enhancement of wildlife and cultural heritage are also important considerations in these areas and should be given great weight in National Parks and the Broads. The scale and extent of development within these designated areas should be limited.'*

Planning policymaking and decision-making should consider the roles and character of different areas, recognising the intrinsic character and beauty of the countryside and the wider benefits of natural capital and ecosystem services. Paragraph 170 of the NPPF states the planning system should contribute to and enhance the natural and local environment by:

- *'protecting and enhancing valued landscapes, sites of biodiversity or geological value and soils (in a manner commensurate with their statutory status or identified quality in the development plan).'*
- *'recognising the intrinsic character and beauty of the countryside, and the wider benefits from natural capital and ecosystem services – including the economic and other benefits of the best and most versatile agricultural land, and of trees and woodland.'*
- *'minimising impacts on and providing net gains for biodiversity, including by establishing coherent ecological networks that are more resilient to current and future pressures.'*

Under Section 6 of the NPPF ('Building a strong, competitive economy'), within the 'Supporting a prosperous rural economy' sub-section, paragraphs 83 and 84 state:

- *'Planning policies and decisions should enable: a) the sustainable growth and expansion of all types of business in rural areas, both through conversion of existing buildings and well-designed new buildings; b) the development and diversification of agricultural and other land-based rural businesses; c) sustainable rural tourism and leisure developments which respect the character of the countryside; and d) the retention and development of accessible local services and community facilities, such as local shops, meeting places, sports venues, open space, cultural buildings, public houses and places of worship.'*
- *'Planning policies and decisions should recognise that sites to meet local business and community needs in rural areas may have to be found adjacent to or beyond existing settlements, and in locations that are not well served by public transport. In these circumstances it will be important to ensure that development is sensitive to its surroundings, does not have an unacceptable impact on local roads and exploits any opportunities to make a location more sustainable (for example by improving the scope for access on foot, by cycling or by public transport). The use of previously developed land, and sites that are physically well-related to existing settlements, should be encouraged where suitable opportunities exist.'*

5.4.2. The National Parks and Access to Countryside Act (1949) (as amended by The Environment Act, 1995)

The statutory purposes for National Parks are as follows:

- *To conserve and enhance the natural beauty, wildlife and cultural heritage of the area.*

- *To promote opportunities for the understanding and enjoyment of the special qualities of the National Park by the public.*

The National Park Authority also has a duty when carrying out the purposes:

- *To seek to foster the economic and social well-being of the local communities within the National Park.*

The *Defra Vision and Circular on English National Parks and the Broads* provides guidance to National Park authorities on how to achieve their purposes and duty. It includes sections and guidance relevant to vineyards and wine production-related infrastructure regarding: climate change adaptation and mitigation; securing a diverse and healthy natural environment; fostering and maintaining thriving rural economies; making tourism sustainable; health and wellbeing; protecting and restoring a dark night sky; and conservation of biodiversity.

5.4.3. Twenty-five-year Environment Plan

In January 2018, the UK Government published a 25-year Environment Plan (Defra, A Green Future: Our 25 Year Plan to Improve the Environment, 2018). The overarching aim of the Environment Plan is:

- '*To help the natural world regain and retain good health … deliver cleaner air and water in our cities and rural landscapes, protect threatened species and provide richer wildlife habitats.'*

More specific 25-year goals are to provide:

- Clean air;
- Clean and plentiful water;
- Thriving plants and wildlife (including increasing woodland in England in line with the aspiration of 12% cover by 2060; this would involve planting 180,000 ha by 2042);
- A reduced risk of harm from environmental hazards such as flooding and drought;
- Using natural resources more sustainably and efficiently; and,
- Enhanced beauty, heritage and engagement with the natural environment.

Of particular relevance to landscape, the Plan pledges to conserve and enhance the beauty of our natural environment and make sure it can be enjoyed, used by and cared for by everyone, improving its environmental value while being sensitive to considerations of its heritage. This includes making sure that there are high quality, accessible, natural spaces close to where people live and work, particularly in urban areas, encouraging more people to spend time in these spaces to benefit their health and wellbeing, and focusing on increasing action to improve the environment for all sectors of society.

At the time of writing, the Environment Bill – the key vehicle for delivering the vision of the 25-year Environment Plan – is going through Parliament.

Following on from the Environment Plan, the Government commissioned a Designated Landscapes Review, which was completed by Julian Glover in 2019 (Glover, 2019). Chapter 3 of the report deals with living in the landscape. It notes that landscape has always been about people and that combining people and nature is a particular challenge for England's national

landscapes. This is particularly relevant to viticulture and the issues addressed in the present report. The Government is currently considering the 27 proposals put forward in the Review.

5.4.4. The SDNPA Partnership Management Plan (PMP) 2020–2025 (SDNPA, 2020a)

The latest SDNPA PMP was adopted in 2020 and is described as the overarching five-year strategy for the management of the SDNP. The Outcomes and Priorities set out in it are what partners across the National Park together hope to achieve by 2050. It provides a framework for local planning decisions and, as with other National Park PMPs, is recognised in the NPPF (see Section 5.4.1.) as being a material consideration when planning decision-making. Several of the outcomes are particularly relevant to vineyards and wine production-related infrastructure:

- ***Outcome 1: Landscape and natural beauty***
  - *To protect and enhance the natural beauty and character of the National Park and seek environmental net-gain from any infrastructure projects;*
  - *To improve green and blue infrastructure to deliver nature recovery networks and connect people to nature within and around the National Park; and,*
  - *To maximise environmental, cultural and economic benefits of agri-environment and forestry schemes across the National Park.*

- ***Outcome 2: Increasing resilience***
  - *To improve soil and water by reducing soil erosion, improving carbon capture and filtration and reconnecting wetland habitats.*

- ***Outcome 3: Habitats and species***
  - *To create, restore and improve areas of priority habitat to be more, bigger, better, and joined up at a landscape scale; and,*
  - *To increase the genetic diversity and resilience of target species and implement a landscape-scale strategy for tackling invasive species, pests and diseases.*

- ***Outcome 5: Outstanding experiences***
  - *To enable everyone to experience the National Park and widen participation for under-represented groups through targeted activities and promotion;*
  - *To improve accessibility through a network of high-quality routes connecting communities with the landscape, heritage, attractions and transport hubs and gateways; and,*
  - *To encourage sustainable access into and around the National Park, encouraging the retention and expansion of rural transport services.*

- ***Outcome 6: Lifelong learning***
  - *To provide high-quality outdoor learning opportunities as part of a locally relevant curriculum.*

- ***Outcome 7: Health and wellbeing***
  - *To develop initiatives which enable local communities and individuals to improve their health and wellbeing.*

- ***Outcome 8: Creating custodians***
  - *To increase and diversify volunteering opportunities that support the National Park.*

- ***Outcome 10: Great places to work***
  - *To strengthen and support sustainably managed land-based industries and local enterprise;*
  - *To increase awareness and desirability of the South Downs as a special place to visit; and,*
  - *To establish the South Downs as an exemplar in sustainable tourism.*

The PMP also seeks to deliver relevant national policy. As part of the first Plan in 2014, in line with Defra guidance, a set of 57 policies was created. Even with the subsequent adoption of the Local Plan (see Section 5.4.5.) and its policies, these 57 policies continue to provide an important foundation for shared future plans. They are set out in the PMP; below are just a few that have particular relevance for this study:

- ***Policy 1****: Conserve and enhance the natural beauty and special qualities of the landscape and its setting, in ways that allow it to continue to evolve and become more resilient to the impacts of climate change and other pressures;*
- ***Policy 2:*** *Develop landscape-scale partnerships and initiatives to focus on enhancing the key ecosystem services delivered by the National Park;*
- ***Policy 3****: Protect and enhance tranquillity and dark night skies;*
- ***Policy 13:*** *Support the financial viability of farm businesses through appropriate infrastructure and diversification developments, in particular, encouraging those that will support sustainable farming;*
- ***Policy 14:*** *Develop and support the market for and production of sustainable food, drink, and other products with a National Park provenance;*
- ***Policy 15:*** *Increase understanding of farming and of farmers as the custodians of many of the special qualities of the National Park;*
- ***Policy 28:*** *Improve and maintain rights of way and access to land, to provide a better connected and accessible network for a range of abilities and users, and to reduce conflict where it occurs;*
- ***Policy 29:*** *Enhance the health and wellbeing of residents and visitors by encouraging, supporting and developing the use of the National Park as a place for healthy outdoor activity and relaxation; and,*
- ***Policy 32:*** *Encourage and support the creative industries, creative economy and cultural activities which connect with and increase appreciation of the National Parks' special qualities.*

5.4.5. South Downs Local Plan (2019) and Neighbourhood Development Plans

The South Downs Local Plan follows on from the PMP. It was adopted in July 2019 and sets out how the National Park Authority will manage development over the next 15 years. This is based on the statutory purposes and duty for National Parks (Section 5.4.2.).

The SDNPA became the local planning authority for the National Park in 2011. The South Downs Local Plan is the first Local Plan to plan for the National Park as a single entity. The Local Plan is the statutory development plan for the whole National Park, along with the minerals and waste plans and 'made' (adopted) Neighbourhood Development Plans (NDP). The planning system in England is plan-led, and statute states that decisions on planning applications must be taken in accordance with the development plan unless material considerations indicate otherwise. Accordingly, this Local Plan is used in the determination of planning applications.

The Local Plan complements the framework of the South Downs National Park Partnership Management Plan (PMP; see Section 5.4.4.), which sets out an overarching strategy for the management of the National Park. The South Downs was designated as a National Park in recognition of its exceptional natural beauty, for the opportunities to learn about and appreciate its special qualities, and as a landscape of national importance. Therefore, the Local Plan takes a landscape-led approach to its formulation.

Whilst the Local Plan establishes the strategic planning policy framework, at a local level, neighbourhood planning provides a powerful set of tools for local people to ensure that they get the right types of development for their community. More than 50 Neighbourhood Development Plans have been produced by local communities and parishes in the National Park, and these should be consulted whenever vineyards or wine production entities are proposed in a designated area.

Some of the Local Plan policies most relevant to this study include:

- Core Policy SD2: Ecosystem Services;
- Core Policy SD3: Major Development;
- Strategic Policy SD4: Landscape Character;
- Strategic Policy SD5: Design;
- Strategic Policy SD6: Safeguarding Views;
- Strategic Policy SD7: Relative Tranquillity;
- Strategic Policy SD8: Dark Night Skies;
- Strategic Policy SD9: Biodiversity and Geodiversity;
- Strategic Policy SD12: Historic Environment;
- Strategic Policy SD17: Protection of the Water Environment;
- Strategic Policy SD23: Sustainable Tourism;
- Strategic Policy SD25: Development Strategy;
- Strategic Policy SD34: Sustaining the Local Economy;
- Strategic Policy SD35: Employment Land;
- Development Management Policy SD39: Agriculture and Forestry;
- Development Management Policy SD40: Farm and Forestry Diversification;
- Development Management Policy SD41: Conversion of Redundant Agricultural or Forestry Buildings; and,
- Strategic Policy SD48: Climate Change and Sustainable Use of Resources.

These policies are referred to in greater detail within the main body of this report.

There are also several evidence-based studies, set out below, that support the Local Plan policies listed above.

5.4.6. South Downs Integrated Landscape Character Assessment (SDILCA) (SDNPA, 2011a)

The South Downs Local Plan is landscape-led, which puts landscape at the heart of decision-making. The SDILCA (SDNPA, 2011a) is the key evidence-based document about landscape character that should be used for the basis of Landscape and Visual Impact Assessments within the National Park and forms the basis of the high-level sensitivity assessment offered in this study. The SDILCA is currently being updated for publication in 2020.

5.4.7. SDNPA View Characterisation and Analysis (2015)

This study identified and described valued views within the SDNP. Of particular relevance to this study are several views from the South Downs Way and other, locally elevated views. The View Characterisation and Analysis study also identified landmarks, views of which are important from the surrounding landscape, as well as being viewpoints that are often elevated.

5.4.8. Ecosystem Services Background Paper (SDNPA, 2018)

The Ecosystem Services Background Paper explains the approach taken to ecosystem services in the Local Plan and is of particular relevance to Section 10.3 of this study. Ecosystem services are the benefits people and society get from the natural environment, and the National Park Authority has sought to embed an ecosystems approach into its Partnership Management Plan and the Local Plan (Sections 5.4.4. and 5.4.5. respectively). Section 10.3. details more specific and important information on ecosystem services and grape and wine production, and what they can deliver in relation to the SDNP.

Core Policy SD2: Ecosystem Services of the Local Plan requires all development proposals to have an overall positive impact on the ability of the natural environment to contribute goods and services, initially achieved through high-quality design. The policy sets out the opportunities to impact positively on the natural environment as follows:

1. Development proposals will be permitted where they have an overall positive impact on the ability of the natural environment to contribute goods and services. This will be achieved using high-quality design, and by delivering all opportunities to:

    a. Sustainably manage land and water environments;
    b. Protect and provide more, better and joined-up natural habitats;
    c. Conserve water resources and improve water quality;
    d. Manage and mitigate the risk of flooding;
    e. Improve the National Park's resilience to, and mitigation of, climate change;
    f. Increase the ability to store carbon through new planting or other means;
    g. Conserve and enhance soils, use soils sustainably and protect the best and most versatile agricultural land;

h. Support the sustainable production and use of food, forestry and raw materials;
i. Reduce levels of pollution;
j. Improve opportunities for people's health and wellbeing; and,
k. Provide opportunities for access to the natural and cultural resources which contribute to the special qualities.

2. Development proposals must be supported by a statement that sets out how the development proposal impacts, both positively and negatively, on ecosystems.

As discussed in greater detail in Sections 10.3 and 12 of this report, there are clearly opportunities through careful vineyard- and wine production-related infrastructure development to contribute to ecosystem services and natural capital benefits within the National Park, and that are in line with the paper and policy.

Finally, within the context of planning policy, both the Farmer's Guide to Agricultural Permitted Development Rights (Section 5.4.9) and Whole Estate Plans (Section 5.4.10) are likely to be of value and relevance to vineyard- and/or wine production infrastructure-related development in the South Downs National Park.

5.4.9. A Farmer's Guide: Agricultural Permitted Development Rights in the South Downs National Park (2019a)

The aim of this guide (SDNPA, A farmer's Guide: Agricultural permitted development rights in the South Downs National Park, 2019a) is to support farmers/landowners by providing them with detailed information on permitted development (PD) rights, as set out in the Town and Country Planning (General Permitted Development, Order 2015, (England)). Permitted development rights relate to certain types of work that can be carried out without the need to apply for planning permission. The document provides a list of 'top tips' to highlight various important matters to consider in relation to permitted development. These tips include: defining what is an agricultural trade or business; identifying development not permitted under class A; evaluating if there is scope to erect a building under Class B; information on the creation of farm tracks; guidance on Permitted Development Rights Withdrawn; and establishing if a building can be demolished as part of the proposals.

5.4.10. Whole Estate Plans

Whole Estate Plans are referenced in Policy SD25: Development Strategy, stating that positive regard will be had to development proposals outside settlement boundaries when they are part of an endorsed Whole Estate Plan. This is in recognition that estates, institutions and farms across the National Park have an important role to play in the conservation of the landscape, the development of a sustainable rural economy and ecosystem services. Policy SD25 recognises that Whole Estate Plans may be able to demonstrate particular material considerations, relating to the purposes and special qualities of the National Park, that justify development outside of settlement boundaries. The Authority will only give weight to such plans where they have been endorsed by the National Park Authority.

5.4.11 Supplementary Planning Documents and Technical Advice Notes

The SDNPA is working on several Supplementary Planning Documents (SPDs) and Technical Advice Notes (TANs) following on from the adoption of the Local Plan. Planning applications should take these into account from an early stage of the development proposal. The most relevant SPDs to viticulture are Sustainable Construction (adopted August 2020) and Design (draft SPD due for consultation spring 2021).

This study incorporates a high-level assessment of the environmental impacts of viticulture and wine production (Section 10) and the relative sensitivity of Landscape Character Types within the SDNP (Section 11). In conjunction with the Natural Capital Report (Section 12), these can be utilised for the delivery of improvements in ecosystem services and environmental net gain. However, before more fully evaluating the visual, character, environmental and economic impacts of viticulture and wine production, the methods used for this study are described (Section 6); the processes and activities involved in viticulture and wine production are discussed (Section 7); and the physical and climatic 'opportunities' (Sections 8 and 9 respectively) that exist are explored in more detail.

5.5. Scope and study themes

Expanding on the aims and objectives, the SDNPA provided 23 potential study themes for expansion within this Viticulture Growth Impact Assessment (VGIA); these are set out in Table 1.

Table 1. SDNPA potential study themes, provided by the SDNPA

Study Theme No.	Description
	Environmental
1	Water/abstraction requirements
2	Winery wastewater treatment and processing impacts on the local environment
3	Biodiversity: birds/pollinators/natural predators/native insectary plants etc.
4	Carbon account (emissions versus sequestration) – including winery energy consumption and CO_2 emissions
5	Vineyard inputs required and potential impacts on surface water and groundwater resources
6	Impacts on soil health: runoff/sedimentation/organic matter/cover crop usage
7	Landscape impacts of viticulture and wine production
8	Visual and noise impacts of vineyard frost protection equipment
9	Future climate change impacts on the viticulture environment
10	Highways/transport impacts of viticulture and wine production
11	Air pollution: burning of prunings and old vines, and frost protection methods
12	Pesticide application
	Economic
13	Number of and type of jobs compared with these aspects of cereal (arable) and grazing farming
14	Number of people working in the industry
15	Number of full-time equivalent employees (including in the wine production, marketing/sales and tourism elements of the sector) per acre or 1000 acres compared with this number in cereal farming and grazing farming
16	Contribution to the local economy and local opportunities for employment in the wine production sector
17	Additional income for the local economy generated through wine tourism
	Social
18	Community perspective on viticulture and wine production in the National Park
19	Produce three case studies (west, east and central)
20	Housing of temporary/seasonal workers
21	Increase in traffic
22	Noise
23	What are the impacts that arise from wine producers building wineries and sales outlets in unison?

Although not explicitly requested within the scope of this study, planning and planning policy are both important constituents in understanding impacts (particularly from winery and related infrastructure) and will be a likely benefactor from this study and its recommendations (Section 15).

This study therefore draws on the SDNPA's Local Plan (SDNPA, Local Plan, 2019), which is landscape led and seeks to deliver multiple ecosystem services.

5.6. Delimitations and opportunities for further research

This study is broad-ranging in nature and, as noted at the beginning of this Section, there is no comprehensive precedent for it. By virtue of the study title and the study's core aims, the emphasis is on viticulture, although where relevant wine production is also assessed, as neither are consistently mutually inclusive or exclusive of each other. This study has incorporated a range of themes, some of which are assessed in greater detail than others (owing either to their potential scale and severity of impact, or available relevant information, or both); however, it must be noted that notwithstanding the limitations of data, information, time and budget, by definition there are several potential associated assessments and desirable outputs that fall outside the scope of this study. These include but are not limited to:

- Field-scale environmental impact assessments, screening and associated recommendations;
- Individual character area landscape capacity studies;
- An audit of all vineyard and winery processes for every vineyard and winery within the protected landscapes;
- The economic viability of grape or wine production businesses within the protected landscapes;
- A planning technical advice note (TAN) on viticulture
- A natural capital account;
- Stress-testing financial assumptions, multipliers and baseline data;
- A tourism/visitor impact and management assessment; and,
- Specific species recommendations or habitat 'types' to increase biodiversity and eco-system services.

Some or all of these could be obtained through further research.

6. Approach and methods

The multi-disciplinary nature of this study, derived from its broad scope, required employment of a range of research and analytical methods. Quantitative and qualitative scientific and social science methods were adopted in different elements of the study. They were used to seek and assess objective and evidence-based information from which conclusions could be drawn or from which information could be presented to advance the SDNPA's knowledge of viticulture and wine production practices and impacts.

In several areas of the study, for example in assessing producers' practices, exploring viticulture sector development or visualising landscape change, case studies are used to illustrate and extrapolate potential impacts of viticulture and wine production, particularly where project resources were not available to undertake relevant primary research.

Further details regarding the research methods for different sections of this study are presented within the sections themselves.

7. UK, SDNP, AONB and New Forest National Park viticulture and wine production: Vineyard establishment, vineyard management and the winemaking process

Section 7 – Key findings:

- Vineyard land preparation takes 1 to 2 years, with vine planting during April to May.
- Vines are generally planted in a north–south direction (or close to this), with rows running in-line with the slope angle, and at densities of approximately 3,500 – 5,500 vines/ha.
- Once planted, under-vine strips are normally kept weed-free using herbicides or cultivation. Inter-row vineyard alleys are allowed to re-establish with 'weeds' and grasses (sward) or are pro-actively established using cover plants, which increase rainfall infiltration, decrease runoff, mitigate soil erosion, and provide areas where biodiversity can exist and be increased.
- Only around 15% – 20% of UK vineyard land is covered by vines.
- Cropping typically starts 3- to 4-years post-planting.
- Initially bare and cultivated land (pre- and post-planting, for up to 2 years) increases the risk of soil erosion. Cover crops (in-season and over winter) can reduce this risk as well as being beneficial to soils.
- Of 33 vineyards in the SDNP (who responded to our Vineyard Survey), 2 vineyards practise (in part) organic methods of production.
- The established vineyards make a minimum of 6 and a maximum of 15 pesticide applications annually, averaging 10.5 sprays per year.
- One of the key environmental hazards when applying pesticides in vineyards is the contamination of bodies of water.
- The report authors are not aware of any UK vineyards that irrigate, although young vines have been known to be 'watered in' to help them establish in the first year following planting.
- Most of the Vineyard managers interviewed mulch vine prunings back into the vineyard floor.
- The main strategies adopted by vineyards for reducing greenhouse gas (GHG) emissions are to reduce the number of tractor operations by combining them (e.g. trimming the vines and mowing the alleys in the same pass), switching to electric vehicles, and encouraging manual labour in the vineyard.
- All Vineyard managers interviewed were very open to supporting environmental conservation and would welcome closer engagement with representatives concerned with environmental conservation in their protected landscapes; several of them expressed interest in the newly launched Sustainable Wines of Great Britain scheme.
- Wine making does have the potential to impact the environment in terms of pollution and GHG emissions where by-products (including wastewater) are not managed effectively.
- Wineries, storage/ageing facilities, ancillary facilities (e.g. cafés, tasting rooms, restaurants and offices), access routes, parking, on-site utilities, staff and visitors all

impact the environment in terms of infrastructure, buildings, vehicle movements, noise and light. The degree and nature of these impacts very much depend on scale, operational/business scope, management and planning.

This Section looks, at a high level, at the practices employed in vineyard establishment, management and winemaking within the Protected Landscapes with which this report is concerned. Vineyard practices were primarily investigated through producer surveys and interviews (in the SDNP, AONB and New Forest areas), conducted as research for this study (Vinescapes Vineyard Survey, 2020). The authors' viticulture and wine production knowledge, desk-top research and reference materials were used to further explore and complement these data, as were investigations of viticulture and wine production practices elsewhere in the world.

7.1. Vineyard establishment

Before planting a vineyard, the land must first be prepared. Site preparation ideally takes place 1 to 2 years before the vines are planted, although in practice 1 year or less is often the case.

To the best of the authors' knowledge and supported by findings from the Vineyard Survey (Section 7.2), the removal of field boundaries (e.g. hedges, trees and woodland) is not commonly undertaken in the UK for the purpose of establishing vineyards. Neither are ad hoc trees or clusters of trees within existing fields removed, and indeed it is difficult to imagine why they should/would be. However, this does not mean such actions have not been undertaken, although if they have then hopefully the appropriate permissions have been sought.

Prospective vineyard land is commonly sprayed with herbicide to reduce weeds during the summer or autumn prior to planting (or further in advance). Soil amends (organic matter, fertilisers and nutrients) are added and the land ploughed and subsoiled, then ideally the land is planted with a nitrogen-fixing and erosion-reducing (note this is not always done) winter cover crop, such as mustard, radish, beet or clover. These crops also provide green manure, add humus and help reduce weeds. In addition, in some cases where the soil is not free draining, land drainage may be installed and/or the land may be mole ploughed. The land is then left to over-winter, before being re-ploughed or disc-harrowed and any remaining macro- or micro-nutrients added prior to power harrowing just before planting in April to May.

In addition to soil preparation, wind break/shelter-bed planting and any required deer, rabbit or badger fencing (or combinations thereof) are usually established pre-planting. Ideally, windbreaks should be well established by the time a vineyard is planted, to afford shelter to young vines, and therefore may be established more than 1 to 2 years in advance. Italian alder (*Alnus cordata*) trees are commonly (but not exclusively) used to create windbreaks in UK vineyards as they grow quickly, allow a breeze through while also deflecting some wind over them, and retain their leaves late into the season.

Site levelling is sometimes undertaken where dips/hollows are levelled out to prevent them acting as cold air accumulation/frost-risk zones. Also, with potential frost damage mitigation in mind, hedges at the bottom of vineyard sites (that may otherwise act as barriers to cold air drainage) are sometimes trimmed to prevent the accumulation of cold air.

Pre-planting, access to and within vineyards may also be improved (tracks, areas of hard standing, gateways or roads) and ditches cleared (to improve drainage). In addition, a water supply will be required on or near the vineyard for pesticide and/or herbicide spraying operations, where these are undertaken.

Vine planting is commonly performed by machine but sometimes, on smaller sites, by hand, followed by the insertion of grow tubes and vine tutors. Trellising is undertaken post-planting.

This initial year, during which land preparation takes place, and particularly where the soil is left exposed or the field is bare (see Figure 8), is when there is the highest risk of soil erosion.

Figure 8. Vineyard with exposed soils soon after planting.

In the UK, vine rows are predominantly orientated downslope (ideally north–south or north-west–south-east), which allows more even ripening on either side of the vine rows and maximum solar radiation capture during the day. This also reduces the risk of shading (which can occur from one row to the next where rows are orientated east– west, at higher latitudes) when the bud-bearing cane is being produced and at flowering. Greater light levels reaching vines increases cytokinin production; if this is restricted by shading it can result in lower yields. Furthermore, the prevailing south-westerly wind direction across much of the UK can cause severe canopy and flowering disruption, as well as reducing air temperatures, if not managed. Having vine rows running at approximately 90° to the wind will help protect most of the vineyard, i.e. the first few outer rows will bear the brunt. Furthermore, where ground is frequently damp and soils relatively soft (as is often the case in the UK), row angles running perpendicular (i.e. downslope) to the slope angle are favourable, as tractors and other machinery may start to 'crab' (slide) if driving across a slope. Furthermore, if driving across a slope angle, the row must be wide enough to prevent the tractor or other machinery from

hitting the top of the downslope trellising (which would be positioned vertically). Both of these considerations are critical aspects of safely, efficiently and effectively managing vineyards. Finally, rows orientated parallel to a slope's aspect will often enable a larger area of land to be planted, as tractors and other machinery are able to travel up and down slopes that are too steep to drive across.

Air frosts, especially radiation frosts during mid-March to May, are amongst the most common detrimental effects of low temperature extremes on *Vitis vinifera* L. grapevines. Without frost-mitigating infrastructure, they pose a significant economic risk to vineyards. Frost events can kill or severely damage emerging buds and shoots and reduce yields and grape quality parameters. Slope angle is also important with regards to frost. Like water, cold air (under radiation frost conditions) flows downslope under gravity. Where barriers to this flow exist, such as hedges, fences, woodland, buildings, vegetation or vine-rows, they obstruct the flow of cold air, which can then accumulate. Flat ground or ground that forms a 'bowl', where there is no natural 'pathway' for the cold air to flow, are likely to cause frost hollows/pockets, and unless frost protection is employed (or there is no frost risk due to favourable climatic conditions) these areas should not be planted.

Typically, vines in UK vineyards are planted at just over 1 m spacing with rows about 2 m apart. Vines are planted as bare-rooted plants (20 – 30 cm tall), trained to stakes and trellising wires, and the foliage is grown to around 2 m in height. The most frequently used method of training in the South Downs is a single or double guyot (Figure 9), for vigour control, vine balance, yield and quality variables, and keeping foliage sufficiently far from the ground to avoid ground frosts and yet at a height that does not shade out valuable sunlight.

Figure 9. Double guyot training system in an English vineyard.

Once planted, all UK vineyards more than 0.1 ha (1/4 acre), or irrespective of size if it is a commercial undertaking, are required to register with and provide harvest and production declarations to the Wine Standards Branch of the Food Standards Agency.

Although the first harvest is likely to occur 3 years after planting, a 'full yield' (which is somewhat subjective) is likely to occur after 4 to 6 years, depending on seasonal, site and management factors. However, from planting through to first production and onward, significant work in the vineyard is required to achieve viable yields of quality grapes.

7.2. Vineyard management

There is work to be done year-round in a vineyard, with bud rubbing, pruning, pulling out, tying down, training, tucking in, thinning, de-leafing, trimming, managing pests and diseases, managing soil and ground cover, repairing trellises, and finally harvesting the grapes at the end of the summer. Most of this work (in terms of volume and effort) requires skilled manual labour, but may also require vineyard or horticultural tractors, mowers (usually driven off tractors), sprayers and possibly trimmers, de-leafers, cultivators, and other more specialist equipment for vineyard management. Access and movement within the vineyard occur year-round but significantly increase at harvest time.

Table 2 sets out annual vineyard operations in the UK and their potential hazards to the environment.

Table 2. Annual vineyard operations and their potential hazards to the environment.

(E = an essential task that is required for the effective management of the vineyard, O = an optional task, A = an alternative task.)

Time of year	Vineyard operation	Task	E, A or O?	Potential hazard to the natural environment
December – March	Winter pruning to manage vine growth and structure to optimise grape yield and quality.	Cut/prune vine canes by hand	E	• Risk of soil compaction when walking in the vineyard
		Remove cut canes from trellis	E	• Risk of soil compaction when walking in the vineyard
		Attach canes to lower wire on trellis	E	• Risk of soil compaction when walking in the vineyard
		Mulch prunings in vineyard alleys	A	• Risk of soil compaction when driving a tractor in the vineyard
		Burn prunings on site	A	• Air pollution through burning of prunings • Reduction in soil carbon levels, as prunings are not returned to the soil
		Remove prunings from site	A	• Risk of soil compaction when driving or walking • Reduction in soil carbon levels, as prunings are not returned to the soil
February – March	Trellis repairs	Replace broken trellis posts and	E	• Soil compaction and damage to alleys and headlands through the use of tractor-driven machinery

		mend broken wires and end-assemblies		
March – November	Vineyard floor management to facilitate access, manage nutrient and water competition, improve soils and encourage biodiversity.	Maintain a grass cover in the vineyard and headlands through mowing	A	• High-frequency mowing will reduce floral biodiversity, habitats and sources of food for vineyard fauna
		Maintain a weed-free vineyard floor through cultivation	A	• Over-frequent cultivation will disrupt soil habitats and increase the rate of breakdown of soil organic matter, which can result in structural breakdown. • Cultivation on slopes will increase the risk of erosion
		Maintain a weed-free vineyard floor using herbicides	A	• Pollution of water sources (see inputs) • Reduction in floral diversity • Harm to soil organisms (see inputs)
March – November	Fertiliser applications	Application of fertilisers to the soil	E	• Pollution of water sources (see inputs) • Harm to soil organisms (see inputs)
		Application of foliar feeds	O	• Pollution of water sources (see inputs)
April – October	Plant protection against pests and diseases to optimise fruit quality and quantity. Methods vary.	Pesticide application (in most vineyards)	O	• Pollution of water sources (see inputs) • Harm to natural fauna (see inputs)
		Deer, rabbit and possibly badger fencing	O	• Disruption to movement of larger animals
		Bird scaring and/or netting	0	• Seasonal disruption to bird populations
April – October	Summer trimming and canopy organisation to optimise vine growth, fruit quality and light interception.	Excess bud and shoot removal	E	• Risk of soil compaction when walking in the vineyard
		Tucking shoots into the trellis	E	• Risk of soil compaction when walking in the vineyard
		Trimming canopies	E	• Over-frequent trimming will generate soil compaction
		Leaf removal	O	• Risk of soil compaction
May – June	Vineyard establishment	Fertiliser application	E	• Pollution of water sources (see inputs) • Harm to soil organisms (see inputs)
		Soil cultivation	E	• Cultivation on slopes will increase erosion
		Vine planting	E	• Risk of soil compaction
		Trellis erection	E	• Risk of soil compaction
September – October	Grape harvesting	Hand harvesting	A	• Soil compaction due to heavy footfall
		Machine harvesting	A	• Soil compaction due to heavy machinery
		Transport of grapes to the winery	E	• Damage to headlands in wet weather

UK vineyard activities commonly include the application of pesticides and herbicides, but where they are used it is to varying extents (See Sections 7.2.1. and 7.2.2.). As noted later in Section 7.2.1, only two vineyards within the SDNP practise (in part) organic methods of production (2 of the 33 who responded to our Vineyard Survey). However, all identified

vineyards are classified as 'conventional', in that they do not operate under certified organic or biodynamic production schemes e.g. through the Soil Association or Demeter, where amongst other practices, pesticide and herbicide applications are significantly restricted or not allowed at all. Note, this is not to say SDNP vineyards are not necessarily environmentally responsible or active in sustainable practices, but rather that they do not fully adhere to certified production schemes. Within the UK as a whole there are currently about 17 organic and around 8 biodynamic (or in the process of converting) vineyards (Skelton, Personal communication, 2020).

Table 3 lists the pesticides and herbicides currently approved for use in UK vineyards, along with associated notes and commentary provided by Chris Foss, who undertook the Vineyard Survey for the purposes of this report (See Sections 7.2.1. and 7.2.2.).

Table 3. Vineyard pesticides and herbicides approved for use in the UK.

(see also accompanying notes below the table)

Application	Active ingredients	Product name	Mode of action				Specific environmental protection measures stated on product approval notice[1]				
			Broad-spectrum	Protective	Curative	Systemic	LERAP[2]	Toxicity to aquatic life V = very LLE = long-lasting effects	Risk to non-target arthropods	Risk to bees[3]	RAG Rating[4]
Pesticides against powdery mildew	Sulphur	Kumulus DF Cosavet DF Solfa WG Microthiol special	Y	Y							
	Penconazole	Topas		Y	Y			Y LLE	Y		
	Kresoxim-methyl	Stroby WG		Y	Y			V LLE			
	Tebuconazole & trifloxystrobin	Nativo 75WG	Y	Y	Y	Y	Y	V LLE			
	Proquinazid	Justice		Y			Y	V LLE			
	Boscalid	Filan		Y		(Y)					
	Cyflufenamid	Cosine		Y	Y	(Y)	Y	Y LLE			
	Fluxapyroxad	Sercadis		Y	(Y)		Y	V LLE			
Pesticides against downy mildew	Mancozeb	Neotec Malvi Mandrake Laminator	Y	Y			Y	V LLE			
	Mancozeb + zoxamide	Unikat 75 WG Electis 75WG	Y	Y	Y		Y	V LLE			

	Metalaxyl-M	SL 567A Clayton Tine		Y	Y	Y		Y LLE			
	Benthiavalicarb-isopropyl + Mancozeb	Valbon		Y	Y		Y	V	Y		
	Cymoxanil	Option		Y	Y	(Y)		V LLE			
	Ametoctradin + dimethomorph	Percos		Y	Y			V LLE			
	Phosphorous acid, phosphite, phosphonate	Frutogard		Y	Y						
Pesticides against botrytis	Fenhexamid	Teldor Agrovista Fenamid Druid		Y				Y LLE			
	Fenpyrazamine	Prolectus		Y				V LLE			
	Pyrimethanil	Scala		Y	(Y)		Y	Y LLE			
	Cyprodinil + Fludioxinil	Switch	Y	Y	(Y)		Y	V LLE			
	Potassium bicarbonate	Karma		Y							
	Bacillus subtilis	Serenade ASO		Y	Y						
	Gliocladium catenulatum	Prestop		Y	(Y)		Y				
Insecticides	*Bacillus thuringiensis*	Lepinox Plus Dipel DF			Y		Y				
	Lambda cyhalothrin	Clayton Lanark Hallmark Markate 50 Major			Y		Y	V LLE	Y		
	Indoxacarb	Steward Explicit			Y		Y	V LLE			
	Spinosad	Tracer			Y		Y	V LLE			
	Spirotetramat	Batavia			Y			Y LLE	Y		
	Methoxyfenozide	Runner			Y		Y	Y LLE	Y		
Herbicides	Propyzamide	Kerb Flo	Residual					V LLE			
	Pelargonic acid	Finalsan	Contact				Y		Y	Y	
	Carfentrazone-ethyl	Shark	Contact					V LLE			
	Glyphosate	Roundup Biactive Cosmic NG Oxalis NG Power Maxx Mon 79991	Systemic								
	Fluazifop-P-butyl	Fusilade Max	Systemic					V LLE			

Accompanying notes:

[1]*All the product labels have the following environmental precautions written on them:*

- *Do not contaminate surface waters or ditches with chemical or used container.*
- *Do not clean application equipment near surface water.*
- *Avoid contamination via drains from farmyards and roads.*

[2]*A Local Environment Risk Assessment for Pesticides (LERAP)* (Health & Safety Executive, 2020) *must be undertaken, using a form available on the internet, when using a LERAP applicable pesticide near a body of water, which can be either static or flowing, such as a lake or river. Its purpose is to ensure that there is an area of untreated ground, referred to as a 'buffer zone', between an area treated with a pesticide and the body of water, in order to minimise issues such as surface runoff or accidental direct application of a pesticide into a body of water. The LERAP forms (records) must be retained by the operator for a period of 3 years.*

[3]*Those products that are dangerous to bees have the following added comment:*

- *To protect bees and pollinating insects do not apply to crop plants when in flower.*
- *Do not use where bees are actively foraging.*
- *Do not apply when flowering weeds are present.*

[4]*The right-hand RAG (red, amber, green) column is a summary of the environmental risks mentioned on the label:*

- *Green: no risks to aquatic life or non-target arthropods mentioned on label.*
- *Orange: risk to aquatic life mentioned on label.*
- *Red: label states both risk to aquatic life and non-target arthropods.*

All the information shown in Table 3 is taken from the product labels. The Health and Safety Executive (HSE) authorises the use of these products via the Chemicals Regulation Division (CRD) (Health and Safety Executive, 2020a), following rigorous statutory approval criteria agreed by EU member states, and further reinforced by CRD to account for UK-specific conditions. No recommendations relating to the protection of personnel using these products have been included, as they are beyond the scope of this study.

The mode of action columns are of interest, as they show broad-spectrum pesticides are less targeted to pests than others, protective products are less effective than curatives, and systemics persist within the plant through rainfall events. Herbicides are either residual (staying in the soil and preventing weed seed germination), contact (wilting just the part of the plant touched by the product) or systemic (killing the whole plant). Some herbicides are more specialised for monocotyledons (e.g. grasses) or dicotyledons, but vineyard products tend to be broad-spectrum in their efficacy.

In terms of application rates, as previously noted, these will vary significantly from vineyard to vineyard depending on need and knowledge. However, as discussed further in Section 10.5, research shows that, on balance, vineyards in the UK use more pesticides (on a per spray ha

basis) than is used on for example wheat or other arable crop that a vineyard is likely to have replaced (Fera, 2018).

The principal environmental hazard when applying pesticides in vineyards is the contamination of bodies of water. To minimise the risk of this contamination, vineyard managers or operators are required to complete a LERAP prior to using pesticides that are toxic to aquatic life. This risk to aquatic life is usually written as a separate statement on the label, sometimes mentioning 'very toxic' or 'with long-lasting effect'. Other environmental hazards listed on pesticide labels include the risk of affecting non-target arthropods, particularly bees. There is no consideration on product labels of hazards to the soil ecosystem or to other fauna in the vineyard.

Once planted, under-vine strips (commonly 50 – 80 cm wide) are normally (but not always – see Sections 7.2.1. and 7.2.2.) kept weed-free (with herbicides or cultivation). Inter-row vineyard alleys are allowed to re-establish with 'weeds' and grasses (Figures 10 a & b) or are pro-actively established with ground cover (grass or cover crops such as clovers or legumes – although these can be detrimental to vines from a nitrogen fixation perspective). Where allowed to re-grow naturally, a multi-species grass and weed sward will, if well managed, provide a habitat and food for predatory insects. Having ground cover in alleys provides a firmer surface for working on and helps reduce soil moisture levels (often a benefit in UK vineyards). Although early-year cultivation of every inter-row alley is not commonly practised in the UK, more common is the cultivation of alternate rows, with sowing or allowing of grasses, weeds or cover crops in the others. Inter-row cultivation encourages vine root growth (to depth), aerates the soil and facilitates the incorporation of fertilisers and compost into the soil. Conversely, however, this can disrupt microbial and biological structures within the soil and lead to the loss of beneficial fungi, fertility and ecosystem services that the soil otherwise provides. Where ground cover is established, this will be mowed to maintain a manageable height and to keep the vineyard as dry as possible. The third option for inter-row alley management is to apply total herbicide (spray off the entire alley) but this has very seldomly been seen in UK vineyards and is practised less and less internationally.

Figure 10 a & b. UK vineyards with ground cover.

Some vineyards mulch prunings into these alleys, while others burn or dispose of them (usually to reduce the potential for diseases to spread). The report authors are not aware of any UK vineyards that irrigate, although young vines have been known to be 'watered in' to help them establish during their first year after planting.

Typically, only around 15% to 20% of UK vineyard land is covered by vines, since inter-row space, headlands and any non-planted areas within the fields remain. Field boundary hedges are generally kept intact, with corners, margins and alleys between rows left open to allow airflow and access. All vineyards within the SDNP have permanent or semi-permanent grass cover on these headlands, margins and alleys, which increases rainfall infiltration, decreases runoff and mitigates soil erosion. They are also areas where biodiversity can exist and be enhanced.

To better understand which of these, and other vineyard management practices, are employed by vineyards within the SDNP, Surrey Hills, Kent Downs and High Weald AONBs, and the New Forest National Park, and to facilitate an assessment of their impact and formulate subsequent recommendations for the SDNP (Section 15), face-to-face interviews were undertaken by Chris Foss with nine SDNP Vineyard managers and one Vineyard manager from each of the other regions. In addition, a vineyard survey was undertaken by Vinescapes in Q4 of 2019, across the 51 SDNP vineyards. A good response rate of 86% was achieved based on hectarage (65% based on vineyard numbers; 33/51 vineyards) (see appendix C for survey questions). This survey provides a benchmark for current within-vineyard practice in the National Park. Results from both the interviews and the survey are presented below.

7.2.1. Vineyard practices within SDNP

Vineyard operations: All vineyards maintain grass cover (and other cover) in their headlands and vineyard alleys, although there is considerable variation in the frequency with which they mow them. Of the nine vineyards interviewed, headlands are mowed 4.9 times per year on average (minimum 3 and maximum 6). Inter-row alleys are mown slightly more often, on average 5.3 times per year (minimum 3 and maximum 10). All vineyards, apart from one, apply herbicides (minimum 1, mean 2.5, maximum 6 times annually) to control under-vine weeds. Two vineyards complement this operation with under-vine soil cultivation, and three vineyards mow the under-vine strip to reduce the number of herbicide applications needed. The one vineyard that does not apply herbicides was not yet fully established, but the Vineyard manager wishes to exclusively mow under the under-vine area. He is also planning to use hand weeding to remove any plants missed by the mower. One vineyard applies PAS100 compost in the under-vine area to improve soil quality and suppress weeds.

As expected, all Vineyard managers interviewed prune their vines then remove cut canes from the trellis. Only two of them do not mulch the cut prunings back into the vineyard floor. One vineyard burns them on site (in the headlands) and another removes them from the site altogether. All vineyards remove excess buds and tuck in shoots by hand, with an average number of passes of 1.9 and 2.7, respectively. Four of the vineyards are trimmed by hand (average two passes) and six by machine (average 2.2 passes). Seven of them carry out leaf removal by hand (average 1.6 passes), and four by machine (average 1.5 passes). Only one of the vineyards used a machine to pick grapes; all the others picked grapes by hand.

Five of the established vineyards add fertiliser annually, whilst three do so only occasionally. Six of the nine vineyards apply foliar feeds at the same time as their pesticide applications. On average, the established vineyards interviewed make a minimum of 6 and a maximum of 15

pesticide applications annually, averaging 10.5 sprays per year. Four of them are fenced to keep animals such as deer, rabbits and badgers out of the vineyard (as they can cause significant vine damage and crop loss), and six of them have to actively protect their crop from birds with scaring devices.

It should be noted here that one should not assume that different products and application rates have a uniform result, i.e. that the minimum applied in one vineyard could therefore be applied in another, since data on grape yields, grape quality and the economic viability of the vineyard ventures are not available through this study. Furthermore, different grape varieties and clones grown in different vineyards will have different degrees of susceptibility to disease and need different levels of protection. Furthermore, vineyard sites themselves will vary with regards to their disease susceptibility, often in relation to their meso- and micro-climates. Conversely, there is likely to be potential to reduce application rates through better training, leading to improved management and targeting of disease and nutrient status through precision viticulture (see Recommendations in Section 15).

When asked which vineyard operations (excluding pesticide and herbicide application) present the greatest risk to the vineyard environment, Vineyard managers responded differently. Pre-planting soil cultivation was cited, as was mowing the grass cover in vineyard alleys, as both disturb habitats and prevent plants from flowering. Two respondents cited the use of tractors, as they compact soil and use carbon-based fuels. All respondents agreed that leaving a grass sward/cover in the inter-row alleys made a positive contribution to conservation. One of them uses a slow-growing mix to reduce the number of cuts required, and another carries out alternate row mowing (See Section 7.2). Some of those interviewed were keen to use under-vine cultivators as they reduce, or even eliminate, the need for herbicides; others were concerned about the effect of intensive cultivation on the soil and the extra diesel required to operate tractors and cultivators. That different management practices are in use is perhaps understandable, as their pros and cons require further research to fully elucidate risks and best practice guidance (see Recommendations in Section 15).

Vineyard inputs: The growers interviewed use a large range of pesticides, the most common of which are set out in Table 4.

The other inputs used are: penconazole (Topas), Kresoxim-methyl (Stroby WG), tebuconazole & trifloxystrobin (Nativo 75WG), boscalid (Filan), cyflufenamid (Cosine), copper oxychloride (Cuprokylt FL), mancozeb + zoxamide (Unikat 75 WG), Metalaxyl-M (SL 567A), fenamidone + fosetyl aluminium (Fenomenal), ametoctradin + dimethomorph (Percos), fenhexamid (Teldor), fenpyrazamine (Prolectus), pyrimethanil (Scala), *Bacillus subtilis* (Serenade ASO), spinosad (Tracer), spirotetramat (Movento), propyzamide (Kerb Flo), carfentrazone-ethyl (Shark), diquat, fertilisers and compost. Comparative application rates with those used in arable farming and horticulture are presented in Section 10.5.

Table 4. Common pesticides used by vineyards in the SDNP.

Active ingredient	Product name	Max. no. of applications per year in any one vineyard	Average no. of applications per year	Reason
Sulphur	Kumulus	10	5.7	PM
Mancozeb	Karamate	6	2.3	DM
Phosphite	Phyte P Plus	6	1.9	DM
Meptyldinocap	Kindred	4	1.7	PM
Cymoxanil	Option	4	1.4	DM
Ametoctradin + demethomorph	Percos	2	1.2	DM
Glyphosate	Roundup	2	1.2	H
Potassium bicarbonate	Karma	3	1.2	PM & B
Cyprodinil + Fludioxinil	Switch	2	1.1	B
Benthiavalicard-isopropyl + Mancozeb	Valbon	2	1.1	DM
Proquinazid	Justice	3	1	PM

B = Botrytis DM = Downy mildew H = Herbicide PM = Powdery mildew

The Vineyard managers were hesitant when asked which vineyard inputs present the greatest risk to the vineyard environment. Some claimed that herbicides (especially diquat and glyphosate), and copper-based pesticides were the worst, but most agreed that insecticides, especially broad-spectrum insecticides, pose a greater risk to the environment. When asked how they would mitigate these risks, several replied that they had plans to stop using herbicides and switch to under-row cultivation. They agreed that pesticide applications should be kept to a minimum, by employing expert plant protection consultants and monitoring for pests (especially spotted wing drosophila; *Drosophila suzukii*) and diseases. Several of them stated that they would not use insecticides; those that did use them said that they would only use them if absolutely necessary. Several of the managers stated that they were very careful to select ideal weather conditions (no rain and minimal or no wind) for their applications, and perform them very early in the morning, to reduce any impacts on the moth population. Several of them use 'tunnel'-shaped recycling or pneumatic applicators that significantly reduce pesticide drift when compared with the drift resulting from the more common single-fan air-assisted sprayers. Windbreaks and hedgerows were also mentioned as barriers to pesticide drift. Some of them use shrouded herbicide applicators. The Vineyard managers were open to the idea of gaining further information on the environmental risks of pesticides.

Four of the Vineyard managers interviewed had no need for LERAP assessments, as there were no water bodies close to their vineyards, three of them routinely carry them out, and two of them did not understand the term. The level of understanding of regulations relating to nitrate vulnerable zones (NVZs) was limited, particularly regarding the storage of nitrogenous fertilisers. This was mainly because they add very little nitrogenous fertiliser to their vineyards. Compost is used, but infrequently, to resolve soil structural problems.

None of the managers surveyed calculated the carbon footprint or greenhouse gas emissions per hectare of their vineyard, although five of them felt that they should do so. One of them had tried using a carbon calculator but found it difficult to relate to the vineyard environment. They were not well informed about the carbon cycle or carbon capture, but, when prompted, stated that the trees and vines that they planted, maintaining soil organic matter, and the grass cover in the alleys were all positive contributors. Their main strategies for reducing greenhouse gas emissions were to reduce the number of tractor operations by combining them (e.g. trimming the vines and mowing the alleys in the same pass), switching to electric vehicles, and encouraging manual labour in their vineyards. One vineyard uses bougies (wax candles) for frost prevention, but only very sparingly, after close monitoring of the temperature.

All Vineyard managers interviewed were very open to further suggestions for environmental conservation and several were trialling new practices/ideas. For instance, one of them was planning to grow ground cover plants (white clover & yellow trefoil) under the vine rows; these plants do not grow too high, so they do not need mowing. Another was asking for advice on how to encourage hedgehogs and slowworms into their vineyard. One was keen to switch to electric vehicles but would require permission to install solar panels on his property, as they cannot economically connect to mains electricity. Some resolved to try to reduce tractor hours to lower their greenhouse gas emissions and soil compaction, and others to reduce pesticide inputs. There was also enthusiasm for better management strategies for vineyards and improved monitoring of soil conditions. One of the managers had ambitions to manage their vineyard using organic practices, and several expressed considerable interest in the newly launched (early 2020) Sustainable Wines of Great Britain scheme (Wine GB, 2020c). One of the managers is an active member of the scheme's Workgroup, and one vineyard is seeking B Corp certification (businesses that meet high standards of verified social and environmental performance, public transparency, and legal accountability to balance profit and purpose (B Corporation, 2020)).

The Vineyard managers responded very positively to the suggestion that the SDNPA might support them in their efforts to be more environmentally sustainable. Suggestions included supporting the grazing of 'scrubland' by ponies, providing information on conservation, NVZs and the contamination of watercourses, and providing growers with targets, particularly regarding conservation of endangered species. They also suggested supporting the work of WineGB and Plumpton College on vineyard sustainability, which includes delivering workshops on environmental conservation. National Park Rangers could be encouraged to attend these, to learn about vine cultivation and subsequently work with growers in supporting best practice. See more associated recommendations in Section 15.

Beyond the nine Vineyard managers interviewed, survey responses from other vineyards within the SDNP revealed that in terms of environmental management they were engaged with:

- Countryside stewardship schemes for land management;
- Linking Environment and Farming (LEAF) schemes, as a basis for farm management;
- Environmental management plans for winery wastewater and vineyards;
- Pre-planting impact assessments;

- Integrated Pest Management (IPM) models to reduce spray rounds;
- Energy generation with photovoltaic panels;
- Rainwater harvesting;
- Organic practices without being officially organic, including organic-approved chemicals;
- Inter-row cover crop growing;
- Efforts to reduce herbicide applications;
- Use of recycling sprayers;
- Using large headlands and having natural reserve areas outside of deer fencing, as well as woodland reserve areas in the centre of the vineyard;
- Reducing, reusing and recycling practices in wineries and vineyards; and,
- Improving environmental awareness through targeted training and education in the vineyard and winery.

7.2.2. Vineyard practices within the Kent Downs, High Weald, and Surrey Hills AONBs and New Forest National Park

The operations carried out in four vineyards whose managers were interviewed in the Surrey Hills, High Weald, and Kent Downs AONBs and New Forest National Park are similar to those in the SDNP area.

The vegetation in headlands is regularly mowed (average 11, minimum 6, maximum 20), as are the vineyard alleys (average 9, minimum 7, maximum 11). In the under-vine area, three vineyards mowed, two cultivated, and three applied herbicides to control weeds. The vineyards that are managed as part of certified organic or biodynamic schemes apply foliar feed supplements more frequently. One vineyard team passes on foot eight times a year to remove unwanted buds and shoots on its vines. There is an average of 3.6 passes through the vineyards each a year to tuck shoots into the trellis, and vine canopies are trimmed about 3 times a year on average, by hand or by machine. Two vineyards do not plough the soil prior to planting vines, preferring to sub-soil then use a power harrow on the surface. One grower composts their prunings and another burns them on site.

One manager was particularly conscious of the environmental risk of applying fertilisers (particularly nitrogen, phosphorus and lime) to vineyards, due to their effect on natural flora and the potential contamination of bodies of water. Therefore, they use these as sparingly as possible, and applied nitrogen and phosphorous only as foliar feeds, using a nozzle-directed pneumatic applicator. Lime is applied as granules encased in apple waste, to reduce the risk of drift and run-off. All growers were aware of the risk of damage/compaction to the soil from using tractors, particularly on wet soils. One vineyard uses tractors with front power take-off shafts, so they can perform two operations, such as mowing and trimming, in one pass. Two vineyards carry out regular sub-soiling to counter soil compaction.

Vineyard inputs: The most common pesticides used by those interviewed in the AONBs are set out in Table 5.

Table 5. Common pesticides used by vineyards in the AONBs.

Active ingredient	Product name	Max. no. of applications per year in any one vineyard	Ave. no. of applications per year	Reason
Sulphur	Kumulus	20	11	PM
Copper oxychloride	Cuprokylt	10	8.25	DM
Phosphite	Phyte P Plus	6	3.7	DM
Potassium bicarbonate	Karma	4	3.3	PM & B
Benthiavalicarb-isopropyl + Mancozeb	Valbon	4	3	DM
Cyprodinil + Fludioxinil	Switch	2	2	B

B = Botrytis DM = Downy mildew H = Herbicide PM = Powdery mildew

The first four products in Table 5 are approved for organic vineyards, and have a low environmental risk rating, but the Valbon label states both risk to aquatic life and non-target arthropod pests. The organic and biodynamic growers also apply the following products for plant protection: 'horn silica', lavender oil, equisetum, nettle and dandelion infusions. Only one vineyard occasionally (and reluctantly) applies insecticides.

Again, as stated in Section 7.2.1., it should be noted that products and application rates applied in one vineyard may not be 'suitable' or lead to the same 'results' if applied in another.

One manager is conscious of the negative impact of sulphur on bees, so uses it sparingly, monitors the risk of powdery mildew (PM) by looking for it on surrounding oak trees, and only applies pesticides to vines if the oak trees show PM symptoms. Copper is generally perceived as being of significant environmental risk and, in one vineyard, is only applied early in the season, when few butterflies are out. When dealing with downy mildew (DM), cutting off diseased leaves (rogueing) is preferred to spraying. Two growers use the fungicide Valbon, whose label states both risk to aquatic life and non-target arthropod pests. Two of the vineyards use orchard-style single-fan broadcast pesticide applicators, which do not position plant protection products accurately on vine canopies.

Two of the vineyards are near bodies of water and so complete LERAP assessments. Two other growers were not aware of LERAP or NVZ legislation and none of the managers take any steps to meet the requirements of NVZ legislation. This is because they are unaware of it, outside of an NVZ zone, or do not store or apply enough nitrogen-containing fertiliser to warrant any action. None of the vineyards measure their carbon footprints or GHG emissions, but two are aiming to do so in the near future. Three of the smaller vineyards confirmed they carry out almost all vineyard tasks by hand.

In the future, there are ambitions to use lighter vehicles, more robotics, and electric vehicles. One vineyard flies a drone to survey vine vigour, hoping to use this to target operations, such

as fertiliser application, to more precise areas of the vineyard where they are specifically needed (known as precision viticulture). There are ambitions to put together a sustainability plan, get involved in local conservation groups, and increase the size of naturally managed land surrounding the vineyards.

All vineyard managers confirmed they would welcome more dialogue with representatives concerned with environmental conservation in their AONB or National Park. One grower works closely with a local environmental group and praised the services of the Sussex Lund charity, which offers support for small-scale, practical projects that improve the landscape of the High Weald AONB.

7.3. The winemaking process

In this study, less emphasis has been placed on the winemaking process than on the viticulture aspects of production, primarily because, as the report/project title suggests, the focus here was on viticulture growth. In addition, much of the modern winemaking process has a less obvious impact on the immediate environment, including soil, ecology and biodiversity. However, both the inputs and outputs of wine production can have environmental risks and do require careful management and mitigation.

Most of the winemaking process takes place indoors, within a winery. Winery buildings can take the form of a simple agri-shed through to an architecturally designed building, or buildings. Once made, wine, especially sparkling wine made using traditional methods, is usually aged for a period before being released to market. For still white and rosé wines (very little red wine is currently made in the UK) this may be for weeks or months, for sparkling wines this could be for several years (or less in bottle, for quality purposes), before disgorging and finishing, and then for months thereafter before release. This process requires temperature-controlled, secure (and bonded) storage facilities that may be within part of the winery or stand as a separate building or buildings. The space required for ageing facilities can be significant compared with that required for the actual winery. Unlike some traditional Champagne ‘cellars’, thousands of metres of underground chalk tunnels for this purpose do not exist in the UK.

During September and October (harvest time), grapes are delivered to a winery, in small picking crates by hand (if the vineyard is in close proximity to the winery), by vehicle (tractor and trailer, van, or truck) or in larger harvest bins (Dolavs or similar). Often the process of loading presses is done manually but may be aided by hoppers and conveyor systems or, where larger bins are used, forklift trucks. This activity often takes place at the entrance to or just inside a winery building or press house, or outside under temporary cover. From then on, the production process continues throughout the year. This process is dependent on the style of wine being made, but will involve some or all of the following steps: settling, racking, tank transfers, inoculation, fermentation, analysis, filtering, fining, blending, bottling, tirage, ageing, disgorging, packaging and preparation for distribution. This may sound simplistic (it has been distilled down to these core activities for the purpose of this study but plenty of literature is available on the various winemaking stages and there is neither the space or need to elaborate further here), but it is a skilled process, involving both science (oenology) and skill, to craft high-quality wine. Wineries in the UK commonly have highly trained winemakers

who are, depending on production scale and complexity, supported by assistant winemakers, cellar hands, sommeliers and vintage staff (see Section 13 for further discussions of vineyard and winery staff). The process of bottling can be undertaken in-house if a winery has its own bottling line, or by a specialist mobile facility (on the back of a lorry or on a trailer).

The wine production process does have the potential to impact the environment in terms of pollution and GHG emissions if by-products (including wastewater) are not effectively managed (see Sections 10.6 and 15).

Wineries, storage facilities, ageing facilities, ancillary facilities (e.g. cafés, tasting rooms, restaurants, offices), access routes, parking, on-site utilities, staff and visitors all impact the environment in terms of infrastructure, buildings, vehicle movements, noise and light. The degree and nature of these impacts will vary depending on, for example, scale, operational/business scope, management and landscape sensitivity. Some of these impacts are subjective, some have both pros and cons, some have policy alignment and others do not. However, in nearly all cases the infrastructure, facilities, buildings, scale, landscape impact and required mitigants are assessed and decided through the planning process (see Section 5.4, including 5.4.9) (SDNPA, A farmer's Guide: Agricultural permitted development rights in the South Downs National Park, 2019a).

These aspects are discussed further in Section 10.6. in relation to impacts and mitigants, but it is perhaps important to note at this point that for the purpose of planning, the making and selling of wine from grapes grown on the premises (associated vineyard), including tours and tastings, are classified as 'ancillary agricultural activities' (Millington;, 1999). Therefore, winemaking is classified as an agricultural activity if the winery only processes their own grapes. Where wineries process grapes on behalf of other growers, wineries may be considered other than agricultural processing facilities. Shops and other ancillary businesses on-site are just that, ancillary.

7.4. The economics of grape growing and wine production

Section 13 addresses the economic impact of viticulture and wine production, within the context of the SDNP. However, as a prelude, and to contextualise the activities discussed above (vineyard establishment, vineyard management and winemaking), it is useful to note here that these processes (when taken as a whole) require significant capital investment. In the UK it is unlikely that a return on investment (ROI) from viticulture and wine production will begin to be seen until at least 10 to 15 years post-planting. This may take less time for growing grapes and selling under contract, although these times and their economic viability are changing. These timeframes assume favourable weather conditions and clear routes to market with an attractive product. UK viticulture is not for the faint hearted and, as competition increases, it is likely that market forces and/or space will result in the failure of some enterprises. Conversely, other enterprises will start or expand.

8. Present land and climatic suitability for viticulture within the SDNP

Section 8 – Key findings:

- Of existing SDNP farmland (arable and grazing; 70% of the National Park; 116,000 ha), vineyards currently cover 0.38%, i.e. approximately 0.27% of the National Park's overall area.
- Application of the viticulture suitability model to the SDNP area identifies approximately 39,700 ha of viticulture-suitable land (34.2% of existing farmland).
- Establishing 10% of this land with grapevines (3,970 ha) would represent an area larger than the entire UK viticulture sector in 2020. Vineyards on this scale could produce more than 22m bottles of wine a year.
- Suitable viticulture land is defined as: having an elevation less than 150 m; having a south-east to south-westerly aspect; lying on a 1% to 15% slope angle; having a land use classified as arable, horticulture or grassland; having a soil descriptor primarily, but not exclusively, classified as free draining (see Section 8.3.); not being situated within an area designated for nature conservation purposes; having an average growing season temperature (GST) of >14°C, growing degree days (GDDs) of >850, growing season rainfall <425 mm and June rainfall (when grapevine flowering commonly occurs) <55 mm. Areas with lower frost risk and wind exposure are also preferred for viticulture.
- Most of the viticulture-suitable land is located within the southern areas of the National Park, particularly south-western and south-central areas, within Downland landscapes. There is also a large band of suitable land that runs between Petersfield and Petworth, where several larger vineyards have been established, and significant areas of suitable land north of Newhaven and south of Firle Beacon. Clusters of smaller vineyards exist within the scarp footslopes, north of the South Downs, around Ditchling and Hassocks.

Site characteristics favourable for viticulture, relating to topography, soils, land cover, weather and climate (longer-term conditions; commonly measured over a 30-year period), are not uniform for all vineyards. While some common features can be identified, distinctive elements will depend on the intended grape varieties and wine style, viticulture decisions and practices (including rootstocks, training systems, automation etc.). Nonetheless, site selection is critical to viticulture and its likely success, profitability, resulting wine styles, marketing and overall sense of place – sometimes described as 'terroir'. Notwithstanding the human element to this, and the history and heritage of the viticulture location or region, weather and climate conditions are critical as they play predominant roles in grapevine physiology and phenology and ultimately determine the commercial viability of viticulture. The effects of climate change are discussed in Section 9.

To facilitate an analysis of environmental, landscape character and visual impacts of viticulture and wine production in the SDNP, and to indicate potential for viticulture growth, this Section presents modelled land and climatic suitability within the National Park to elucidate the spatial distribution and scale of viticulture potential.

The spatial and varietal distribution of longer established wine producing regions of the world, often termed the 'old-world', largely results from centuries of trial and error, experience, learning and adaptation. For newer regions such as the SDNP, decisions regarding terrestrial and climatic suitability cannot readily be made from empirical or regression-based predictions. Defined quantitative relationships between variables such as locality, topography, soil characteristics, seasonal weather profiles, inter-annual variability, grapevine yields and grape quality parameters for different varieties are not yet objectively established in England and Wales, nor in the SDNP. Vineyard site selection continues to be done on an ad hoc, case-by-case basis, often lacking systematic spatial comparisons and potentially subject to value judgements around critical characteristics, their relative degrees of importance and the weightings that should be applied to them. However, to obtain an objective, high-resolution local and regional assessment of climatic and terrestrial (soil, topography, land use) suitability, modern geographic information systems (GIS) for data integration and spatial analysis provide a rapid means of identifying land suitability for viticulture, thus bypassing the decades or even centuries of exploration previously required. GIS tools have been employed here to deliver a high-resolution (50 x 50 m) SDNP viticulture suitability map, which in turn will help direct the strategy and policy relevant actions forthcoming from this impact assessment.

8.1. Model development/methodology

Predictor variables, thresholds, data sources and the methodology for model development can be found in a previous report (Nesbitt, Dorling, & Lovett, A suitability model for viticulture in England and Wales: opportunities for investment, sector growth and increased climate resilience., 2018). There are two key differences in this present study: Growing degree days (GDDs) are also used as bioclimatic viticulture suitability indicators, and the climate data are derived from the UK Climate Projections 2018 (Met Office, UKCP18, 2020a) analysis tool, using 5 km resolution. Further information about this can be found in Section 9. Here, climate variables have been modelled as 20-year averages (2021 – 2040). Whilst not representative of the time in which current vineyards were established, since the focus of this study was

'growth', the 2021 – 2040 time period was deemed more relevant than using past climate data.

Figures 12 a–k show the model layers that were subsequently integrated to produce a suitability map (Figures 13 a–b).

8.2. Model limitations

Further guidance on the desirable terrestrial and climatic 'characteristics' of vineyards within the SDNP are set out below. However, it must be noted that whilst these variables have been employed for modelling work within this study, this **does not** mean vineyards will not be established on land with variables that fall outside of these desirable ranges. Indeed, some existing vineyards within the National Park could be described as 'sub-optimal', as they fall outside of these variable ranges. In a similar vein, it may be somewhat surprising to note that soils classified as slowly permeable, seasonally wet and with impeded drainage are included in the model. Whilst these are undesirable characteristics, several well established vineyards within the National Park share this soil type and in all likelihood, with appropriate soil and ground management, rootstock selection, and viticulture practices, the prima facie challenges of such soils may be overcome or mitigated.

Therefore, whilst this study includes an objective assessment of present land suitability, it should be expected that vineyards exist, and may in future be planted, in locations not highlighted by the suitability model.

Land within the SDNP has been modelled using 50 x 50 m grid cells, which were deemed representative of field scale. However, it should be noted this scale will not necessarily resolve or show smaller landscape features, such as hedges, which run through the landscape.

Model outputs (Figures 13 a and b) do show limited suitable land within several hundred metres of the coast. Whilst coastal proximity for viticulture is undesirable due to exposure (wind) and the risk of sea salt being deposited onto vines (which can burn/damage vines and inhibit photosynthesis) and soils, no exact 'safe' distance threshold is available to apply to a model, so potential vineyard sites would need to be assessed on a case-by case basis.

8.3. Model variables

Model variables and their relationship to viticulture are explained further below:

Elevation: There is no stipulated 'ideal' elevation for vineyards in England and Wales or the SDNP but guidance suggests vineyards would be best sited below 100 m and not above 150 m (Skelton, 2014). Elevation suitability is restricted by decreasing temperatures at higher altitudes and the greater potential for wind exposure.

Aspect: At higher latitudes, south-facing slopes (in the northern hemisphere) have greater direct solar radiation gain potential (Coombe & Dry, 2004; Jackson, 2014), particularly during the ripening period when the sun is higher in the sky. They are also conducive to reducing the lag phase during which a site heats up and dries out after a cold night (Jackson, 2014). All else

being equal, such slope aspects are favourable to both yield and grape berry quality parameters.

Slope angle: Optimal slope angle for viticulture (with conventional practices and equipment) is 1% to 15%. The potential for mechanical vineyard-management activity becomes increasingly limited on slopes greater than 10% (Jackson, 2014) and erosion risk increases. Below 1% there is an increased risk of cold air accumulation and potential frost damage (Jones, Snead, & Nelson, 2004).

Land cover: Potentially suitable areas for viticulture are limited in this work to those classified as arable, horticulture or grassland in the Centre for Ecology and Hydrology's Land Cover Map (LCM) (2007), because they were deemed most likely to exhibit viticulture suitability parameters and correspond to the landcover type that preceded most existing vineyards.

Soil: Soil texture, drainage, pH, fertility, nutrient and organic matter content are all important attributes in determining viticulture suitability. Their influences on vine nutrient and water availability, soil temperature and humidity, the solubility of metal ions and the supply of nutrient cations and anions, the number of beneficial microbes, and contributions to soil chemical, physical and biological properties all impact vine health, growth and productivity (Davenport & Stevens, 2006; Field, Smith, Holzapfel, Hardie, & Emery, 2009; Lanyon, Cass, & Hansen, 2004; Riches, 2013). Although a range of desirable soil characteristics exist for viticulture, for example it is generally accepted that soil pH should be between 5.5 and 7.5 for optimum vine growth and soil microbial composition (Cass & Maschmedt, 1998; Lanyon, Cass, & Hansen, 2004; Riches, 2013), no single prescriptive 'ideal' set of soil properties exists. Rather, a broad and generalised range of soil properties is presented as being suitable under different environmental circumstances and for different rootstocks, clones, varieties, planting densities and training systems. It should also be noted that many soil characteristics, particularly nutrient availability, can be ameliorated via soil management activities to achieve desired traits. However, to best represent the range of soil characteristics deemed desirable for viticulture, the Soilscapes data series was selected as it provides useful, concise, easily interpreted and applicable descriptions of the soils of England and Wales. Whilst not necessarily 100% representative of soil 'types' at individual field scale, it was found to be more representative than other soil mapping data (Nesbitt, Dorling, & Lovett, A suitability model for viticulture in England and Wales: opportunities for investment, sector growth and increased climate resilience., 2018). There were 9 out of the 27 Soilscapes soil descriptors/'types' selected for this study. Whilst accepting that 'Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils; Slowly permeable seasonally wet acid loamy and clayey soils; and, slightly acid loamy and clayey soils with impeded drainage' are not theoretically ideal for viticulture, they were included because several well established vineyards within the National Park are present on such soils and presumably have employed appropriate vines and viticulture practices to grow on them. This holds true for UK vineyards generally, outside of the National Park.

Designated areas: It was assumed that where land areas had been awarded a special designated status for nature conservation purposes, for example, a Site of Special Scientific Interest, and were therefore 'protected', that they would not be available for viticulture.

Temperature and bioclimatic indices: Temperature plays a major role in viticulture viability, grapevine growth and modulating the final content of compounds in grape berries, such as sugars, acids, phenolics, flavour compounds and proteins (Gladstones, 1992). In viticulture climate research, temperature is often presented through bioclimatic indices (BCIs), metrics which provide simplistic illustrations and assessments of present or future viticulture or varietal suitability (Anderson, Jones, & Tait, 2012; Duchêne & Schneider, 2005).

BCIs commonly place numerical or descriptive envelopes around summed or averaged daily or monthly growing-season temperatures to express varietal suitability ranges. They are applied in different regions, for different timescales, using different spatial resolutions, and are driven by both observed and modelled climate data. Here, modelled data were used, and it should be noted that these data do not necessarily resolve the range of climatic processes, intra-annual variability, or critical daily or hourly time-scale events that can impact productivity and quality and which are likely to influence sub-regional climate–viticulture relationships (Jones, Moriondo, Hall, & Duff, 2009; White, Diffenbaugh, Jones, Pal, & Giorgi, 2006). However, the modelled 5 x 5 km resolution does provide a meso-scale assessment which indicates local viticulture suitability. Where temperature was applied to model BCI viticulture potential in the SDNP it was used as an analogue, with the assumption that larger bioclimatic values present increased opportunity when the bottom end of 'cool-climate' viticulture is being explored.

There were two temperature BCIs employed in this modelling work. The first was the growing season average temperature (GST), calculated as the monthly mean (April – October in the Northern Hemisphere) summed (for the 7 months) and divided by 7. The classifications awarded to GSTs are shown in Figure 11, from Jones (Jones G. , 2006).

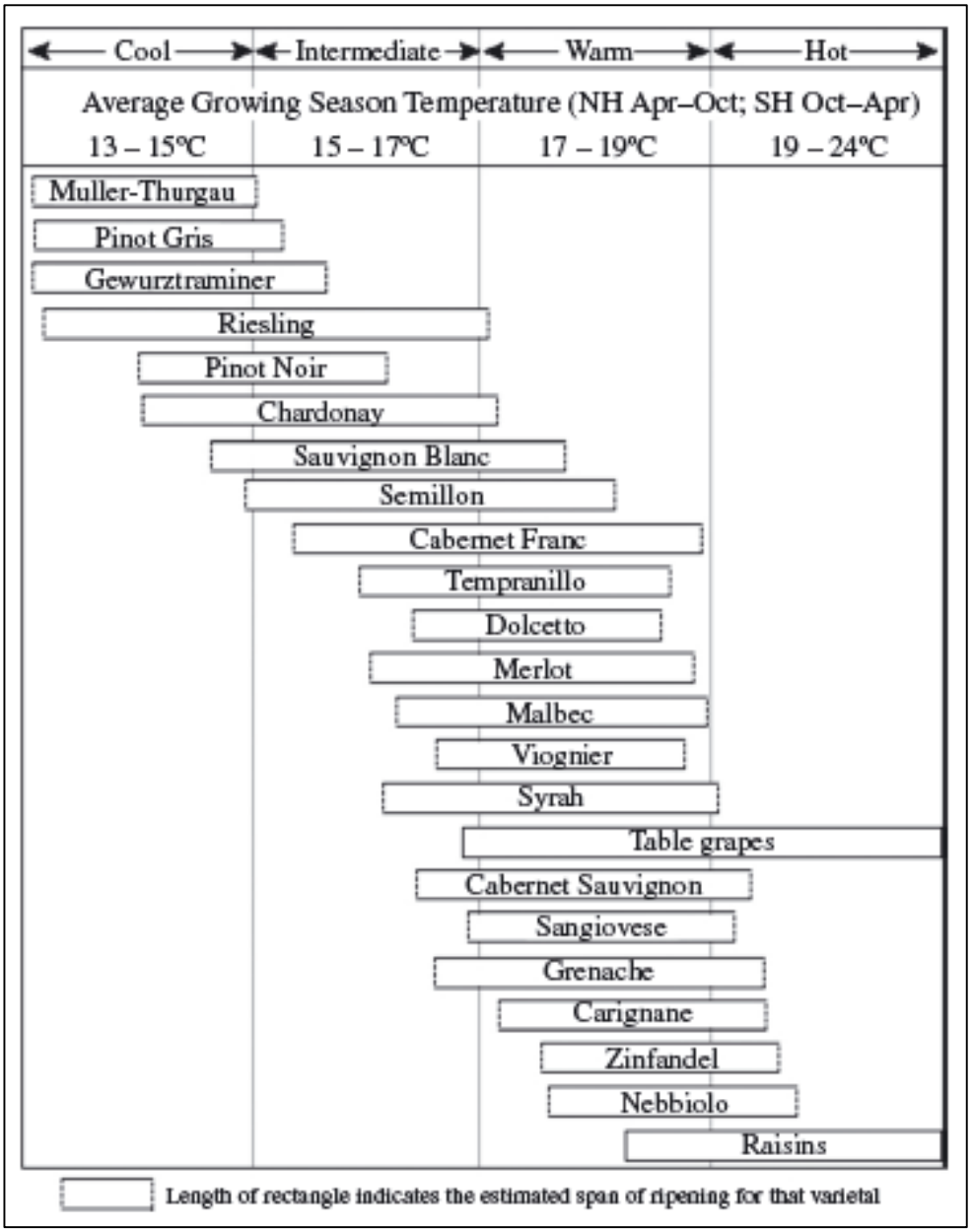


Figure 11. Climate–maturity thresholds for GSTs and varieties (Jones, 2006).

The second BCI employed in this work was the Winkler Index, which classifies the climate of wine growing regions based on heat summation or GDDs. In this system, geographical areas are divided into five climate regions (I-V), based on temperature converted to growing degree days (see Table 6). The system is based on both the hypothesis and observation that grapevines do not grow if the daily mean temperature is less than 10°C (although it should be noted that this is not the case for all varieties). Each day during the growing season is assigned growing degree days according to the amount that the day's average temperature exceeds this 10°C threshold; one degree day per degree over 10°C. All days during the growing season are then added up (all negative values are set to zero), with the sum of the growing degree days used to determine the region's classification in the index, as shown in Table 6.

Table 6. WI GDD classifications.

Region/class	GDDs	General ripening capability and wine style
Region Ia	850–1111	Only very early ripening varieties achieve high quality, mostly hybrid grape varieties and some *V. vinifera*.
Region Ib	1111–1389	Only early ripening varieties achieve high quality, some hybrid grape varieties but mostly *V. vinifera*.
Region II	1389–1667	Early and mid-season table wine varieties will produce good quality wines.
Region III	1668–1944	Favourable for high production of standard to good quality table wines.
Region IV	1945–2222	Favourable for high production, but acceptable table wine quality at best.
Region V	2223–2700	Typically, only suitable for extremely high production, fair quality table wine or table grape varieties destined for early season consumption are grown.

Spring air frosts can injure developing buds and shoots, which are among the most common detrimental effects of minimum temperature extremes on *Vitis vinifera* L. grapevines. Without frost protection, these frosts pose a significant economic risk to vineyards (Trought, Howell, & Cherry, 1999). Cool-climate wine producing regions are particularly exposed to the risk of early season frost events when the advancement of budburst occurs in response to periods of increased spring air temperatures (Molitor, Junk, Evers, Hoffmann, & Beyer, 2014; Mosedale, Wilson, & Maclean, 2015).

Rainfall: Wine grape quality and quantity are affected by precipitation and water availability (Makra, et al., 2009; Moutinho-Pereira, et al., 2007). High levels of rainfall, usually accompanied by reduced sunlight, can negatively affect vine growth, berry quality and quantity through associated issues such as increased disease pressure, overstimulated vegetative growth, reduced flowering, millerandage (where grape bunches contain berries that differ greatly in size and maturity, sometimes referred to as 'chicken and hen'), coulure (where flowers fail to set and are shed at or after flowering), and a sugar/acidity imbalance.

High rainfall levels during June, when grapevine flowering usually occurs in the UK, have previously been shown to have a negative impact on flowering and subsequent grape yield (Nesbitt, Kemp, Steele, Lovett, & Dorling, 2016).

Wind: Wind speed and direction have not been included within this model, as detailed near-surface wind speed data for the growing season within the SDNP were unavailable. Wind, at vineyard level, is likely to be influenced by local topographical and geospatial factors. However, it can generally be expected that the prevailing wind throughout most of the National Park is south-westerly. Wind mitigation is critical in vineyards, as it can disrupt canopies and flowering. A breeze, on the other hand, is beneficial, as it helps dry out a vineyard and keep diseases at bay. The elevation restriction to 150 m within this model is in

part due to more likely wind exposure at higher elevations, although there are vineyards within the National Park at significantly lower elevations which are exposed and still challenged by wind.

Sunshine and **solar radiation** are also important with regards to the ripening of wine grapes. Within such a relatively small area (the SDNP), it has been assumed for the purposes of this work that the criterion of south-facing slopes captures optimal land, in terms of sunlight exposure and solar radiation capture. Where this land is in valleys or 'shaded' by surrounding higher land, its suitability for viticulture would require careful, individual site assessment.

8.4. Suitability model results

Figures 12 a–k show the different mapped data layers, overlaid onto the National Park area. Subsequently, the GIS mapping process resulted in Figure 13a and 13b, which show the combined viticulture suitability map.

Before commenting further on this output, we must state that this map alone **should not** be used as the basis for viticulture investment decisions. All land considered for planting with vines will require a comprehensive viticulture site evaluation by experts.

At present, 436 ha of land within the National Park is established vineyard land. This represents 0.27% of the National Park's 1,627 km^2 (162,700 ha) area. Of overall existing farmland (arable and grazing; 70% of the National Park; 116,000 ha), vineyards cover 0.38%.

The viticulture suitability model results for the SDNP indicate there is approximately 39,700 ha of suitable land, representing 34.2% of existing farmland within the National Park. By comparison with more established wine producing regions, this is larger than the current viticulture area of Champagne in France (35,000 ha). Whilst it is not possible to say with certainty to what scale the viticulture sector within the SDNP may grow, land use needs, market limitations, investment requirements, potential for viticulture outside of the National Park area (in some areas with greater suitability; see Nesbitt et al. 2018), and risks associated with a changing climate could restrict the scale of any growth. Furthermore, future policy regarding land use and land status may, in any event, restrict such potential. As an indication of growth and area, the model predicts that:

- Were 2.5% of suitable area to be planted with grapevines, this would represent just over a doubling of existing SDNP vineyard area, to approximately 990 ha;
- 5% would be 1,980 ha, similar to the scale of viticulture in Tasmania;
- 10% would be 3,970 ha, which is larger than the entire UK viticulture sector in 2020;
- 25% would be 9,925 ha, at which point WineGB's (2018) predicted 40 million bottles by 2040 would have been exceeded by about 15 million bottles in the SDNP alone; and,
- 50% would be 19,850 ha.

The average sparkling wine output in the UK is around 5,600 bottles (0.75L) per hectare, but this varies considerably depending on variety, yield, press extraction rates, etc. Given this

production volume, for the area percentages described above, the model predicts the bottle output per annum would be:

- 2.5% – 5,544,000 bottles;
- 5% – 11,088,000 bottles;
- 10% – 22,232,000 bottles;
- 25% – 55,580,000 bottles; and,
- 50% – 111,160,000 bottles.

It is not possible to state with any degree of certainty how many wineries or what infrastructure would be required to accommodate the various scales of potential growth. The economic Section (Section 13) of this study sets out workforce requirements but building and infrastructure requirements will be dependent on how the sector evolves for the purposes of production and marketing. For example, one large production facility (winery) and associated large storage warehouses could accommodate the production and storage of tens of millions of bottles. Conversely, every vineyard could have its own small winery, but we know that is not the case currently. Or, there could be a mixture of small, medium and large wineries for several individual producers, groups, or co-operatives of such (as in more established wine producing regions). We can say with a good degree of confidence that there is little economic sense in producers all having their own facilities; pooling of resources, equipment and facilities is something seen in wine production the world over and is likely to be the case in the future in England, Wales and the SDNP, as the economics of wine production are realised in an increasingly competitive space.

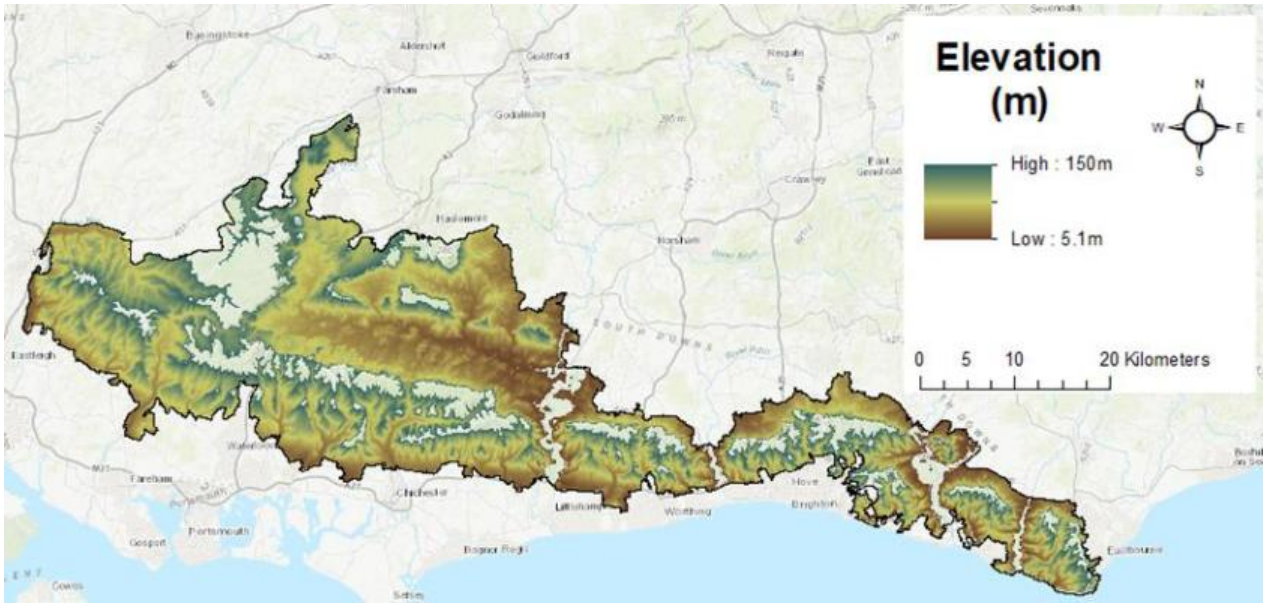


Figure 12a. Elevation.

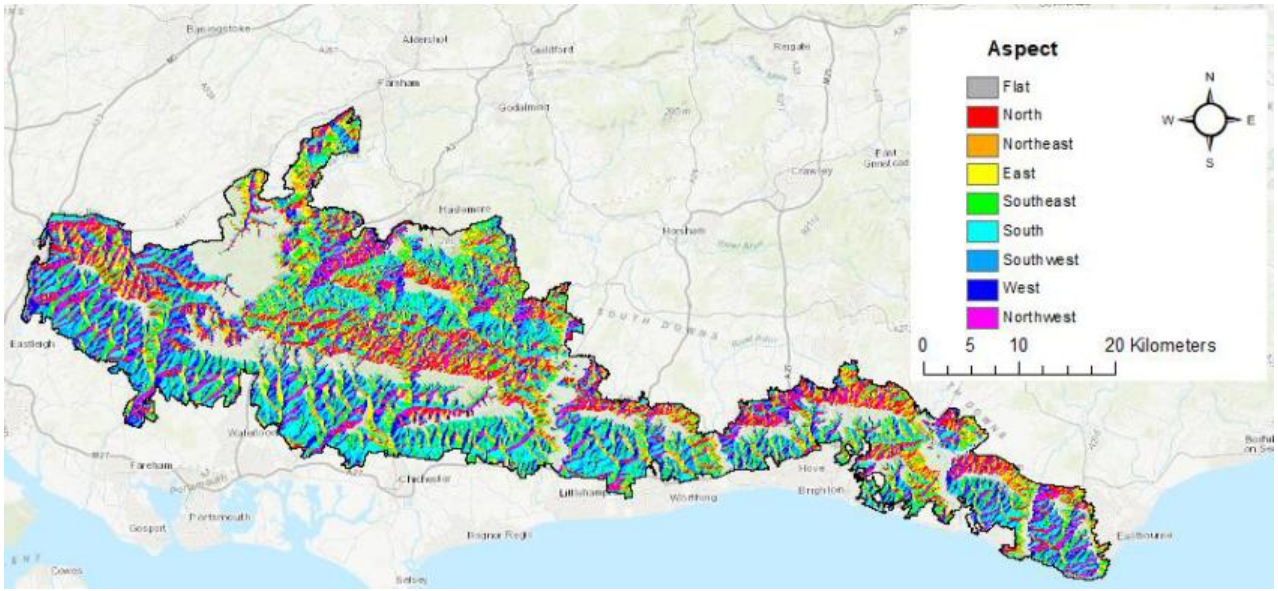


Figure 12b. Aspect.

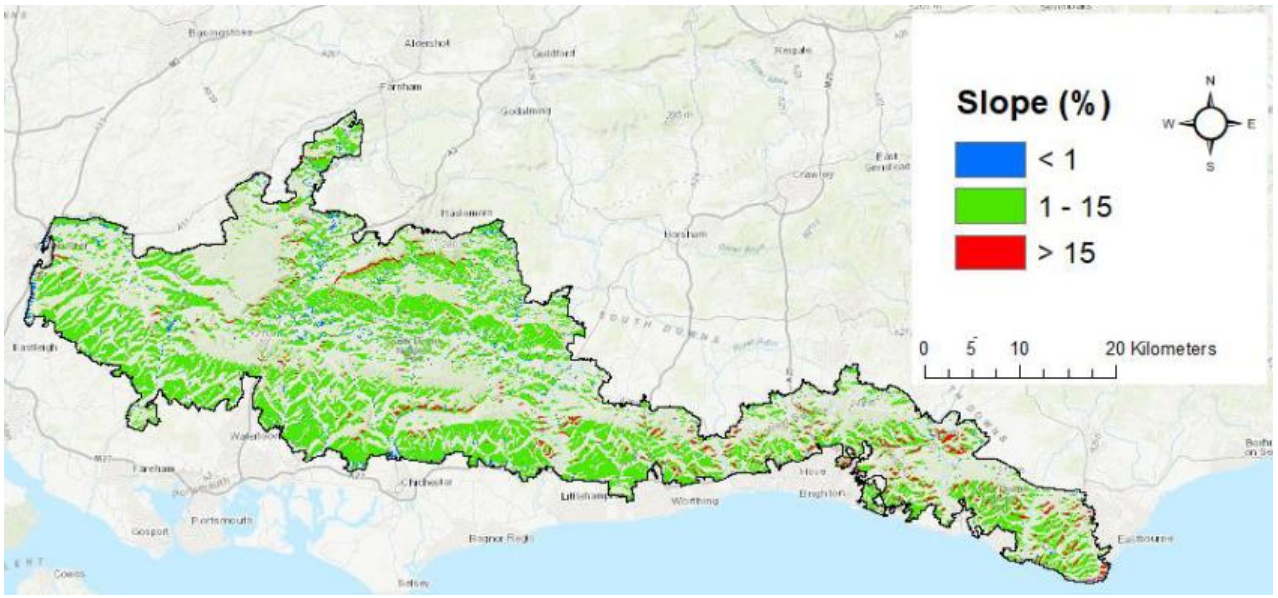


Figure 12c. Slope gradient.

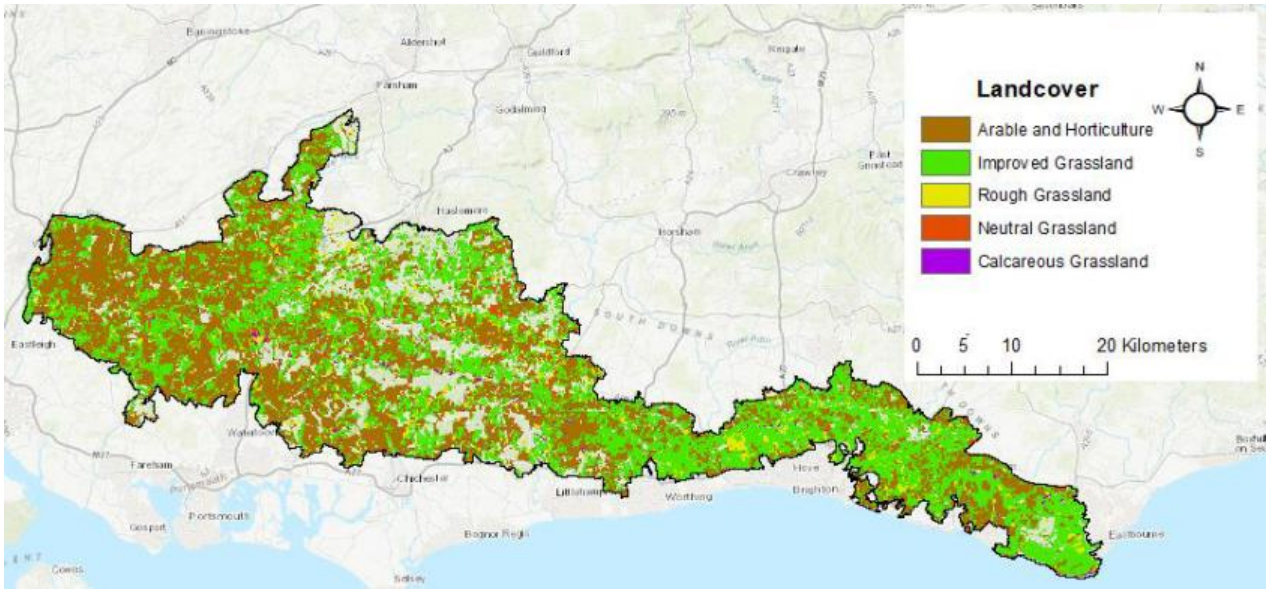


Figure 12d. Land cover.

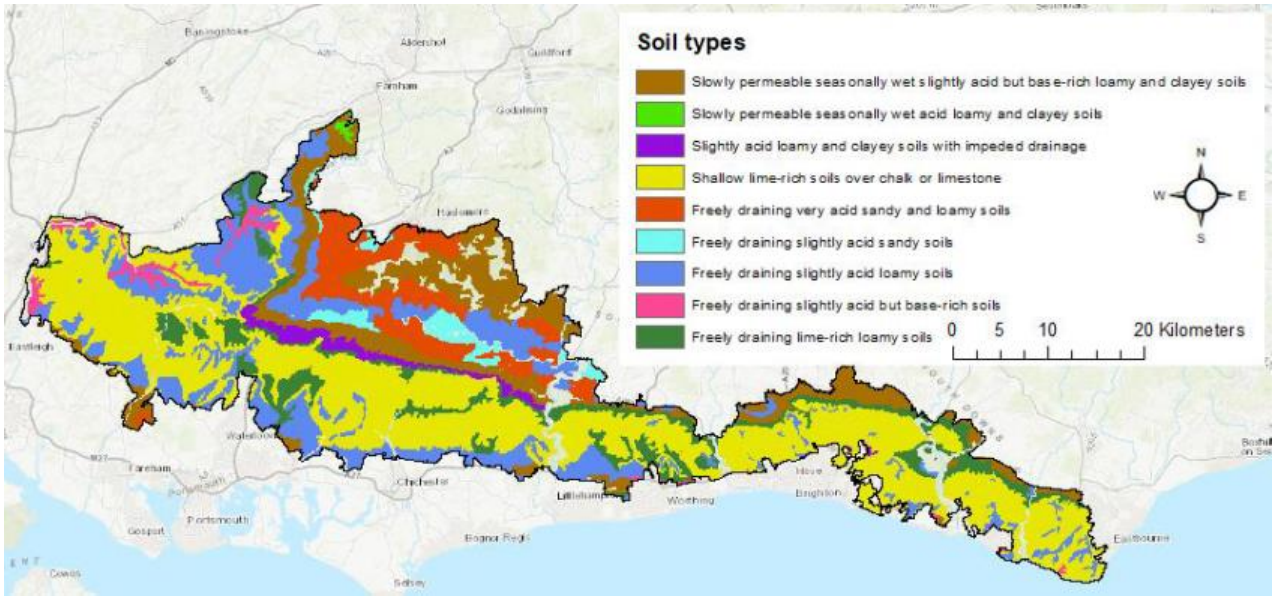


Figure 12e. Soils.

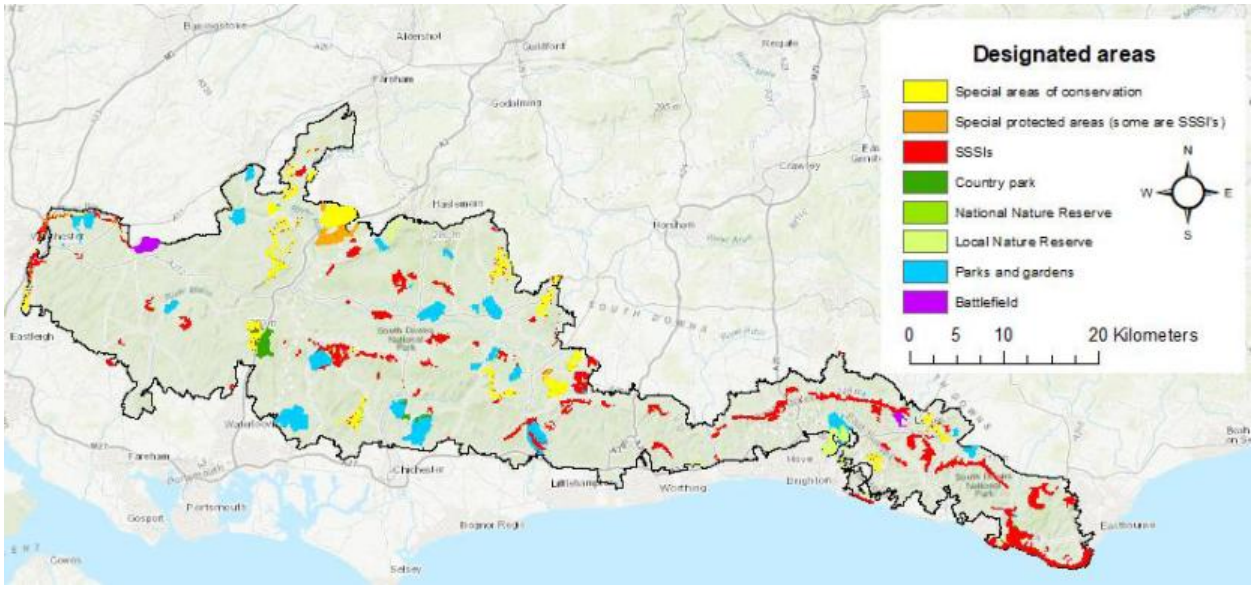


Figure 12f. Designated nature conservation areas.

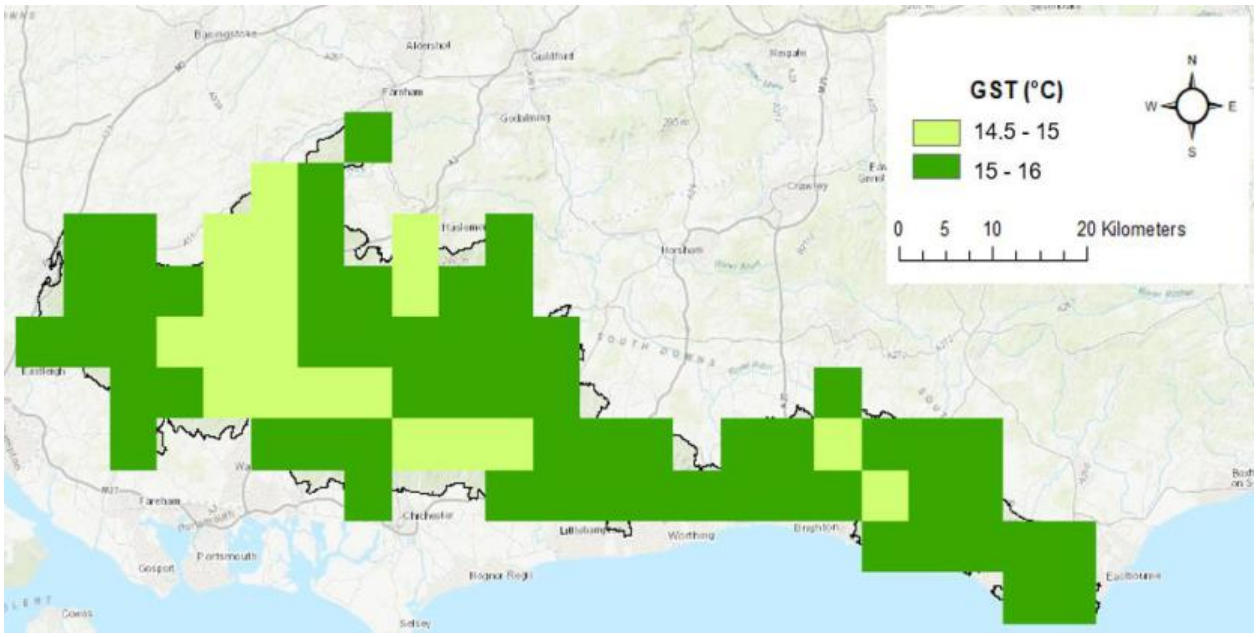


Figure 12g. GSTs.

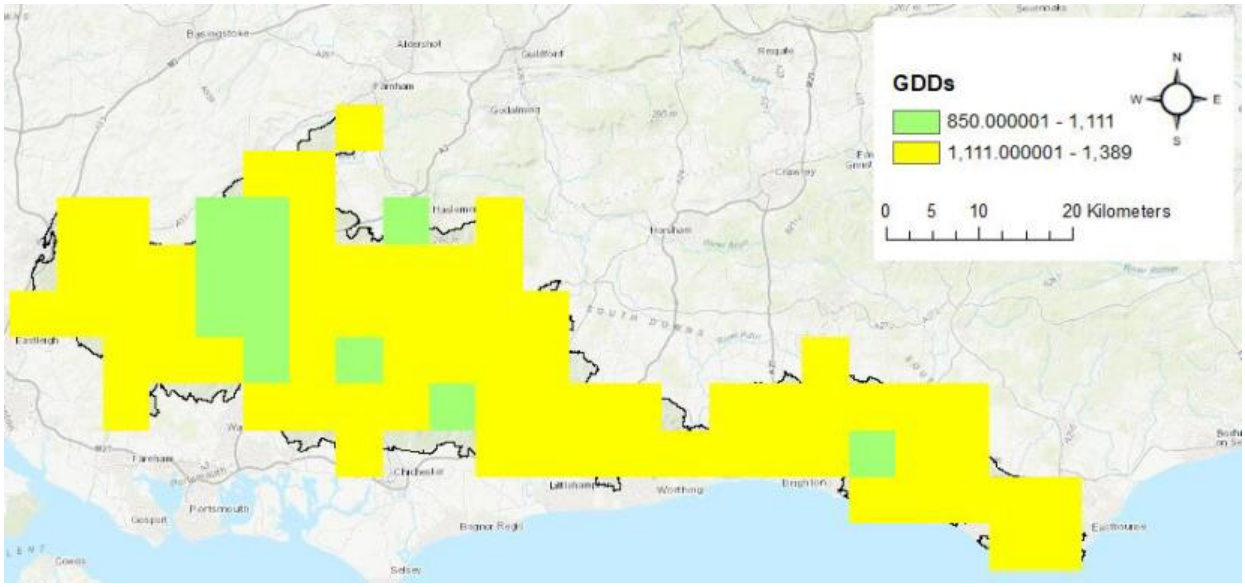


Figure 12h. GDDs.

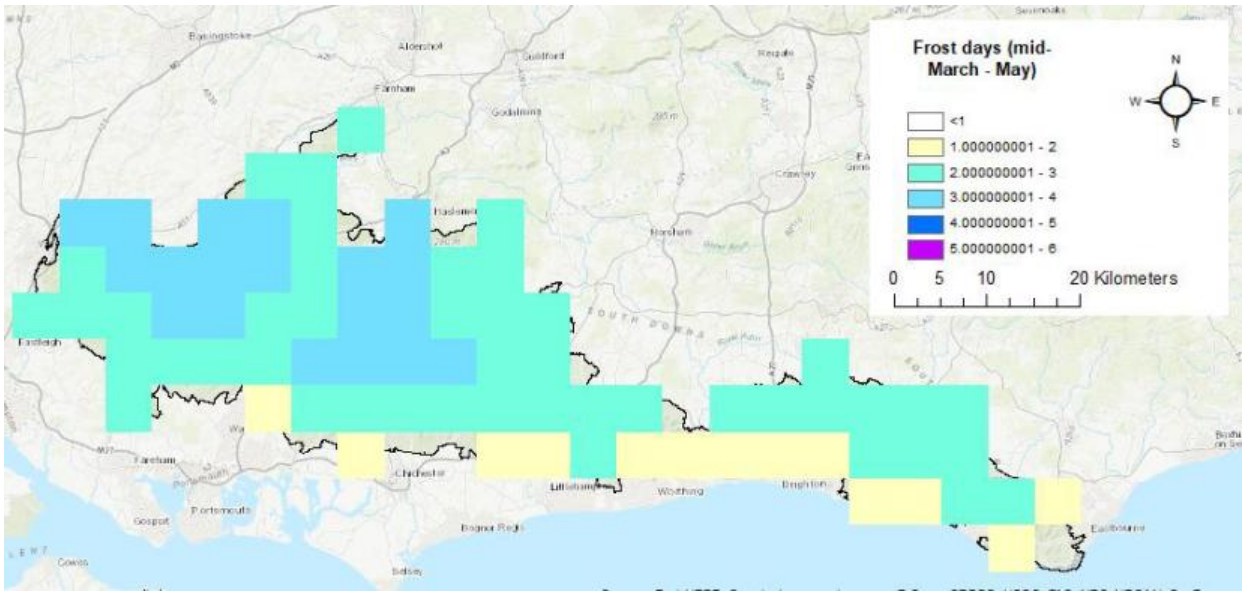


Figure 12i. Frost days.

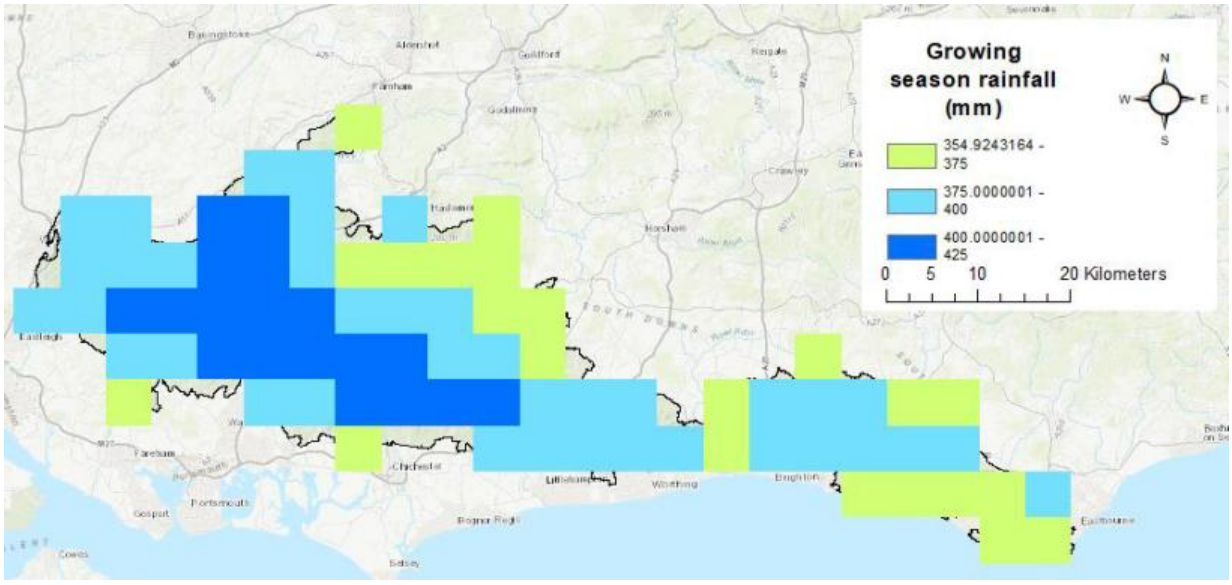


Figure 12j. Growing season rainfall.

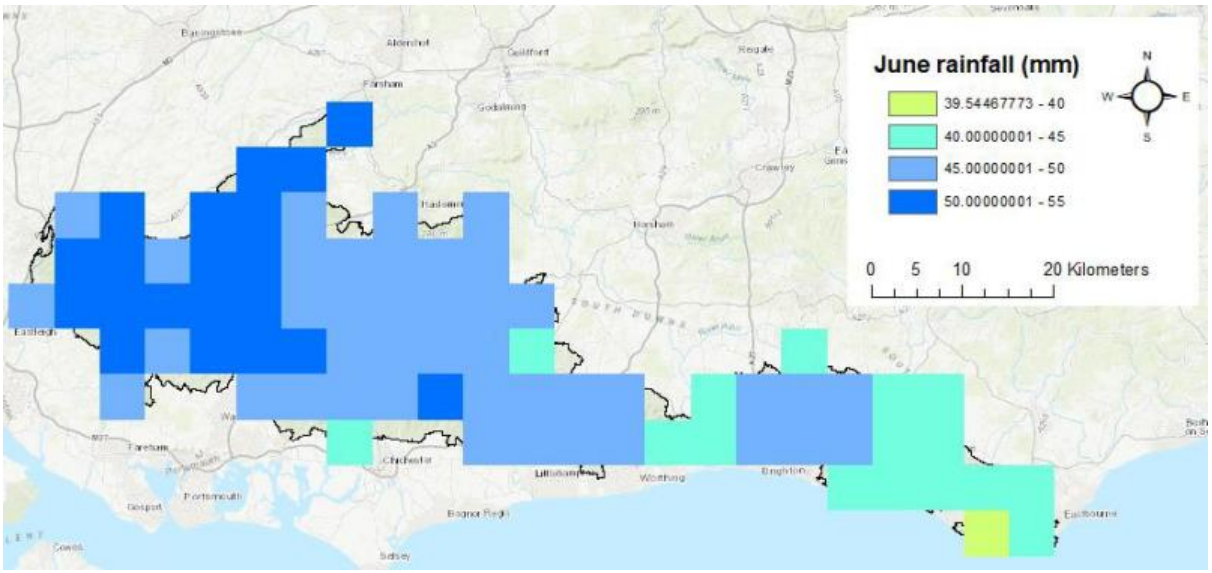


Figure 12k. June rainfall.

Figure 12 a–k. Mapped data layers, overlaid onto the South Downs National Park.

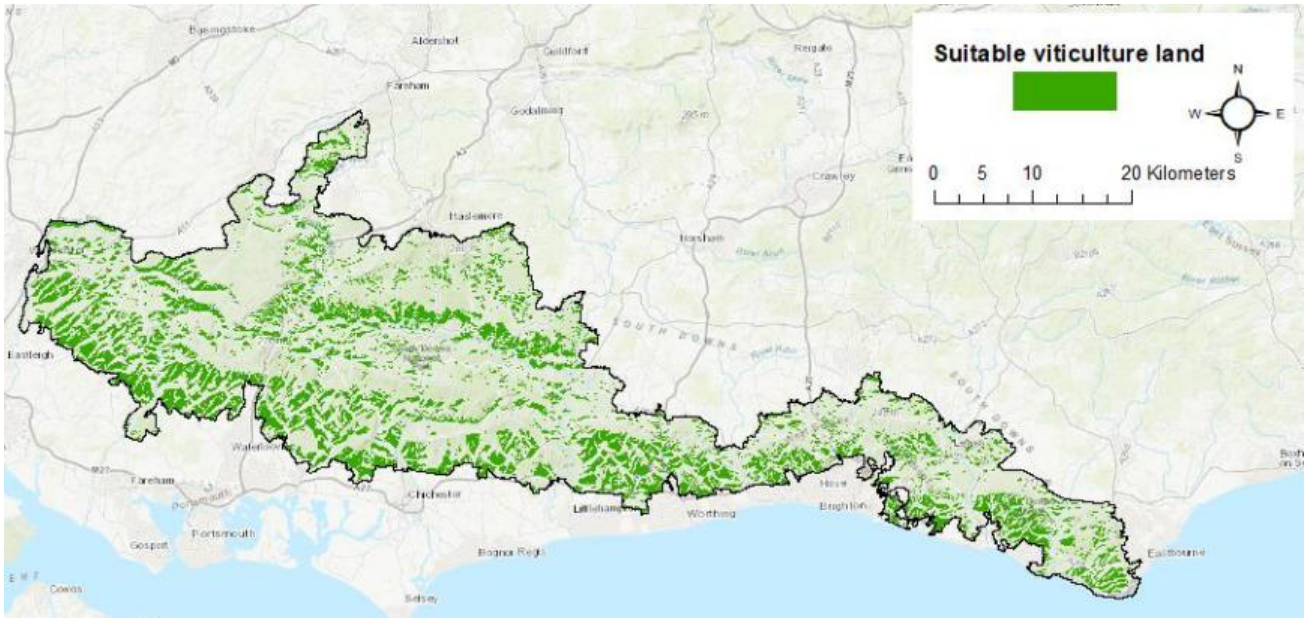


Figure 13a. Viticulturally suitable areas (dark green) within the SDNP.

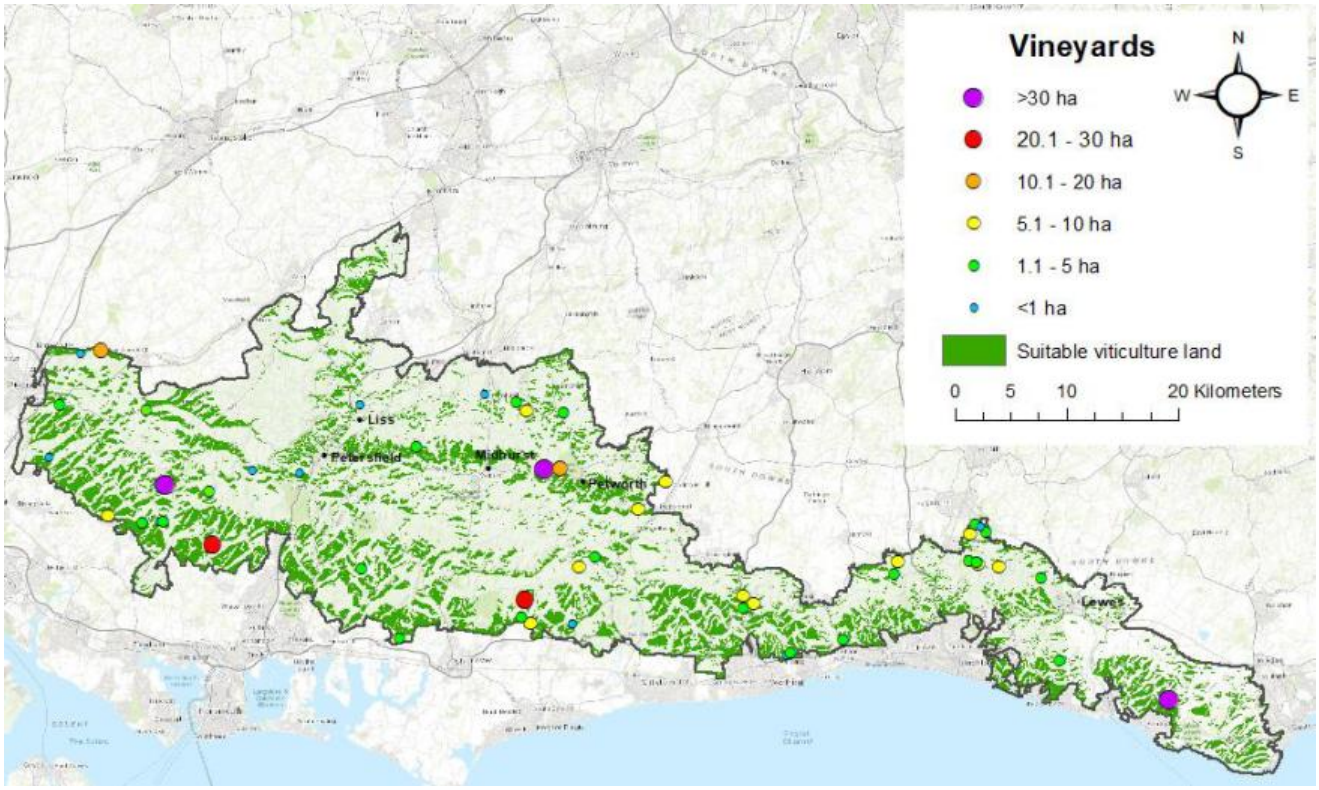


Figure 13b. Viticulturally suitable areas (dark green) within the SDNP, overlaid with existing vineyards.

Figure 13 a & b. SDNP Viticulturally suitable areas

Figures 13 a and b show that the majority of suitable land (from a viticulture perspective alone) is located within the southern areas of the National Park, particularly south-western and south-central areas within downland landscapes (See Section 12). There is also a suitable band of land that runs between Petersfield and Petworth, where several larger vineyards are

established, and significant areas of suitable land north of Newhaven and south of Firle Beacon. Clusters of smaller vineyards exist within the scarp footslopes north of the South Downs, around Ditchling and Hassocks.

9. Climate change and future land suitability for viticulture within the SDNP

Section 9 – Key findings:

- The future viability of the status quo in global wine production has been brought into question by recent and rapid shifts in climate. Previously marginal viticulture regions, such as the UK, are rapidly expanding as their climate becomes more viticulture-friendly.
- Future climate projections to 2050 are relatively insensitive to the choice of socio-economic scenario.
- General climate change trends projected for the UK in the 21st century show an increased chance of warmer, wetter winters and hotter, drier summers, along with an increase in the frequency and intensity of extremes. In the context of vineyards, relevant extreme events may be very short-term (e.g. an air frost during bud burst or a hail event once fruit is established) or much longer term (such as an anomalously warm or cool growing season).
- Recent observed trends in air temperature, along with projections from UKCP18 for the coming decades, reveal the SDNP becoming more widely suited not only to the production of sparkling wine but also, in the future, of highly marketable still wines.
- Hot summers are expected to become more common. The summer of 2018 was the equal-warmest summer in the UK (with 2006, 2003 and 1976) and a record-breaking year for UK grape production. Climate change has already increased the chance of seeing a summer as hot as 2018 to between 12% and 25%. With future warming, hot summers by mid-century could become even more common, increasing the chance nearer to 50%.
- Despite overall summer drying trends in the future, increases in the intensity of heavy rainfall events in the summer are likely. If associated with an increase in the incidence of hail, this could represent an increasing risk to vineyards.
- Phenological changes under a changing climate, such as the typical timings of budburst and flowering moving earlier in the growing season, mean that UK vines will remain at risk to climate variability, even under anticipated future climate change.

Suitability for viticulture relies upon a regional climate that is well aligned to the growing requirements of one or more grape varieties (Carbonneau, 2003; Fraga, Malheiro, Moutinho-Pereira, & Santos, 2013). Within such a generally supportive climate, superimposed local microclimate variations also support a patchwork of grape varieties and wine types that bring complexity and value to the wine market. However, the climatic sensitivity of *Vitis vinifera* L. exposes viticulture to both threats and opportunities associated with climate change (Tóth & Végvári, 2016; Webb, Watterson, Bhend, Whetton, & Barlow, 2013).

Recent and rapid shifts in climate have led to uncertainty within the global wine sector, bringing the future viability of the status quo in global production into question. Whilst short-term resilience can be increased through local climate adaptation measures (e.g. shading, sunscreens, irrigation and precision viticulture management), more radical medium- to long-term solutions may be needed when local climate adaptation measures prove insufficient. Changes in varieties grown, moving to higher (i.e. cooler) growing elevations, or latitudinal shifts may need to be considered, always keeping in mind agility constraints associated with the typical 25-year lifetime of grapevines. Although there is little additional land available for southward viticulture migration in the Southern Hemisphere, in the Northern Hemisphere new, higher latitude areas are already offering potential.

9.1. Climate Change

Whilst there is currently little evidence of the UK viticulture sector attracting investment that is driven by migration and re-location of production, the sector has nevertheless benefitted from recent climate change, especially the warming trend over the last 50 years (see Figure 7 in Section 5.3; Nesbitt et al. 2016 & 2018), as has the expansion of cool-climate viticulture in countries such as Denmark, Sweden, Norway, Poland and Canada. To date, it is known that two Champagne houses have planted vineyards in southern England, but the degree to which climate change has directly prompted this investment is unclear. Marketing, land values, potential for exceptional quality wine and a desire to be part of the sector's growth in the UK may have as much to do with this trend as the increasing climate risk.

Climate-influenced changes in the UK viticulture sector are also very likely to be a feature in the climate to come. Future climate changes, their pace, severity and manifestations (positive or negative), will not only affect viticulture potential in the SDNP but also impact other forms of land use, agriculture and the special landscape within the National Park. Hence, although this study is restricted to viticulture growth and impacts, when contextualising this within the framework of a changing climate, the wider environment and landscape will also be changing over the coming decades.

Of course, the future direction of climate change will partly be influenced by our societal reaction to it in terms of climate change mitigation measures – our response will shape the rate and pattern of climate change and therefore its impacts. Combining future socio-economic scenarios with climate models enables us to project how climate change may impact viticulture in the SDNP over the next 60 years; we do this here based on the most recent UK Climate Projections, published in 2018 (Met Office, UKCP18, 2020a).

Global and regional climate projections into the future depend first of all on the availability of alternative future scenarios of socio-economic change, each of which leads to different spatial and temporal trends in the atmospheric concentration of the gases and aerosols that impact climate through what is known as 'radiative forcing'. Core to this study then are the Shared Socio-economic Pathways (SSPs), of which there are five, shown in Figure 14. These are composed of several baselines regarding future socio-economic developments and policy actions (Riahi, et al., 2016). They describe SSP1 as 'taking the green road', where sustainable and less intense industries result in lower challenges to mitigation and adaptation to climate change. They subsequently describe SSP5 as the scenario of 'fossil-fuelled development'.

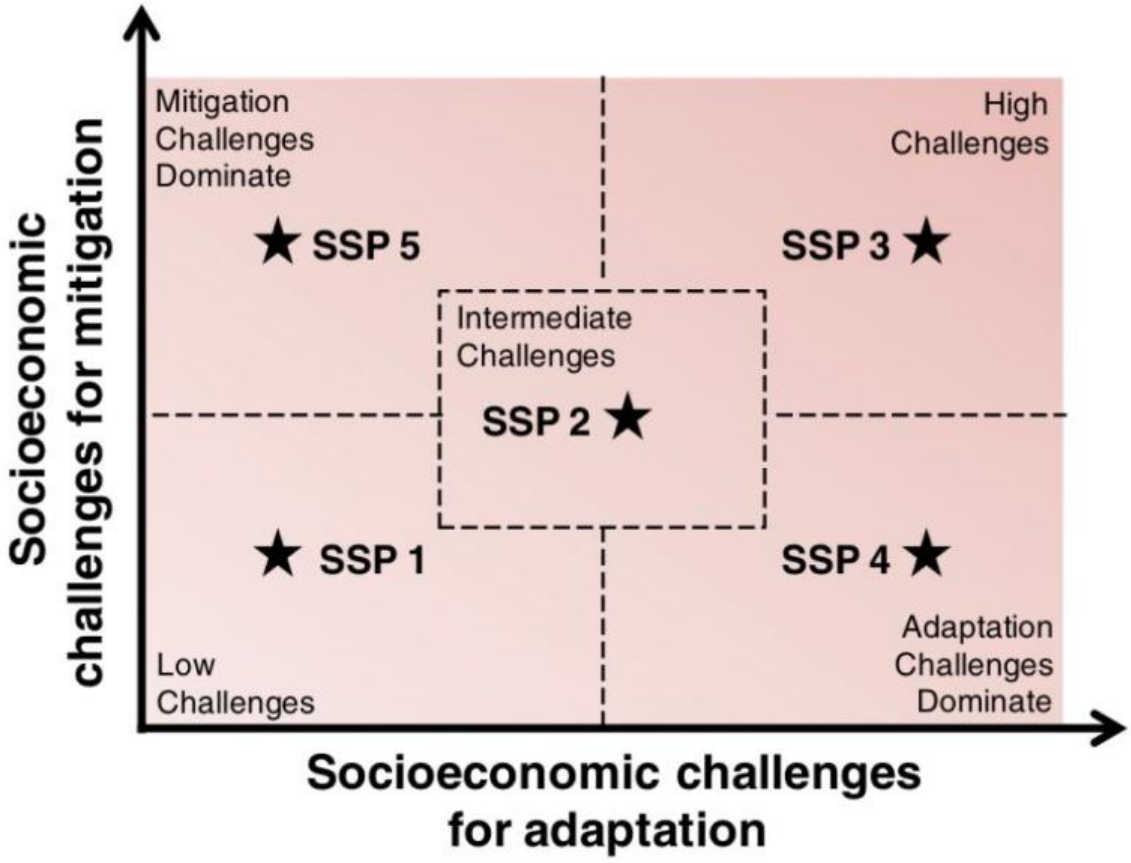


Figure 14. The socio-economic challenges related to each Shared Socio-economic Pathway scenario (O'Neill, E. Kriegler, & Riahi, 2014).

Greenhouse gases (GHGs) and aerosols force the climate by altering the transmission of short-wave radiation from the sun and longer-wave radiation from the Earth through absorption, scattering or reflection. The size of this forcing can be described in terms of Representative Concentration Pathways (RCPs). For example, RCP8.5 assumes that little progress is made over the coming decades in reducing GHG emissions and an additional forcing of 8.5 Wm^{-2} occurs relative to the net radiative flux by 2100. On the other hand, RCP2.6 is a pathway where radiative forcing peaks at approximately 3 Wm^{-2} prior to 2100 and then declines. Note that a significant amount of climate forcing to the middle of the 21st century is already built in, regardless of which RCP we follow, due to the relatively long atmospheric lifetime of GHGs that have already been emitted.

SSPs and RCPs are combined to form a Scenario Mix Architecture (SMA) framework (Riahi, et al., 2016), which is more commonly used than individual RCPs or SSPs. Figure 15 shows that RCP8.5 will only be met under SSP5, the scenario with the most fossil fuel usage and the least mitigative technologies (O'Neill, E. Kriegler, & Riahi, 2014).

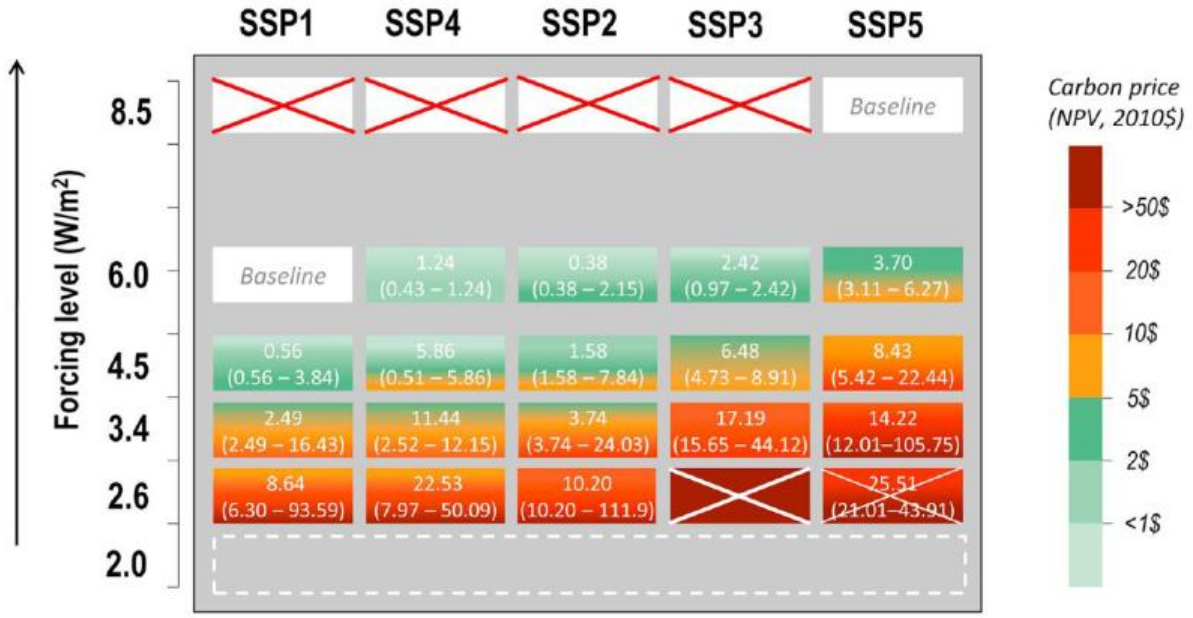


Figure 15. Relationship between SSPs and climate forcing RCP's (Representative Concentration Pathways), showing the carbon pricing with regards to the cost of mitigation efforts (Riahi et al., 2017).

The baseline scenarios result in a global energy consumption of 400 – 1,200 EJ by 2100, with annual CO_2 emissions in these scenarios ranging from 25 $GtCO_2$ to more than 120 $GtCO_2$.

Climate models simulate the key processes and interactions that naturally occur within and between the atmosphere, the land, the ocean and the ice environment (collectively known as the Earth System), taking account of GHG and aerosol forcing. As a result, climate models are capable of realistically simulating the patterns of weather experienced in the UK, both at the national and local scale.

Together with SSP-RCP combinations, therefore, climate models can be used to provide plausible projections (note these are not predictions) of climate change over time, but with some uncertainty and bias. Uncertainties in the future climate trajectory come from three main sources and the relative contribution of each of these sources to total uncertainty can be seen to change significantly over time (Figure 16):

- We cannot know which SSP-RCP scenario we will actually follow through this century – the contribution of this to total uncertainty increases significantly in the second half of the century, but does not add much up to 2040 (Figure 16 – green);
- Differences in simulations between alternative climate models (the 'model spread' – blue) in terms of their structure or representation of some processes (either due to

the limitations of our scientific understanding or due to limitations in computing resources that constrain the level of detail which models can include); and,

- Internal variability (orange) – aside from climate change over decades and longer timescales, there is a natural variability in climate from year to year that we are used to experiencing. This normal variability can mask any climate trends occurring over longer timescales and be either in or out of sync with the climate trend in any particular year.

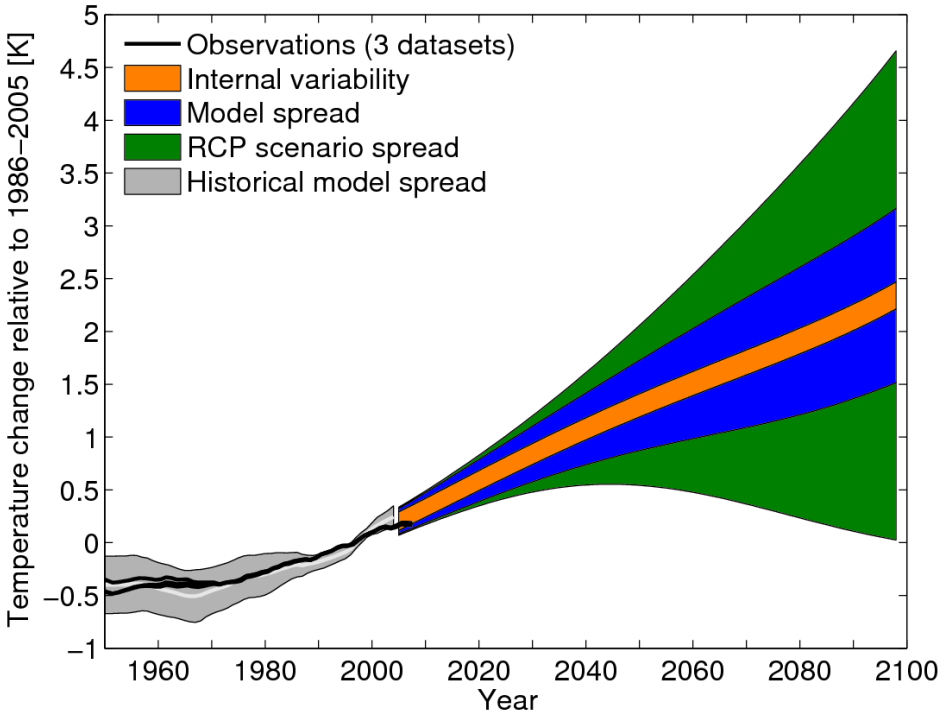


Figure 16. Sources of uncertainty in CMIP5 Climate Model projections (Climate Lab, 2013).

At present, RCP8.5, which is only compatible with SSP5, most closely reflects society's limited response to climate change mitigation thus far and, as a result, this scenario has been the context for the most detailed climate modelling recently undertaken for the UK within UKCP18 (at 2.2 km resolution). The climate projection is also relatively insensitive to the socio-economic scenario out to 2050.

Hence, to usefully reflect the uncertainties over the next 20 to 30 years, we focus on uncertainty types 2 and 3 in this high spatial resolution study of the SDNP, by analysing projections from a suite of twelve climate models (from the Met Office Hadley Centre's global climate model (HadGEM3-GC3.05) and 5th Coupled Model Intercomparison Project (CMIP5) model members), driven by just one scenario, RCP8.5, available through UKCP18. Whilst RCP8.5 is somewhat of a worst-case scenario, it remains representative of the emissions pathway we are currently on and, for the purposes of this study, a full range of possible changes, from the recent past (1981 – 2000) to the near- (2021 – 2040) and far-future (2061 – 2080) are available at the high spatial resolution required through UKCP18. The model development approach is described in more detail in the UKCP18 Derived Projections Report (Gohar, Bernie, Good, & Lowe, 2018).

Before presenting high-resolution climate change results specifically for the SDNP, based on UKCP18 2.2 km projections released in 2019, it is helpful to first summarise high-level findings from UKCP18 at the UK scale:

- The average annual temperature in the UK over the most recent decade (2009 – 2018) was on average 0.3°C warmer than the 1981 – 2010 average and 0.9°C warmer than the 1961 – 1990 average. All of the top-ten warmest years for the UK, in the series from 1884, have occurred since 2002.
- The most recent decade (2009 – 2018) has been on average 1% wetter than 1981 – 2010 and 5% wetter than 1961 – 1990 for the UK overall.
- Winters in the UK, for the most recent decade (2009 – 2018), have been on average 5% wetter than 1981 – 2010 and 12% wetter than 1961 – 1990. Summers in the UK have also been wetter, by 11% and 13% than 1981 – 2010 and 1961 – 1990, respectively'. However, very long period natural variations are also seen in the longer observational record. These show periods in earlier parts of the historical record with similar levels of UK summer rainfall to that seen during 2009 – 2018.
- General climate change trends projected over UK land for the 21st century show an increased chance of warmer, wetter winters and hotter, drier summers, along with an increase in the frequency and intensity of extremes.
- Hot summers are expected to become more common. The summer of 2018 was the equal-warmest summer ever for the UK, along with 2006, 2003 and 1976. Climate change has already increased the chance of seeing a summer as hot as 2018 to between 12% and 25%. With future warming, hot summers by mid-century could become even more common, nearer to 50%.
- Hot spells, typically defined as maximum daytime temperatures exceeding 30°C for two or more consecutive days, are largely confined to the south-east UK in the present day. In the future (by the 2070s), under a high emissions scenario, the frequency of hot spells will increase, from an average of 0.25 occurrences per year at the moment to 4.3 by 2070.
- Despite overall summer drying trends in the future, increases in the intensity of heavy rainfall events in the summer are likely. For urban areas in particular, this will impact on the frequency and severity of surface water flooding.
- Future climate change is projected to bring about a change in the seasonality of extremes. UKCP18 projects an extension of the convective (intense) rain season from summer into autumn, with significant increases in hourly rainfall intensity in the autumn and significant increases in hourly precipitation extremes in the future. For example, rainfall associated with an event that currently typically occurs once every 2 years increases by 25% (central estimate). This has several implications for how water is managed. It is worth noting that while the intensity of hourly rainfall is projected to increase in the future, summers are projected to become drier.

9.2. Climate change projections over the SDNP area

Following downscaling, output from projections was made available to the user-community at 5 km resolution and subsequently formed the basis of this section of the study. An area embracing the full SDNP area was extracted and the results clipped using an SDNP shapefile within a GIS.

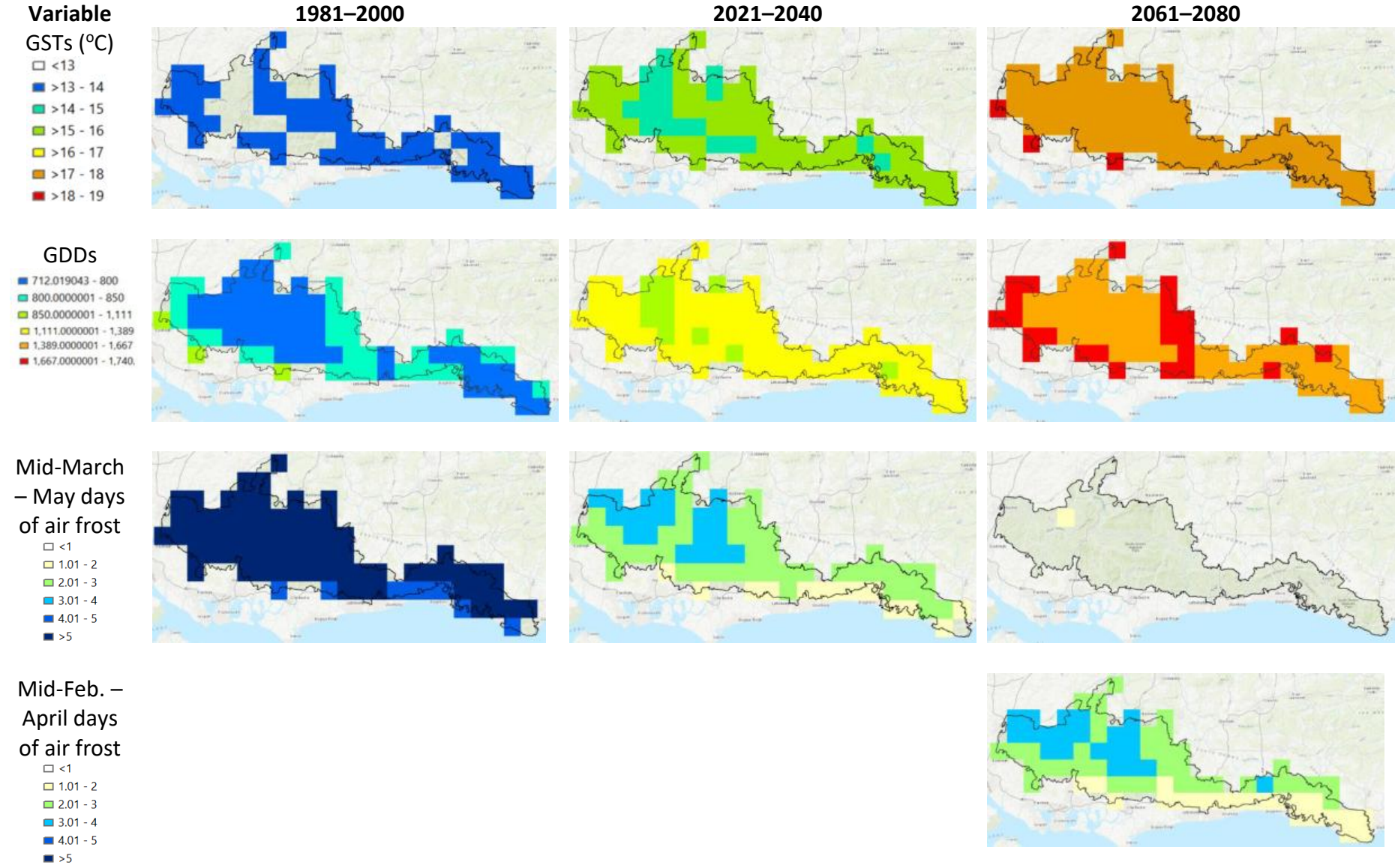
9.2.1 Model output

The average of these twelve downscaled model members – the ensemble mean – was determined for across the SDNP, for the key bioclimatic indices, for the three simulated 20-year periods, 1981 – 2000, 2021 – 2040 and 2061 – 2080 (Figure 17).

The output in Figure 17 shows that during the 1981 – 2000 period there were areas within the National Park that were not warm enough to be conducive to commercial production of the currently dominant varieties of Pinot Noir and Chardonnay, and that were exposed to high levels of early season air-frost risk. As the climate warms, within the next period (2021 – 2040), and as is already being witnessed, GSTs and GDDs both indicate increasing suitability for Chardonnay and Pinot Noir, but also varieties not currently commonly grown in the National Park (or indeed in the UK), such as Riesling, Sauvignon Blanc and Semillon. Future (2061 – 2080) warming of the growing season is likely to bring shifts in vine phenology but also significant changes to varietal suitability. Whilst the projections indicate that vineyards within the SDNP will be too hot for Chardonnay and Pinot Noir (without significant adaptation), they indicate that varieties that we currently associate with much warmer regions of the world could be grown in the SDNP, including Viognier, Shiraz, Cabernet Franc, Tempranillo, Merlot and Malbec. A shift from cool-climate sparkling wine to still white and red wines would seem likely under such growing-season temperature regimes.

Additionally, early-season frost risk is reduced significantly in the current risk period (mid-March to May), but with corresponding (due to warming spring temperatures) advancement of phenology earlier in the season (mid-February to April), frost risk may remain. The point at which irrigation may be beneficial is difficult to determine and is driven by a multitude of factors, including the temporal nature of rain (both the distribution and seasonality of rain events). However, by 2061 – 2080 growing-season rainfall will be reduced compared with that of the near current period (2021 – 2040) by approximately 100 mm in some areas and under some circumstances, and in some years partial irrigation may be required.

One of the current key risks to yields in UK viticulture is rainfall at flowering (around June; Nesbitt et al. 2016). Under these modelled conditions this risk decreases and, certainly in the next 20 years with increasing summer temperatures, more 2018-style bumper grape harvests in the UK are likely. It should be noted, however, that if flowering advances to May in a warming climate then Figure 17 shows that this risk of rainfall at flowering is exacerbated.


Variable
1981–2000
2021–2040
2061–2080
GSTs (°C)
<13
>13 - 14
>14 - 15
>15 - 16
>16 - 17
>17 - 18
>18 - 19
GDDs
712.019043 - 800
800.0000001 - 850
850.0000001 - 1,111
1,111.0000001 - 1,389
1,389.0000001 - 1,667
1,667.0000001 - 1,740.
Mid-March – May days of air frost
<1
1.01 - 2
2.01 - 3
3.01 - 4
4.01 - 5
>5
Mid-Feb. – April days of air frost
<1
1.01 - 2
2.01 - 3
3.01 - 4
4.01 - 5
>5

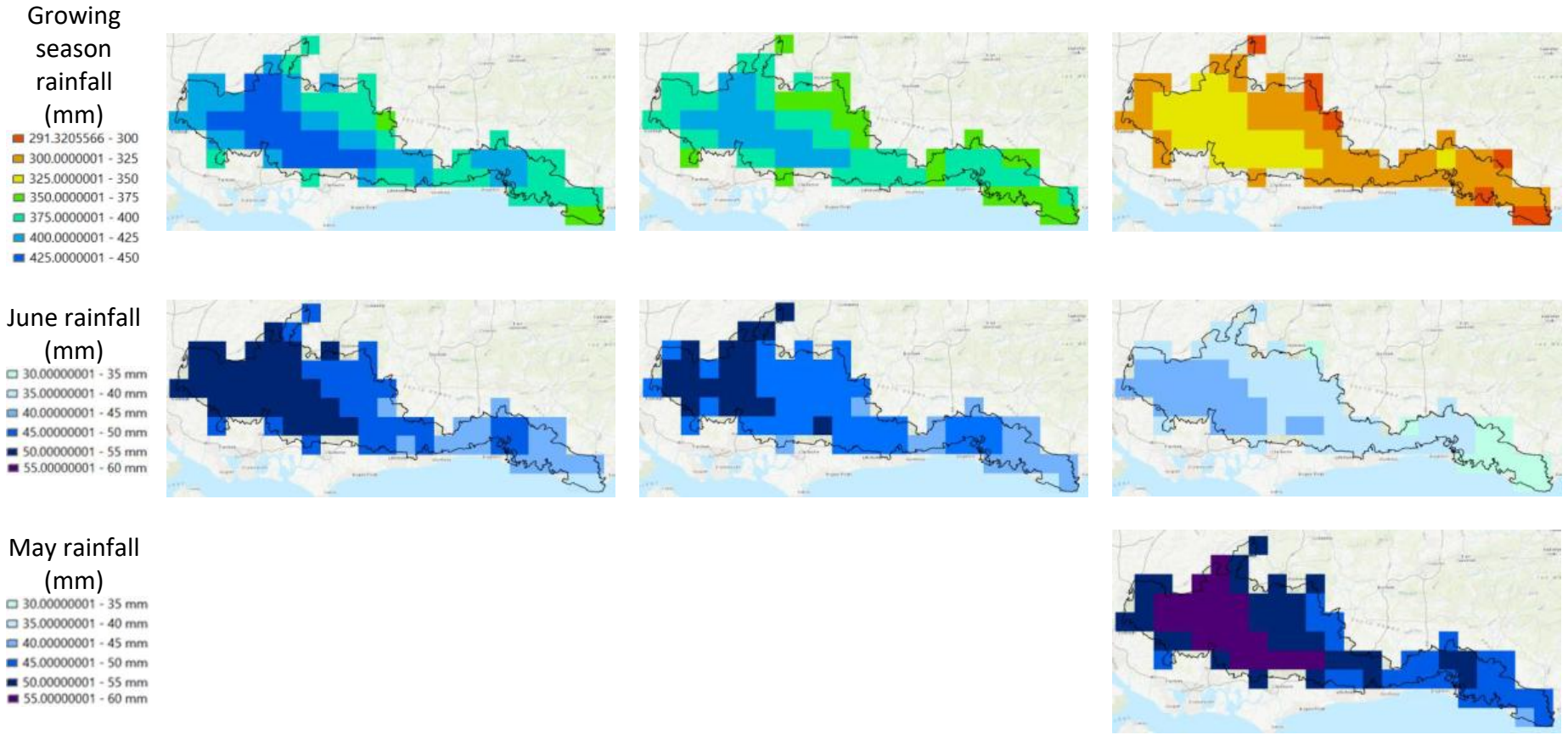


Figure 17. Viticulturally-relevant climate change scenarios in the SDNP (1981 – 2000, 2021 – 2040, 2061 – 2080) under RCP8.5, derived from UKCP18 projections.

9.2.2 Model uncertainty

Uncertainty Type 2: Having presented impactful changes over time, based on the ensemble mean of the twelve climate models (Figure 17), it is important to now consider the variability between models (uncertainty type 2). The range for each of these viticulture indices, across the twelve models, averaged across the SDNP region for each of the three 20-year periods, is shown in the form of box and whisker plots (Figure 18), where **x** represents the mean of the twelve-member ensemble, the box ends are the 25th and 75th percentiles and the whiskers are the lowest and highest ensemble members.

Figures 18 a and b both show increasing model uncertainty between the 2021 – 2040 and 2061 – 2080 20-year periods. However, within this growing ensemble member spread the mean trajectory of a warming growing season is clear and even the coolest model member in the 2061 – 2080 period is almost above the warmest from the 2021 – 2040 period. Over an 80-year period, these model means, driven by the RCP8.5 scenario, project an approximately 4°C GST and 800 GDD temperature increase within the National Park. Under such conditions, the likely impact on the National Park's environment would be significant.

Model member agreement regarding the reduction in early-season frost risk (Figure 18c) increases and uncertainty regarding growing season rainfall (Figure 18d) also increases, although not significantly, between the 2021 – 2040 and 2061 – 2080 periods.

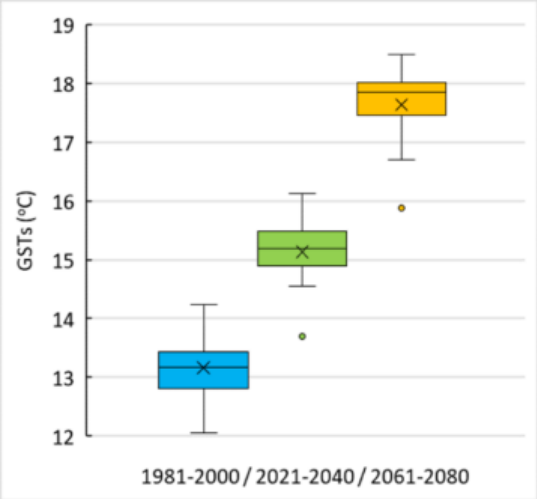


Figure 18a: *The x in each box and whisker plot represents the model ensemble mean GST averaged over each 20-year period:*

- 1981 – 2000: x=13.16°C
- 2021 – 2040: x=15.13°C
- 2061 – 2080: x=17.63°C

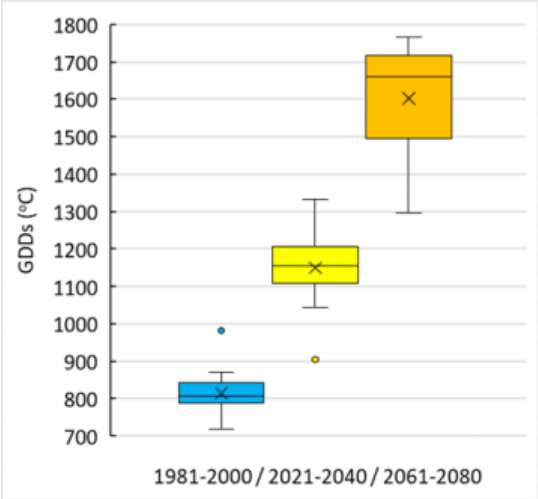
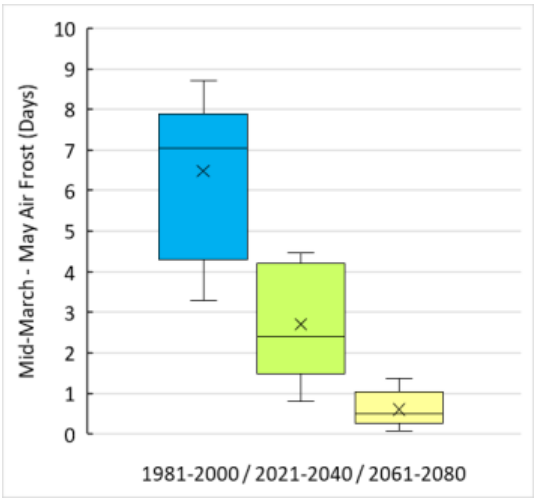


Figure 18b: *The x in each box and whisker plot represents the model ensemble mean GDD averaged over each 20-year period:*

- 1981 – 2000: x=815
- 2021 – 2040: x=1150
- 2061 – 2080: x=1600



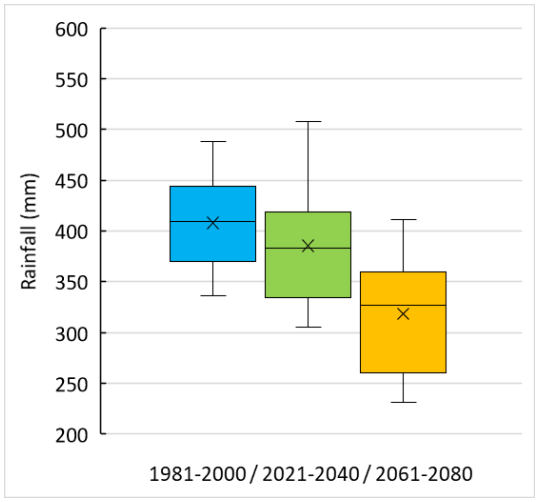


Figure 18c: *The x in each box and whisker plot represents the model ensemble mean air-frost frequency between 15th March and 31st May averaged over each 20-year period:*

- 1981 – 2000: 6.5 days
- 2021 – 2040: 2.7 days
- 2061 – 2080: 0.6 days

Figure 18d: *The x in each box and whisker plot represents the model ensemble mean growing season rainfall averaged over each 20-year period:*

- 1981 – 2000: 408 mm
- 2021 – 2040: 386 mm
- 2061 – 2080: 318 mm

Figure 18 (a–d). Box and whisker plots of the UKCP18 twelve model member spread averaged over the SDNP area.

Uncertainty Type 3: Uncertainty type 3 (internal variability) was addressed by presenting the year to year variability in GST for each of these twelve climate models in each of the 20-year periods, for a grid cell and vineyard location in the centre of the SDNP (Figure 19).

The overall trend of increasing GSTs is clear, despite the year to year variability, first of all within each time period (Figure 19 – black dotted lines) and then also moving forward in time, from 1981 – 2000 to 2021 – 2040 and on to 2061 – 2080. What is also evidenced in Figure 19 is that significant inter-annual variability remains, i.e. warming is not linear year-on-year. The size of this year to year variability does not obviously change among the three 20-year periods. However, the variability poses more of a risk in today's climate because growing conditions are closer to the minimum threshold for suitability, with less resilience to year to year fluctuations.

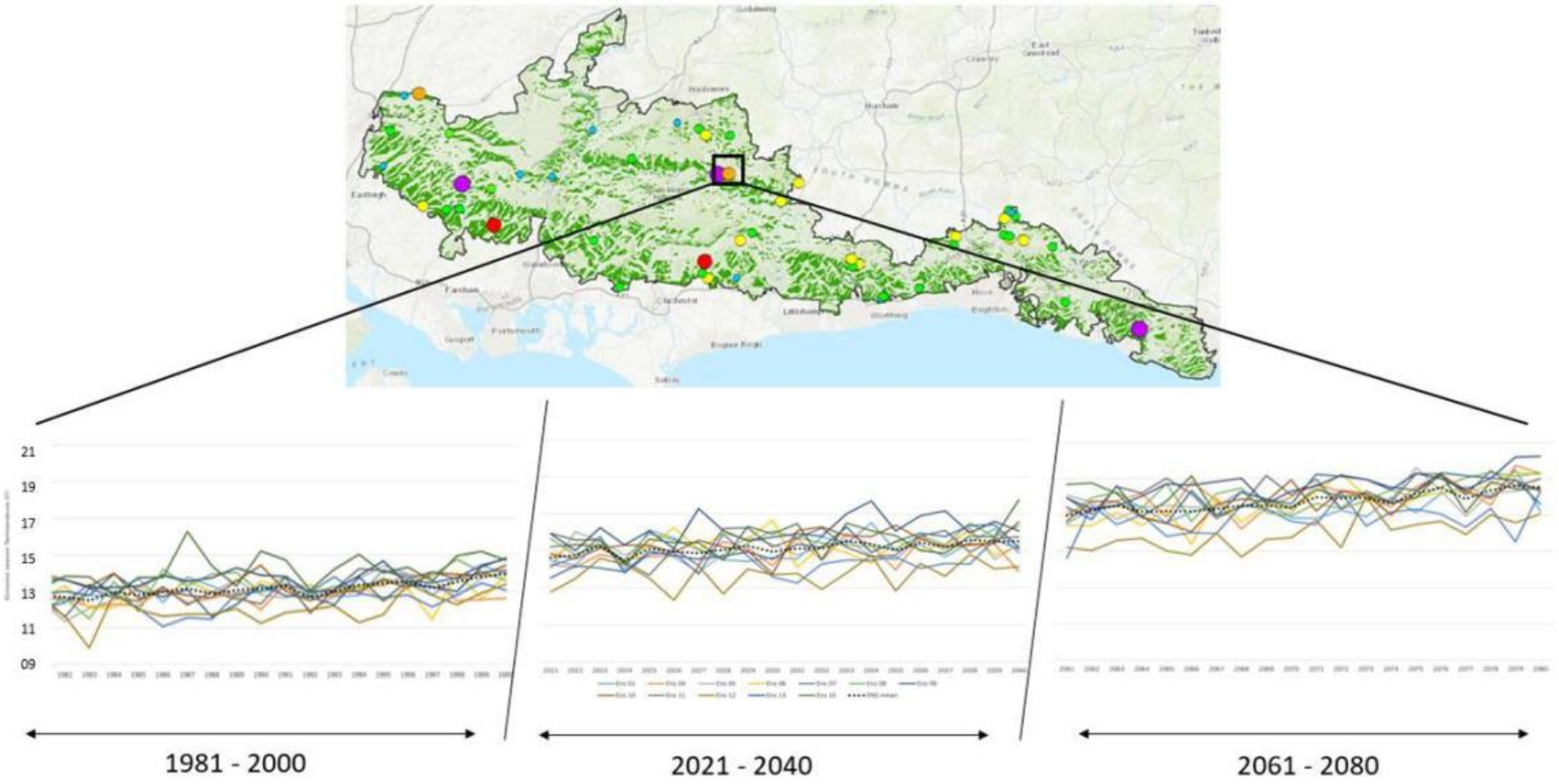


Figure 19. Inter-annual variability in GST,
for each model ensemble member, for a central SDNP vineyard location for 1981 – 2000, 2021 – 2040 and 2061 – 2080.

9.3. Comparing and contrasting the climate change methodologies used in the South Downs National Park Climate Change Adaptation Plan (SDMP-CCAP) with those used in this Viticulture in the South Downs National Park report.

This study was based on the most recent UKCP18 climate projections. The South Downs National Park Climate Change Adaptation Plan SDNP-CCAP (SDNPA, 2016b) referred to projections from the earlier UKCP09. The headline messages emerging from UKCP18 (Met Office, 2020a) and UKCP09 (Met Office, 2009) remain unchanged, namely that hotter and drier summers and milder and wetter winters are anticipated in the UK as the 21st century progresses. Nevertheless, it is helpful to briefly comment on the similarities and differences between these two sets of projections, both in terms of output and methodology.

UKCP09 generated monthly/seasonal/annual results for the 2020s, 2050s and 2080s on a 25-km grid for three different SRES emission scenarios (low, medium and high). In the main UKCP09 report, results were spatially aggregated into regions – it is not entirely clear which region is referred to in Annex 2 of the SDNP-CCAP, possibly south-east England, although the numbers quoted are a little different to those published in the official UKCP09 documentation (Met Office, 2009). Both model uncertainty and internal (inter-annual) variability were incorporated into the UKCP09 probabilistic output format by expressing results in the form:

- Unlikely to be less than X (the 10th percentile from the projection distribution);
- Central estimate = Y (the median from the projection distribution); and,
- Unlikely to be greater than Z (the 90th percentile from the projection distribution).

Much of the focus was on the summer and winter seasons and on air temperature and precipitation.

In this report, the UKCP18 2.2 km daily data output was used, made available to the user community at 5 km resolution, in order to be able to calculate bioclimatic indices of specific relevance to viticulture. This fine-resolution information, suitable for mapping variation across the SDNP and available for an ensemble of twelve different downscaled models, was only available for a high emission scenario, the so-called RCP8.5, for each year within three different 20-year periods: 1981 – 2000, 2021 – 2040 and 2061 – 2080 (in effect 20 x 12 = 240 projections per 20-year period). The high emission scenario is currently an accurate depiction of the trajectory in global emissions today and, it is important to note, climate projections to 2050 are in any case fairly insensitive to the assumed emission scenario. The aim here was to support the SDNPA with the best possible evidence-base with which to assess risks and opportunities and identify and implement actions, all within the context of the Partnership Management Plan (SDNPA, 2020a).

9.4. Conclusions

This Section has provided information on how climate change may affect viticulture in the SDNP over the next 60 years, based on UKCP18 – a tool developed through the Met Office Hadley Centre Climate Programme, supported by BEIS and Defra. It has also provided important information to caveat and explain the limitations and uncertainties that exist in

climate modelling. Therefore, the projected changes portrayed in this Section should be seen as scenarios.

The findings show that the size of the projected climate change by 2061 – 2080, under a high emissions scenario, is very significant for the wider agro-ecology and socio-economy of the South Downs National Park.

With specific respect to viticulture, while air frost events are projected to become less frequent through this century during the present budburst 'at risk' period (mid-March to May), such risk may remain if it is accompanied by changing phenology. Land that is currently too cool due to its elevation is likely to become 'available' (subject to wind exposure). Notably, land that does not have a south-facing aspect is likely to become more suitable for viticulture as the climate warms. The projected trend of increasing growing season air temperatures, moving the climate further away from the minimum threshold for viable production of marketable varieties, will further increase investor confidence, although inter-annual climate variability remains. The projected drying of the summer season may lead to additional irrigation infrastructure costs.

While there are too many elements here to reliably estimate the resulting future change in land area suitability for viticulture, the sum total of projected changes in climate (not accounting for related interactions with, for example, soil and diseases) will clearly lead to a net increase in suitability, all other things remaining equal.

What is also apparent is that summer conditions in the UK such as those experienced in 2018, which led to a bumper harvest and a shortage of winery space, are more likely to be repeated over the next 20 years and beyond. Higher yields, better returns and potentially higher quality wine will likely result in increasing interest in UK viticulture and wine production and, therefore, interest in land within the National Park for vineyard and wine production purposes. Furthermore, pressures on other crops may drive increasing consideration of diversification and adaptation into viticulture. Climate change adaptation may also, more clearly, push producers from areas of the world where the climate is becoming a threat to grape production and existing wine style, to explore opportunities at the still cooler regions of northern Europe and the UK, especially where the range of suitable grape varieties increases.

This scenario of viticulture and wine production growth should, however, be framed by wider socio-economic changes. Alcohol consumption is decreasing and less wine is being drunk globally. There is increasing pressure on land-use, and under severe climate change scenarios wider issues relating to agro-ecology (water, pests and diseases, food requirements, wildfires, extreme weather, etc.) may threaten the viability of viticulture within the SDNP. Resilience planning, already a feature of the SDNP Climate Change Adaptation Plan, will likely attract an increasing focus.

10. Environmental impact of vine growing and winemaking in the South Downs National Park

Section 10 – Key findings:

- Vineyard staff are keen to engage and do more to protect and enhance the protected landscape environments in which they work and live.
- Vineyard activities did not significantly differ in nature between conventionally managed vineyards in protected landscapes, although the frequency of some activities differed, for example the number of pesticide applications varied between vineyards, from 6 to 20 times/year.
- Despite differing landscape types, environmental impacts did not significantly differ between conventionally managed vineyards in protected landscapes.
- Soil health and biodiversity are principally maintained and promoted in vineyards through regeneration of ground cover post-planting, planting/sowing native species e.g. downland wildflower mixes in non-vine areas, minimal or no soil cultivation, mulching prunings back into the soil, and increasingly by adopting integrated pest management techniques to reduce reliance on pesticide applications. Under-vine areas are commonly sprayed with herbicide or cultivated but some vineyards strim or grow under-vine plants. Soil fertiliser was very rarely used.
- Pesticide applications in conventionally managed vineyards are higher than for arable crops (0.74 kg/spray ha versus 0.34 kg/spray ha) with sulphur accounting for the bulk of this. However, the lower application rates in arable production mask the strength of applied products. Vineyards have much more opportunity to use bio-control agents which rely on higher rates of use than traditional chemistry.
- Viticulture has less compliance procedures in place and is less regulated than some other forms of crop production.
- Best practice for spraying in vineyards can be found through the Voluntary Initiative and the NFU Good Neighbour Initiative. The WineGB Green Book on Pesticides is provided to support growers.
- Pesticide leaching and run-off into water courses remains a concern despite LERAP requirements and requires more research to quantify risks.
- Irrigation is not commonly practised in UK vineyards.
- There is significant interest in and uptake of the new Sustainable Wines of Great Britain sustainability accreditation scheme.
- In wine production, most GHG emissions come from power usage and as fermentation by-products (CO_2). Conversely, CO_2 is captured by the vineyard.
- In vineyards, the main noise comes from tractors and associated equipment used for various activities including mowing, spraying and harvesting. There will also be noise from labour in the vineyard at key points in the year, an inevitable part of the working landscape.
- Protected areas with higher levels of tranquillity may be unsuitable for vineyards and wineries.

The aim of this Section is to assess the impacts (risks and derived opportunities) of viticulture and wine production on the natural environment within the protected landscapes that this study is concerned with. The natural environment is defined as the biotic and abiotic features that influence the survival, development and evolution of ecosystem services and biodiversity.

As with Section 7, the environmental impacts of viticulture and wine production in these protected landscapes were in the first instance derived from Vineyard manager surveys and interviews. Vineyards in the SDNP were categorised into nine groups according to size, then nine vineyards, one from each group, were selected using a random number generator. Informal, face-to-face interviews were completed with Vineyard managers from each of the nine vineyards and subsequently with one vineyard manager from each AONB and the New Forest National Park. The managers were told they would be asked to give details of operations and inputs but were not given the questions in advance (copies of the questions can be seen in Appendix B). Their conclusions and interpretations of impacts were questioned, built upon, complemented, and added to external expertise (see Acknowledgements), using examples of impacts from elsewhere and desk-top evaluation of related science. The summary of winery and winemaking impacts was drawn mainly from previous work by the lead author of this report. Recommendations that could reduce negative impacts and enhance positive impacts are subsequently presented in Section 15. Section 12 provides greater detail on ecosystem services in relation to natural capital and assets within the SDNP.

Several distinct environmental elements within the SDNP have influenced the focus of this Section. They include:

- The soil, which is vital in providing a medium for plant growth (both natural and cultivated) and nutrient and water cycling. Particularly slow to form on chalk downland, soils can be quickly degraded and eroded because of poor management. Light sandy soils in the Western Weald are also unstable and prone to erosion.
- The chalk aquifers and catchment rivers, which provide an essential resource for the area's ecosystems and for food production and domestic uses. The water catchments, rivers and streams help regulate the flow of water and drainage of the land. If properly managed they can help reduce flooding at times of high rainfall and sustain river flows and surface water levels during dryer periods.
- The diversity of plants and animals in the SDNP, which is essential to the maintenance of many ecosystem services.

These important elements of the SDNP's natural environment direct the focus of this Section but they must be addressed within the context of the SDNPA Partnership Management Plan (SDNPA, 2020a) (see Section 5.4.4.), which sets out a vision for the National Park.

Table 2 in Section 7.2. provides a list of annual vineyard operations and their associated risks, classified as essential, optional or alternative tasks. The main risks identified, relating to vineyard operations and inputs, are:

- Enhanced loss of soil through erosion;

- Degradation in soil health due to over-cultivation, loss of organic matter and compaction;
- Loss of soil biodiversity through pesticide and fertiliser application;
- Loss of surface biodiversity and native species through habitat destruction and pesticide applications (including spray drift);
- Pollution and eutrophication of bodies of water; and,
- Greenhouse gas emissions.

Table 3 in Section 7.2. lists the vineyard pesticides and herbicides approved for use in the UK and is accompanied by notes about them.

10.1. Viticulture impacts on the environment in the SDNP: Vineyard manager interviews

General findings: All the Vineyard managers interviewed were keen to collaborate and were very supportive of this study. They viewed environmental conservation as being important for reasons beyond the economic sustainability of their vineyard enterprises. From most there was clear positive engagement with the more philosophical aspects of environmental conservation, recognising the value and importance of the area they live and work in. Several commented that conservation was a global issue, of which their customers are increasingly aware (and concerned about). Most of those interviewed were new to farming and were conscious that they were producing a 'luxury' product in a very discerning market, hence environmental management is integral to their brand.

Vineyard managers were particularly concerned about the state of their soils, tree protection and the potential drift of pesticides onto surrounding land, which includes native habitats, farmland, gardens and people. In addition, one vineyard was very focused on maintaining biodiversity in freshwater streams, and two were also very keen to regenerate natural chalk downland areas near their vineyards (within the same estate or farm holding). One of the growers also expressed concern about switching from extensive livestock production to a crop that needs to be sprayed on a 'regular basis'.

Two of the Vineyard managers were not aware of any important natural habitats on or around their vineyard, but others were conscious of the importance of drainage ditches, large headlands, hedgerows, woodland areas, steep slopes above the vineyards and other non-vine planted areas. One of them had 40% of their estate as natural grassland or 'scrub'. One of them delighted in the presence of owls and other birds, and most were keen to see active badgers, rabbits, deer, and a range of birds, as long as numbers were sufficiently low not to impact too much on their vineyard's productivity. Buzzards were regarded as particularly beneficial, as they deter other birds from eating the grape crop.

Some of the Managers from the larger vineyards made a point of discussing environmental conservation issues with their workers (particularly regarding housekeeping issues), but most of the vineyards were too small to have a staff team as such. None of the vineyards had a written environmental policy beyond that required for the High-Level Environmental Stewardship scheme, and none of them regularly measured or recorded any aspects of environmental conservation.

All the growers stated that they were enthusiastic to learn more and to work with the SDNPA to conserve the National Park's natural environment.

In Sections 10.1.1 – 10.1.3, the findings with regard to soil health, water and biodiversity as these relate specifically to Outcomes 2 and 3 of the SDNPA Partnership Management Plan (2020; see Section 5.4.4.) are evaluated.

10.1.1. Soil health

Erosion, due to both wind and rainfall, is an important contributor to land degradation and is a major threat to agricultural sustainability. Defra estimates that soil erosion results in an annual loss of around 2.2 million tonnes of topsoil in the UK. Erosion is exacerbated by inappropriate soil management techniques. In most Mediterranean vineyards, for example, continuous tillage and the absence of plant cover (see Figure 20) accelerate erosion. In parts of Italy, approximately 32 t/ha of soil loss in winter alone has been recorded in vineyards (De Simone C, 1995). The main reasons for continuous tillage practice in Mediterranean vineyards are that it is an effective method of weed control and that competition for soil water from wild plants is unacceptably high in dry summers. However, neither of these reasons are applicable in the SDNP or other protected landscape areas looked at for this study, as the levels of precipitation in summer and throughout the growing season are relatively high (see Section 8). Hence, all the vineyards surveyed had permanent or semi-permanent grass cover on their vineyard headlands and alleys.

Figure 20. Mediterranean vineyard with no ground cover.

The biggest risk of soil erosion in UK vineyards is during the pre-planting stage (see Section 7.2), when land is cultivated to minimise competition between young vines and other vegetation for soil, water and nutrients. During this first year, bare soil is potentially subject to erosion, and it is important that risk mitigants are employed (see Sections 7.2 and 15).

Soil health and biodiversity are principally maintained and promoted in the vineyards by maintaining grass and other plant cover in the inter-row alleys (see Section 7.2 for more references to these practices). This also enables the soil to resist erosion and compaction – a serious problem mainly caused by tractor movements up and down vine row 'tramlines', several times a year over decades of a vineyard's lifespan. Other strategies that can be employed to reduce erosion are the use of all-terrain vehicles (ATVs) for mowing, wider tractor tyres to reduce pressure, and the combination of multiple operations (e.g. trimming and mowing) when operating machinery in the vineyard to reduce total vehicle movements. Some of the Vineyard managers interviewed employed one or more of these strategies. All the vineyards had commissioned an analysis of their soil properties before vines were planted, and most of them analyse their soil for principal nutrients on a regular basis. One of them periodically checks the soil for worms.

Once vines are pruned (Table 2, Section 7.2.), prunings are commonly placed into alternate rows then shredded or mulched into the soil as a way of improving or maintaining levels of soil organic matter. Two vineyards use small amounts of organic fertilisers (PAS100), and one of them carries out a subsoiling operation as and when needed to reduce compaction in the inter-row alleys. Another vineyard uses sheep (Figure 21) straight after harvest and just before budburst to cut the grass. One grower uses a special seaweed preparation as a foliar feed, which claims to 'activate' soil organisms. Several managers rely on their vines looking healthy and being productive to indicate that their soil environment is in good shape. Most growers recognise the negative effect of herbicides on soil life but viewed their use as the most economic method of managing competition from wild plants in the under-vine area. Although two of the vineyards regularly augmented the level of organic matter in their soil by applying PAS100 compost, none of them regularly measured organic matter content.

Figure 21. Example of sheep in a UK vineyard (Source: woodchurchwine.co.uk).

Over-cultivating soils in vineyards, particularly when wet, can cause structural damage, leading to the leaching of finer particles and the formation of cultivation pans. It also aerates the soil, thus increasing the rate of soil organic matter mineralisation by microorganisms,

leading to the loss of soil organic matter (see recommendations in Section 15). However, this is very unlikely to occur in UK vineyards because they are only cultivated prior to planting, and this is not likely to occur more than once within 35 to 50 years.

Perhaps the area that the interviews picked up as most 'challenging' in terms of weed growth and soil management was the under-vine area (strips of land directly under the vines, between 50 to 80 cm wide), where it is difficult and costly to control weed growth by mowing. Traditionally, this area of the vineyard is cultivated, but the equipment required to carry out this operation effectively is expensive, and the operation must be carried out several times a year at slow tractor speeds by skilled personnel. Herbicides have been used very successfully to control weeds in the under-vine area for the last fifty or so years, but there are concerns about their sustainability. Once a vineyard has been established, growers could be encouraged to carry out trials of low-growing cover crops in the under-vine area to reduce the need for cultivation and herbicides. Similar work to find plant-based solutions has been successfully undertaken in other viticulture regions and is referred to in Section 15 (recommendations).

It is interesting to note that there was no notification of any adverse effects on soil biodiversity on the labels of pesticides or herbicides used in the SDNP, AONB or New Forest National Park vineyards (see Table 3, Section 7.2). This could point to the resilience of soil microbial flora to the specific pesticides or herbicides, or it could be due to a lack of research into and knowledge about this very important topic. Preliminary investigations as part of this study noted that, according to Mackie (2012), copper fungicide (used by viticulturists to combat downy mildew) can create problems through its accumulation in the soil. Copper-based fungicides are unlikely to be available in five years' time.

The Vineyard manager interviews identified that soil fertiliser applications are very light and infrequent in their vineyards, and so were deemed to pose an insignificant risk to soil biodiversity. The only time when major applications are made is pre-planting, when low-solubility products (with no, or minimal, nitrates), designed to last for an extended period after planting, are used. Subsequently, vines rely on their extensive root systems and on foliar feeds for their nutrition.

10.1.2. Water

There is no current risk to water resources from the development of vineyards in the Protected Landscapes because UK vineyards do not require irrigation. Under future climate change projections, even 'worst case scenarios' (see Section 9), irrigation is unlikely to be required before the end of the century (ADVICLIM, 2020), by which time it is not known if viticulture or other forms of farming will be viable or whether adaptation strategies will have been developed.

Water use in vineyards is restricted to that used for dilution of pesticides and herbicides for the purpose of spraying, and cleaning spray tanks.

As noted in Table 3 (Section 7.2), however, there is considerable risk to water purity from the pesticides and herbicides used in vineyards. Most of these products are toxic to aquatic life

(some of them with long-lasting effects), and so must be used with great care near bodies of water, especially near permeable, chalky downland soils. Only three of the Vineyard managers interviewed had bodies of water adjoining their vineyards, and they were all aware of the LERAP requirements. Another associated risk factor relates to the type of pesticide applicator used. Three of the growers used orchard-style, large fan air-assisted sprayers which, if not well managed and/or used at inappropriate times (i.e. in windy conditions) can spread the products over a very wide area. This could affect bodies of water but could also negatively affect neighbouring land or habitat and other people who are exposed to the output. It should be noted that the Sustainable Use Directive requires that all commercial pesticide applications in the UK must be carried out by a trained operator. This is enacted in the UK as 'The National Action Plan', which is updated every 5 years, and comprises statutory regulations. However, the degree to which on-site supervision or regulation takes place is unknown, and there appears to be no uniform method of doing so employed in UK vineyards. Beyond initial application training and the National Register of Spray Operators (NRoSO) continuing professional development (CPD) requirements, compliance and crop assurance may fall below the level of focus that is applied to crops that grapes may be replacing.

To assist with impact reduction and increased efficiency, tunnel, recycling and electrostatic sprayers are available in the UK and are used by several vineyards. All else being equal these can significantly reduce spray drift and run-off when used appropriately (see Section 10.4 and recommendations in Section 15).

Without a comprehensive scientific study, it is not possible to say what the leaching potential/risk of vineyard pesticide residue (or arable farming pesticide residue) into groundwater is within various soil and geological areas of the SDNP, but the Catchment Sensitive Farming Project will identify any plant protection products causing an issue under the Water Framework Directive, and these can be cross-referenced with those which are allowed to be used on vines.

10.1.3. Biodiversity

From a vineyard perspective, aboveground biodiversity is of crucial importance. Notwithstanding the benefits previously mentioned, others include: the benefit of wasps for the evolution of natural wine yeast populations (Stefanini I., 2012) and subsequent variability in natural strains of yeast, which contribute to the 'terroir' characteristic of wines; facilitation of habitats for natural pest predators and insectaria; additional crop income (in particular wild flower mixes); and overall enhancement of the vineyard environment (both in terms of ecology and aesthetics).

Within the vineyards, above-soil biodiversity is primarily promoted through continuous ground cover. Two of the growers interviewed were experimenting with different cover crops to promote invertebrate biodiversity and others were encouraging the growth of flowering plants in these 'spaces' to attract hoverflies and predatory wasps, to combat grapevine pests such as light brown apple moths. A range of grasses and wildflowers are common in vineyard headlands (usually around 13 m or more at the ends of rows, leaving space for tractors etc. to turn), and these can be encouraged by non-disturbance. One of the managers let the grass on the headlands grow up to waist-high before cutting. All but two of the nine vineyards

actively planted a range of cover crops in the inter-row alleys (e.g. buckwheat, phacelia, meadow grass mixes and conservation mixes). Some were paying for ponies to graze their scrubland and two had created ponds: one to service water from the winery, the other purely as a wildlife habitat. Most of the properties have significant uncultivated areas, hedgerows (only trimmed every four years) and woodland, as well as headlands. Some of the growers look for butterflies and slowworms; one vineyard has 45 bird boxes, a wildlife pond and a very impressive bird-feeding station. One large vineyard has planted hundreds of windbreak trees across their fields, which as well as reducing canopy wind exposure and potential soil erosion, now serve as routes for wildlife crossing the vineyard area. However, there was also sometimes a poor appreciation of the importance of hedges, scrub, woodland and bodies of water from an ecological perspective.

Only one Vineyard manager was aware of the need to conserve a specific native species. This grower's wife runs a wart-biter cricket preservation group, trained by SDNPA Rangers. The other growers were keen to see butterflies, hedgehogs, woodpeckers, skylarks, yellowhammers, goldfinches, bats, bees, butterflies and orchids in their vineyards. None of the growers were really aware of the need to control non-native invasive species, apart from pheasants from local shoots, and spotted wing drosophila, which are a serious vineyard pest recently imported from Japan.

Only one of the Vineyard managers consulted had a map of the significant habitats or other conservation features on their vineyard. This was commissioned as part of an ecological report written by a consultant to seek planning permission for a farm building.

A key tool in the preservation of aboveground biodiversity in vineyards is the reduction and optimisation of pesticide use. Growers need to be more aware of the hazards linked to specific pesticides, particularly those that generate a risk to non-target arthropods (including bees), such as Valbon (rated 'green' in Table 3, Section 7.2). By far the most common pesticide applied (an average of 5.7 times / season, maximum 10 times / season) was sulphur, a naturally occurring substance that has been used as a plant protection product for thousands of years. Sulphur is a non-systemic contact and protectant fungicide with secondary acaricidal activity. However, its level of systemic toxicity to humans is high (Pesticide Property DataBase, 2020) and, given earlier observations about spray drift, significant caution and care should therefore be employed when using it in vineyards. It was interesting to note the variation in the number of pesticide applications in the same year (see Section 7.2) between different vineyards within a small geographical area. This points to an opportunity to develop a more integrated approach to plant protection, using a range of different pest management methods and using pesticides only when justified through monitoring the pest, host and environment. Some of the growers were not aware that, since 2014, there has been a legal requirement for them to have a written Integrated Pest Management (IPM) plan for their farm (a cornerstone of the EU's Sustainable use of pesticides directive implemented in the UK National Action Plan for the Sustainable Use of Pesticides (Plant Protection Products), (2013). A good illustration of the value of an IPM plan is the case of light brown apple moths in European vineyards, non-indigenous pests which have negatively affected many vineyards in southern England over recent years. Abiotic factors (primarily weather patterns) and, to a lesser degree, biotic factors (such as predator numbers) play a crucial role in their population dynamics and therefore the extent of damage caused. Growers are advised to take steps to

help prevent small populations becoming large populations by utilising pest monitoring methods and weather records to time the application of their control of choice. Spray timing can be correlated with pest build-up by using pest-specific pheromone traps. Growers can then judge the build-up of pest populations and spray as appropriate.

10.2. Viticulture impacts on the environment in the SDNP: Vineyard survey

To complement the Vineyard manager interviews, a survey was sent to all vineyards (in some cases to multiple vineyard entities where they were owned and managed by the same business) within the SDNP to gather information and insights about their practices. The responses received accounted for 86% of vineyard hectarage (65% of vineyards – 33 vineyards). A copy of the survey can be found in Appendix C.

While some of the results simply reinforced the impacts and approaches identified through the Vineyard manager interviews, and hence the interview outputs are deemed broadly representative of actions across SDNP vineyards in general, several other environmental impact mitigation activities/strategies were reported as being employed in the SDNP. In summary, these include:

- Some vineyards are members of the Linking Environment and Farming (Linking Environment and Farming (LEAF), 2020) scheme and use it as a basis for farm and environmental management;
- Some have environmental management plans for the vineyard;
- Pre-planting environmental impact assessments were undertaken;
- IPM strategies are employed to reduce spray rounds;
- Though not officially recognised, organic practices are followed, including the use of organic-approved chemicals;
- Efforts to reduce herbicide applications;
- Use of recycling sprayers;
- Large vineyard headlands and natural reserve areas outside of deer fencing;
- Woodland reserve areas in vineyards;
- Commitment to improving environmental awareness through targeted training and education in the vineyard and winery; and,
- Reduce, Reuse, Recycle are key principles that inform winery and vineyard practices.

In addition, with reference to wineries:

- Some have environmental management plans for winery wastewater;
- Some use energy generated from solar panels; and,
- Rainwater is harvested.

10.3. Viticulture impacts on the environment in the AONBs and New Forest National Park

As part of this study, the SDNPA extended their reach to include the protected landscapes of the Surrey Hills, Kent Downs and High Weald AONBs and the New Forest National Park. This extension aims to ensure collaboration with these nationally important landscapes.

In addition to meetings with the Kent Downs and Surrey Hills AONBs to discuss whether the impacts of viticulture and wine production found in the SDNP area were likely to remain similar in these areas (questions available in Appendix B), interviews were undertaken with Vineyard managers from these areas (see below).

By way of summary, the first piece of this work identified that, although the landscapes are different, in many ways the environmental risks that viticulture poses do not differ among the SDNP, the AONBs or the New Forest National Park. This is because the environmental risks are mainly driven by viticulture practices and these practices remain constant across landscape areas. However, they do vary at a vineyard to vineyard level, depending on the practices used.

The key risk is to the special landscape character of the AONBs and the New Forest National Park. This is due to the sensitivities of the landscape character across these protected landscapes, a key attribute that is particularly protected. At a high level, some of the considerations for viticulture impact/mitigants in these special areas include:

- Where they are more wooded, this is likely to obfuscate any new vineyard plantings.
- Parts of the Kent Downs AONB, particularly around Faversham, have extensive orchard plantations. Diversification to vineyards in this limited area is not anticipated to impact landscape character, as trellising systems are already extensively used.
- The scale of the receiving landscape and the proposed business is important.
- Key viewpoints could be impacted by an increase in vineyard numbers or scale, although this is a similar risk to that seen in SDNP (see Section 11).

In order to gain a broader and comparative picture of vineyard practices and environmental impacts within different landscapes, vineyards in the High Weald (East Sussex), North Downs (Kent), Surrey Hills (Surrey) AONB's and New Forest (Hampshire) National Park were also surveyed, using the same methodology as with those in the SDNP. Only one vineyard from each area was surveyed, except for the New Forest National Park, where, in the absence of any large vineyards, two small but commercial vineyards were canvassed. The survey results are not therefore necessarily representative of all vineyard activities in the four areas; the responses are purely illustrative. At the request of the commissioner of the report, a very large commercial vineyard was selected for the Kent Downs AONB and the others selected had strong reputations for sustainable practices, including one which was certified as both organic and biodynamic. The most common pesticides and processes used by the vineyards surveyed are set out in Section 7.2.2.

10.3.1. General issues

As within the SDNP, all respondents affirmed a growing positive attitude to environmental conservation and an awareness of the need to mitigate climate change. One grower stated '*you can't make interesting wine from an uninteresting vineyard*'. However, two of them reiterated the need to balance environmental and economic sustainability. Soils were managed in much the same way as in vineyards in the SDNP.

Natural habitats near or on vineyards included the vineyard floor (particularly the headlands) and nearby ponds, streams, orchards and deciduous woods. The surrounding AONB landscape was felt to be a positive factor (in terms of biodiversity and ecosystems), contributing to the high quality of the wine produced. Only one vineyard mapped their habitats, working with a local conservation group, but another had included significant semi-natural habitats in a self-guided tour for visitors.

To conserve native flora and fauna, one Vineyard manager consulted his local AONB environmental advisor and obtained a list of the most common wild plants in his area. He selected those most suitable for a vineyard floor (of low-growing habit and moderate level of vigour), and, working with a commercial seed supplier, sowed a mix of the four most appropriate plants on the floor of newly established vineyards. Another grower had also created a seed-mix specific for her area, but this must be re-sown every four years or so, as the plants become outgrown by grasses.

To encourage environmental conservation, some Vineyard managers leave the grass and wildflowers to grow tall, both inside and outside the vineyard. One vineyard manager cherished the presence of coralroot bittercress (*Cardamine bulbifera*) on land adjoining the vineyard; quite a rare plant in their area; another nurtured small blue butterflies (*Cupido minimus*) on their land. One grower noticed that the application of compost under vine rows significantly improved the range of arthropods on their vines, causing a significant increase in spiders, ladybirds and lacewings, and a reduction in spider mite and scale insect numbers. Surrounding hedgerows are carefully managed, with native plants inserted to fill in any gaps, and trimmed just once a year, after the grape harvest (as they provide a good alternative to the ripening grapes). The rabbit population in one vineyard is carefully managed, with numbers kept at a sustainable level by shooting all diseased and older rabbits. Some rabbit carcasses are left on the land to encourage buzzards. Regarding non-native invasive species, one vineyard manager removed all rhododendrons and Spanish bluebells (*Hyacinthoides hispanica*) in surrounding woodland; another had discovered Japanese knotweed (*Reynoutria japonica*), which he controlled by smothering it with a piece of old carpet; and a third is a beekeeper, who monitors for Japanese hornets.

The managers of the larger vineyards discuss environmental conservation with their fellow workers, and it was interesting to note that they reported a marked increase in concern about the environment in both vineyard staff and senior management. Three growers had informal, unpublished, conservation policies, one was recording hawk numbers and varieties, and another had engaged a Plumpton College Masters student to measure the diversity of flora on their vineyard floor.

Two of the vineyards are near bodies of water and so complete LERAP assessments. However, two of the growers were not aware of LERAP or nitrate vulnerable zone (NVZ) legislation (Environment Agency, 2020). None of the growers take any steps to meet requirements of NVZ legislation, either because they are unaware of it, outside of NVZ zones, or do not store or apply enough nitrogen-containing fertiliser to warrant any action. As with vineyards in the SDNP, none of the AONB vineyards measure their carbon footprints or GHG emissions but two are aiming to do this in the near future. One vineyard has a policy not to burn any plant material, to retain carbon in the field. One vineyard reduces the number of tractor passes by

performing two operations (such as under-row cultivating and alley mowing) in one pass, and three of the smaller vineyards confirmed that they carry out almost all tasks by hand; in fact, one vineyard does not own a tractor at all.

One of the vineyards has ambitions to develop a sustainability plan, get involved in local conservation groups and increase the area of naturally managed land surrounding the vineyard. The manager of the largest vineyard in the group is a founder member of the Sustainable Wines of GB (SWGB) Accreditation Scheme (Wine GB, 2020c) and stated that '*the right mindset is now in place at all levels of the company*'.

All the Vineyard managers confirmed that they would welcome more dialogue with representatives concerned with environmental conservation in their AONB, but recognised that these organisations' budgets were very restricted. One grower works closely with a local environmental group, and praised the services of the Sussex Lund charity, which offers support for small-scale, practical projects that improve the landscape of the High Weald Area of Outstanding Natural Beauty.

Table 7 shows a comparison of potential increased risks within the five Protected Landscapes, caused by viticulture in general, i.e. not just from those surveyed or interviewed.

Table 7. Comparison of key environmental features and potential increased risks from viticulture among the SDNP, AONBs and New Forest National Park

Protected Landscape & size (km^2)	Geology/principal soil types	Principal habitats/land use	Conservation projects	Unique features	Potential heightened risks
South Downs National Park (~1,627)	Chalk downland: shallow, lime-rich, freely draining loamy soils, poor in both minerals and nutrients, over chalk or limestone. Chalk eroded in places to reveal underlying lower and upper greensand and Gault clay. These soils are usually acid, nutrient poor and with impeded drainage. Underlying chalk acts as an aquifer.	Sheep-grazed grassland, lowland heath, woodland, coastal cliffs. Farming: sheep, arable, semi-natural grassland, vineyards. River valleys: chalk streams, wetlands.	Planting disease-resistant elms for the white-letter hairstreak butterfly; 6 km of hedge planting in Woolbeding; Beelines appeal to restore habitat for pollinators; planting 5,000 trees in community spaces, along roads and walking routes.	Large estates (Goodwood, Cowdray, Petworth and Firle), and large areas of the eastern Downs owned by local authorities or the National Trust; South Downs Way National Trail; Well-conserved historical features. Large population (110,000), with large market towns.	-Loss of soil through wind erosion - Degradation in soil health due to over-cultivation and loss of organic matter - Loss of soil biodiversity through pesticide and fertiliser application - Loss of aboveground biodiversity through habitat destruction and pesticide application.
Kent Downs AONB (879)	Chalk downland: shallow, freely draining, lime-rich loamy soils over chalk or limestone, eroded to reveal underlying slightly acid loamy greensand and clayey soils with impeded drainage	Chalk grassland, deciduous woodlands (20%), chalk coastal cliffs, chalk rivers, wet pasture, ponds and heathland. Mixed farming: (64% of the AONB) sheep, horses, arable, orchards, cobnut plants, hop gardens, vineyards	Darent Valley Landscape Partnership Scheme; Green Pilgrimage; undergrounding power lines; community orchards	Many habitats have become isolated, so need to create corridors between them Remains of Neolithic megalithic monuments, Bronze Age barrows, Iron Age hill-forts, Roman villas and towns, medieval villages and churches, post-medieval stately homes and historic defence structures.	- Loss of soil through wind erosion - Degradation in soil health due to over-cultivation and loss of organic matter - Loss of soil biodiversity through pesticide and fertiliser application - Loss of aboveground biodiversity through habitat destruction and pesticide application.

High Weald AONB (1,461)	Mostly slightly acid loamy and clayey soils, with impeded drainage, some slowly permeable. Seasonally wet, slightly acid but base-rich loamy and clayey soils, with underlying clay sandstone ridges (with outcrops).	Agricultural (65%) and pastoral landscape: improved and unimproved grassland, arable, woodland, gill streams, stone extraction pits, quarries and ponds.	Sussex Lund grants programme Landscape Enhancement Initiative Beautiful Boundaries Scheme; Dark Skies; Upper Rother and Dudwell Farm Cluster; The Weald Meadows Network; Local deer management groups	Late medieval hamlets and villages (a surviving medieval landscape with some of the best-preserved medieval farmsteads in western Europe). Criss-crossed by sunken drove roads. Main iron producing region in the UK during Roman and Tudor periods Gill streams with rare plant populations. Vision 2034	- Loss of soil through water erosion - Soil compaction - Pollution and eutrophication of bodies of water - Loss of aboveground biodiversity through habitat destruction and pesticide application.
Surrey Hills AONB (422)	Chalk downland: shallow, lime-rich, freely draining loamy soils over chalk or limestone. Greensand hills, plateaux and valleys Some clay Weald areas, plus freely draining, very acid sandy and loamy soils.	Woodland (40%), chalk downland, heathland. Agricultural land (40%).	Conservation work at Quarry Hangers; Safeguarding Farnham Heath Nature Reserve against fire damage.	One of the most wooded nationally protected areas in the country, an intriguingly diverse landscape characterised by hills and valleys, traditional mixed farming, a patchwork of chalk grassland and heathland, sunken lanes, picturesque villages and market towns. A diverse landscape that is 40% woodland (of which 14% is ancient), 40% agricultural land and 18% heathland and commons, 1% remnant chalk grass land. There is 25% of the AONB open to the public, including Leith Hill, the highest point in south-east England.	- Loss of soil through wind erosion - Degradation in soil health due to over-cultivation and loss of organic matter - Loss of aboveground biodiversity through habitat destruction and pesticide application.
New Forest National Park (566)	Elevated plateau with rivers and streams. A bed of clay below the surface offers an impervious layer and creates the characteristic saturated, spongy earth, marshy bogs or mires.	Woodland, heathland, rivers, valley mires, coastal mudflats and saltmarshes.	Restoring, enhancing and creating boundary features; monitoring biodiversity; protecting Sites of Importance for Nature Conservation (SINCs); control of invasive non-native plants.	The most extensive area of lowland heathland in Europe. Common land grazed by horses. Highest concentration of ancient trees in Europe.	- Degradation in soil health due to over-cultivation and compaction - Loss of soil biodiversity through pesticide and fertiliser application - Pollution and eutrophication of bodies of water.

10.3.2. Soil health

Operations carried out in the AONB and New Forest National Park vineyards are similar to those in the SDNP area, with one grower composting their prunings and another burning them on site. The vegetation in the headlands is regularly mowed (average 11, minimum 6, maximum 20), as is that in the vineyard alleys (average 9, minimum 7, maximum 11). In the under-vine area, three vineyards mowed, two cultivated and three applied herbicides to control weeds. The vineyards that are managed 'sustainably' apply plant protection products roughly twice as often as the conventional vineyards, with significantly more frequent use of foliar feed supplements. One vineyard team passes on foot eight times a year to remove unwanted buds and shoots on its vines. There is an average of 3.6 passes a year through the vineyard to tuck shoots into the trellises, and vine canopies are trimmed about 3 times a year on average, by hand or by machine. Two vineyards do not plough the soil prior to planting to vines, preferring to subsoil then pass a power harrow over the surface.

The risk of compromising soil health in the vineyards interviewed is judged to be low, as their managers are aware of the importance of soil health to environmental conservation. The operations carried out to minimise soil erosion and to conserve levels of organic matter are similar to those used in the SDNP vineyards, with four of the five growers either mulching their prunings on site, or composting then returning them.

10.3.3. Water availability and purity

The Vineyard managers recognised the importance of nearby ponds and streams as natural habitats near or on their vineyard and of the need to conserve them. They try to control run-off by leaving strips of grass on cultivated land and reduce contamination by applying fertilisers through foliar as opposed to ground application; lime is applied in pellet form. The range of pesticides employed is narrower than that used in the SDNP area; those employed generally pose a lower risk to aquatic life. Only two of the vineyards are near bodies of water and so complete LERAP assessments, and none of the growers posed a significant risk to subterranean water nitrate levels.

10.3.4. Biodiversity

One grower appeared particularly conscious of the environmental risk of applying chemicals (particularly nitrogen, phosphorus and lime) to vineyards, because of the natural flora and the potential contamination of bodies of water. Therefore, she uses these as sparingly as possible, and applies nitrogen and phosphorous only as foliar feeds, using a nozzle-directed pneumatic applicator. Lime is applied as granules encased in apple waste, to reduce the risk of drift and run-off. All the growers were aware of the risk of damage to the soil from using tractors, particularly on wet soils. One vineyard is using tractors with front power take-off shafts so that they can perform two operations, such as mowing and trimming, in one pass. Two vineyards carry out regular sub-soiling to counter soil compaction.

Hedgerows surrounding the vineyards are carefully managed. Wild plants in the grassy areas on the borders are left to flower, being cut just once or twice a year.

Furthermore, as vines are grown off the ground on trellises, the vineyard floor can be managed as a wildlife habitat, as demonstrated by the managers who plant native species of plants rather than commercial cover crops in their alleys. However, there is a very considerable thirst for further knowledge about native flora and fauna, and how to protect them, amongst the growers surveyed.

10.4. Viticulture environmental impacts: Conclusion and potential risk mitigation strategies

The loss of aboveground biodiversity through habitat destruction and pesticide application was of major concern to the grape growers interviewed for this study. Pesticide applications in vineyards are higher in terms of volume/spray ha than in arable/cereal farming (Fera, 2018) (see Section 10.5 and associated caveats). Further research is needed to facilitate a like for like comparison. What was clear from the vineyard survey and interview results was that the number of pesticide applications in the SDNP vineyards ranged from 6 to 15 per year (mean: 10.5 per year) and up to 20 applications per year in an AONB vineyard. Whilst pest/disease pressure and pesticide requirements vary between vineyards due to meso- and micro-scale climatic differences, varietal differences and vineyard management differences, and the resulting fruit quality and quantity and therefore value will vary, it is clearly plausible that with improved training, skills and knowledge, pesticide application rates could be usefully reduced.

This also points to an opportunity to develop a more integrated approach to plant protection, using a range of different pest management methods and using pesticides only when justified through monitoring the pest, host and environment, and using softer chemistry, such as biological control agents.

There is significant potential (see Section 15) for vineyards to increase native flora and fauna in vineyard environments, boosting both biodiversity and ecosystem services, indeed such approaches have been adopted elsewhere (Section 15) and with some research could be readily adopted in the UK.

It is therefore important to note and not underestimate the desire of Vineyard managers to learn and do more to be good custodians of the land on which they operate. It is also important to note that whilst different practices are employed in different vineyards, the impact of these activities may affect yields and fruit quality, which in turn impact the economic productivity and viability of the vineyard ventures.

Viticulture has fewer compliance procedures in place and is less regulated than other forms of crop production, potentially due to the historic lack of a requirement from the end customer of an audit scheme. Where good practice is employed, as in many of the vineyards in the SDNP and AONBs, the risks of soil loss, soil health degradation, loss of soil biodiversity, pollution and eutrophication of bodies of water, and the loss of aboveground biodiversity, are decreased. Table 8 summarises best practices as found in the SDNP and AONBs.

Table 8. Summary of best practice to mitigate environmental impact.

Hazard	Best mitigation practice	Areas practiced*
Loss of soil through erosion	Minimal cultivation – only pre-planting	All
	Leaving strips of grass in cultivated areas	HW
Degradation in soil health due to over-cultivation, loss of organic matter and compaction	Carry out regular soil analyses, including of organic matter	All
	Return of organic matter from prunings to soil by mulching	All
	Addition of organic matter (e.g. PAS 100 compost) to soil	SD, KD, HW
	Subsoiling in alleys to counter compaction	SD, NF, SH
	No ploughing pre-planting	KD, SH
	Tractors with multiple implements to reduce passes	KD
Loss of soil biodiversity through pesticide and fertiliser application	Controlled use of herbicides and pesticides	All
	No use of insecticides	SD, SH, HW, NF
	Use of qualified agronomist to organise a plant protection programme	SD, KD
	Monitoring for vineyard pests	SD, HW, KD, SH
	Very infrequent use of soil-applied fertiliser	All
Pollution and eutrophication of bodies of water	Use of LERAP assessments	All
	Use of 'tunnel'-shaped (recycling) and directional pesticide applicators	SD, KD, HW
	Granular lime applied to soil	HW
Loss of aboveground biodiversity through habitat destruction and pesticide application	Being conscious of the value of natural habitats in or around their vineyard	SD, NF, HW, SH
	Workers discuss environmental conservation amongst themselves	SD, KD, HW, SH
	Significant part of estate is managed as a naturally wild area	SD, NF
	Continuous grass cover in vineyard alleys, mowed infrequently	All
	Alternate alley mowing	SD
	Cover crop trials to promote invertebrate biodiversity	SD, SH
	Alleys planted with native naturally occurring plants	SD, KD, HW
	Allowing plants in alleys and headlands to grow tall and flower	SD
	Infrequent trimming of hedgerows	SD, HW, SH
	Planting trees around and across the vineyard	SD
	Significant habitats and conservation features mapped	All
	Habitat creation (e.g. pond)	SD
	Informal biodiversity monitoring	SD
	Working with local conservation group	SD, HW
	Conservation of specific native species at risk	SD, SH, HW
	Removal of invasive non-native species	HW, NF, SH

*SD = South Downs National Park, KD = Kent Downs AONB, HW = High Weald AONB, SH = Surrey Hills AONB, NF = New Forest National Park

The discussions with vineyards that occurred whilst developing this Section of the report clearly indicated a very significant level of support for environmental conservation among vineyard enterprises, which could be further encouraged by developing education and training, particularly in the following aspects:

- Evaluation of erosion risk when preparing land for planting vineyards;
- The importance of organic matter in vineyard soils;
- Managing the vineyard floor to promote biodiversity;
- Minimising environmental and human risks generated by pesticide applications;

- Promoting biodiversity in the vineyard environment through habitat management;
- IPM techniques for grapevine protection;
- Conserving native species and controlling non-native invasive species;
- Monitoring and reducing greenhouse gas emissions and water, energy and carbon footprints; and,
- Mitigating, and adapting to, climate change.

To put these ideas into practice, growers may find it more effective to take part in certified sustainability production schemes, such as organic (Soil Association, 2020) or biodynamic (Demeter, 2020) production. Indeed, speaking with SDNPA Rangers and other stakeholders as part of this study, the question was raised as to why more vineyards are not managed under such certified schemes, especially as to date and to the best of our knowledge, these have had no formal take-up by wine producers in the SDNP. It was not a question put to producers as part of this study, but the authors hypothesise that the reason may be because they are (or are perceived to be) onerous in terms of administrative time and finance (both production costs and accreditation costs). Anecdotal evidence suggests that yields in organic and biodynamic vineyards in south-east England are significantly lower, and for some sites such a detriment may make viticulture unviable. Producers are also concerned about potential impacts on grape quality, are unfamiliar with the practices and regulations of such schemes, view them (not necessarily correctly) as presenting little marketing advantage, or regard them as not being specific enough to address the circumstances of perennial plants like grapevines (which are almost always the sole commercial crop produced in a vineyard enterprise).

However, there are a couple of important observations to make in relation to this point. First, the majority of UK-trained (normally at Plumpton College, near Lewes) and internationally trained Vineyard managers and operatives are highly likely to have had some education in sustainable production as this becomes integrated into core syllabuses of viticulture education in response to increasing awareness of environmental degradation and climate change and, as was noted earlier, that customers are also increasingly aware of such. Second, during the lifespan of this study, WineGB, the national industry association for English and Welsh wines, has begun to address environmental conservation in UK vineyards and wineries through the Sustainable Wines of Great Britain (SWGB) Accreditation Scheme (Wine GB, 2020c); also, see further information in Section 15. This ‘grass-roots’, ‘bottom-up’ approach to addressing risks and promoting opportunities where they exist may be somewhat in contrast to other farming regulations and subsidy incentives, but it will provide a platform for engagement with and development of further sustainable practice. As this scheme incorporates more subject areas, training and greater rigour in practice and assessments will undoubtedly follow.

10.5. Pesticide usage in UK viticulture versus arable farming

One of the objectives of this study was to look at the impact of viticulture versus that of the land use it is replacing. Within the SDNP, AONBs and New Forest National Park, some of the land that has been replaced with vineyards was pastureland. It seems logical that the impact of viticulture on the environment is greater when compared with the impact of pasture, simply by virtue of the activities and practices employed in land preparation and crop

production as set out previously (Section 7). However, significant areas of land (especially where larger plantations have occurred) have been converted from previous arable use. One of the questions raised by stakeholders during the course of this study was: how much more or less pesticides are used in viticulture versus conventional arable production?

The main types of plant protection products are insecticides, fungicides, herbicides, molluscicides and plant growth regulators. The Health and Safety Executive (HSE) aims to ensure that plant protection products do not harm human health or have unacceptable effects on the environment. This is done by following rigorous statutory approval criteria agreed by EU member states and is further reinforced by the CRD to account for UK-specific conditions (Health and Safety Executive, 2020a). These are legal requirements. The environmental fate of the breakdown products of plant protection products is key to gaining approval. The CRD works with other Government agencies to ensure there is an understanding of the fate and behaviour of these products as they breakdown. As previously mentioned, the Sustainable Use Directive requires that all commercial pesticide applications in the UK must be carried out by a trained operator and all spray operators are required to follow the Code of Practice for Plant Protection Products. Many spray operators are NRoSO registered and regularly gain CPD points to maintain their high standards of training.

Best practice for vineyards can be found through the Voluntary Initiative (2020), an industry (agriculture) led programme, and the NFU Good Neighbour Initiative (2018), which describes best practice when spraying near residential areas. The WineGB Green Book (Wine GB, 2020d) on pesticides is provided to growers to support them with this important area.

With regards to comparisons between arable and viticulture, in 2018 Defra surveyed pesticide usage among arable and soft fruit farming (Fera, 2018). The survey included 22,916 fields of arable crops (1,237 holdings), 6% of the UK total, and the soft fruit analysis included 317 holdings growing soft fruit (41% of the UK total), including 2,213 ha of grapevines. Wheat comprised 42% of the area of all arable crops grown, oilseed rape 14%, spring barley 18%, winter barley 9%, oats 4%, beans 4%, ware potatoes 3%, sugar beet 3%, peas, rye and linseed 1% each and seed potatoes and triticale less than 1%.

The Defra pesticide surveys focused on the ‘treated area’, also referred to as spray hectares, which is the gross area treated with a pesticide, including all repeat applications. The survey found that:

- Wheat comprised 51% (25.5 million spray hectares) of the arable total of 50 million spray hectares; and,
- Vines accounted for 18% (44,500 spray hectares) of the soft fruit total of 243,000 spray hectares.

As the largest area, by hectarage and spray hectares, wheat was selected as the comparator crop to wine grapes in terms of pesticide usage in the UK. Cereals, including wheat, are commercially grown across 35,000 ha of the SDNP (Defra, Agriculture Survey, English National Parks statistics, 2016), with the following pesticide application regime for wheat (Fera, 2018):

- 0.35 kg of pesticides/spray ha were applied;

- Wheat received on average three fungicide, three herbicide, two growth regulator and one insecticide spray rounds; and,
- Timing of pesticide applications was centred on the growing season, April to June, with additional herbicide and insecticide in the Autumn (Figure 22).

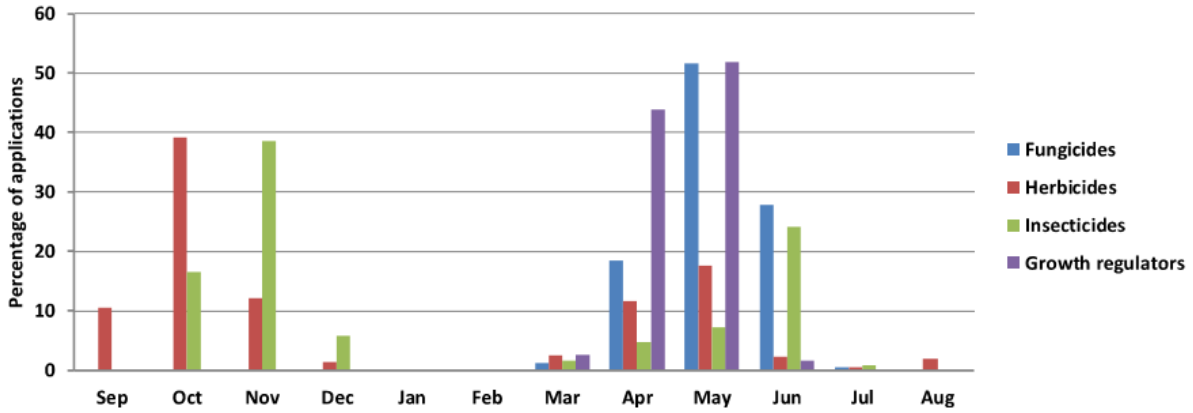


Figure 22. Timing of pesticide applications for wheat, from the Arable Pesticide survey (Fera, 2018).

The results for grapevines were:

- 0.74 kg of pesticide/spray ha were applied;
- On average there were nine fungicide, six sulphur, two herbicide and two insecticide spray rounds; and,
- Timing of pesticide applications was centred on key vine and berry growth stages from March to July and then September to December for herbicides and insecticides (Figure 23).

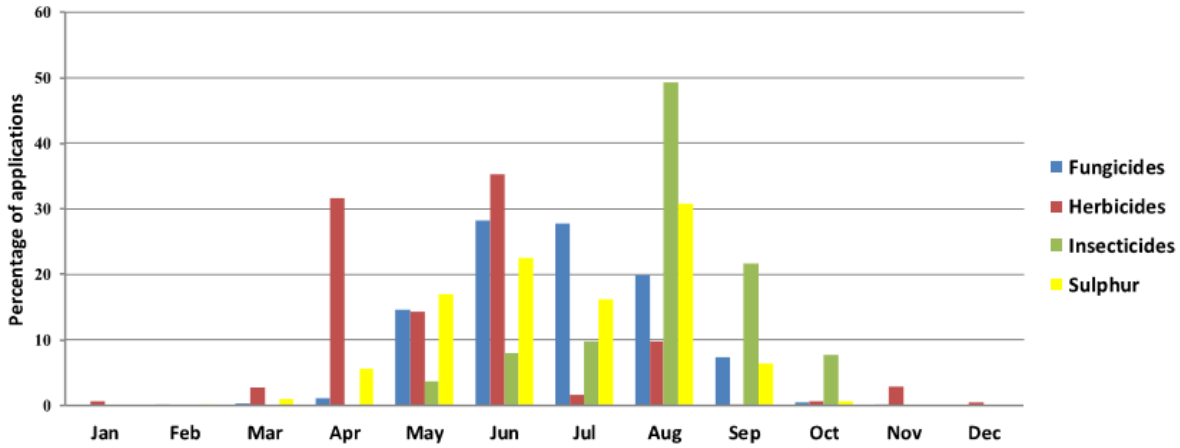


Figure 23. Timing of pesticide applications for grape vines from the Soft Fruit Pesticide survey (Fera, 2018).

The overall breakdown and variation is shown in Table 9. The data in Table 9 were calculated based on the weight of pesticides applied over the spray hectares (Fera, 2018).

Table 9. Pesticide applications to wheat versus vines.

Pesticide	Wheat kg/spray ha	Vines kg/spray ha	Variation kg/spray ha	Description
Fungicide	0.28	0.55	0.27	**More** used on vines
Herbicide	0.52	0.26	(0.26)	**Less** used on vines
Sulphur	1.24	1.75	0.51	**More** used on vines, minimal use on wheat (sulphur is applied as a fertiliser to wheat)
Growth regulator	0.48	0.15	(0.33)	**Minimal** use on vines
Insecticide	0.01	0.04	0.03	**More** used on vines, particularly because the light brown apple moth is a particular issue for vines in these areas, whereas the wheat orange blossom midge is only problematic in some years
Molluscicides and repellents	0.12	0.00	(0.12)	**None** used on vines
Seed treatments	0.06	0.00	(0.06)	**None** used on vines
Total pesticide kg/spray ha	**0.35**	**0.74**	**0.39**	**Overall, more used on vines**

Based on the results of this survey, conventional viticulture in the UK uses more pesticides overall than conventional arable farming, with sulphur accounting for the bulk of this:

- Vines: 0.74 kg/spray hectare; and,
- Wheat: 0.35 kg/spray hectare (overall arable crops 0.34 kg /spray ha).

However, it should be noted that the lower application rates in arable production does not account for, or qualify, the strength of applied products. Vineyards have much more opportunity to use bio-control agents (Biological Control Agents or occasionally Bio-rationals), such as Fytosave or Botector, which, if used, are applied at a higher rate than a conventional fungicide (which uses traditional chemistry) used on Cereals (which only have 3-4 key fungicide application times with a much wider portfolio of traditional chemistry products to choose from). It should also be noted that with the loss of neo-nics for use in Arable production (very active insecticides, used at low doses and very persistent), the use of insecticides may increase in this sector as reliance shifts to older Pyrethroid chemistry. When the data was collected (for the Fera (2018) report) the neo-nics may have skewed the results making it appear that more insecticides were used on grapes than in arable systems.

Viticulture pesticide use is, however, comparable with that used for other soft fruit crops (0.62 kg/spray ha all soft fruit, 0.54 kg/spray ha for strawberries, 1.01 kg/spray ha for

blackcurrants – processing). Currently, horticulture crops only account for 1,271 ha in the SDNP (Defra, Agriculture Survey, English National Parks statistics, 2016), while viticulture comprises 436 ha (Vinescapes Vineyard Survey, Q4, 2019).

The type of pesticides used differs between arable and viticulture. Insecticides, fungicides and sulphur (minimal in arable) are used to a greater degree in viticulture; herbicides and growth regular (minimal use on vines) are used more in arable (wheat) crop production. This is perhaps not surprising because the key diseases that affect viticulture are powdery and downy mildew and Botrytis. However, from the Defra survey, for the whole of UK viticulture in 2018, insecticide applications were 65 kg.

It should be noted again here that although foliar applications are targeted there are mitigants that vineyards can employ to reduce drift and run-off, including the use of re-cycling/tunnel sprayers (see Figure 24 for an example) and electrostatic sprayers.

Figure 24. A double-row vineyard recycling sprayer.

It should also be noted that in the case of the three commonly used herbicides (Roundup, Shark and Kerb), these are (at the time of writing) all undergoing re-registration, so the conditions of their use may change or the products might not be re-approved. Some fungicides and insecticides are in the same situation. New products include general biocontrol agents that have no or minimal environmental impact, such as Fytosave or Botector.

10.6. Winemaking impacts on the environment in the SDNP

As previously noted in Section 7.3, less emphasis has been placed on the winemaking process in this study than the viticulture aspects of production, primarily because, as the report/project title suggests, the focus was on viticulture growth. However, in terms of

specific environmental impacts from the wine production process, GHG emissions, wastewater and noise were the three that stakeholders engaged in this study focussed on the most and which can be tangibly addressed here in terms of their environmental impact. In Section 15 we make recommendations and identify considerations that should be of value to both producers and bodies involved in relevant planning processes.

10.6.1. GHG emissions

At a global scale, the wine sector is responsible for around 0.3% of annual GHG emissions from anthropogenic activities, corresponding to around 2% of the agriculture sector's contribution, which is estimated to be 14% of total emissions. During wine production, most of the emissions come from power usage and as fermentation by-products (CO_2).

There are many different systems, spaces and processes required in the modern winemaking facility. Many of these activities have a corresponding energy requirement, which collectively relates to an energy input necessary to produce the finished product. Recently (in 2013), one of the authors of this study (Dr. Alistair Nesbitt) and colleague Dr. Mervyn Smyth, undertook a walk-through assessment and audit of energy use in English wineries.

The combined (average yearly) bottle production for the wineries surveyed was 1,032,194 bottles, representing almost 26% of the total wine production capacity in the UK at the time (note, the sector has grown since then), expending 512,350 kWh of energy. Extrapolating the study findings to the entire English winemaking industry (wineries only) indicated that 2,008 MWh of energy was expended, which is equivalent to the energy released by burning 1,181 barrels of crude oil. In approximate terms, this is equal to the annual energy use of 200 households in the UK per year, producing 736.8 tonnes of CO_2 per year, the same emissions as from a family sized car travelling 2,211,137 miles. The average energy benchmark for UK wine production is 0.557 kWh/litre, ranging from 0.040 kWh/litre to 2.065 kWh/litre. This value compares favourably with other wine producing regions and is lower than many, probably due to lower cooling requirements in the UK, although a number of wineries globally have demonstrated that significantly lower values can be attained, indicating that there is still a substantial reduction in energy usage potentially available within the English winemaking industry.

Figures 25, 26 and 27 show the key activities within English wine production that contribute to energy use. The wide range of energy use between wineries is somewhat surprising and undoubtedly many variables will affect this. However, this also indicates opportunities for improvements to reduce consumption. For example, lighting offers a significant energy saving opportunity. Ideally, most wineries should have enough natural light to not need lighting during most of the working day. Modern lighting technologies, such as compact fluorescent lamps (CFLs) and light emitting diodes (LEDs), consume much less energy, and can provide similar, if not better, lighting than conventional incandescent light bulbs. Replacing five 75-watt incandescent light bulbs with 19-watt CFLs can reduce a carbon footprint by 125 kg per year.

Heating, cooling and ventilation were the greatest sources of energy consumption found in English wineries. Again, there are significant opportunities here for energy efficiency

improvements, some of which come from the use of more efficient, modern refrigeration systems and renewable energy use (onsite renewable energy systems, such as solar power, wind power and geothermal energy), others from improved winery design, discussed further in Section 15. Internal environments can be designed with efficient mechanical systems and responsive localised controls, using strategies such as efficient mechanical ventilation and heat recovery systems which reclaim energy from expelled air to preheat fresh air for heated areas, use of variable speed fans and pumps which adapt to the required output, and high efficiency air source heat pumps to heat large occupied spaces.

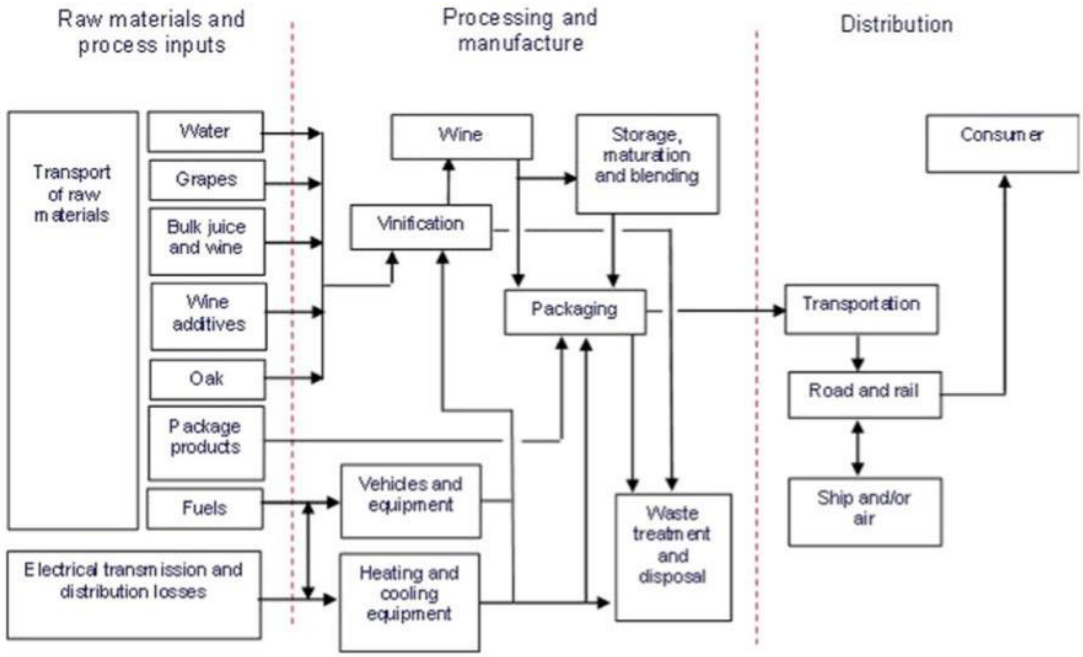


Figure 25. Winery supply chain showing fuel and energy inputs (Smyth & Nesbitt, 2014; adapted from Forsyth et al., 2008).

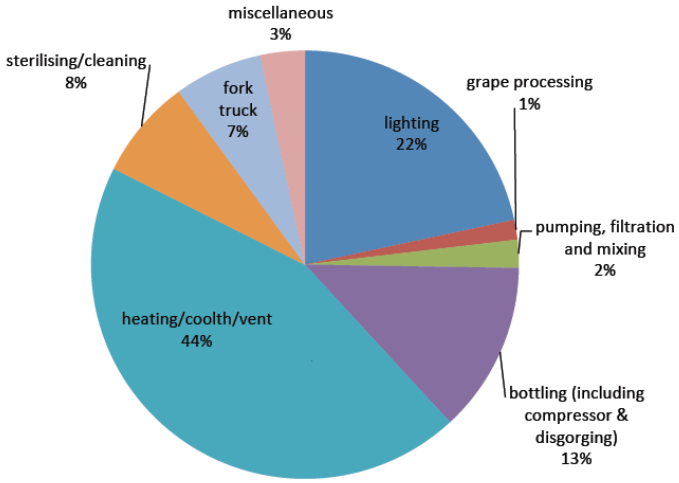


Figure 26. Distribution of energy expended in English wine production (Smyth & Nesbitt, 2014; adapted from Forsyth et al., 2008).

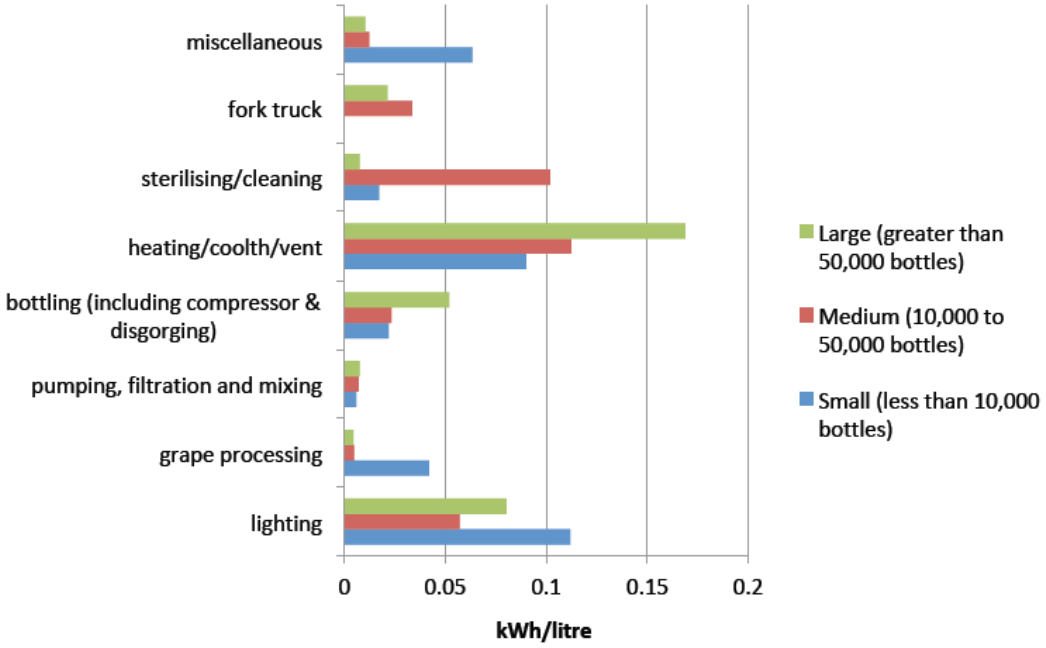


Figure 27. Distribution of energy expended in production for large, medium and small English wineries (Smyth & Nesbitt, 2014; adapted from Forsyth et al., 2008).

The siting of a winery building needs particular care, as its position in relation to other elements in the supply chain, such as suppliers and consumers, can have a bearing on energy consumption. Where possible, the winery (or at least the press house) should be located as close as possible to vineyards where the grapes are grown to reduce vehicle/transport movements (as well as for quality, operational and strategic business considerations). There can also be considerable energy savings if major winemaking operations, such as grape processing and juice or wine movements, can be carried out using gravity, although these can be offset by increased embedded CO_2 in materials used or the building of multi-storey buildings.

CO_2 is a by-product of fermentation and indeed a significant health and safety consideration for wineries and staff working in them (it can be a killer). However, technology exists to capture CO_2 from fermentation and, although not yet widely used (presumably due to cost and potentially limited commercial availability), it is employed in some wineries around the world to close the loop on CO_2 emissions, being reused for other purposes. The Jess J. Jackson Sustainable Winery Building, at the Robert Mondavi Institute at the University of California, Davis campus, was the first self-sustainable, zero-carbon teaching and research winery in the world. CO_2 is captured from all fermentation processes in the winery and converted into calcium carbonate, later used in brewing activities. The building has no conventional heating or air conditioning; temperature is controlled by efficient night air cooling in summer and warm day heating in winter. Rainwater is filtered for cleaning; in fact, 90% of the water and chemicals from each winery cleaning cycle is captured and processed for future use in the complex, eventually being reused as much as ten times. Although a different climate and wine

style, examples of good practice exist that could be adopted by UK based wineries to reduce GHG emissions (see Section 15).

Last but by no means least, it must be remembered that whilst discussing energy use and GHG emissions from wine production and wineries, the associated activity of vine growing also uses energy (tractor movements, the manufacturing of trellising materials etc.). The use of nitrogen fertiliser (very uncommon in UK vineyards) is another important source of GHGs. When soil is fertilised with nitrogen, some of the nitrogen is converted to nitrous oxide (N_2O). The significance of N_2O is that it is roughly 300 times more effective per molecule than CO_2 at trapping heat in the Earth's atmosphere, so a small amount of N_2O can cause as much global warming as a very large amount of CO_2.

However, CO_2 is of course captured by the vineyard as it grows, absorbed from the atmosphere through grapevine photosynthesis. Unfortunately, this part of the accounting equation (life cycle assessment) is less well understood and more research is needed; until now, this figure has not been determined for a grapevine or vineyard. To do so will require detailed and expensive research into vine photosynthesis, respiration and nutrient cycling. Therefore, models currently used for calculating the fixation of CO_2 by vineyards are those created for other species of plants, and assumptions must be made about grapevine physiology and vineyard nutrient cycling. That said, through the use of such models it has been concluded that, on balance, GHG emissions in viticulture are smaller compared with those of other agricultural sectors (Nistor, et al., 2018) and indeed that where sustainable practices are applied to viticulture the system acts as a net carbon sink, able to completely compensate for any anthropogenic emissions arising from vineyard management (Chiriacò, Claudio, Chiti, Trotta, & Sabbatini, 2019).

10.6.2. Water usage and wastewater treatment

As previously mentioned, vineyards in the SDNP, AONBs or anywhere else in the UK do not need to practice irrigation, except for the purpose of watering in during particularly warm years such as 2018. Vineyard water consumption is therefore minimal and restricted to dilution of sprays. Within the wine production process, however, water consumption can be significant, with estimates ranging between 1.5 to 14.8L/litre of wine (WRAP, 2012). The majority of this water will be used in the physical cleaning of tanks, floors, walls, equipment etc., and the chemical and biological oxygen demand (COD/BOD) of the wastewater will be high, not least because of the chemicals used for cleaning that are often diluted with water. Whilst the first priority, by wineries, should be given to reducing water consumption through efficient practices and the use of simple technologies to aid cleaning, for example using hose pigs (hose cleaning sponges), recycling and reusing water should be practiced where possible. Other important considerations relate to the treatment and disposal of 'toxic' wastewater. The high organic and salt content in winery wastewater, if leached into groundwater or waterways, can cause eutrophication. It can also significantly negatively affect soils and soil microorganisms. How to treat winery wastewater is a complex and technical study in its own right, but, where permissions to discharge to mains (by the relevant water authority) is not granted, collecting then treating and disposing (off-site) of wastewater by an authorised contractor or treating it onsite (using aerobic or anaerobic filtration and digestion technology) is required. The use of reed beds or above-ground treatment ponds in the vineyards in the

UK, let alone in sensitive landscapes such as the SDNP or AONBs, is not recommended due to risks associated with them and anecdotal evidence that they are less effective and, with smaller volumes of wastewater, inefficient.

10.7. Noise

Noise from wineries is usually restricted to vehicle movements, people, and chillers or presses being operated (presses at harvest time). Careful selection and appropriate siting of chiller/cooling units can attenuate noise output. People and day-to-day activities that result in noise during the winemaking process are often located within winery buildings. At harvest (which can take 1 to 4 weeks, depending on winery scale), crushing and pressing may take place at the entrance to a winery or just outside a building envelope. The resulting noise volume will depend on a multitude of factors (press types, press cycles, whether muffled compressors are used, physical location, number of operators etc.) but is generally very low and often considered during the planning process. However, although only in use for a very short period of time, winery operators should consider local residents, noise impacts and potential noise mitigants. Likewise, noise from vehicle movements and visitors, and any restrictions or mitigants, are likely to be addressed through the planning process. although 'good neighbour' initiatives would no doubt assist in addressing any residual issues.

There are many different sources of noise in agriculture, ranging from large equipment such as combine harvesters and heavy load tractors to animal noise and even shotguns. The degree and frequency of noise generated depends on the type of agriculture, the time of year and the equipment being used. In vineyards, as with agriculture, the main noise comes from tractors and associated equipment used for various activities, including mowing, spraying and harvesting. However, there will also be noise associated with labour in the vineyard at key points during the year, an inevitable part of the working landscape.

Figure 28 shows typical noise levels associated with different agricultural work activities. As can be seen, these range in volume (decibels), and the type and amount of noise will depend on the farming activity. Viticulture uses small horticulture or vineyard tractors due to the width of vine rows and the activities required. These tractors are therefore generally quieter than the heavy load tractors (>90 Db) used in other forms of agriculture. Flail mowers (average working level noise 88 Db), trimmers and sprayers (orchard 97.9 Db /misc. 87.2 Db) are also used in vineyards.

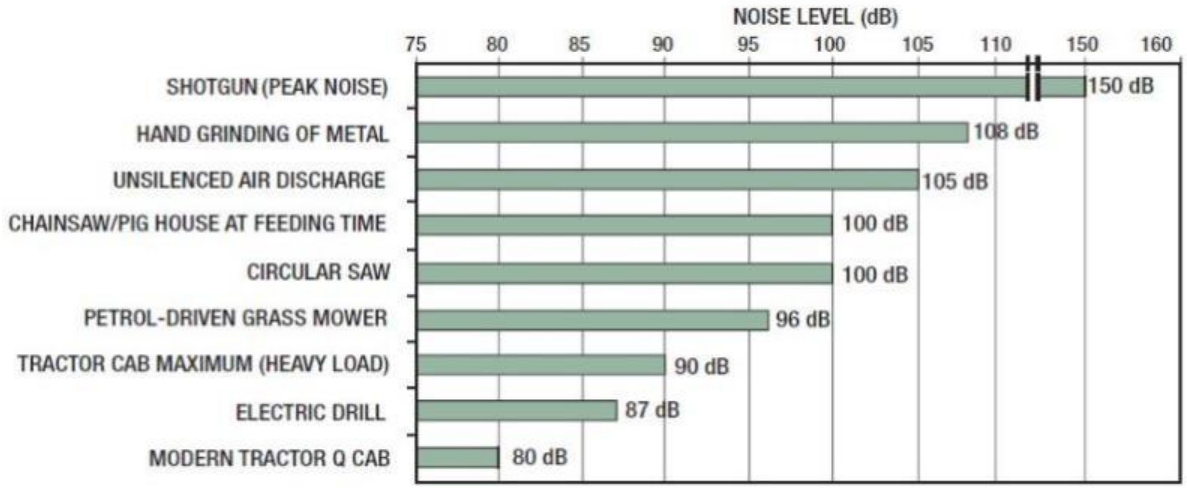


Figure 28. Typical maximum noise levels (Db) associated with agricultural work activities (Defra, Noise in agriculture (HSE AS8), 2020b).

Where vineyards differ compared with many other forms of agriculture is that the number of operations (passes) and people working in the landscape is higher, as viticulture remains a manually intensive activity. Stakeholder feedback indicated that, in some cases, this activity and the working landscape was appreciated (understood and seen as a good thing), in others it was not. Based on the SDNP vineyard survey, the average number tractor hours per annum was 71.25 hours/hectare/year, equivalent to about 10 days per year, including harvest. These tractor movements include mowing, spraying and harvesting (September – October).

Noise can also be generated by those working in the vineyard; this would be more prevalent during pruning and tucking, and harvest. Throughout the year seasonal labour in a vineyard is roughly 7.8 FTEs for 12 weeks. During the winter months, November to February, limited vineyard activity takes place.

In addition, noise can be emitted from vineyards for a few nights/early mornings between mid-March and May, when frost protection may be used. Frost protection is used in some vineyards and can take the form of fans (which mix warm air from above inversion layers with lower cold air), heat blowers or candles. Large, fixed (and noisy) fans are not used in the UK (partly due to planning restrictions), nor are helicopters, as far as we know. Whilst these operations can emit noise and be 'disruptive' for a few mornings (usually 2–4/year for 3–5 hours), they are essential for protecting crops and a local issue to be addressed with anyone affected.

Within the SDNP, tranquillity is a core attribute and, in 2017, relative scores were attributed to different locations (Figure 29). Tranquillity is not purely about noise – that is the quantifiable/measurable aspect of it – but tranquillity and other related perceptual qualities are a fundamental part of landscape character and sense of place. Many of the areas with higher levels of tranquillity are unsuitable for vineyards (e.g. the tops of the downs), but other, more terrestrially suitable areas (see Sections 8 and 12, where this Figure is repeated) are in locations with >medium (approximately 0) tranquillity scores. In these (and all) areas, due

consideration should be given to opportunities for reducing noise, e.g. combining tractor-based activities, not mowing without good cause, using indoor or muffled presses or compressors on presses, etc., all activities which many of the vineyards within the SDNP and AONBs already practice. With regards to vineyard workers chatting in the landscape as they tend vines, this is surely an acceptable part of rural activity and a working landscape.

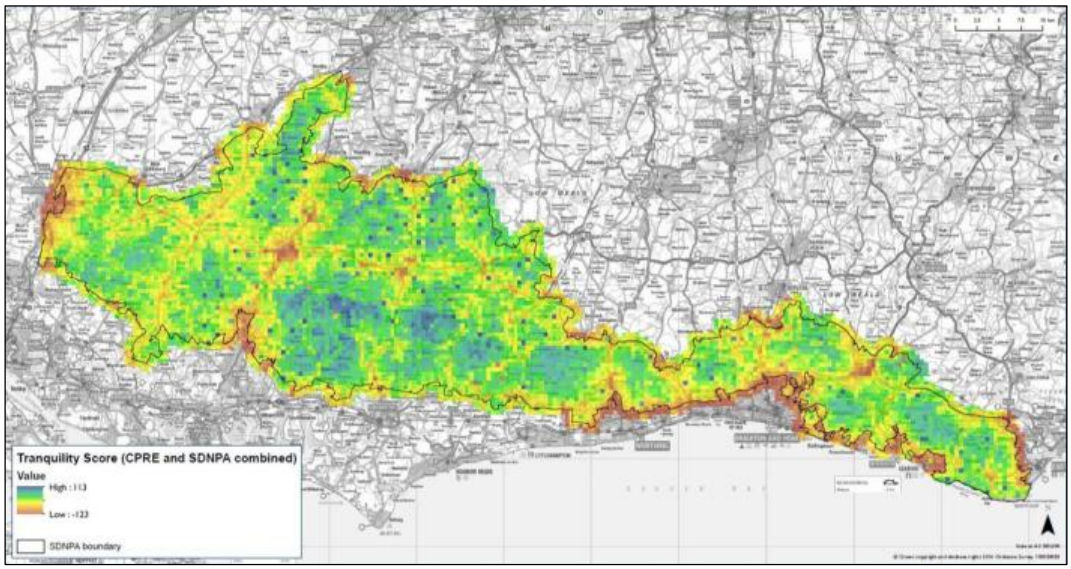


Figure 29. SDNP relative tranquillity scores (2017).

Beyond GHGs, wastewater and noise, other by-products of winemaking include grape marc and general packaging waste. Grape marc is often put back onto vineyards as fertiliser or taken off-site for treatment (including making grappa). Certain associated by-products have been used to produce toothpaste and skin care products. Packaging waste should be reused or recycled, as with any other similar waste processing streams. Whilst not discussed further in this report there are increasing opportunities for improved packaging, recycled or lighter glass, and sustainable material use in the wine production process.

11. Visual and landscape character impacts of vineyards and wine production entities in the SDNP.

Section 11 – Key findings:

- What appears to have been consistent in the SDNP landscape through the millennia, following the initial clearances, are the openness and views from the high ground; the short grassland; the well-travelled and grazed pasture of the downland hills; the winds and exposure; the interaction between nature and agriculture; the rivers; the wooded slopes; the interactions with both the sea to the south and the Weald to the north; its historic trade and transport links; and key views to and from the scarp slopes of the South Downs. A significant amount of land and settlement patterns have remained unchanged.
- What has changed are the scale and types of farming, the scale of settlements, building styles and materials, and the nature of ecosystem habitats, with changes in woodland make-up, loss of chalk grassland, and erosion of soils.
- For centuries, vineyards and wine producers have drawn on landscape character, soils and a sense of place (*terroir*) to impart or explain the difference and uniqueness of their wines. Vineyards in the SDNP are no exception.
- A loss of fundamental character, e.g. the open quality of the South Downs or the pastoral quality of the Weald, could be affected by vineyards; the raised, linear nature of vines and trellising and vineyard fencing is very different to arable or pasture land and there is potential for visual degradation if their scale is too extensive. Although the folds of topography are not lost through viticulture, scale and location are major factors in vineyard–landscape integration.
- Without a capacity analysis, the tipping point relative to landscape groups or character remains unquantified, but the open tops of downland should be kept free from plantings and, in the valleys and slopes where other sensitivities exist, vineyards should work within existing hedgerows, field boundaries and woodlands for more successful integration in the landscape.
- To address a potential loss of openness, key views and public rights of way should be respected to minimise any negative effects on the user experience.
- For wineries, associated buildings, yards, access tracks, operational movements and infrastructure, which all fall within the remit of planning and planning policy, scale is again key to landscape impact, but so too is the expectation to see these as parts of traditional farmyard groupings, settled into their landscape and not encroaching into open countryside. Opportunities to see exemplary design interventions should be encouraged and the SDNPA is working on several Supplementary Planning Documents (SPD) and Technical Advice Notes (TAN) in this area, following on from the adoption of the Local Plan (see Section 5.4.).
- Vineyards are intensively managed compared with the management of the land use they often replace; they are truly a working landscape and therefore their impact on tranquillity (a key component of much of the SDNP – see Section 12) can be greater.

As set out in Sections 8 and 9, there is a significant and potentially increasing (under climate change scenarios) area of land within the SDNP that has viticulture suitability. Both existing vineyards and wine production entities, and any future scale of increase, will change the current landscape. There is debate around which aspects of viticulture, vineyards, wineries and wine production are generally positive and which could be potentially harmful from a landscape and visual impact perspective. This is not surprising given the sensitivity and designated status of the landscape within the National Park, its special qualities and the proximity of people to rural areas within it.

There has been very little research conducted globally into viticulture–landscape sensitivity, and the landscape and visual impacts of viticulture in the UK have not been investigated in any detail. Whilst some Old World vineyard areas have received special protected World Heritage status, such as St Emilion (Bordeaux, France), the Douro (Portugal) and the Valais vineyards (Switzerland), and are recognised for their own contribution to the landscape character, newer vineyard areas impose a landscape change to which there is an inevitable reaction. Vineyard scale, people's perceptions, subjective and objective viewpoints and landscape change are all important elements to evaluate in assessing the impact of any growth in viticulture. In this Section, we consider the landscape and visual impacts of viticulture and wine production in the context of its expansion within the SDNP.

This Section should be read in conjunction with the wider study, in particular the findings reported in Section 7 (Viticulture Practices), Section 12 (Natural Capital), Section 14 (Stakeholder Perceptions) and Section 15 (Recommendations).

11.1. The South Downs landscape

In 2012, the SDNPA published the 'State of the South Downs National Park' (SDNPA, 2012) as an initial review of the National Park at its commencement, providing a baseline from which future change could be measured. The document recognises this cultural landscape is the result of thousands of years of human interaction with nature and that the National Park's designation was '*not about creating an island within which some mythical idyll can be recreated. Change has been a constant factor in shaping its special qualities'*. The document also states that: '*It is the job of the National Park Management Plan* (see Section 5.4.4.), *built on the foundations of this report, to find an appropriate response to these and other influences, to build a shared vision of the future and to inspire and engage the people, communities and organisations who live in, work in or visit the area*.'

At the time it was published, it was stated that 110,000 people lived within the National Park boundaries with a further 1.97 million on its doorstep. The State of the South Downs National Park document set out that the benefits of the National Park are, of course, not just for those living within it. The balance between people and nature is articulated through the definition of landscape and the terminology of ecosystem services; those that are regulatory services, such as water and air; those that support this, such as soil and nutrients; those that are cultural, such as education, inspiration and renewal; and those that are provisionary, such as water, food and raw materials.

The State of the South Downs National Park identified key pressures on the landscape that are as diverse as losses of habitat, tranquillity, water quality and soil health but also threats to heritage, tourism, recreation and access, and, for those living in the National Park, socio-economic factors including employment and housing. These went on to form the basis for the ecosystems services and landscape led approaches set out in the South Downs Local Plan, which was adopted in 2019.

Perhaps it is important to consider what has and has not changed over the most recent few thousand years of human interaction with the area that is now the SDNP. What appears to have been consistent throughout the millennia following the initial clearances are the openness and views from the high ground; the short grassland; the well-travelled and grazed pasture of the downland hills; the winds and exposure; the interaction between nature and agriculture; the rivers; the wooded slopes; the interactions with both the sea to the south and with the Weald to the north; its historic trade and transport links; and key views to and from the scarp slopes of the South Downs. A significant amount of land and settlements in what is now the SDNP have remained unchanged over the millennia. A large proportion of the landscape is historically intact and has remained unchanged in use (often pasture) and pattern for several hundred years. What has of course changed are the scale and types of farming, the scale of settlements, and building styles and materials. Along with this, the nature of the ecosystem habitats has changed, with changes in woodland make-up, loss of chalk grassland, and erosion of soils and shorelines.

Landscape is therefore the result of people interacting with nature over time, through which cultural landscapes are created, and so conservation of these landscapes requires ongoing intervention. The SDNPA is charged with guiding this intervention in a way which conserves and enhances the whole landscape.

11.2. The landscape and visual effects of viticulture

As set out in Sections 7 and 8, for land to be suitable for consideration as a vineyard in the SDNP, it is most likely to meet the following conditions:

- Currently used for agriculture or pasture, where fields and access are available;
- Have relatively free draining soils;
- Be on gentle southerly (south-east through to south-west) facing slopes, for maximum solar incidence and sunlight capture; and,
- Be below approximately 150 m elevation to lessen exposure to cooler temperatures and wind (climate change projections suggest this elevation threshold may rise with regards to temperature thresholds, but wind/exposure would still be problematic).

Vineyard structures and design, operational activities and infrastructure requirements are set out in more detail in Section 7, along with a description of vineyard operations, but in summary most vineyards contain:

- Linear rows of vines, around 2 m apart;
- End or row headlands: strips of grass approximately 10 to 15 m wide;

- Trellising (wooden or metal posts, wires for fruiting and foliage, anchors and sundries such as tiebacks, clips and chains), up to 2 m in height;
- Tutors (thin metal, plastic or wooded tutors/stakes to train the vines; about 1 m high);
- Grow tubes/rabbit guards for the first 3 to 4 years (these come in a range of styles and colours);
- Ground cover (grass or plants) between the rows;
- Cultivated or sprayed (herbicide) strips of ground (approximately 60 to 80 cm) under vines;
- Deer, rabbit and possibly badger fencing surrounding the vineyards, with access gates;
- Surrounding and/or internal hedges, trees and vegetation;
- Vineyard equipment movement (tractors with sprayers, mowers, cultivators, trimming equipment, etc.); and,
- People working in the vineyards.

Some vineyards also contain:

- Windbreaks (usually linear rows of trees but could also be plastic meshing);
- From mid-March to May some vineyards have frost protection equipment in them. These could be candles/bougies, mobile wind fans, or cold air drains or heaters (static or towed);
- Access tracks (grass, hard core, gravel, concrete or tarmac) of varying lengths; and,
- Vineyard equipment storage facilities, workshop facilities, welfare facilities, offices, spray tank wash down areas, and possibly public areas, although these are more often associated with winery buildings.

A range of images in Figure 30 shows some typical English vineyards.

As set out in Sections 7, 10.1 and 16, vineyards have significant potential for delivering ecosystem services because the actual land area within a vineyard that is planted with vines is only 15% – 20%. How a vineyard is managed impacts the degree of enhancement opportunity but cover crops (between vine rows and potentially under vines as well), wildflower mixes, native grasses, habitat areas and corridors, and windbreaks both actively support ecosystem services and can contribute to the vineyard landscape character.

For centuries, vineyards and wine producers have drawn on landscape character, soils, and a sense of place (terroir) to impart or explain the difference and uniqueness of their wines. Vineyards in the SDNP are no exception. However, a managed, regimented and controlled landscape may not enhance some areas of the SDNP landscape and could even be associated with harm and loss of openness.

The visual impact of vineyards is clear from the descriptors and images provided herein. As with other changes of land use and landscape installations, receptiveness of them and the opinions of residents, visitors and stakeholders is somewhat subjective and can be influenced by many variables. In Section 14, stakeholder perceptions are presented.

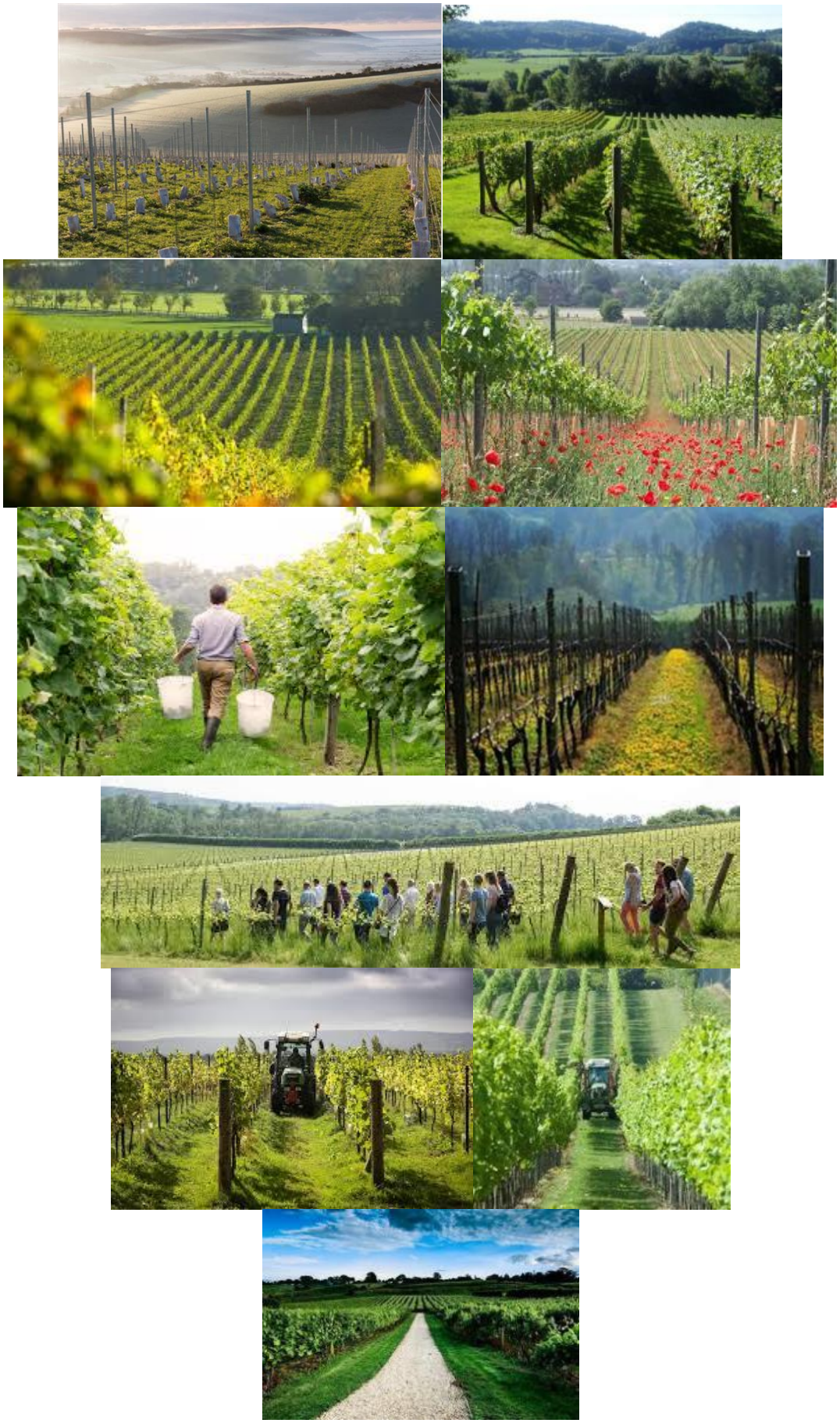


Figure 30. English vineyards.

There are also other activities/impacts that can be associated with vineyards, such as events, tours and a higher presence of human interaction, than was the case with previous land uses. These can have significant effects on landscape and visual qualities, including tranquillity (see noise impacts in Section 10.7).

11.3. The landscape and visual effects of wineries

Not all vineyards have their own 'on-site' winery. Of the 51 vineyards in the SDNP, 11 have wineries. The remaining vineyards are involved in the production of grapes for sale to wineries/wine producers within or outside of the National Park, or to their own (same business entity) wineries that are located outside of the National Park. Traditionally, English wineries have grown out of historic farmsteads and the permitted development rights for stores and barns that go with UK agriculture and planning. This emanates from the opportunities for farms to diversify. There is a logic to utilising existing services, access, infrastructure and even buildings, and this approach may result in wineries and related infrastructure sitting comfortably within the landscape (See examples in Section 7).

The basic requirements for a winery and wine storage are set out in Section 7.3. In their simplest form they require large 'sheds' with tanks, possibly barrels, temperature control and access to power and water. As the UK viticulture sector has matured through the last decade or so, bespoke designed wineries have been established with point-of-sale facilities (including tasting rooms, catering, conference facilities, accommodation, etc.), intended to create an integrated production/wine tourism offer. These are likely to have further reaching impacts than the basic agricultural yard and buildings required solely for production. New facilities such as these will require planning permission and mitigations, discussed more fully in Section 15, but they may have landscape and visual impacts including from car parking, access routes (possibly new access routes/tracks/roads), services (and installation thereof), traffic movements, and hospitality/offices for staff.

Landscape impacts associated with wineries and related infrastructure are likely to be case-specific and very much a matter of location and scale. Any planning application in the SDNP will go through a thorough process of evaluation and will need to be shown to be landscape-led, in line with the South Downs Local Plan, and deliver multiple ecosystem services, in line with Policy SD2 (see Section 5.4.5.), taking into account the full range of potential environmental impacts in both its establishment and operation. Landscape and visual factors will need to be assessed against the existing baseline of the local landscape character and address the specific sensitivities found that could include particularly valuable areas of landscape and key views.

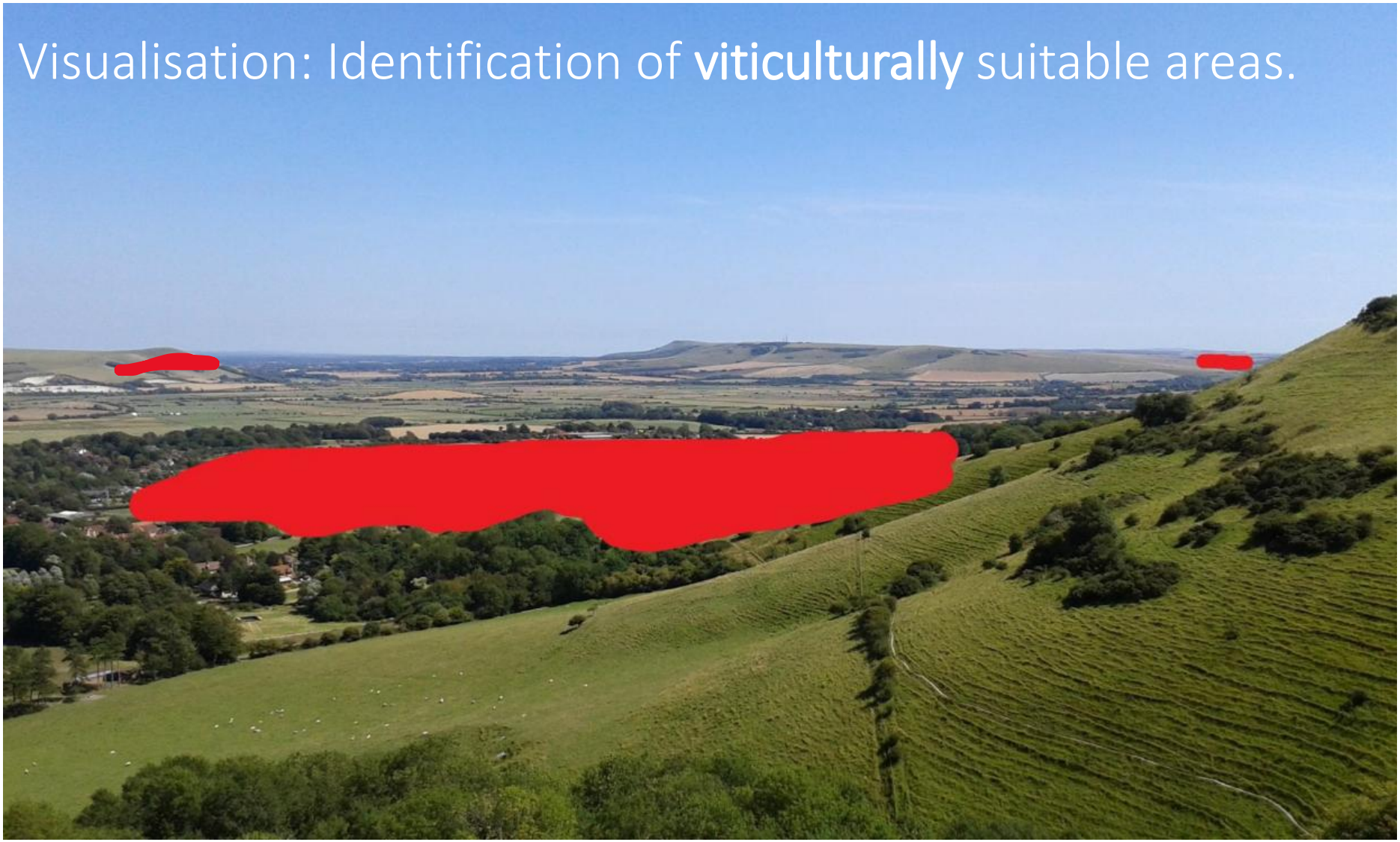
11.4. What are the risks to landscape character from viticulture expansion?

The key risk mitigation strategies as covered in Section 10.1. effectively deal with specific environmental impacts, as do the conclusions of the *Natural Capital and Asset Statement and Risk Register* (Section 12). Here, we specifically explore landscape impacts; fundamentally these revolve around landscape character. For example, how does replacing a field of cereal crops or pasture (the most common prior uses) with vines affect experiences and perceptions of the SDNP landscape? Notwithstanding additional infrastructure or buildings, a loss of

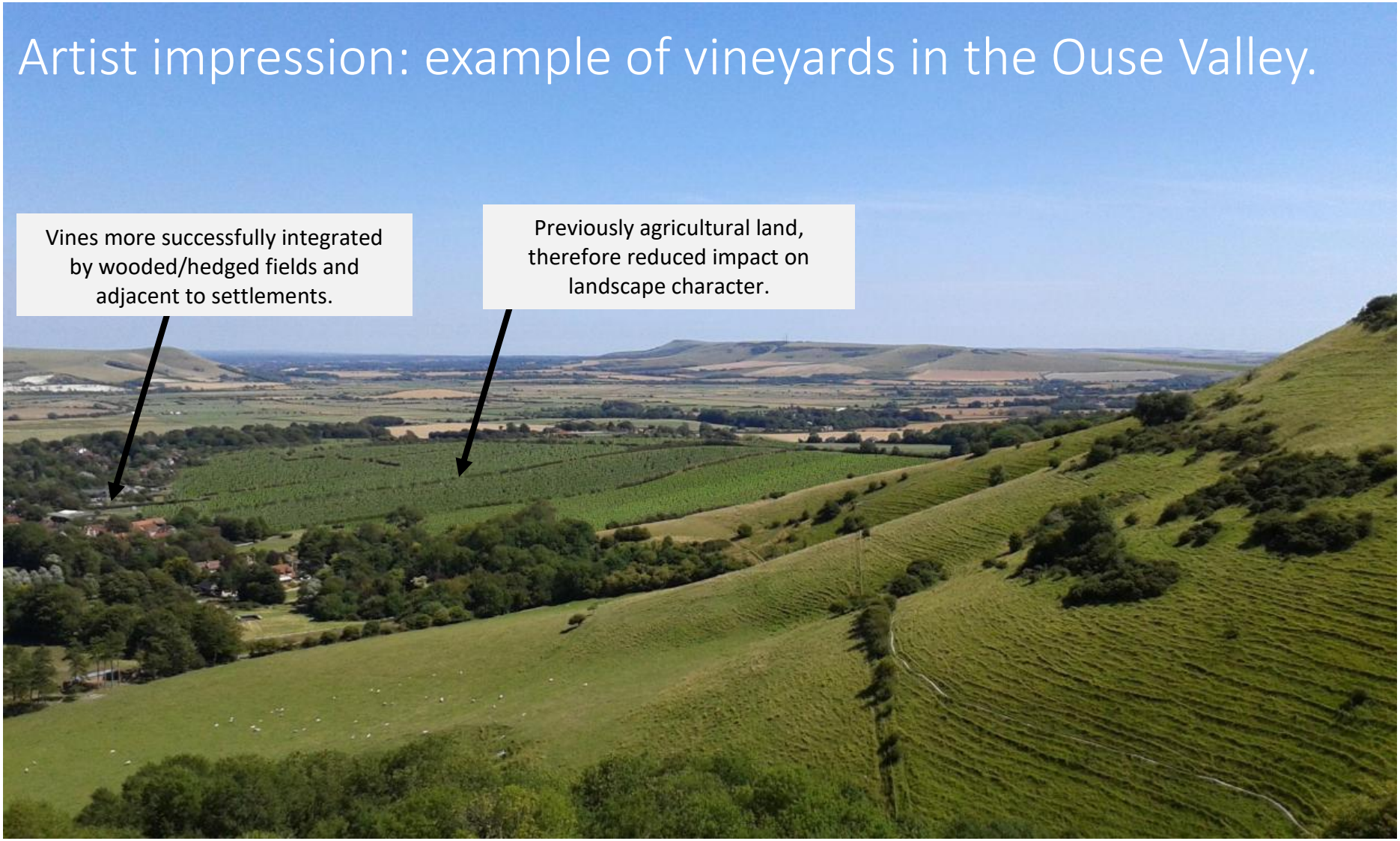
fundamental character, i.e. the open quality of the South Downs or the pastoral quality of the Weald could be affected; the raised linear nature of vines and their posts and wires is, after all, very different and there is the potential for visual degradation with too extensive a view of regimented lines of vines and trellising. Scale and location are therefore major factors with the integration of vineyards, particularly in open downland. Where contained by rolling topography, woodland blocks and field boundary hedgerows – all elements characteristic of much of the South Downs – their integration is far more successful.

Figures 31 a to r show visualisations prepared for this study of four of the 'Representative Views' that were identified in the SDILCA (SDNPA, Integrated Landscape Character Assessment SDILCA, 2011a) and 'View Characterisation and Analysis' undertaken by LUC (Land Use Consultants) in 2015 (SDNPA, 2015). These views are Temple of the Winds (on Blackdown Hill near Haslemere), Devils Dyke (on the South Downs Way near Brighton and Hove), Kingston Ridge (near Lewes) and Firle Beacon (south of Glynde on the South Downs). There is a series of views, showing the existing view, the view overlaid with areas appropriate for vines (from a viticulture perspective only, as identified and developed through the landscape viticulture suitability modelling work discussed in Section 8) shown in red, then finally visualised with vines in full growth. Further, contrasting images for summer and winter are also provided, as seasonality is also likely to play a role in perception and impacts. Field scale, access, surrounding habitat or designation considerations may render these locations undesirable for vineyards (i.e. considerations beyond viticulture) but it is important to note that, in each case, the folds of the topography are not lost and the retention of the existing woodland and hedgerow framework contains the new plantings within the pre-existing field and woodland patterns. There is a change in both the landscape character and land-cover in every case. Scale will determine whether the change negatively affects landscape character and sense of place. Scale and land use being replaced will also have impacts upon the land's ability to deliver ecosystem services. In the bigger picture, fundamental field patterns remain but with an element of openness gone, especially where pastureland is being replaced. It might be argued that this would be acceptable to the extent shown, but should the remaining fields throughout these pictures all be assessed as suitable land for vines, would the whole of that panorama covered in vines be so palatable? The tipping point, in terms of scale and impact, remains unquantified and requires a landscape capacity assessment. Additional infrastructure, for example access roads, storage facilities or wineries, is not shown in these images, but existing examples can be seen in Figure 32. Such infrastructure would be subject to planning permissions and suitability and impact determined on a case by case basis in accordance with planning policy (see Section 5.4.).

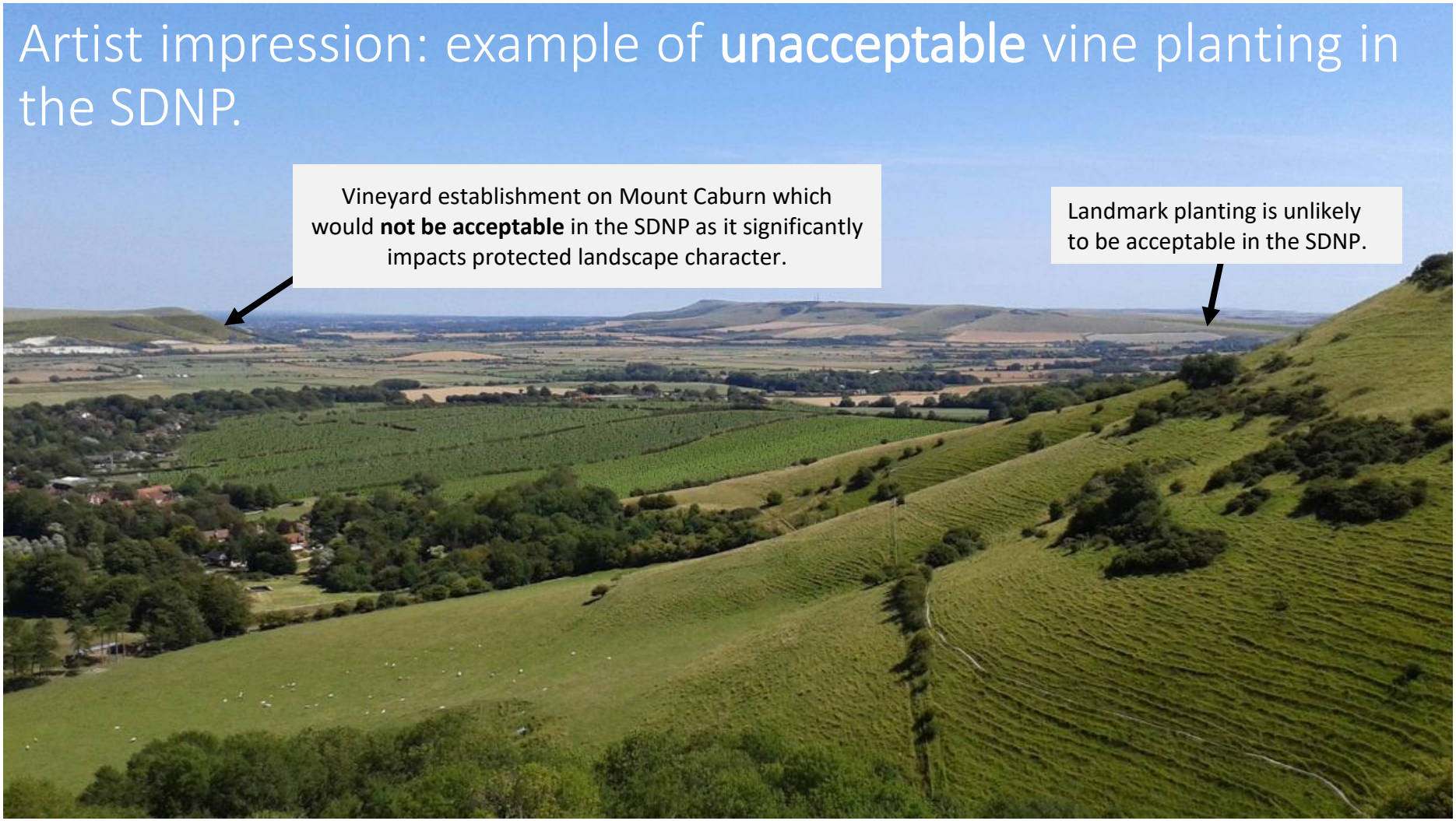
Visualisation: Original image – Kingston Ridge, near Lewes.

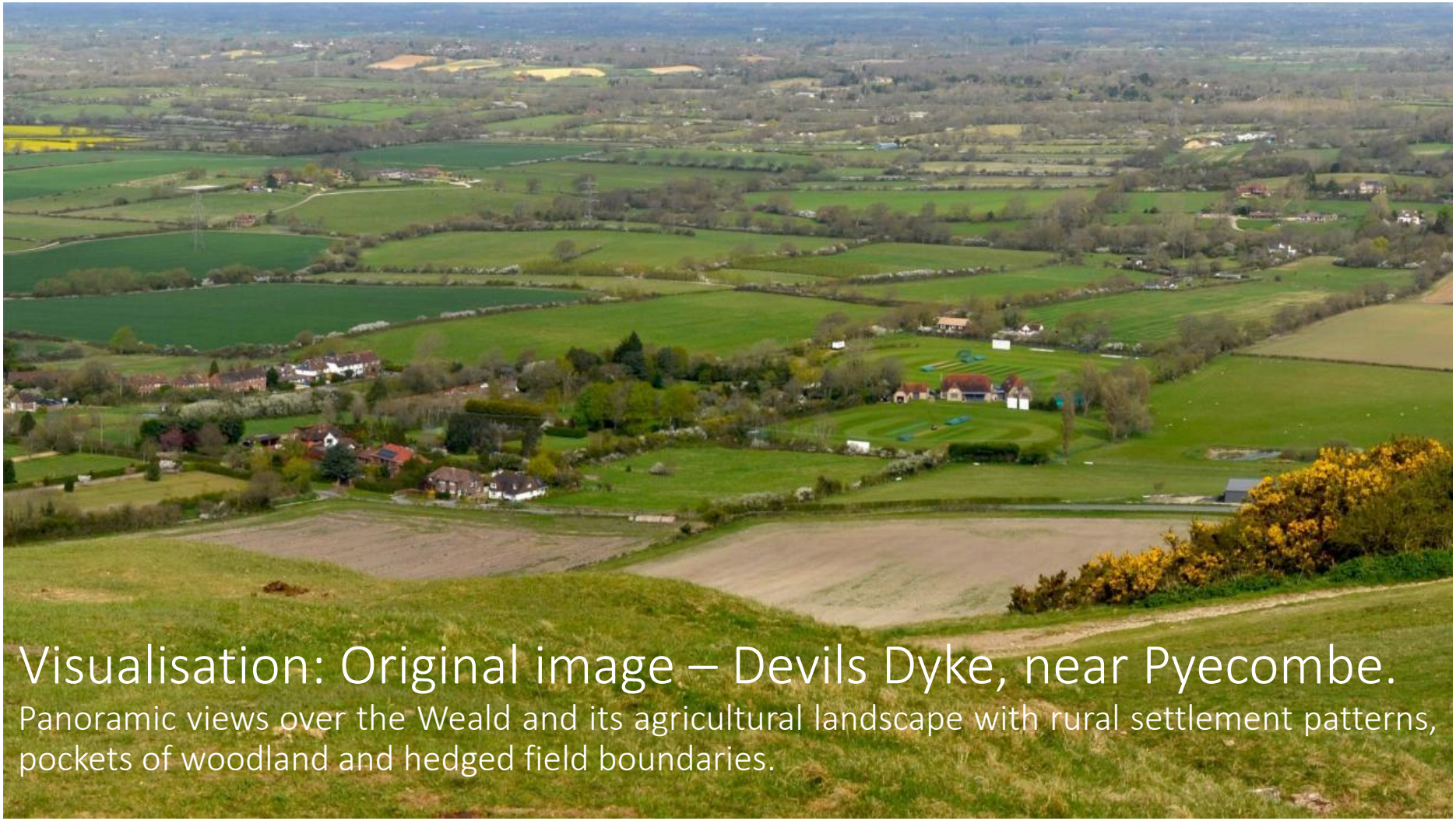

Visualisation: Identification of viticulturally suitable areas.

Artist impression: example of vineyards in the Ouse Valley.



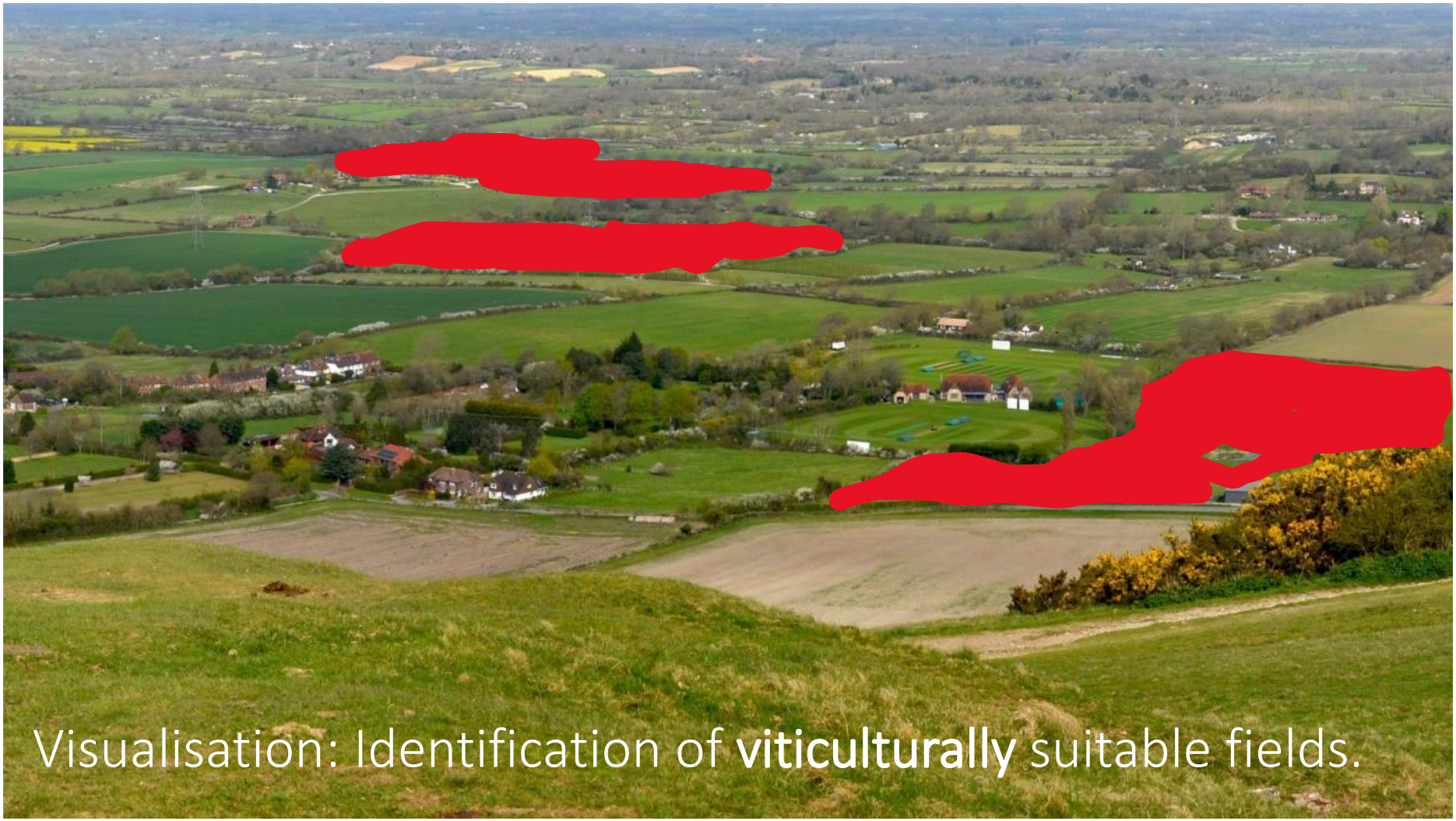
Artist impression: example of **unacceptable** vine planting in the SDNP.

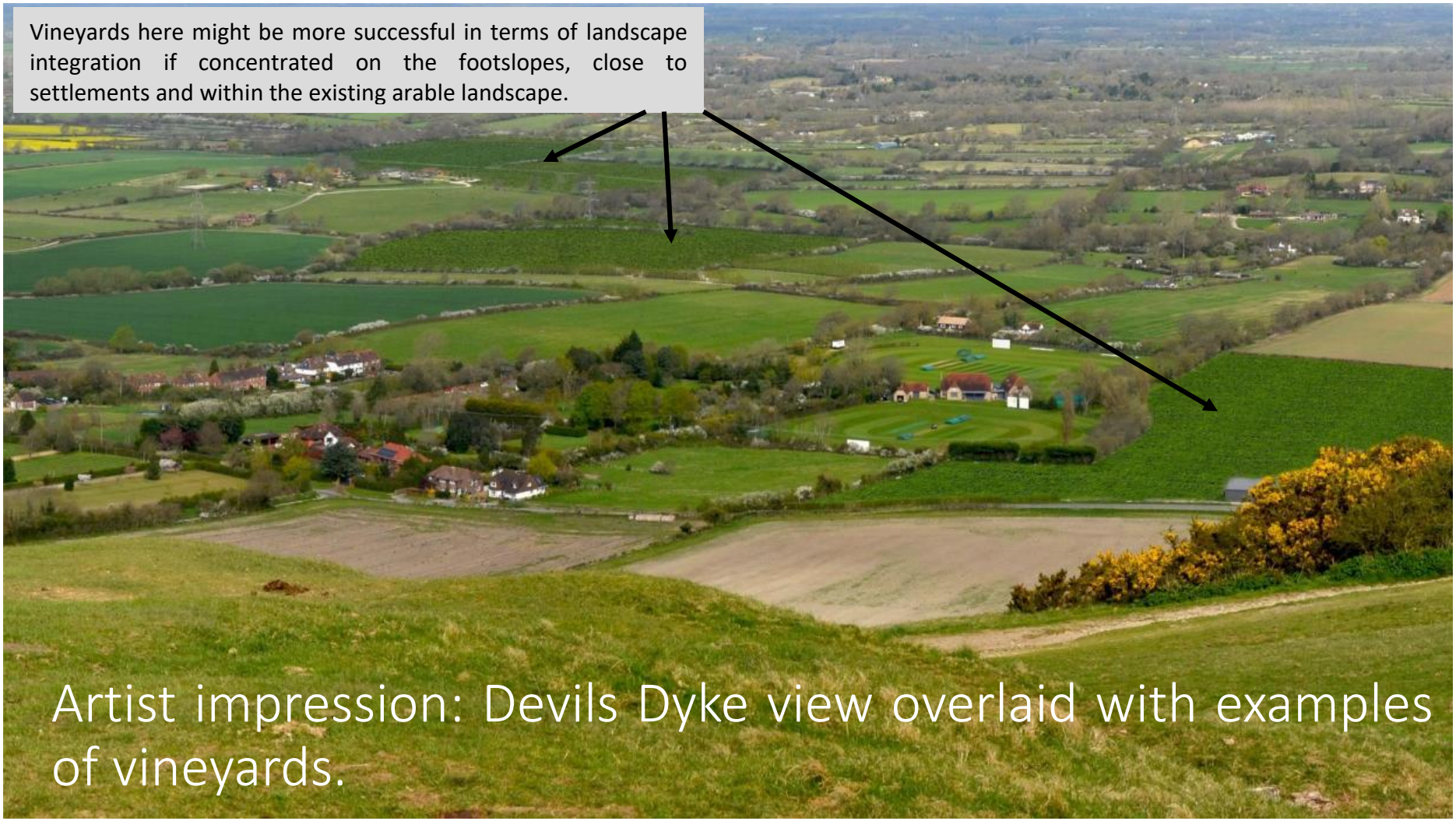




Visualisation: Original image – Devils Dyke, near Pyecombe.

Panoramic views over the Weald and its agricultural landscape with rural settlement patterns, pockets of woodland and hedged field boundaries.


Visualisation: Identification of **viticulturally** suitable fields.

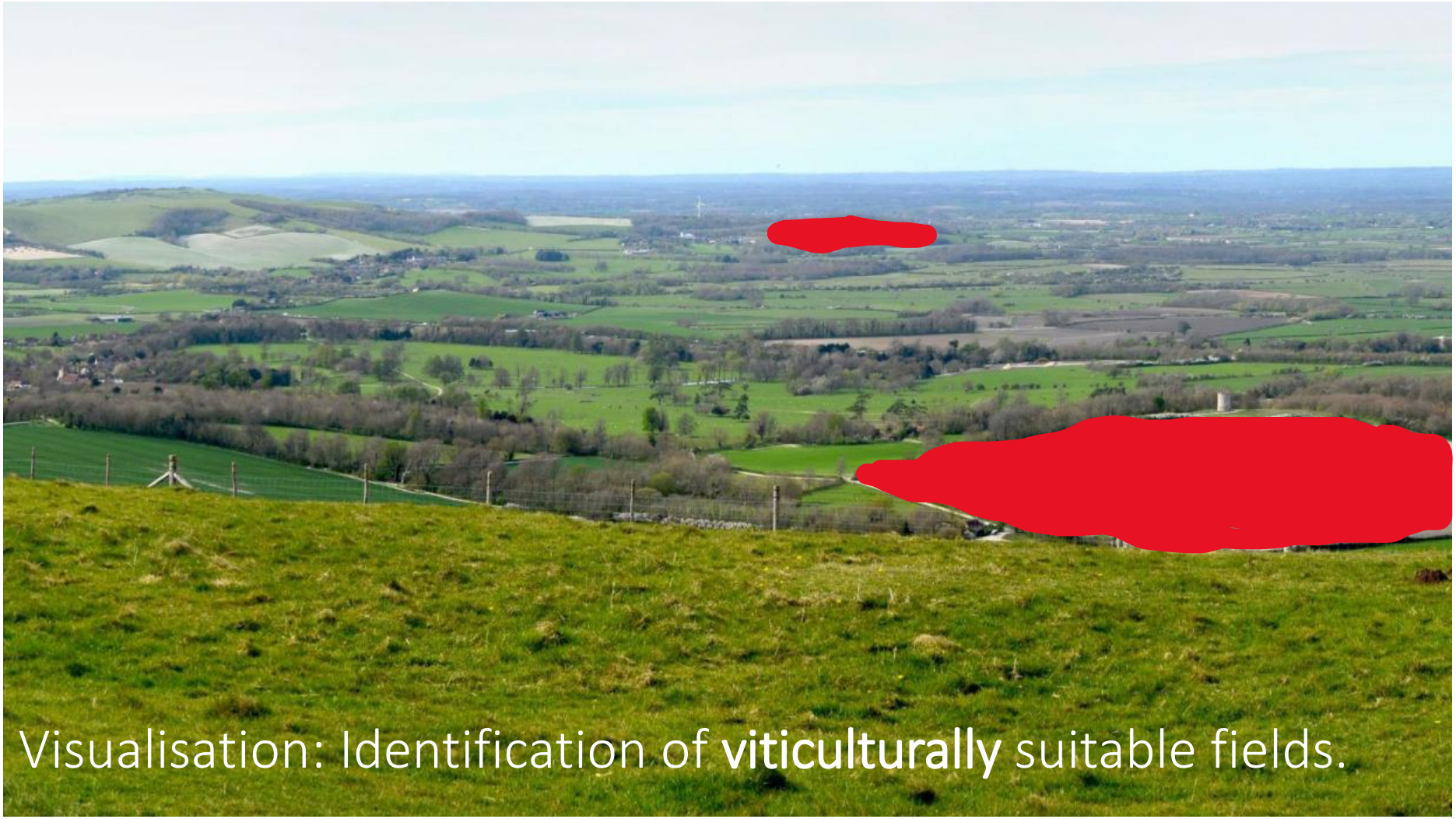


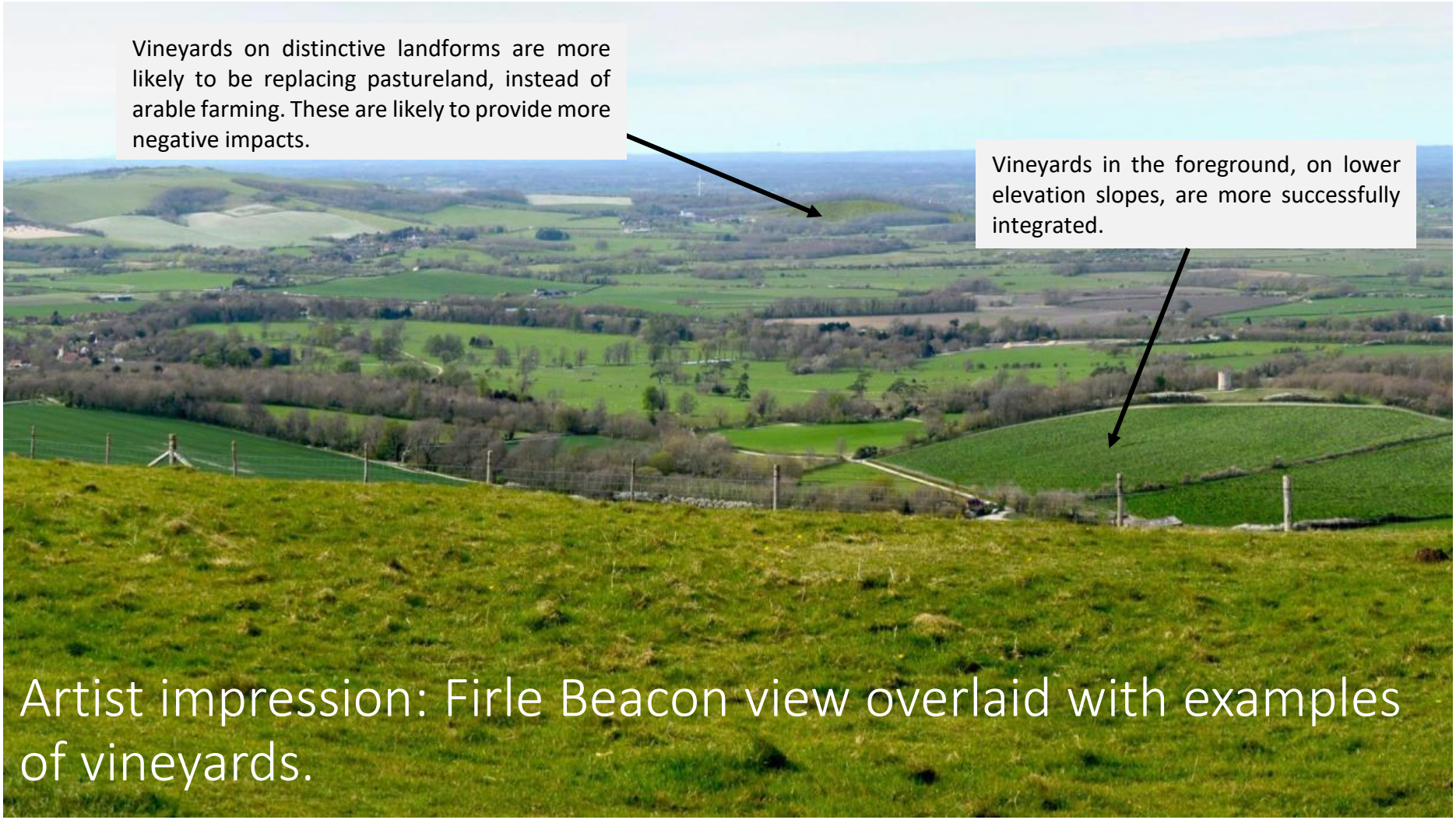
Artist impression: Devils Dyke view overlaid with examples of vineyards.

This area includes a rich variety of wildlife and habitats, including the iconic SDNP sheep-grazed grass chalkland. The view sets out the tranquillity and sense of space in the South Downs, due to the lack of intrusive development.

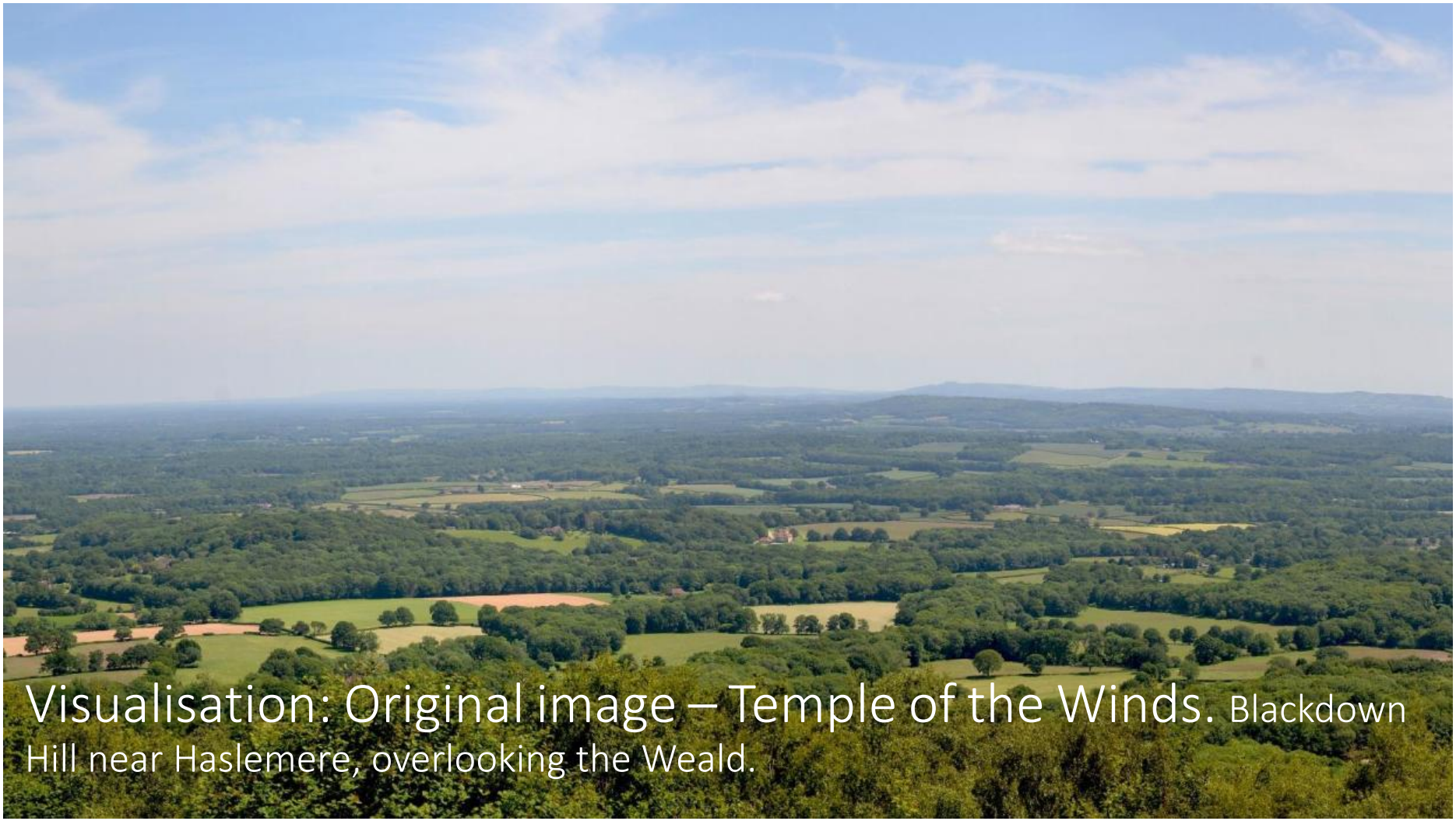
Visualisation: Original image – Firle Beacon, near Lewes.

Looking north from Firle Beacon across the scarp footslopes (inside the SDNP) and over the Low Weald.

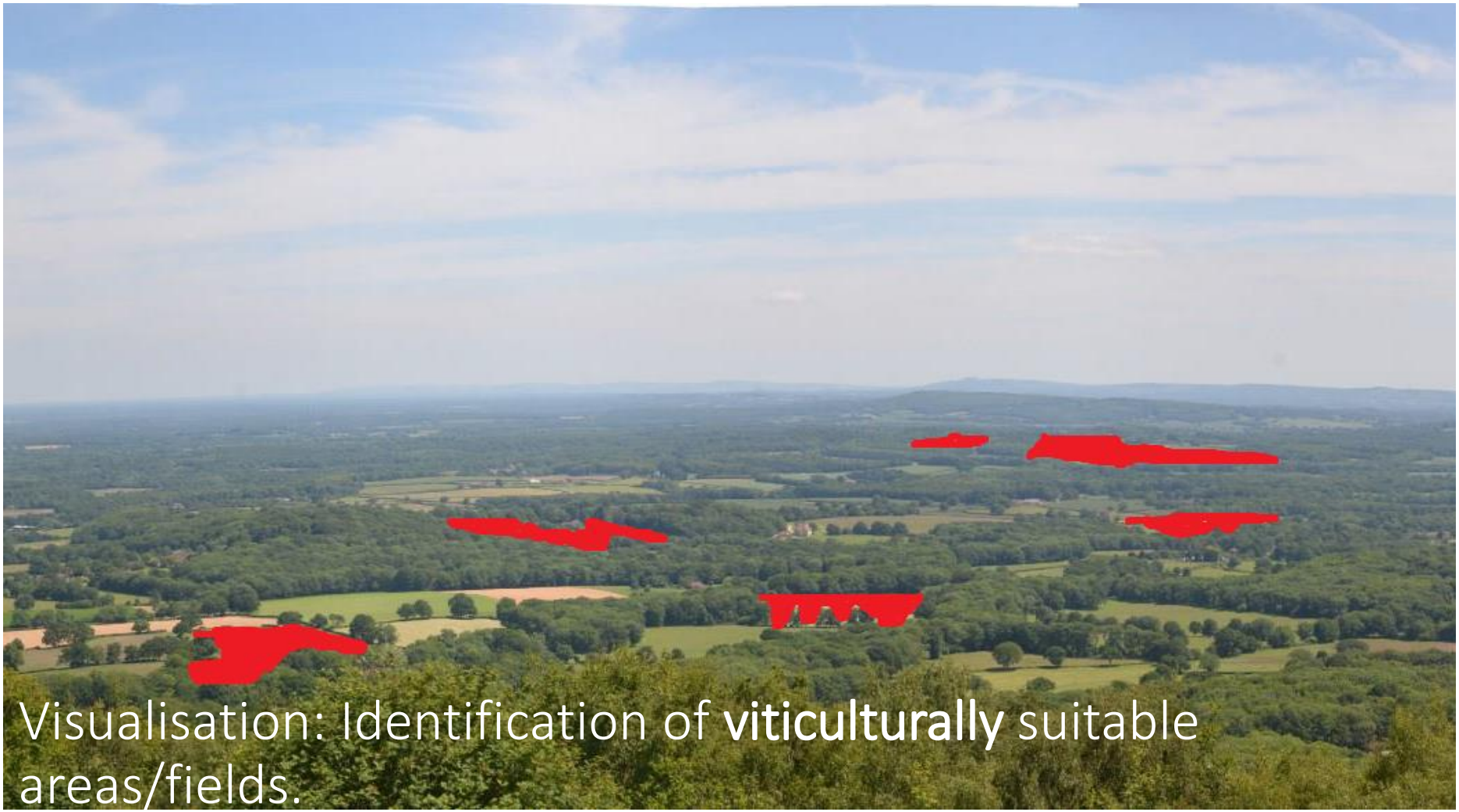

Visualisation: Identification of **viticulturally** suitable fields.



Artist impression: Firle Beacon view overlaid with examples of vineyards.



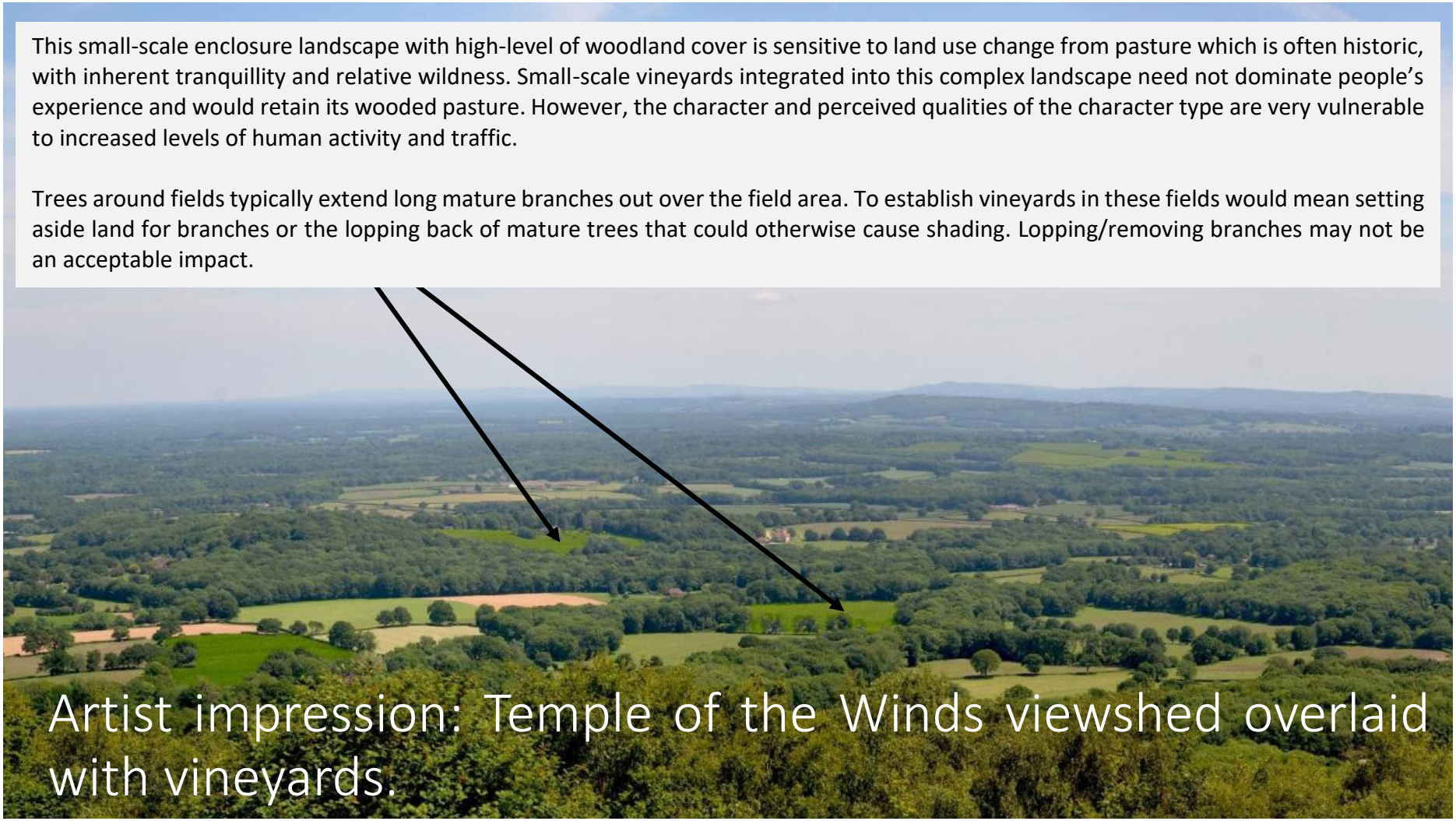
Visualisation: Original image – Temple of the Winds. Blackdown Hill near Haslemere, overlooking the Weald.



Visualisation: Identification of **viticulturally** suitable areas/fields.

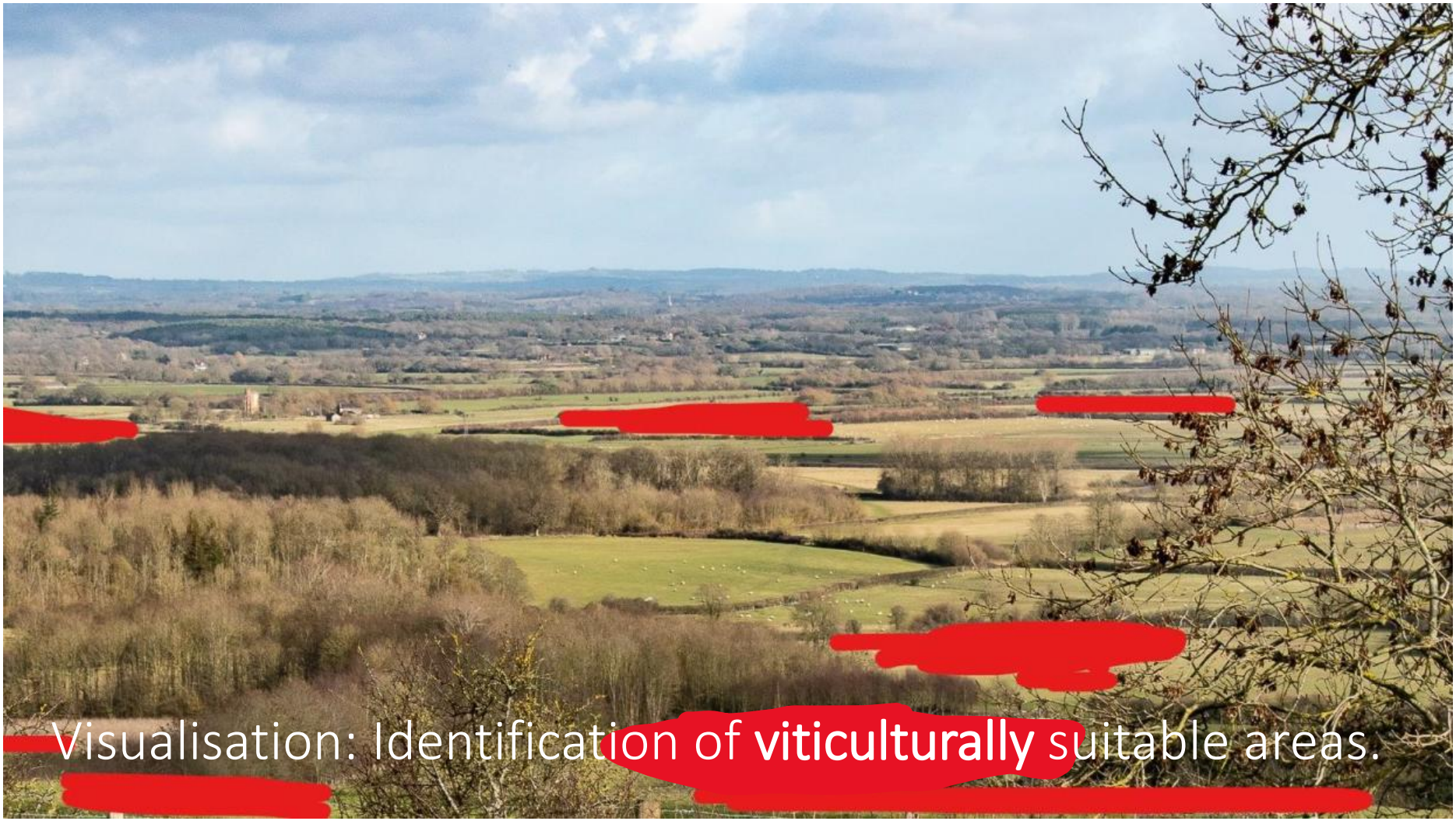
This small-scale enclosure landscape with high-level of woodland cover is sensitive to land use change from pasture which is often historic, with inherent tranquillity and relative wildness. Small-scale vineyards integrated into this complex landscape need not dominate people's experience and would retain its wooded pasture. However, the character and perceived qualities of the character type are very vulnerable to increased levels of human activity and traffic.

Trees around fields typically extend long mature branches out over the field area. To establish vineyards in these fields would mean setting aside land for branches or the lopping back of mature trees that could otherwise cause shading. Lopping/removing branches may not be an acceptable impact.

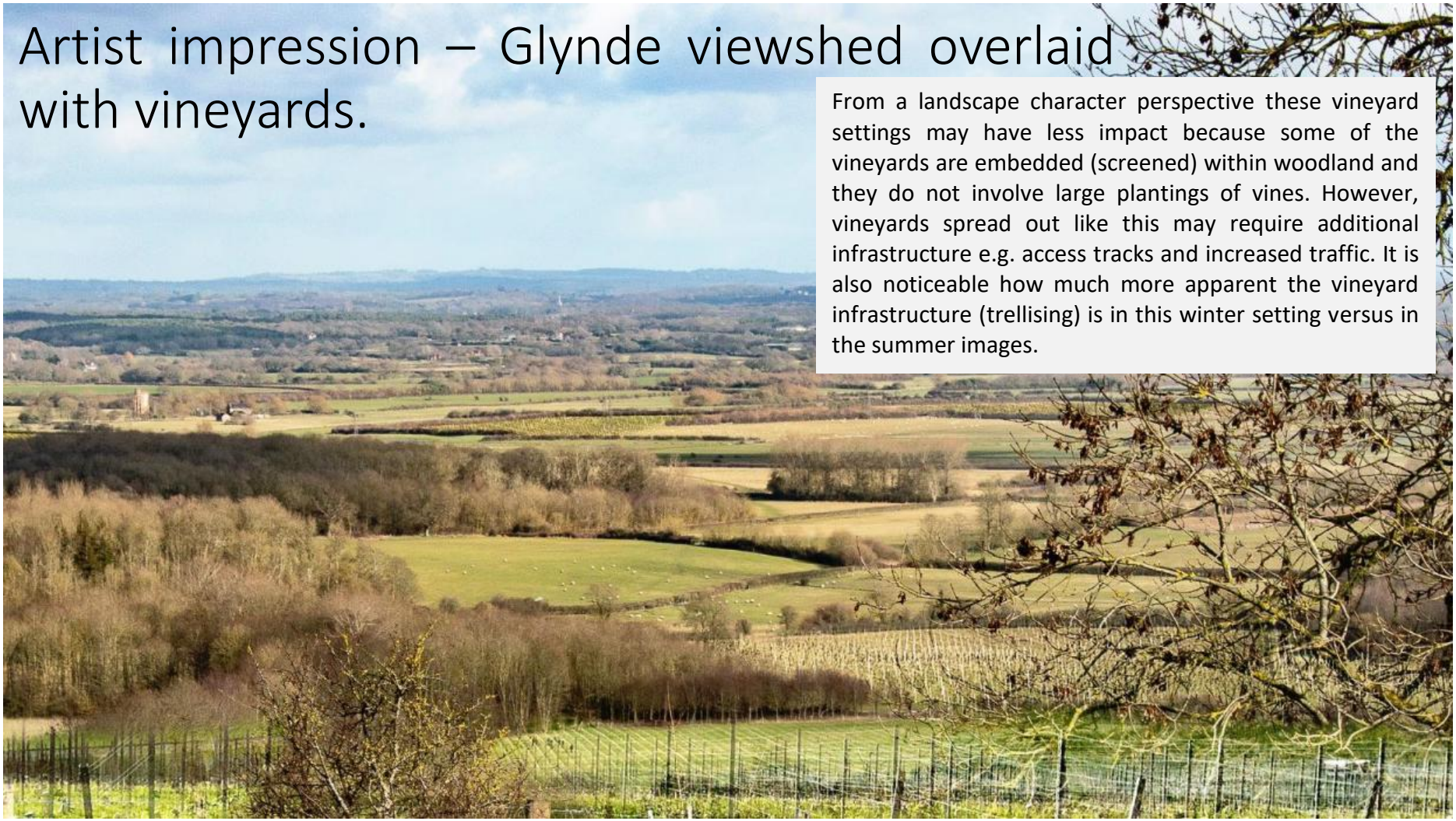


Artist impression: Temple of the Winds viewshed overlaid with vineyards.

Visualisation: Original image from Glynde, near Lewes, in winter.


Visualisation: Identification of viticulturally suitable areas.

Artist impression – Glynde viewshed overlaid with vineyards.



From a landscape character perspective these vineyard settings may have less impact because some of the vineyards are embedded (screened) within woodland and they do not involve large plantings of vines. However, vineyards spread out like this may require additional infrastructure e.g. access tracks and increased traffic. It is also noticeable how much more apparent the vineyard infrastructure (trellising) is in this winter setting versus in the summer images.

Visualisation: Original image – Harting Down, near Petersfield, in winter (black and white).


Visualisation: Identification of viticulturally suitable areas.

Figure 31 a-r. Landscape visualisations identifying viticulturally suitable land within the SDNP and using artists impressions to show fields overlaid with vineyards.

This brings us back to what is consistent in the SDNP landscape and what will inevitably change as different agriculture and land management practices evolve. Landscape character and visual impact sensitivity are key to whether the landscape change would be considered acceptable (low/zero impact) or unacceptable (high adverse impact). For example, the open tops of downland are particularly sensitive and should be kept free from plantings (these are high plateaux where true remoteness and 'escape' can be experienced). In the valleys and slopes, where other sensitivities exist, it is important to make sure vineyards work with existing hedgerows, field boundaries and woodlands, reinforcing and increasing them in accordance with local landscape character area guidance, where scale is in danger of being overwhelming (see recommendations in Section 15). To address any loss of openness, key views and public rights of way should be respected to minimise any negative effects on the experience of the user. The question over the impact of rabbit, badger and deer fencing around vineyards is one that relates to proximity, PROWs (Public Rights of Way) and impacts on wildlife and habitat corridors (see Section 15). Ultimately, walking right next to a deer fence would change a sense of openness that was otherwise previously there. Unless permissions have been granted for changes in footpath or access routes, fencing should not block open public access.

For wineries and associated buildings, yards, operational movements and infrastructure, which all fall within the remit of planning, scale is again key to landscape impact, but so too is the expectation to see these as parts of traditional farmyard groupings, settled into their landscape and not encroaching into open countryside. Within the National Park, wineries such as Stopham, Breaky Bottom and Court Gardens are within older, established buildings (primarily old flint barns) and indeed from a visual perspective one would not necessarily know if they were a winery or used for other agricultural purposes. Others, such as the Rathfinny (see Figure 32) and Wiston Estate wineries, are established within a mix of existing farm buildings and new buildings, surrounded by both vineyards and other forms of farmland and/or woodland. The opportunities to see exemplary design interventions should be encouraged, and the SDNPA is working on several Supplementary Planning Documents (SPD) and Technical Advice Notes (TAN) in this area, following on from the adoption of the Local Plan (SDNPA, 2019) (see Section 5.4.)

Figure 32. Different winery building styles in the SDNP.

11.5. Landscape Character Assessment

A Landscape Character Assessment is the process of identifying and describing variations in the character of the landscape. The SDNP is composed of several different landscape characters and their characterisation underpins the approach to landscape sensitivity assessments.

The European Landscape Convention (ELC) (2020) recognises that all landscapes matter, be they ordinary, degraded or outstanding. There is, however, recognition that value is also ascribed to landscapes, and their Topic Paper 6 identifies the need for judgements about landscape capacity to reflect that certain landscapes are valued by society for different reasons. Landscape value reflects local and national landscape designations as well as other factors such as:

- Natural heritage assets;
- Cultural heritage assets; and,
- Recreational resources, including long-distance paths.

With reference to England, An Approach to Landscape Sensitivity Assessment (Natural England, 2019) replaces Topic Paper 6 and should assist in informing judgements and decisions concerning the planning and management of change. Landscape sensitivity, within the context of spatial planning and land management, is a term applied to landscape character and the associated visual resource, combining judgements of their susceptibility to the specific development type/development scenario or other change being considered together with the value(s) related to that landscape and visual resource. Sensitivity and capacity have different meanings. When dealing with an area's sensitivity, the question relates 'to what'? When dealing with an area's landscape capacity – perhaps to absorb a certain amount of development without unacceptable changes to landscape character – the question generally relates to 'how much'?

A landscape capacity assessment fell outside of the scope of this study, but it is recommended that one be undertaken to evaluate more fully the significant and various sensitivities (relevant to viticulture) across the National Park's landscape character areas.

12. Natural capital asset statement and risk register for the SDNP

Section 12 – Key findings:

- Eighteen different Landscape Character Types are defined within the SDNP. These are important for representing local distinctiveness and a sense of place.
- Chalk is the dominant bedrock geology in the SDNP, with a significant area of sandstone and mudstone in the Western Weald. These two types of geology are both aquifers and, overall, more than 78% of the SDNP is classed as a highly productive aquifer. Soils are heavily influenced by the underlying geology and since the majority are relatively light then there is little to prevent surface pollution from reaching the underlying aquifers.
- The soil characteristics and topography also mean that erosion is a well-known problem in parts of the SDNP.
- More than three-quarters of the SDNP is classed as arable land or grassland, although there are also substantial areas of woodland in the Dip Slope and Western Weald. Just 3.5% of the SDNP is rated as the best quality agricultural land (Grades 1 or 2), compared with 17% of land in England as a whole, but nearly two-thirds of this is concentrated in the Dip Slope and Scarp Slope regions.
- One particular attraction of the SDNP is the tranquillity provided by some landscape settings. The Dip Slope, Western Downs and Western Weald are areas with relatively high tranquillity scores.
- There are current pressures in the SDNP relating to urban expansion, visitor numbers and agricultural change. Within the agricultural sector it is intensification of activities, leading to increased water demands, pollution or soil erosion that are of particular concern. Climate change is another.
- An expansion of viticulture and wine production will obviously result in an increase in food and drink production (provisioning service) and could potentially increase the number of visitors to the SDNP through wine tourism. Other effects that need to be evaluated include the consequences for water demand and supply, carbon sequestration, leaching of fertilisers and pesticides (especially on land above vulnerable aquifers), and soil erosion (particularly where this could increase sediment load into streams or rivers).
- Natural capital in the Chalk Valleys, Dip Slope, Scarp Slopes, Western Down and Western Weald could be particularly sensitive to any expansion.
- Climate change and urban growth are likely to have much greater overall future impacts on the natural capital of the SDNP than an increase in viticulture.
- There is potential for vineyards to deliver significant ecosystem services through biodiversity, recreation and tourism, and climate and carbon storage, potentially to a greater degree than was provided by the dominant land uses they often replace.
- With regards to tranquillity, vineyards deliver less ecosystem service benefits as they require more intensive management.

One of the aims of this study was to produce a Natural Capital Asset Statement and Risk Register that would underpin any future natural capital account relevant to viticulture in the SDNP. To aid with this study and future work, this Section begins with a review of the subject matter and methodology.

12.1. Defining natural capital: capital assets and ecosystem services

Natural capital is a fundamental component of an economy's stock of resources upon which human health, wellbeing and wealth depend. HM Treasury (2018) defined it as follows:

'*Natural capital includes certain stocks of the elements of nature that have value to society, such as forests, fisheries, rivers, biodiversity, land and minerals. Natural capital includes both the living and non-living aspects of ecosystems.'*

Economic growth and development are conditioned by an economy's overall capital stock, which includes produced capital, i.e. factories, power stations, infrastructure; human capital, i.e. people; social capital, i.e. social networks and communities; and natural capital, i.e. assets such as landscapes, soils, water, air and ecosystems.

Ecosystem assets underpin the provision of ecosystem services and benefits to people. Ecosystem benefits are substantial and, for example, the Office for National Statistics (ONS) estimated a partial monetary value for natural capital in the UK in 2016 of £950 billion (ONS, 2019a). Four main categories of ecosystem service (provisioning, regulating, cultural and supporting) are commonly distinguished (see Figure 33).

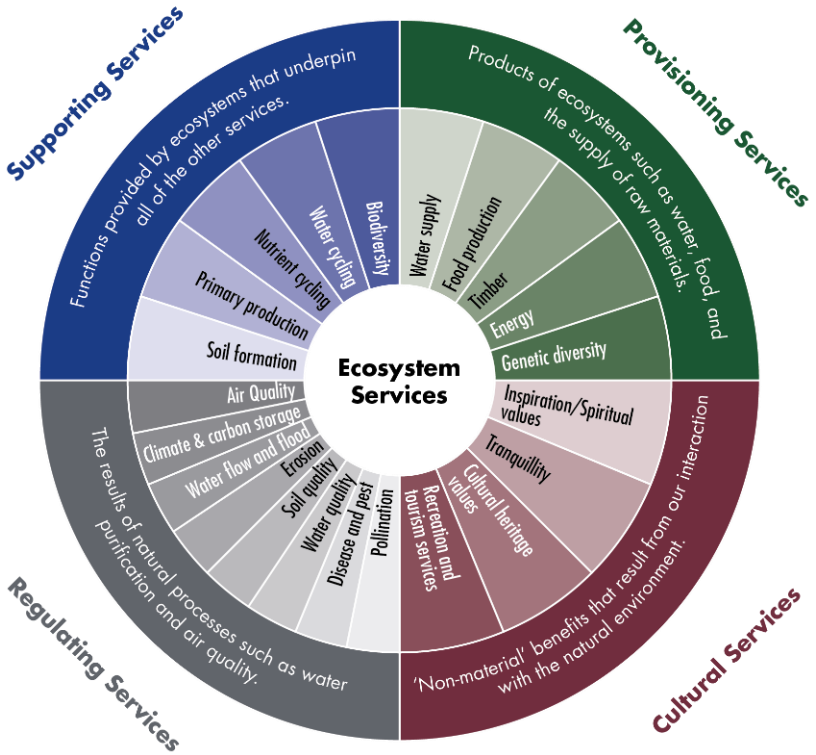


Figure 33. A categorisation of ecosystem services; source: categories from Millennium Ecosystem Assessment (2005), diagram from the SDNPA Local Plan (2019).

12.2. Decision support systems for natural capital planning and management

Environmental change and consequent impacts on human welfare can be scoped and assessed using a natural capital approach encompassed within a so-called Drivers-Pressures-State-Impacts-Responses (DPSIR) framework, as illustrated in Figure 34.

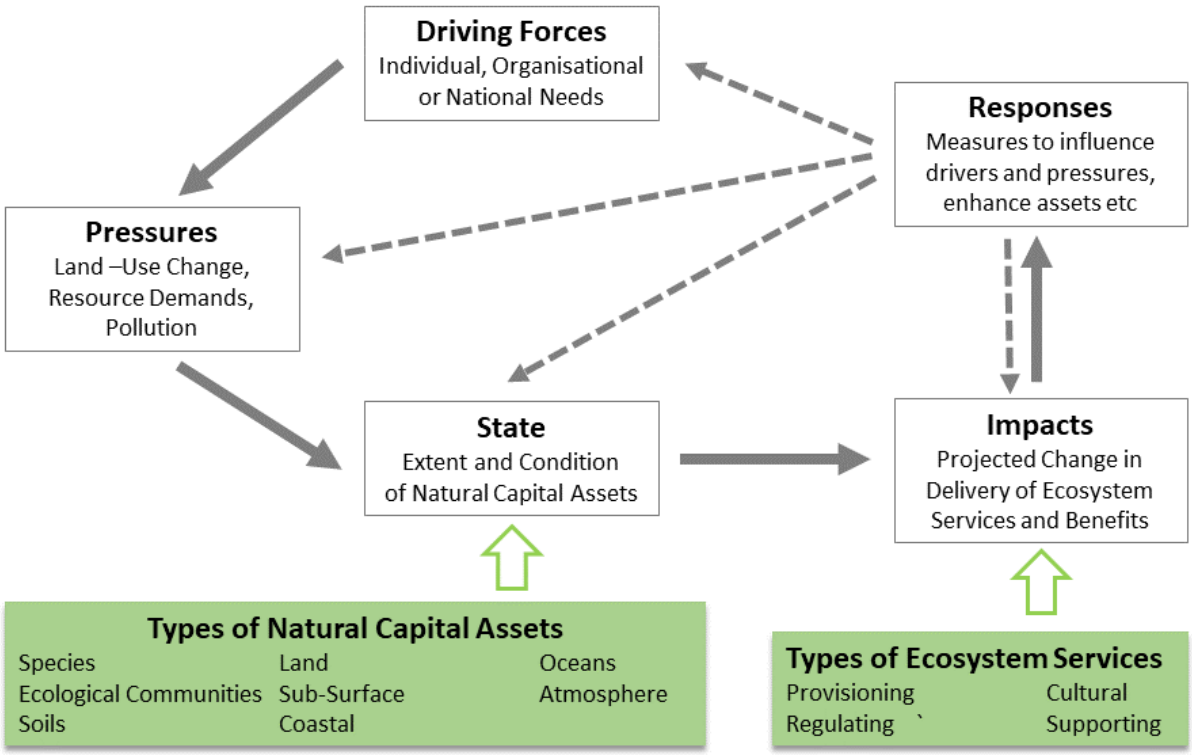


Figure 34. The DPSIR scoping framework;
source: adapted from Von Haaren, Lovett & Albert (2019).

The DPSIR framework provides a scoping framework to highlight the indicators needed to enable feedback to policymakers on drivers and pressures of environmental quality changes and resulting socio-economic impact of the choices made (policy responses), or to be made in the future. In the land management context, a DPSIR assessment could take the following form: drivers such as climate change and public demand for food or drink can stimulate agricultural change activities, such as new crops or cultivation practices, which can lead to increased soil erosion or release of nutrients into streams and aquifers. The result is a change in water quality, increasing the costs of treatment for drinking water, and reducing recreation and amenity benefits with adverse welfare consequences. The water quality impact and flow problems may be further exacerbated by urban and infrastructure expansion, with increased demand for water supplies and accentuated rates of runoff.

Interest in assessing changes in natural capital assets and the delivery of ecosystem services has stimulated a range of initiatives to support such studies. These include software tools for modelling changes in ecosystem services provision and undertaking monetary valuations of the outcomes, databases summarising valuation study results, and guidance on applying different approaches and methods. Appendix D provides details for a number of these resources.

At a national level, a recent report from Natural England (2020) provides an overview of variations in asset quantity and quality indicators. Very recently, the results of the Enabling a Natural Capital Approach (ENCA) initiative were released, which includes a guidance document, assessment template, assets and services data-books, and a set of case studies (Defra, 2020). A four-step strategy was outlined that overlaps with the broader approach suggested by the Natural Capital Committee (2017) for the planning and management of natural capital now and in the future. These steps are summarised on the left-hand side of Figure 35.

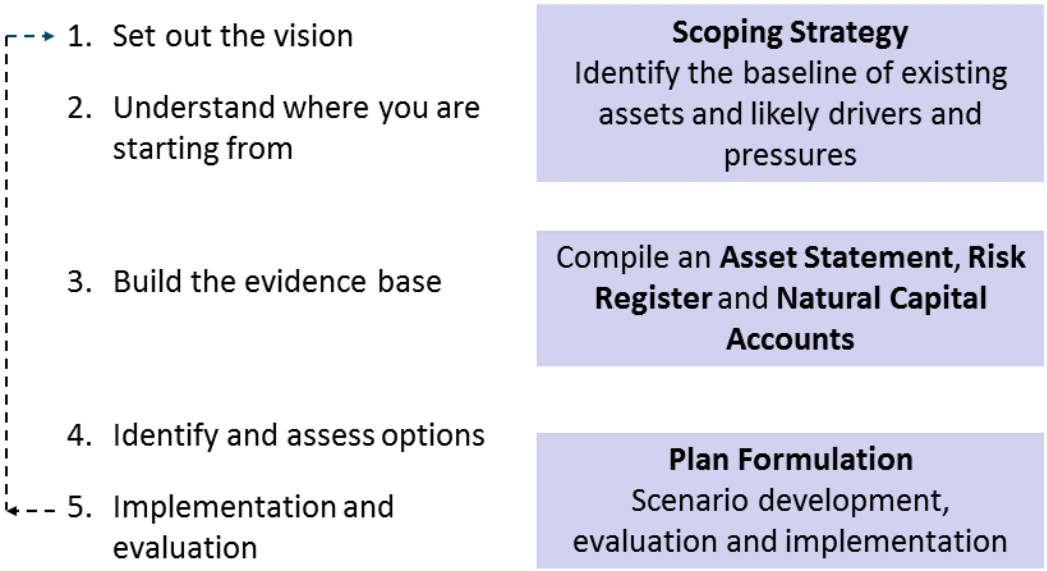


Figure 35. Steps in the planning cycle for a natural capital plan; source: adapted from the Natural Capital Committee (2017)***.***

The final stages of this planning cycle are to consider options for action, intervention and investment in the form of a plan. This is exemplified by the South Downs Local Plan (SDNPA, 2019), where concepts of natural capital and ecosystem services are central to the portrait of the area and the assessment of development options.

12.3. An Asset Statement for the SDNP

12.3.1. Spatial framework for assessment

Eighteen different Landscape Character Types have been defined (SDNPA, Integrated Landscape Character Assessment SDILCA, 2011a), to be updated in 2020. These are important for representing local distinctiveness and a 'sense of place', but in some respects are too detailed to provide an overview of natural capital assets. Two small modifications have been made namely to keep the Chalk Valleys as a separate category (rather than combining it with the remainder of the Dip Slope), and the other was to distinguish the small area of Shoreline. Both modifications were made because of distinctive natural assets in these two areas.

Table 10 shows how the eighteen Landscape Character types relate to the eight broader Landscape Groups; the distribution of the latter is illustrated in Figure 36.

Table 10. Relationship between Landscape Character Types and Landscape Groups.

Landscape Type	Type Description	Landscape Group	Area in km^2
A	Open Downland	Dip Slope	267.0
A	Open Downland	Western Down	40.4
B	Wooded Estate Downland	Dip Slope	211.8
C	Clay Plateau	Western Down	50.9
D	Downland Mosaic	Dip Slope	167.5
D	Downland Mosaic	Western Down	76.8
E	Chalk Valley Systems	Chalk Valleys	106.3
F	Major River Floodplains	River Valley	53.1
G	Major Valley Sides	River Valley	36.7
H	Major Scarps	Scarp Slope	46.1
I	Scarp footslopes	Scarp Slope	98.0
J	Greensand Terrace	Scarp Slope	84.2
K	Mixed Farmland and Woodland Vales	Western Weald	86.2
L	Wealden Farmland and Heath Mosaic	Western Weald	71.6
M	Sandy Arable Farmland	Western Weald	55.3
N	Greensand Hills	Western Weald	79.2
O	Low Weald	Western Weald	100.0
P	Wooded Claylands	Coastal Plain	6.7
Q	Upper Coastal Plain	Coastal Plain	12.8
R	Shoreline	Shoreline	2.2
Total area			**1,652.7**

In most cases, each Landscape Character type occurs entirely within one Landscape Group but there are two exceptions. The Open Downland and Downland Mosaic types are split across the Dip Slope and Western Down groups, primarily a consequence of producing larger contiguous zones in the latter classification. As shown in Figure 36, the Dip Slope and Western Weald represent the largest Landscape Groups by area, with the Scarp Slope, Chalk Valleys and River Valleys representing elongated features.

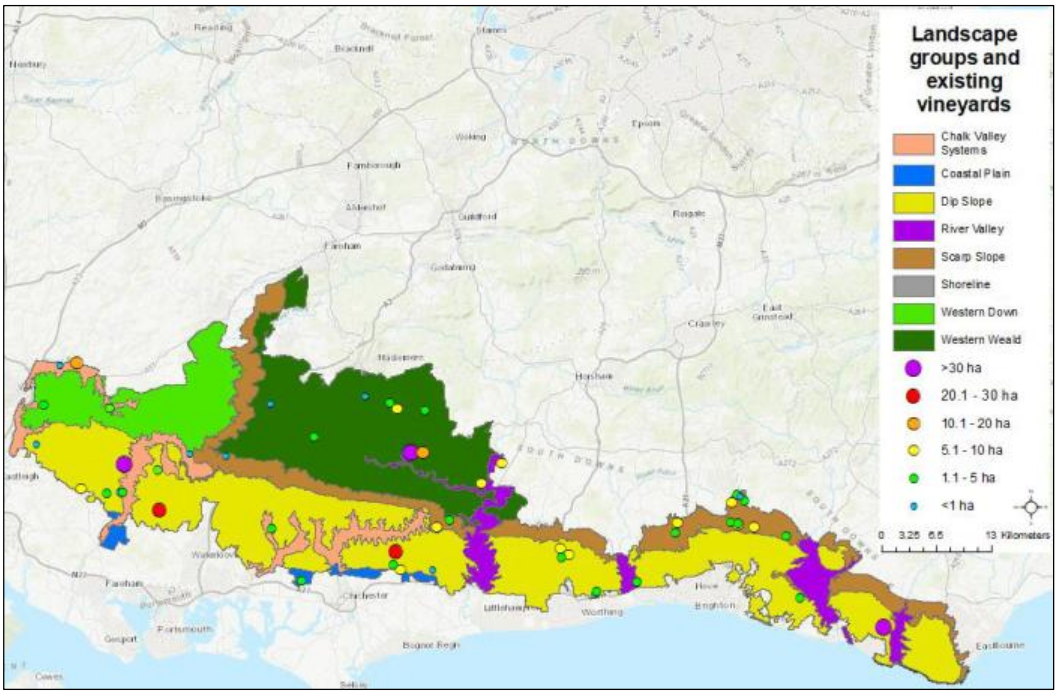


Figure 36. The distribution of Landscape Groups in the SDNP overlaid with existing vineyards.

12.3.2. Data on natural assets

The main types of natural capital assets are defined by Mace et al. (2015) as species (including genetic variation), ecological communities, soils, freshwaters, land, minerals, the atmosphere, sub-soil assets, coasts and oceans. As illustrated in Figures 33 and 34, these assets combine in a variety of ways with other forms of capital (e.g. human investments) to deliver ecosystem services and produce goods which are consumed to provide benefits to people. One example of this complexity is the way food is the product of natural assets such as soils, land, water, species and ecological communities, as well as produced by human capital (in the form of equipment and expertise). Partly because of such interdependencies, but also because data on some types of assets (e.g. the status of ecological communities) are relatively limited, it has been common to use major land cover or use categories as a 'lens' through which to investigate the relationships between natural capital and the derived benefits (Natural Capital Committee, 2014). This approach also has the advantage that the availability of spatial data on aspects of land use is relatively good and facilitates the assessment of contrasts between different areas.

Given this context, the SDNP was characterised by compiling a series of spatial data sets on aspects of land and water use for the whole of England. These datasets were imported into ArcGIS software (ESRI, 2020) and subsets extracted using the boundary of the SDNP, so that the region could be compared with the remainder of England. Datasets were selected to include the main categories of land use (following the Broad Habitats framework used by the UK National Ecosystem Assessment, (2011), as well as importance for key benefits, such as the potential for food production, water resources, support for biodiversity and recreation use. The main data sources used are provided in Appendix D.

12.3.3. Natural assets in the SDNP

Detailed tables to accompany this Section are provided as supplementary material to this report. Geological characteristics for the SDNP and England are summarised in Table 11.

Table 11. Geological and hydrogeological characteristics.

Indicator	SDNP km²	England km²
Bedrock Geology		
Chalk	1,071.1	19,241.0
Clay, silt, sand and gravel	30.7	7,639.8
Mudstone, sandstone and limestone	187.1	2,336.5
Mudstone, siltstone and sandstone	80.0	41,710.6
Sand, silt and clay	1.7	2,208.1
Sandstone and mudstone	246.6	1,717.7
Sandstone and siltstone, interbedded	34.4	2,098.1
Other types of bedrock geology	0.0	53,196.6
Total Area	**1,651.7**	**130,148.5**
Hydrogeological Character		
Highly productive aquifer	1,302.8	33,478.5
Moderately productive aquifer	109.1	38,893.5
Low productivity aquifer	20.4	29,100.5
Rocks with essentially no groundwater	219.4	29,159.8
Total Area	**1,651.7**	**130,632.2**

Chalk is the dominant bedrock geology in the SDNP, with a significant area of sandstone and mudstone in the Western Weald. These two types of geology are both aquifers and, overall, more than 78% of the SDNP is classed as a highly productive aquifer. Soils are heavily influenced by the underlying geology and since the majority are relatively light (e.g. fewer than 36 km^2 are classed as peaty) there is little to prevent surface pollution from reaching the underlying aquifers.

The soil characteristics and topography also mean that erosion is a well-known problem in parts of the SDNP (Boardman, 2003; Boardman, 2013; Boardman, Bateman, & Seymour, 2017). Using data from modelling conducted by the EU Joint Research Centre (Panagos, Borrelli, & Poeson, 2015), it can be estimated that there are approximately 50 km^2 of land where soil loss rates from rainfall are more than 5 tonnes/hectare/year and another 250 km^2 where the rate is between 2 and 4.9 tonnes/ha/year. Overall, these areas represent some 18% of the SDNP with the highest loss rates concentrated in the Chalk Valley, Dip Slope and Scarp Slope Landscape Groups.

Table 12 lists water resource and quality indicators. The information on overall Water Framework Directive (WFD) (European Commission, 2020) status indicates a situation where there is considerable scope for improvement. Just over 53% of the SDNP is rated as Moderate or better status, compared with a proportion of 71% nationally. There are also obvious issues in terms of water resources, with more than 70% of the SDNP categorised as having no water available for abstraction licensing (using the Q95 flow measure). Taken together, these indicators emphasise some very real challenges for water resource management.

Table 12. Water quality and resource status indicators.

Indicator	SDNP km²	England km²
WFD Overall Water Body Status		
High	0.0	113.6
Good	167.5	14,623.2
Moderate	717.6	83,008.7
Poor	365.7	24,528.5
Bad	80.9	4,238.8
Other/Not Assessed	316.7	10,295.0
Total Area	1,648.4	136,807.9
Water Resource Availability		
Water available for licensing	155.9	83,903.9
No water available	1,178.1	46,659.6

Information on broad land cover types and agricultural land quality is summarised in Table 13. It should be noted that some of the national categories are slightly misleading (e.g. Mountains, Moorlands and Heaths is entirely heathland in the SDNP), and the resolution of the CORINE data is a factor in the apparent absence of Freshwaters. More than three-quarters of the SDNP is classed as arable land or grassland, although there are also substantial areas of woodland in the Dip Slope and Western Weald. Just 3.5% of the SDNP is rated as the best quality agricultural land (Grades 1 or 2), compared with a proportion of 17% for the whole of England, but nearly two-thirds of this is concentrated in the Dip Slope and Scarp Slope regions.

Table 13. Land cover and agricultural land quality indicators.

Indicator	SDNP km²	England km²
Broad Habitat Classes		
Arable crops and fruit	701.4	57,594.0
Coastal margins and marine	0.4	469.8
Freshwaters	0.0	762.3
Mountains, moorlands and heaths	13.3	6,709.8
Pastures and natural grassland	572.6	39,667.0
Urban and human activities	75.0	16,961.9
Woodlands	288.9	8,310.0
Total Area	1,651.7	130,474.6
Agricultural Land Classification		
Excellent (Grade 1)	0.2	3,516.5
Very Good (Grade 2)	58.9	18,443.2
Good (Grade 3)	1,015.6	62,589.8
Poor (Grade 4)	312.9	18,279.7
Very Poor (Grade 5)	20.6	10,913.7
Non-Agricultural	228.3	6,443.3
Urban	13.9	9,342.6

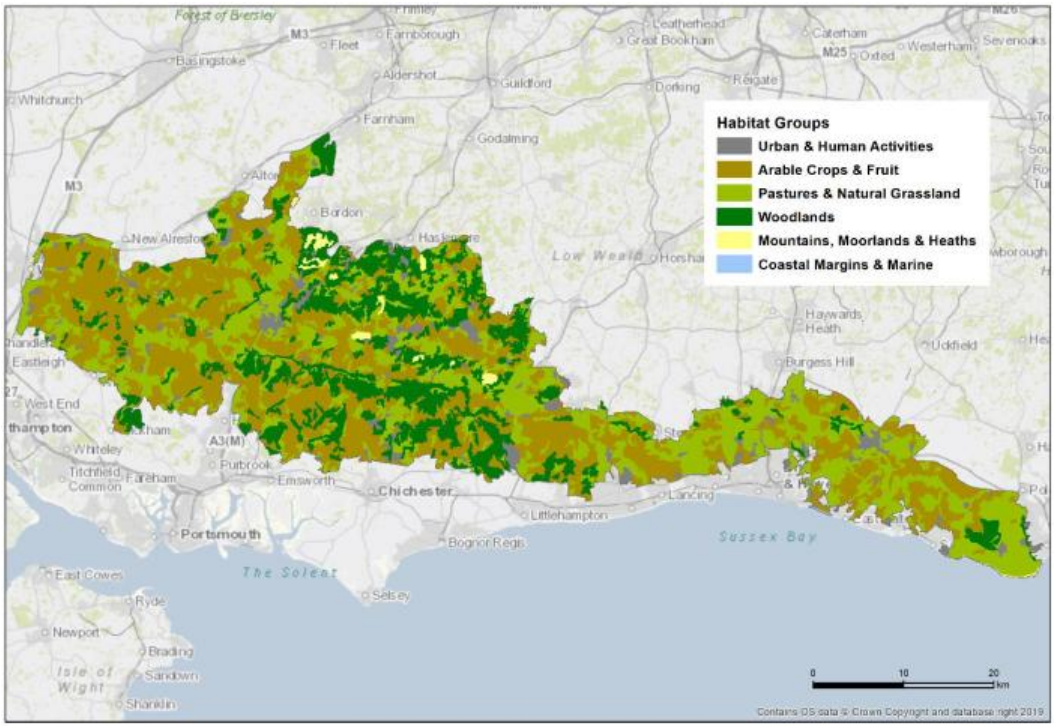


Figure 37. The distribution of Habitat Groups in the SDNP.

Table 14 summarises data relating to Priority Habitats defined under Section 41 of the (Natural Env. & Inventory Rural Comm Act, 2006). As might be anticipated, some types of habitat (e.g. related to upland environments) do not occur in the SDNP, but it is also apparent that the region is particularly important for deciduous woodland (3.6% of the England total), semi-improved grassland (8.4%) and lowland calcareous grassland (8.7%). In addition, the SDNP contains 174 km^2 of recognised ancient woodland (4.8% of the England total) and 125 km of chalk streams and rivers (3.2% of the England total). The Dip Slope and Western Weald are particularly important for ancient woodland, while (unsurprisingly) nearly all the chalk streams and rivers are within the Chalk Valleys Landscape Group.

Table 14. Extent of priority habitats in the SDNP and England.

Main Habitat Type	SDNP km^2	England km^2
Blanket bog	0.0	2,309.5
Calaminarian grassland	0.0	3.0
Coastal and floodplain grazing marsh	30.7	2,176.2
Coastal saltmarsh	0.2	341.1
Coastal sand dunes	0.0	102.3
Coastal vegetated shingle	0.1	39.9
Deciduous woodland	265.1	7,365.1
Fragmented heath	0.0	90.2
Good quality semi-improved grassland	62.7	741.8
Grass moorland	0.0	1,473.2
Limestone pavement	0.0	12.7
Lowland calcareous grassland	53.7	618.6
Lowland dry acid grassland	0.6	151.8
Lowland fens	3.5	202.9
Lowland heathland	9.5	564.2
Lowland meadows	2.0	211.8
Lowland raised bog	0.0	78.1
Maritime cliff and slope	1.6	133.5
Mountain heaths and willow scrub	0.0	14.1
Mudflats	0.2	612.6
Purple moor grass and rush pastures	0.3	91.1
Reedbeds	0.1	31.4
Saline lagoons	0.1	13.6
Traditional orchard	0.8	160.2
Upland calcareous grassland	0.0	92.2
Upland flushes, fens and swamps	0.0	100.1
Upland hay meadow	0.0	24.4
Upland heathland	0.0	2,276.5
No main habitat but additional habitats present	40.9	2,078.6
Total Area of Priority Habitats	**472.0**	**22,110.4**

Many priority habitats are also protected through some form of designated status (see application/omission of these areas in the suitability mapping, Section 8). Just over 99 km^2 of the SDNP is designated as a Site of Special Scientific Interest (SSSI), with 47 km^2 classed as in Favourable condition and a further 49 km^2 as Unfavourable Recovering. Favourable status refers to those sites where the designated features are being adequately conserved and meeting all the mandatory site-specific monitoring targets (Natural England, 2013). In total some 6.5% of the SDNP is designated as a nature conservation site, with proportions of 12% and 16% in the Scarp Slope and River Valley Landscape Groups, respectively. Designations regarding public access to land are another feature of the SDNP. There are more than 3,300 km of Public Rights of Way (at an average density of 2 km per km^2) and 106 km^2 of open access land defined under The Countryside and Rights of Way Act (2000). A further 39 km^2 of parks, recreation areas or other open greenspace can be identified from Ordnance Survey mapping.

One particular attraction of the SDNP is the relative tranquillity provided by some landscape settings. This characteristic is highlighted as a special quality of the SDNP, and a project has been undertaken to map tranquillity scores for the region (SDNPA, Tranquillity Study, 2017a). The resulting map is shown in Figure 38 and highlights several areas with relatively high tranquillity scores, particularly in the Dip Slope, Western Downs and Western Weald.

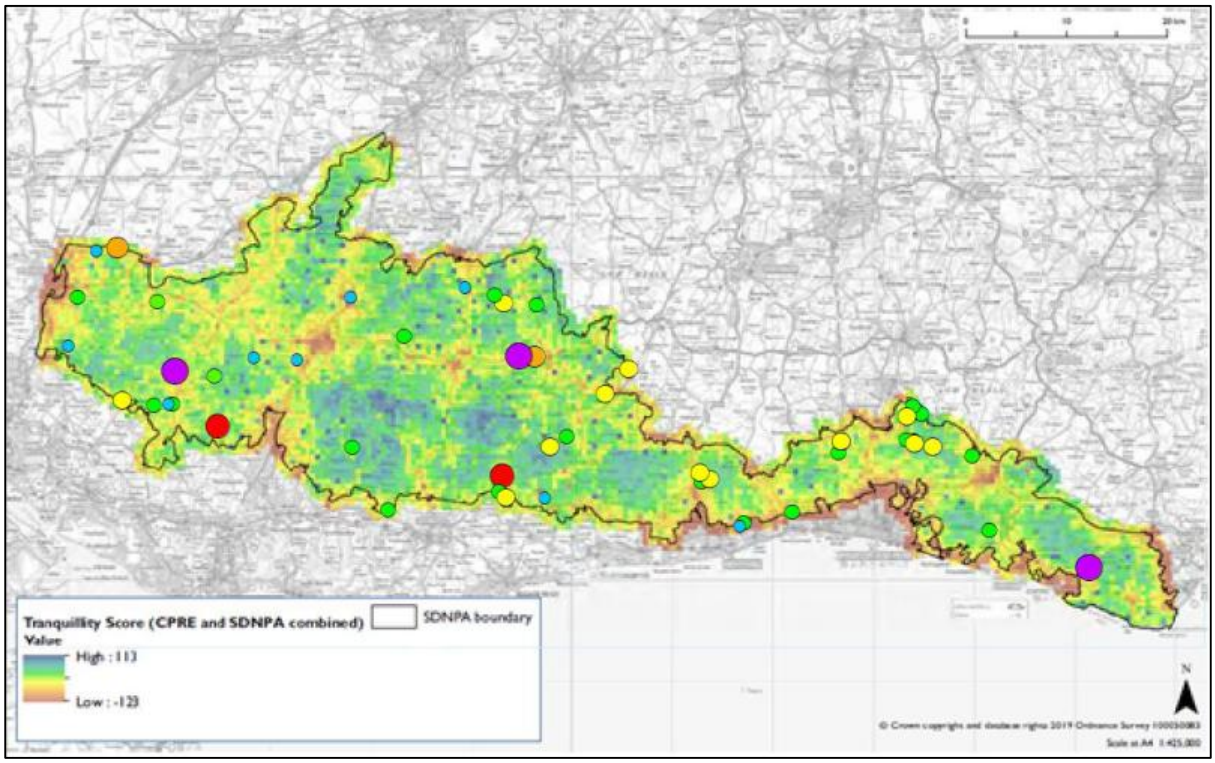


Figure 38.Tranquillity scores in the SDNP overlain with existing vineyards (see Figure 4)
(SDNPA, Tranquillity Study, 2017a)

Two final indicators are relevant to aspects of climate change. Data from the Environment Agency can be used to identify areas at risk of flooding from rivers and sea, and there are more than 70 km^2 with a greater than 1 in 100 chance of flooding each year in the SDNP. More than half of this land is in the River Valleys Landscape Group, and 29 km^2 of this is rated as

having a higher than 1 in 30 risk of flooding. The mitigation of any further increase in risk should therefore be a priority.

Carbon sequestration is also an important consideration in terms of limiting future climate change. Publicly available data from the CEH can be used to estimate carbon levels in soils and vegetation across the SDNP. Table 15 shows the results for individual Landscape Groups and the SDNP. Aboveground carbon is heavily influenced by the presence of trees (hence the highest values seen in the Western Weald) but is typically no more than a sixth of the topsoil carbon density. Aboveground and topsoil carbon densities for the SDNP are slightly higher than the England averages (6.9 and 58.7 t/ha respectively) and enhancement of this natural capital asset will be important for future climate regulation.

Table 15. Carbon sequestration in the SDNP.

Landscape Group	Aboveground Carbon		Topsoil Carbon		Total
	Tonnes	T/ha	Tonnes	T/ha	Tonnes
Chalk Valleys	117,532	11.1	638,778	60.2	756,311
Coastal Plain	37,598	19.3	116,218	60.4	153,816
Dip Slope	842,884	13.1	4,067,051	63.7	4,909,934
River Valley	64,893	7.3	575,013	65.6	639,905
Scarp Slope	235,542	10.3	1,377,810	61.0	1,613,351
Shoreline	107	0.5	11,367	67.8	11,474
Western Down	149,812	8.9	896,744	53.5	1,046,556
Western Weald	874,979	22.4	2,378,906	61.9	3,253,885
National Park	2,323,346	14.1	10,061,886	61.7	12,385,232

Having identified the main natural capital assets of the SDNP, the next Section of this report constructs a risk register to assess the key pressures these assets face and the implications for the future delivery of benefits for the population.

12.4. A natural capital risk register for the SDNP

Mace et al. (2015) constructed the first natural capital risk register for the UK, using a combination of existing data and expert judgement, to highlight those natural capital assets whose current condition was such as to put at risk a sustainable flow of ecosystem services into the future. Further information about this can be found in Appendix E.

There are several challenges in creating a regionally specific natural capital risk register. These include limitations in accessing regionally relevant information, since much can reside in the knowledge of personnel from different organisations rather than existing in any published form (Lovett, Turner, & Sünnenberg, 2018). There is also the issue that as the focus becomes more geographically specific, so the pressures, natural assets and benefits are likely to vary. Consequently, there seems to be limited merit in trying to replicate the type of national-level output for the SDNP; instead, the approach taken below involves two main steps.

a) Identifying the key pressures and risks to benefits in the different Landscape Regions of the SDNP.

b) Considering the implications of an expansion in viticulture in terms of benefits and how these compare alongside other pressures in the SDNP.

As noted previously in this report, there are current pressures in the SDNP relating to urban expansion, visitor numbers and agricultural change. Within the agricultural sector it is the intensification of activities, leading to increased water demands, pollution or soil erosion, that are of concern. Climate change is another increasingly important consideration and the most recent assessment by the Committee on Climate Change (2017) identified the following top six areas of inter-related climate change risks for the UK.

- Flooding and coastal-change risks to communities, businesses and infrastructure;
- Risks to health, well-being and productivity from high temperatures;
- Shortages in public water supply, and for agriculture, energy generation and industry;
- Risks to natural capital, including terrestrial, coastal, marine and freshwater ecosystems, soils and biodiversity;
- Risks to domestic and international food production and trade; and,
- New and emerging pests and diseases, and invasive non-native species, affecting people, plants and animals.

All of these are applicable to the SDNP.

Relevant natural assets and their benefits can be identified from the discussion of special qualities and other features in the South Downs Local Plan (SDNPA, 2019). Bringing these sources together, several benefits from nature have been identified as particularly important in the SDNP (Table 16).

Table 16. Important benefits from nature in the SDNP.

Type of benefit	Type of ecosystem service
Food and drink production	Provisioning
Water supply	Provisioning
Hazard protection (flood mitigation)	Regulating
Climate regulation (carbon sequestration)	Regulating
Landscape aesthetics (views, tranquillity)	Cultural
Recreation opportunities	Cultural
Biodiversity (habitats for wildlife)	Supporting or aggregated

As shown in Table 16, the seven benefits are delivered by all the main categories of ecosystem service. However, it is also important to emphasise that some types of natural capital asset deliver multiple services and benefits. A good example is Chalk Rivers and Streams, which as well as providing distinctive habitats for species also have aesthetic appeal and are a resource for fishing and watercress production (e.g. in the Chalk Valleys and Western Downs).

Combining the above information on pressures and benefits, Table 17 presents an overview of these for the individual Landscape Groups. It should be emphasised that the table seeks

only to identify the most important considerations, so just because a particular pressure or benefit is not mentioned in a region this does not mean that it is absent there. What is apparent, however, is that there are multiple pressures and benefits at potential risk in most sub-regions. Since the actual combinations of pressures and benefits also vary, this implies that measures and policies to support and enhance natural capital may need to differ across the Landscape Groups.

Table 17. A risk register for sub-regions of the SDNP.

Landscape Group	Key pressures on natural capital	Benefits at possible risk
Chalk Valleys	Climate change, agricultural intensification	Water supply, chalk river habitats, landscape views and tranquillity
Coastal Plain	Urban expansion	Food production, recreation opportunities
Dip Slope	Climate change, agricultural intensification, increase in visitor numbers	Food production, water supply, grassland and woodland habitats, recreation opportunities, landscape views and tranquillity
River Valley	Climate change, urban expansion	Flood risk mitigation, wildlife habitats, landscape views and tranquillity
Scarp Slope	Climate change, agricultural intensification, increase in visitor numbers	Grassland habitats, landscape views and tranquillity
Shoreline	Climate change	Wildlife habitats, landscape views and tranquillity
Western Down	Agricultural intensification, climate change	Food production, chalk stream habitats, landscape views and tranquillity
Western Weald	Agricultural intensification, climate change, urban expansion	Food production, water supply, heathland and woodland habitats (including carbon sequestration), landscape views and tranquillity

12.5. Implications of an expansion in viticulture

An increase in viticulture is one example of an agricultural change that could impact upon natural capital. The extent of such impact will depend upon the following factors:

- The land use(s) that viticulture replaces;
- The location and amount of land converted to viticulture; and,

- The consequences of viticulture for resource demands, pollution and the functioning of other natural processes e.g. supporting services.

In the context of the SDNP, an expansion of viticulture will obviously result in an increase in food and drink production (provisioning service) and could potentially increase the number of visitors to the SDNP through wine tourism. Other effects that need to be evaluated include the consequences for water demand and supply, carbon sequestration, leaching of fertilisers and pesticides (see Sections 10 and 15) (especially on land above vulnerable aquifers), and soil erosion (particularly where this could increase sediment load into streams or rivers, with consequences for habitat conditions or even downstream flood risk). In addition, the evaluation in Table 17 suggests that natural capital in the Chalk Valleys, Dip Slope, Scarp Slopes, Western Down and Western Weald could be particularly sensitive to any expansion. To put these possible effects into perspective, however, it should be noted that climate change and urban growth are likely to have much greater overall future impacts on the natural capital of the SDNP than an increase in viticulture.

12.5.1. Viticulture and wine production ecosystem service delivery

Using the categorisation of ecosystem services provided in the SDNPA Local Plan, (SDNPA, 2019), Figure 33, and the benefits and regional risks set out in Tables 16 and 17, viticulture and wine production related ecosystem services and risks can be identified, as set out in Table 18. Mitigants to risks are presented as recommendations in Section 15.

Table 18. Viticulture and wine production ecosystem services.

Service category	Service	Viticulture and wine production related ecosystem services	Viticulture and wine production related ecosystem service risks
Supporting services	Soil formation	• Pre-planting and ongoing soil nutrient and organic matter maintenance/improvements. • Ground cover/swards (grasses and other plants) and vines reduce water and rain erosion risks post-establishment, improve stability of soil aggregates and maintain favourable soil structure and porosity in vineyards. • Composted cover crops increase soil cation exchange capacity.	• Risk of soil erosion pre-planting (years 1 to 2), when more bare soil is present. • Risk of soil erosion from bare soils, if left under-vine. • Risk of soil compaction by vehicle movements in inter-row areas. • Reduced soil fertility through excessive cultivation and/or herbicide use.
	Primary production	• Vines and grapes. • Ground cover/swards and vineyard flora and fauna.	• Reduced through excessive cultivation and/or herbicide use.
	Nutrient cycling	• Through ground cover and surrounding vineyard flora and fauna. • Mulching of vine prunings back into the vineyard. • Winery pomace/marc can be added back onto vineyards as compost. • Through nutirent additions and maintence, e.g. phosphorous and nitrogen.	• Competition from vines for nutrients. • Vine prunings are burnt. • Grape marc is taken off-site for use or disposal.
	Water cycling	• The ability of ground crops/cover to improve rainfall infiltration and enhance soil water storage is valuable. • Winery wastewater is treated, and it can be re-used if treated on-site.	• Potential competition from vines for water in very dry seasons. • Winery wastewater is not recycled or re-used. • Pesticides or chemicals leach into ground-water or aquifers and reduce water quality.

	Biodiversity	• Increased through maintenance or promotion of a vineyard's ecological infrastructure, such as ground cover, surrounding hedges, trees, grassland, wild flower strips, habitats and associated plant species richness. Also through species of earthworms, beetles, butterflies, birds, spiders, grasshoppers, insect pollinators and predatory vertebrate species that exist in and/or are attracted to vineyard environments. • Can be actively encouraged through beehives, owl boxes, wood piles, etc.	• Limited within the planting area during the early years (years 1 to 2) of vineyard establishment. • Limited if ground cover is over-mown. • Limited if ground cover is restricted to limited species. • Pesticides can negatively impact biodiversity, including invertebrate species assemblages.
Provisioning services	Water supply	• Winery and other related buildings can be used for rainwater collection/harvesting (from roofs) which, if treated, can be used in wine production and spray operations. Particularly useful in the Chalk Valleys, where water supply has been identified as being at risk from climate change and agriculture intensification (see Table 17).	• Climate change modelling work regarding viticulture suggests it is not expected that irrigation will be required during the next 50 years, but if it became a requirement this would put increased pressure on water supplies (Adaptation of Viticulture to Climate Change (ADVICLIM), 2020).
	Food production	• Grapes (cultivated crops) for wine. • Inter-row areas can be used for the production of other crops, e.g. legumes.	• Vineyards reduce space for the production of arable crops or livestock or horticulture.
	Timber	• None provided	
	Energy	• None provided	
	Genetic diversity	• Through vineyard biodiversity.	• Possibly less than pasture although where pasture cover is allowed to re-generate in vineyards, loss is restricted to the planting strips.
Cultural services	Inspiration/spiritual values	• Vineyards can provide these services but not necessarily to a greater or lesser degree than the land use they are replacing (see Section 11). • The degre of inspriation and spiritual value is somewhat subjective (see Section 11).	

	Tranquillity	• As set out in Sections 7 and 10, vineyards in the SDNP are managed to varying degrees of intensity, which will impact relative tranquillity. • Where open to the public, vineyards and wineries can provide walking routes and benches or viewpoints from which people can enjoy the countryside, vineyard views, and rural environment, often with associated peace and quiet. However, vineyard and winery activity can equally erode this tranquillity.	• Vineyards are generally more intensively managed compared with the management of the land they often replace and can therefore impart a reduction in tranquillity. The sense of tranquillity may be further encroached upon by winery related developments/infrastructure and operations. This includes noise from equipment, management activities and vehicle movements, and lighting that can negatively impact the SDNP's dark skies at night. • As identified in Table 17, the impact of agricultural intensification and climate change in the Chalk Valleys, Dip Slope, Scarp Slope, Western Downs and Western Weald (areas with most viticulture potential) could negatively affect tranquillity.
	Cultural heritage values	• Vineyards and wineries can promote local and regional cultural heritage, and indeed often integrate elements of it into their brands/products. • Vineyards and wine production can enhance cultural heritage by virtue of creating it through their enterprise and products, and can form part of regional identities, cultures and traditions. The United Nations Educational, Scientific and Cultural Organization (UNESCO) has designated multiple vineyard landscapes (globally) as World Heritage Sites.	• Where replacing arable fields or pastureland, vineyards change the landscape and in doing so can negatively affect cultural heritage associated with the prior landscape. • Research has found that in older, established wine producing regions, the heritatge of vineyards is more welcome than in newer regions, such as south-east England, where the heritage has had less time to become established (Gillman, Winkler, & Taylor, 2016).

		• If farming and working the land is part of the SDNP's cultural heritage, then vineyards in particular are a newer form of such enterprise. • If locally produced food and beverages are part of the SDNP's cultural heritage, then vineyards and wineries are a newer form of such enterprise. • Heritage and cultural services in the form of regional traditions of wine production contribute to *terroir*, the 'sense of place' that reflects the unique aspects of a growing region, with its typical winemaking traditions.	
	Recreation and tourism services	• Vineyard walks, cycle rides and visits/tours can be (and are) provided by vineyards and wineries in the SDNP. • Can be provided through on-site accommodation, cafés/restaurants, tasting rooms, meeting spaces, etc. • Vineyards and wineries that are open to the public often provide car parking and bicycle racks. • Vineyards in south-east England have visitor's guides and wine-routes to help guide and encourage visitors/tourism (see Section 13 for more details) .	• Increased traffic and visitors can cause noise, nuisance and congestion. In the Dip Slopes and Scarp Slopes in particular (see Table 17), visitor numbers have already been identified as a key pressure on natural capital.
Regulating services	Pollution		• Pollution can be produced from vineyards and wineries, e.g. through tractor and machinery use (unless they are electric), visitors, pesticide leaching (see Water Quality, below, and Sections 7 and 10), and winery energy consumption.

	Disease and pests	• These can be regulated in vineyards. See Sections 7 and 10 regarding pest management, in particular Integrated Pest Management methods, which reduce the need for chemical pesticides.	• Vineyards can introduce disease and pests into an area or field that may not previously have been present.
	Water quality	• Requires careful management and further research into pesticide leaching and run-off potential, but leaching may be reduced with a cover crop. Likewise, nitrogen leaching may be reduced by the direct uptake of residual soil nitrogen by cover crops, but also by decreasing runoff and stimulating microbial activity, which could promote nitrate immobilization and recycling.	
	Soil quality	• Promoted by soil biodiversity/biological activity and careful soil management (see Sections 7 and 10). • See Soil formation (above).	
	Erosion	• Ground cover reduces erosion risk.	• Prone to erosion in pre- and early post-establishment phases. Also, from bare under-vine strips (see Soil formation, above).
	Water flow and flood	• Ground cover in vineyards improves rainfall infiltration and reduces run-off.	
	Climate and carbon storage	• Vines and ground cover provide a route for carbon sequestration (Winkler, Viers, & Nicholas, 2017).	• CO_2 is emitted as a by-product of fermentation (see recommendations in Section 15). • In the Western Weald, heathland and woodland habitats were identified in Table 17 as being at risk of losing benefits of carbon sequestration under agricultural intensification and climate change scenarios. Neither of these land types would be suitable for viticulture.
	Air quality		• Can be reduced due to emissions from vineyard equipment.

The results shown in Table 18 indicate, therefore, that vineyards can be multifunctional landscapes that not only produce grapes but also, for example, serve as biodiverse areas and wildlife habitats, sequester carbon, and are places of culture (Winkler, Viers, & Nicholas, 2017). The degree of benefit or risk regarding specific services is often determined by the management approach or activities employed (how ecosystem management choices affect the provision of key ecosystem services; see recommendations in Section 15). However, where 'good practice' is employed there are opportunities for greater benefits than risks. Appropriate strategies can support long-term sustainable use of the land and optimise ecosystem service delivery.

Vineyards in the SDNP often replace pasture or arable land. Table 19 indicates, at a high level, whether vineyards, arable or pasture, when managed conventionally i.e., not through organic, biodynamic, sustainable, or regenerative practices, present the highest ecosystem service opportunity, and why, and where there are gaps in knowledge that need addressing before a comprehensive like-for-like assessment can be completed.

Table 19. Indicative high-level comparison of vineyard, arable and pastureland ecosystem service opportunities in the SDNP.

Service	Service category	Land use that can provide higher ecosystem service opportunity	Reason or dependency
Supporting services	Soil formation	Pasture	No cultivation and limited erosion potential
	Primary production	Requires additional scientific research	
	Nutrient cycling	Pasture or vineyards	Depends how pasture is used and whether grape marc is placed back onto the vineyard and prunings are mulched.
	Water cycling	Requires additional research that includes non-irrigated vineyards	
	Biodiversity	Pasture or vineyards	Depends how pasture is used and its habitat and species status, and how vineyards are managed.
Provisioning services	Water supply	N/A	
	Food production	Arable	Although a cultivated crop, wine grapes are not a staple foodstuff.
	Timber	N/A	
	Energy	N/A	
	Genetic diversity	Requires additional scientific research	
Cultural servic	Inspiration/spiritual values	Is a subjective assessment.	

	Tranquillity	Pasture or arable	Vineyards are more intensively managed than arable or pastureland.
	Cultural heritage values	Is a subjective assessment and, as noted in Table 18, is highly dependent on perception and time. All three land uses are associated with cultural heritage values.	
	Recreation and tourism services	Vineyards	Multiple opportunities are presented where vineyards are open to the public, and opportunities are enhanced where winery related businesses exist 'on-site'.
Regulating services	Pollution	Pasture	Very limited pollution from vehicles/machinery.
	Diseases and pests	Pasture	Arable and viticulture are more actively managed for pests and diseases.
	Water quality	Pasture	Likely to be a higher risk from arable or viticulture due to potential leaching or run-off of pesticides.
	Soil quality	This really depends on how well soils are managed. Soil is often ameliorated and improved for viticulture and arable purposes. Pastureland can be of limited fertility but conversely allows for nutrient cycling, organic matter accumulation and biodiversity.	
	Erosion	Pasture	Permanent and total groundcover.
	Water flow and flood	Pasture or vineyards	Ground cover and canopy interception aids water flow and infiltration.
	Climate and carbon storage	Pasture or vineyards	Significant opportunity for carbon sequestration through plants.
	Air quality	Pasture	Very limited pollution from vehicles/machinery.

Tables 18 and 19 illustrate, at a high-level, the broad range of ecosystem services that vineyards and wine production can offer. In the cases of biodiversity, recreation and tourism, and climate and carbon storage, there is potential for vineyards to deliver significant ecosystem services, potentially to a greater degree than was provided by the dominant land uses they often replace (especially if replacing conventionally managed arable land), although much depends on the site specifics and how the land was/is managed. With regards to tranquillity, vineyards in particular are likely to deliver less ecosystem service benefits as they require more intensive management. A significant scientific study is required to compare ecosystem service delivery within the SDNP (or the UK) among arable, pasture and vineyard

land use, to fill knowledge gaps and establish empirical baselines, and determine the impact on these that different management practices deliver.

A natural capital account is required to look at improvements or reductions in natural capital resulting from an expansion of viticulture, beyond those relating to ecosystems.

12.6. Insights from natural capital accounts

Natural capital accounting seeks to bring a systematic, standardised and repeatable framework to assessing and monitoring natural capital and the services provided, whether those services have a market value or not. In so doing, these accounts can help to measure, value, monitor and communicate the state of natural assets within a given territory/area.

Stocks and flows reflect the distinction in natural capital frameworks between assets and the services they help deliver. At present, natural capital accounting is in its infancy and methodologies and conventions are under extensive discussion, e.g. Turner et al., (2019). This is partly a consequence of the large amounts of data that are required to underpin accounts but also reflects debates regarding both the feasibility and desirability of placing monetary values on environmental assets (Lovett, 2019). Within the parameters of this project it is simply not feasible to construct a substantive natural capital account for the SDNP, but it is possible to review relevant work at a national scale and identify some implications for the possible impacts of viticulture expansion.

12.6.1. Examples of natural capital accounts

The ONS and Defra have been developing initial national capital accounts and practical methodologies for the UK since 2013. The most recent results (Office for National Statistics, 2019a) are shown in Table 20. In total, the assets are valued at just under £950 billion, but it must be emphasised that this is a partial assessment and does not, for instance, include biodiversity or many types of cultural services. Provisioning services are generally the most straightforward to value because they often have a market price associated with their benefits and services. Even so, it would be unwise to interpret the valuations in Table 20 too precisely, but what should be noted is their relative magnitude. In particular, recreation is by far the largest component (41% of the total) and the valuation of carbon sequestration is nearly equivalent to that of all agricultural production. These values can be interpreted as indicators of relative importance to society and therefore could also be used to prioritise the risks to different benefits, such as those identified for the SDNP in Table 19.

Many of the methods used to derive the valuations are relatively complex and are discussed in (Office for National Statistics, 2019b). An excellent summary of current information on assets, services and valuations is provided in the workbooks associated with the Defra (2020a) *Enabling a Natural Capital Approach* initiative, but even then there is considerable diversity in measurement units and underlying assumptions, meaning it is not a simple matter to calculate valuations for different assets or geographical regions. One of the few cases where there is more standardisation is in the value of carbon, so Table 21 takes current carbon values documented by HM Treasury and used by ONS and applies them to the estimates for aboveground and topsoil carbon previously presented in Table 15.

Table 20. A partial asset valuation of UK ecosystem services; source: ONS, (2019a).

Ecosystem service	Asset valuation in 2016 (£million)
Provisioning Services	
Agricultural biomass	118,426
Fish capture	7,584
Fossil fuels	95,285
Minerals	5,483
Timber	8,517
Water abstraction	76,370
Renewables generation	7,887
Regulating Services	
Carbon sequestration	103,947
Air pollutant removal	43,152
Urban cooling	11,398
Cultural Services	
Recreation	393,707
Aesthetic (house prices)	9,428
Recreation (house prices)	68,552
Total	**949,736**

Table 21. A valuation of carbon sequestration in the SDNP.

Landscape Group	Aboveground carbon (£million)	Topsoil carbon (£million)	Total (£million)
Chalk Valleys	8.0	43.4	51.4
Coastal Plain	2.6	7.9	10.5
Dip Slope	57.3	276.6	333.9
River Valley	4.4	39.1	43.5
Scarp Slope	16.0	93.7	109.7
Shoreline	0.0	0.8	0.8
Western Down	10.2	61.0	71.2
Western Weald	59.5	161.8	221.3
National Park Total	**158.0**	**684.2**	**842.2**

Note: Values are based on £68 per tonne (BEIS non-trade price of carbon in 2019).

The results in Table 21 indicate a total carbon value of £842 million in the SDNP, with particularly large contributions made by the Dip Slope and Western Weald Landscape Groups (note these areas are of differing scales). This again highlights the importance of protecting and enhancing the underlying soil and vegetation assets when considering the implications of any expansion in viticulture activities.

12.7. A natural capital account for viticulture in the SDNP

The production of a natural capital account for viticulture and wine production in the SDNP falls outside of the scope of this report. Should an exercise be undertaken to deliver one, to fully establish the links between environmentally sustainable practices (among SDNP wine-grape growers) and long-term financial performance, the gathering of detailed viticulture, wine production and vineyard management data (inputs and outputs) regarding ecosystem responses, abiotic variables, impacts and development scenarios (including business types and scales) would be required. To do this it would be necessary to establish a monitoring framework (a customised approach would be needed, with associated resource and cost implications) to assess the flows of services over time (e.g. amount of wine produced, levels of carbon sequestration, extent of any soil erosion), so the state of assets could be compared at the start and end of an accounting period. The data gathered through this complex exercise would then require a monetary value to be ascribed to each service flow and these values could then be used to create discounted values (e.g. net present values) for the assets, to calculate risks and rewards.

The challenge with the last phase is that methods of monetary valuation are more robust for some service flows than others. In particular, those regarding biodiversity and some cultural services are often debated or disputed. Nevertheless, there have been important advances in such methodologies (see examples in ONS 2019a and 2019b) and further refinements can be expected as more examples of natural capital accounts are produced.

The recreation, tourism and economic value of SDNP vineyards and wine production is presented in Section 13. Quantification of supporting, provisioning and regulating services for different management practices of different scales and in the different landscape groups would be required, through a series of scientific studies, to fill knowledge gaps. Whilst there is a body of work (referred to previously) that looks at ecosystem services in viticulture, existing studies/work that go beyond these and into natural capital accounting in viticulture and wine production are very limited. The Joint Nature Conservation Committee (Barbosa, et al., 2019) has undertaken a pilot study in the Colchagua Valley, Chile, which looked at a natural capital approach to landscape planning, while a study by the Food Agility Co-operative Research Centre (CRC) in Australia, involving the National Australia Bank (NAB) and Australian Wine Research Institute (AWRI) data scientists from Queensland University of Technology (QUT) commenced in 2018 (Natural Capital Coalition, 2018). Other cultural services (inspiration, tranquillity, heritage) are perhaps more straightforward to quantify, and Section 14 provides a useful insight into some related perceptions and initial benchmarking in these areas. However, findings in this Section (14) are not based either on objective quantifications of related natural capital or derived from questions regarding the scalability of viticulture against natural capital market value.

13. Economic and social impacts of viticulture and wine production in the SDNP

Section 13 – Key findings:

- Vineyards in the SDNP currently cover less than 0.5% of the total farmed area.
- Viticulture and wine production have a positive impact on the SDNP economy across key metrics: gross value added (GVA), employment, education, and tourism. The estimated economic contribution in the SDNP based on current hectarage is:

    - GVA: £24.5 million;
    - Employment: 358 people, including seasonal labour)
    - Education: wine producers in the SDNP employ highly skilled staff;
    - Tourism: >33,000 visitors to SDNP wine destinations each year; and,
    - GVA and employment, when compared with these values for average cereal and grazing/ha (see Section 13.5), were both found to be higher in viticulture.

- A modelled growth scenario, based on 2.5% of suitable land area (990 ha) in the SDNP being established with vines (approximately a doubling of existing vineyard area), showed contributions to the economy of:

    - GVA: £127 million (directly and indirectly);
    - Employment: Approximately 800 FTEs directly and indirectly employed, including annualised seasonal labour;
    - Education: a growth in viticulture is anticipated to provide more opportunities for skilled employment in the National Park; and,
    - Tourism: >75,000 visitors to SDNP wine destinations each year.

- Evidence of this positive impact on local economies has been seen in other developing and established wine regions, such as Oregon (USA) and Marlborough (New Zealand) (Section 13.7).
- Vineyards have a much higher labour intensity (0.17 FTEs/ha) than either cereal growing (0.01 FTEs/ha) or lowland grazing (0.02 FTEs/ha).
- Where wineries attract and encourage tourism, this can significantly impact local communities, both positively, e.g. through increased employment, but also negatively, e.g. through reduced tranquillity.
- Wine producers are encouraged to connect with local communities to mitigate any negative impacts and optimise shared opportunities that viticulture and wine production bring (see recommendations in Section 15).

13.1. Background

13.1.1. National context

Despite a trend of declining alcohol consumption globally, a recent survey by the Wine and Spirits Trade Association (2020) showed that wine is now the most popular alcoholic drink among UK adults. The market for English wine continues to show strong growth, with a 31% increase in sales between 2015 and 2017 (Wine GB, 2018). Supermarket prices for English sparkling wine (which represents more than 70% of production) range from around £25 to £45 a bottle and significantly more in on-trade (restaurants/bars) environments. English wine remains a premium product. Many customers are 'baby boomers' or 'Generation X' – those firmly into or approaching their middle age – with sizeable disposable incomes (in the top 25% to 30% for income in the country).

Wine GB has identified that wine tourism is an area that has 'massive' potential for growth as the sector develops. Their research was carried out by comparing where the UK industry is now in relation to where other similarly sized emerging viticulture regions were at a comparable stage in their development. WineGB predicts that tourism spend associated with wine could be in the region of £378 to £658 million by 2040, if the wine industry is producing 40 million bottles per annum (Wine GB, 2019) (see Figure 39). Wine routes are already being established in Kent, Surrey and Hampshire to entice local, national and international visitors. WineGB South East have recently produced a visitor guide to support these.

Figure 39. Forecast production of English and Welsh wine (Wine GB, 2019)

Latest WineGB estimates showed 2,248 FTEs (2018) were employed in English and Welsh viticulture and wine production, an increase of 7% since 2017. WineGB are also predicting 20,000 to 30,000 additional full-time roles being created within the sector over the next two decades (Wine GB, 2019); of these, 21,400 are anticipated to be in south-east England.

Based on a survey undertaken by WineGB (2018), it can be concluded that the UK viticulture and wine production sector requires additional training and support to develop and increase its resilience and sustainability. Training options are currently limited, mainly to on-site training at Plumpton College, near Lewes, the only land-based college in the south-east providing viticulture and wine production courses. As the SDNP stretches from Winchester to Eastbourne, this training location may limit opportunities for some, but it should be noted that no other English wine producing region hosts a training college – the SDNP has the only one.

13.1.2. Local context

Situated within an hour of London and with proximity to seaports and Gatwick airport, the SDNP has a complex economic narrative and includes a wide range of business sectors. The National Park is also unique in having the largest market towns of any UK National Park, including Lewes, Petersfield, Petworth and Midhurst (see Section 5). The settlements in the National Park are strong and vibrant communities with much invested in the future of where they live. Establishing and maintaining a healthy rural economy is essential to these communities and the National Park Authority, in line with its statutory socio-economic duty (see Section 5.4).

Agriculture, forestry and fishing industries within the National Park are some of the largest business sectors (an approximately 9% share of all businesses), with the only larger sectors being professional, scientific and technological (21%) and construction (10.5%) (SDNPA, 2018a). The visitor economy includes industries such as accommodation, food and drink, and sports and recreation. In total, the visitor economy sector accounts for 10.6% (860 businesses) of SDNP businesses, food and drink businesses making up 40% (345 businesses) of that total. Wine production businesses are included within agriculture, forestry and fishing (SDNPA, 2020c).

There were approximately 55,000 people employed in the SDNP in 2018 (SDNPA, 2020c) with the largest employment sector (accommodation, food and drink) providing 6,000 jobs.

13.1.3. Vineyards and wine estate business models

There are various business models adopted by grape growers and wine producers, including:

- Growing grapes for market (under contract or for the spot market);
- Growing grapes for own production (vineyards associated with a winery/wine production);
- Making own brand wine from grapes bought in (grown under contract or from the spot market, i.e. the wine producer does not have their own vineyard);

- Making wine for other brands (contract), i.e. for those with vineyards or who have bought grapes that require making into wine for others;
- Co-operative style wine production (not a model currently used within the SDNP); and,
- A mixture of some of the above.

All of these business models, with the exception of co-operative style wine production, exist within the SDNP.

13.2. Methodology

In carrying out this economic impact assessment, four key metrics that are key to the SDNP were focused on: GVA, employment, education and tourism. Growth scenarios were also used to determine the increased impact on the SDNP.

The Vinescapes Vineyard Survey (Q4 2019) data were extracted for the SDNP GVA, employment, education and tourism data. This Vinescapes Vineyard Survey comprised 51 SDNP vineyards of which 86% responded (based on hectarage; 65% based on vineyard numbers - 33/51 vineyards). Please see appendix C for survey questions.

13.2.1. GVA

GVA was calculated using the approach/method set out in Figure 40.

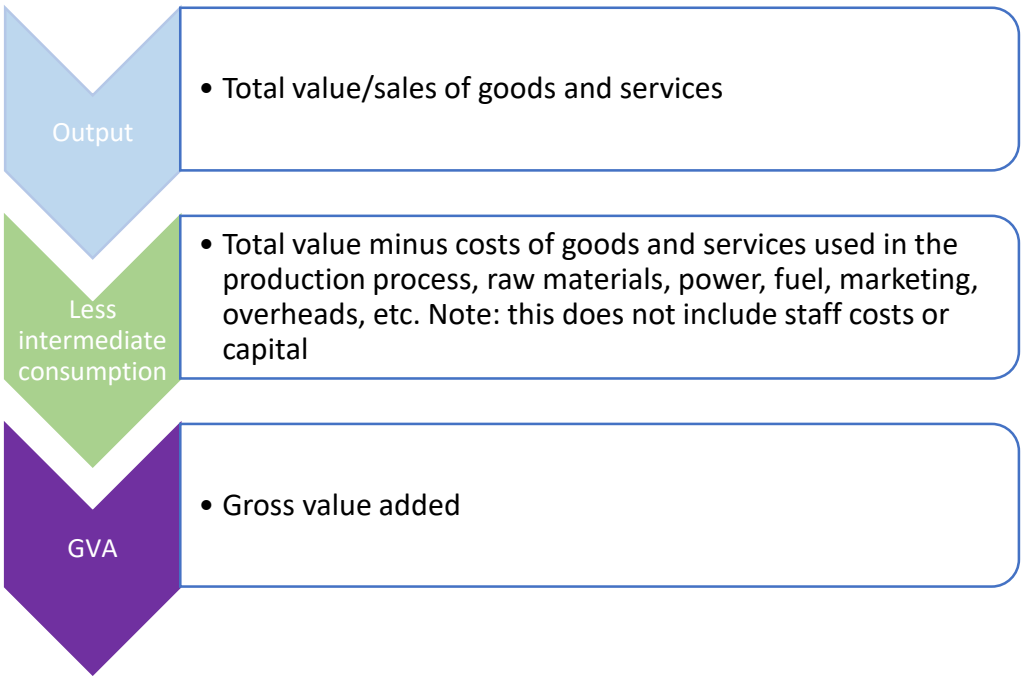


Figure 40. The production method of assessing gross value added, or GVA (P)

GVA calculations estimate the direct impact of viticulture and wine production on the local economy, but to assess impacts on the wider economy, including supply chains, we used industry multipliers with growth scenarios. The ONS has not produced industry multipliers for

GVA but these have been developed by the Northern Ireland Statistics and Research Industry (NISRA) (2016), so their multiplier of 2.2 was used for agriculture, forestry and fishing. The volume and value of products and services purchased at vineyards or wineries, other than wine, were not available for this study and were therefore not included within the GVA calculation. The current and growth GVA figures are therefore likely to be an underestimate of the true GVA. GVA was calculated assuming full production and sales from the planted hectarage.

13.2.2. Employment

Employment data was extracted from the Vineyard Survey, undertaken as part of this report (Appendix C). These data were extrapolated to obtain average FTEs for the wine production sector. Seasonal labour was converted to FTEs using information about the number of staff and their weeks on-site, provided through the survey. Again, industry multipliers were used to calculate the indirect effects of employment on the wider economy. There are no UK industry multipliers specifically for the viticulture or wine production sector and it is doubtful whether those from other countries would be applicable, so the UK employment multiplier of 1.74 for the Group 1: Agriculture, Forestry and Fishing sector was used, which is the ONS standard multiplier for the sector (2015b).

13.2.3. Education

The qualification levels of permanent staff were obtained from the Vineyard Survey, undertaken as part of this report (see Section 7 and Appendix C). A total of 22 respondents provided qualification data. These qualifications were assessed against the Government's qualification levels (Department for Education, What Different Qualification Levels Mean, 2020) and analysed using the proportion of skilled permanent staff per business, both in vineyards and wine production. These skills were compared with those found in the primary sector and utilities, including agriculture (Department for Education, Employer Skills Survey, 2017).

13.2.4. Tourism

Tourism numbers were obtained from the Vineyard Survey, undertaken as part of this report (see Section 7 and Appendix C). Growth scenarios were used to extrapolate numbers from this survey. However, these numbers could be significantly higher with the induced effect of the industry growing and drawing visitors to the south-east wine producing region, a 'pull through' that has been seen in other wine producing regions globally (Section 13.7).

The wider impact of tourism, the multiplier, was not available. This would include, for example, overnight stays and spend in non-vineyard/winery related establishments. These impacts are significant for the economic growth of the SDNP and would benefit from further study.

13.2.5. Growth scenarios

Building on the findings in Section 8, three growth scenarios were established to enable an exploration of the potential economic impact of viticulture and wine production. These growth scenarios were based on the percentage of viticulturally suitable land in the SDNP. A time period was not assigned to these potential growth scenarios as they will depend on many environmental, economic and socio-economic factors.

- Scenario 1: 2.5% of suitable viticulture land in the SDNP (990 ha);
- Scenario 2: 10% of suitable viticulture land in the SDNP (3,970 ha); and,
- Scenario 3: 50% of suitable viticulture land in the SDNP (19,850 ha).

13.2.6. Viticulture versus agriculture

13.2.6.1. Viticulture versus agriculture: GVA methodology

GVA for viticulture was compared with that of the most common forms of farming in the SDNP: cereals (specifically winter/spring wheat and barley) and lowland grazing (beef/sheep).

Grapes, as opposed to wine production, were used for comparison with agriculture, since grapes and crops/grazing are raw materials and are therefore comparable.

Data were obtained from the John Nix Pocketbook, 50th Edition (2019), unless otherwise stated. The key assumptions made were as follows:

- Production method used in calculating the GVA was as per Section 13.2.1;
- Average production and cost data were used;
- Fixed costs were used for farms <200 ha. The average cereal farm size in the SDNP is 154 ha (based on ha/number of holdings (Defra, 2016);
- Whole-farm costings per ha were used for lowland beef and sheep grazing, with the following whole-farm details assumed:
    - Lowland grazing beef and sheep farm of 110 ha;
    - Herd of 75 autumn-calving suckler cows and their progeny are taken through to finishing over the following winter;
    - Flock of 650 lowland ewes;
    - Figures were based on average farm performance (John Nix Pocketbook, 2019);
- The GVA excluded basic farm payments and diversification income; and,
- Grape and vineyard operating figures were based on John Nix Pocketbook (2019).

13.2.6.2. Agriculture employment calculation methodology

Cereal (wheat/barley) standard man days per crop/ha were converted to FTEs. Lowland beef and sheep grazing FTEs were calculated using regular labour costs/ha (paid an unpaid), as per the whole-farm costing, against the total annual cost to the employer (John Nix Pocketbook, 2019).

13.2.6.3. Agriculture education methodology

The Government Employer Skills Survey 2017 (HM Government, 2017) was used to assess the general skill level in agriculture. 'Primary sector and utilities' data were used, because separate agriculture data were not available. The primary sector and utilities category includes agriculture, mining and quarrying, electricity, gas and water supply, as well as sewerage and waste management.

13.2.6.4. Agriculture tourism methodology

SDNP tourism data for the agricultural sector were not available at the time of writing this report, therefore a comparison with vineyards and winery tourism has not been provided.

13.2.7. Case Studies

Information and data from other wine producing regions have been used for comparisons/case studies. Data obtained in Sections 13.6 and 13.7 used varying methodologies from multiple sources and were therefore not directly compared with UK statistics in this report.

13.3. Detailed findings

13.3.1. Contribution (GVA)

The 51 vineyards in the SDNP are estimated to produce around 2.5 million bottles of wine per year, 95% of which comprise sparkling wine and 5% still wine (Vinescapes Vineyard Survey).

Based on the current SDNP vineyard area (436 ha), wine production is estimated to directly contribute £24.5 million (GVA) from wine sales. This increases to £54 million if impacts in the wider economy are included (Section 13.4). Growth scenarios see this contribution to the economy increase to £127 million, based on 2.5% of the SDNP's viticulturally suitable land being established, just over a doubling of current area to 990 ha, in line with the WineGB growth prediction of 40 million bottles by 2040. When compared with the GVA of agriculture, the GVA for grapes (raw material) is much higher as cereal crops attract much lower prices per ha (GVA £13k/ha grapes versus GVA <£1k/ha cereal) (Section 13.5).

Case studies for other established wine regions provide strong evidence of this positive impact on the local economy, with many established regions now heavily reliant on this sector for economic stability (Section 13.7).

13.3.2. Employment

Grape growing and wine production businesses within the SDNP who responded to our Vineyard Survey (Section 7 and Appendix C) directly employ 358 people during the year, of whom 116 are permanent with a further 242 seasonal labourers taken on during key periods (bud-rubbing, pruning, tying down and harvesting) (see Figure 41 for the breakdown).

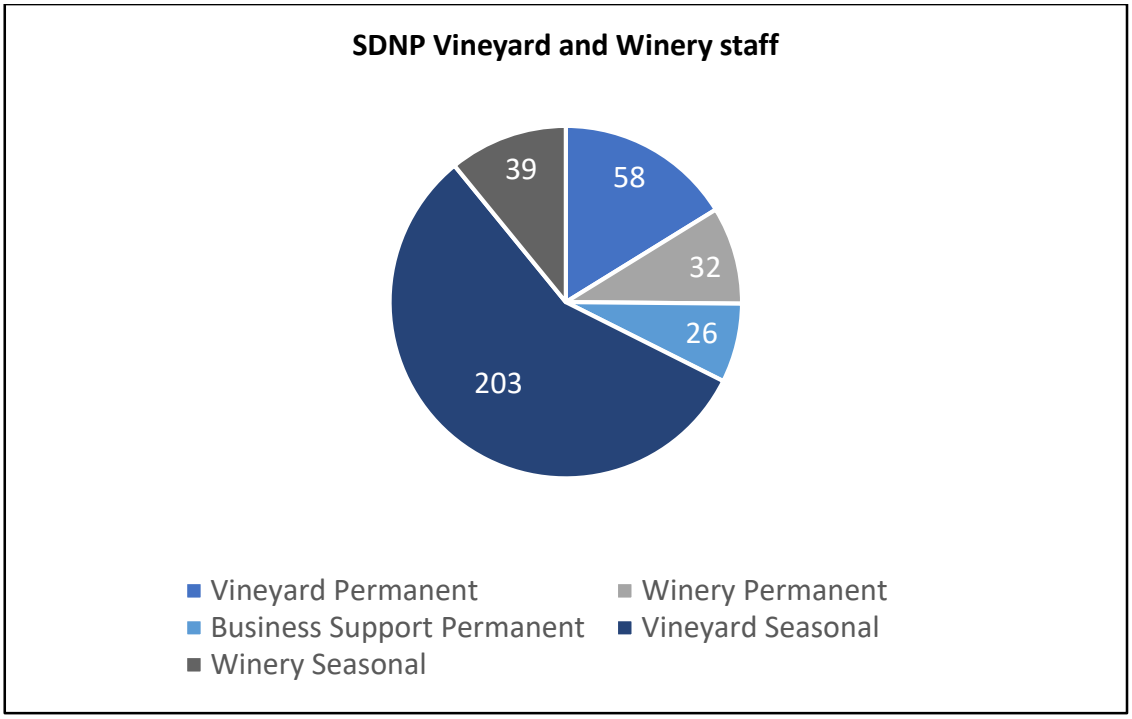


Figure 41. SDNP vineyard and winery staff (Q4 2019 Vinescapes Vineyard Survey).

Converting this employment to FTEs provides 0.30 (0.48) FTEs/ha, excluding (including) seasonal labour (see Figures 42 and 43, and section 13.2.2 for the methodology).

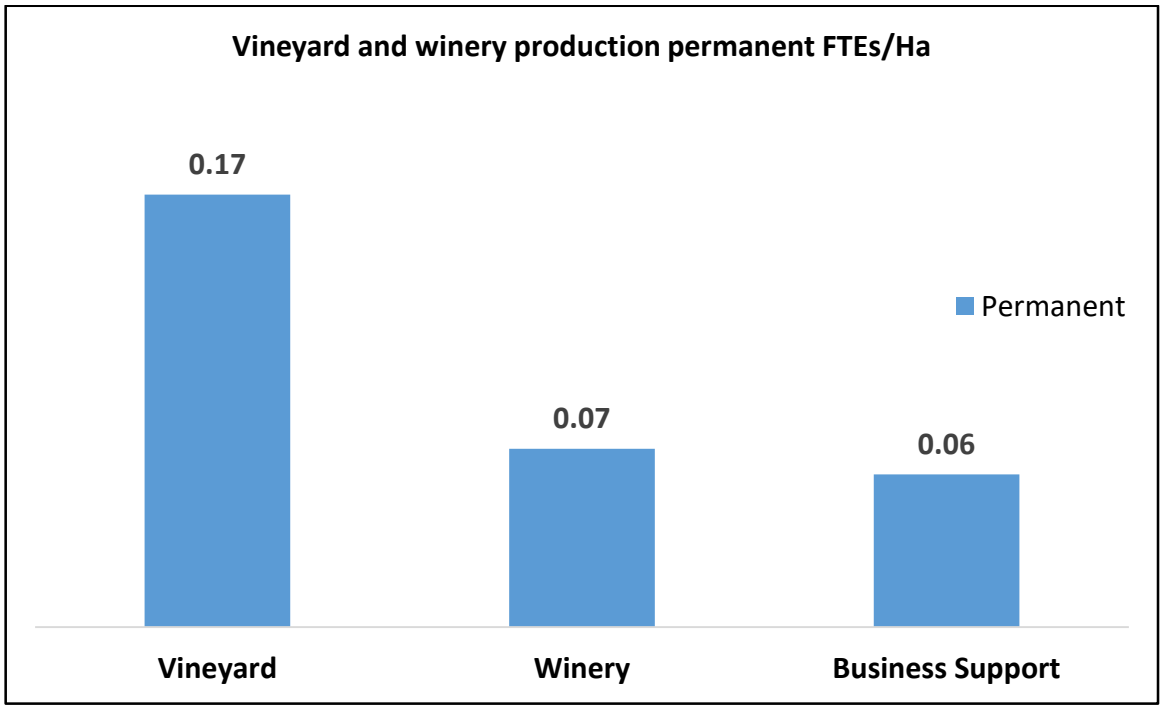


Figure 42. SDNP vineyard and winery permanent FTEs/ha, excluding seasonal labour (Q4 2019 Vinescapes Vineyard Survey).

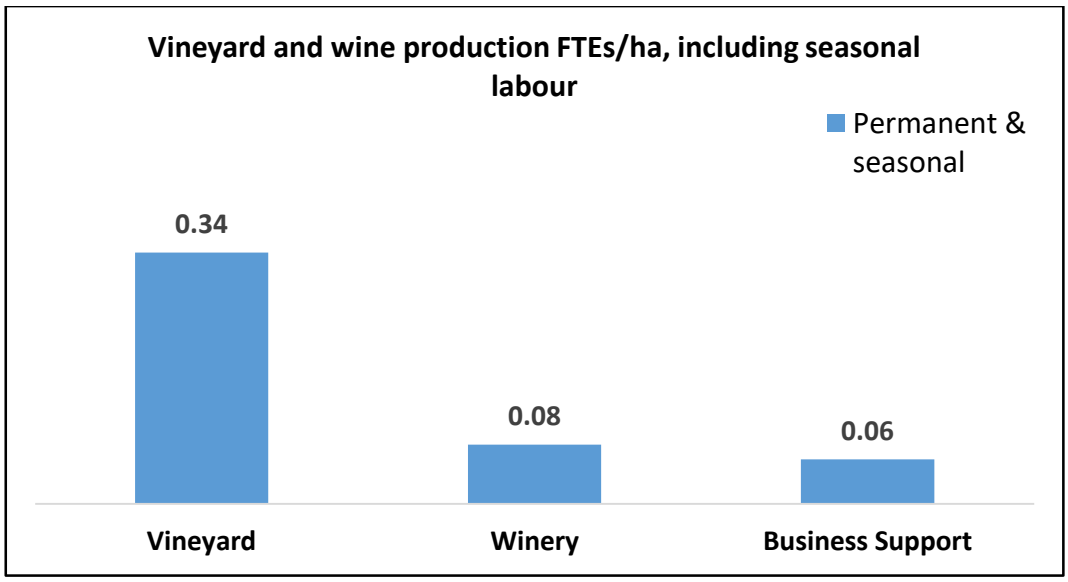


Figure 43. SDNP vineyard and wine production FTEs/ha, including seasonal labour (Q4 2019 Vinescapes Vineyard Survey).

The SDNP vineyards directly employ 358 people during the year (116 permanent; 242 seasonal). When the 242 seasonal labour is annualised and added to the permanent staff it is estimated that there are around 211 FTEs (permanent and seasonal) employed in the SDNP's wine producing sector, per annum. If the indirect impact on the wider economy is included, using multipliers (see methodology in Section 13.2.2), this increases to approximately 400 FTE's.

Expansion to 990 ha sees this employment figure increase to approximately 800 FTEs (including annualised seasonal labour) when the indirect impact on the wider economy is included, using multipliers (see section 13.4 and 13.2.2, methodology in for more information).

Vineyards have a much higher labour intensity (0.17 FTEs/ha) than either cereal (0.01 FTEs/ha) or lowland grazing (0.02 FTEs/ha). Vineyard management requires significant time to undertake labour-intensive, manual operations, unlike the highly mechanised and larger scale processes found in arable production.

Much of the seasonal labour force is contracted by vineyards through specialist UK vineyard management businesses, with many of these staff being highly skilled, trained and experienced in viticulture work. They comprise a mixture of students, local temporary workers and foreign nationals.

13.3.3. Education

Vineyard management and winemaking are technical roles and those managing and assisting in the vineyard or winemaking need either significant experience and/or qualifications. Vineyards in the SDNP employ more staff who are highly skilled than found in other forms of agriculture, according to primary sector and utilities data, which includes agriculture

(Department for Education, Employer Skills Survey, 2017), and this skill level is expanded if wineries are included in the comparison (Section 13.5.3). Skill levels are lower where repetitive tasks, such as bud-rubbing, are required in the vineyard. Data from the Vinescapes Vineyard Survey (2019) show that in vineyards, 55% of the workforce is unlikely to be educated to level 4, however the remainder (45%) of the workforce is likely to be highly educated (to level 4 or above), and this increases further, to 54%, when wineries are included. (See section 13.5.3).

Training options in viticulture and wine production within the vicinity of the SDNP are currently limited to Plumpton College, where a range of part-time and full-time courses and degrees are offered but it should be noted that no other English wine producing region hosts a training college – the SDNP has the only one.

13.3.4. Tourism

WineGB predicts that tourism spend associated with wine could be in the region of £378 to £658 million by 2040, if the wine industry is producing 40 million bottles per annum by then (WineGB 2018). Based on the Vinescapes Vineyard Survey results, wine related tourism brings more than 33,000 visitors per annum to the eleven vineyards and wineries in the SDNP that are open to the public, providing a significant economic contribution to the local economy. This figure varied widely between businesses, with one receiving 20,000 people per year on average and others 500 people or fewer. Most although not all of those receiving visitors also had a winery. The average spend per visitor in the SDNP was £62, on wine purchases, tours, tastings and meals. However, this again varied across businesses, ranging from £50 to £200 per person per visit.

Based on the survey undertaken with the SDNPA Citizen Panel as part of this study (see Section 14), 30% of respondents said they had visited a vineyard in the SDNP and 15% said they would visit one within the coming year. These results indicate growing interest in vineyards and wine production within the SDNP, and perhaps the desire to support these local businesses. These findings are also representative of survey data from Wine Intelligence (2019), which showed that 28% of the surveyed population (approximately 1000 people) had visited an English wine producer and, once they had visited, were very likely to return (68%), indicating a positive experience (Figure 44). Interestingly, however, of the remainder that had not visited before (72%) more than half of respondents (56%) stated they were unlikely to visit an English wine producer in the near future, although reasons for this were not provided.

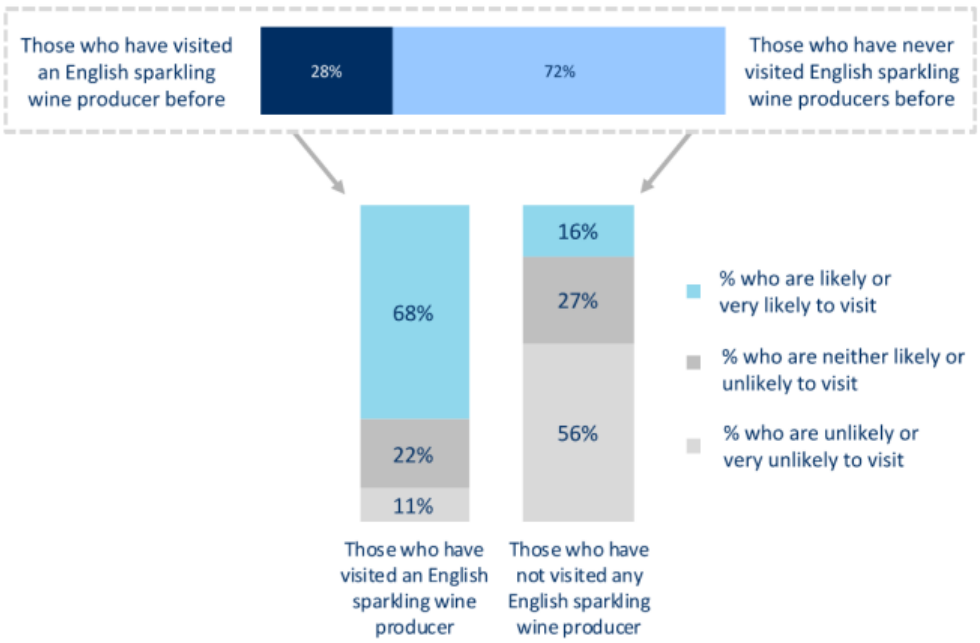


Figure 44. Visitors to English vineyards (Wine Intelligence, 2019).

Based on a growth scenario of expansion to 990 ha, the SDNP could see an increase to 75,000 tourist visits/year, more than double current numbers.

Case studies (Section 13.7), for example in Marlborough, New Zealand, provide evidence that wine tourists spend more than 'general tourists' and also stay in the country or region longer. Currently, 20% of international visitors to New Zealand visit a winery. In Oregon, USA, research has confirmed that wine tourism complements agri-tourism, with wine tourists also engaging in other local attractions and events e.g. hospitality, festivals and holiday rentals.

13.3.5. Socio-economic

The UK National Parks' Impacts of Tourism report (2020) identified that tourism provides a unique challenge for National Parks, as tourists have both positive and negative impacts on the landscape and local communities, as set out below.

Positive impacts of tourism:

- Jobs for local people;
- Income for the local economy;
- Helps preserve rural services like buses, village shops and post offices;
- Increases demand for local food and crafts, and,
- Tourists mainly come to see the scenery and wildlife, so there is pressure to conserve habitats and wildlife.

Negative impacts of tourism:

- Damage to the landscape, e.g. litter, erosion, fires, disturbance to livestock and vandalism;
- Traffic congestion and pollution;
- Local goods can become expensive because tourists will pay more;
- Shops stock products for tourists and not everyday goods needed by local people;
- Demand for holiday homes makes housing too expensive for local people;
- Demand for development of more shops and hotels; and,
- Jobs are mainly seasonal, low paid and with long hours.

Although not all vineyards in the SDNP accept visitors or tourists, the socio-economic impact on the local communities where tourists are encouraged can be significant, with both positive (e.g. employment) and negative (e.g. reduced tranquillity) impacts.

Case studies suggest that there must be a balance struck between an increase in vineyards, wineries and wine destinations on one hand and the impact on local communities on the other, to provide sustainable wine tourism. In rural and remote areas, where increased wine tourism can have profound impacts, rural communities may find amenities under pressure. Conversely, however, community amenity improvements could also be delivered. To help manage these pressures, risks and opportunities, strong links between producers and local communities are required, and vineyards in the SDNP already undertake the following relevant activities (Vinescapes Vineyard Survey, Q4 2019):

- Community harvest participation;
- The Steyning Downland Scheme – inspiring opportunities for people through volunteering, engaging events and inclusive access;
- Supporting charitable organisations and holding a small number of charity tasting events;
- Annual open days for local communities;
- Open-door activities to engage communities and provide information about wine production; and,
- Hosting visits and career talks for local schools; also providing work experience opportunities.

As has been seen in other, more established wine producing regions around the world (see section 13.6), more could be done to engage with local communities in the SDNP to understand local community concerns and strengthen links where possible.

Should winery scale significantly increase, for example through co-operative style ventures, then larger scale movements of grapes, juice and/or wine are likely to occur, which could further impact on tranquillity.

13.4. Growth scenario findings

It is not possible to say with certainty what scale the viticulture sector within the SDNP may grow to, or by when. Other land use needs, market limitations, investment requirements,

potential for viticulture outside of the National Park, and risks associated with a changing climate may curtail significant growth.

Table 22 illustrates the potential economic contribution that further growth (by percentage of suitable land area; see Section 8) could bring to the SDNP. See Section 8 methodology for more information on the growth scenarios.

Table 22. Projected viticulture and wine production potential economic contribution to the SDNP under the three viticulture growth scenarios.

	Percentage of viticulturally suitable area			
Key metrics	**Baseline (current)**	**2.5%**	**10%**	**50%**
Hectares	436	990	3,970	19,850
GVA £m	54	127	507	2,500
FTEs '000'	0.4	0.8	3	17
Tourists '000'	33	75	300	1,502

Note: GVA and FTEs include direct and indirect impacts using multipliers (see methodology, Section 13.2).

13.4.1. Gross value added

Should viticulture and wine production increase in scale within the National Park to 2.5% of potential land area (990 ha) it is estimated that, at today's values, this would provide a contribution to the SDNP economy of £127 million. That figure could reach £2.5 billion with an increase to 50% (approximately 20,000 ha) of potential area (see Figure 45).

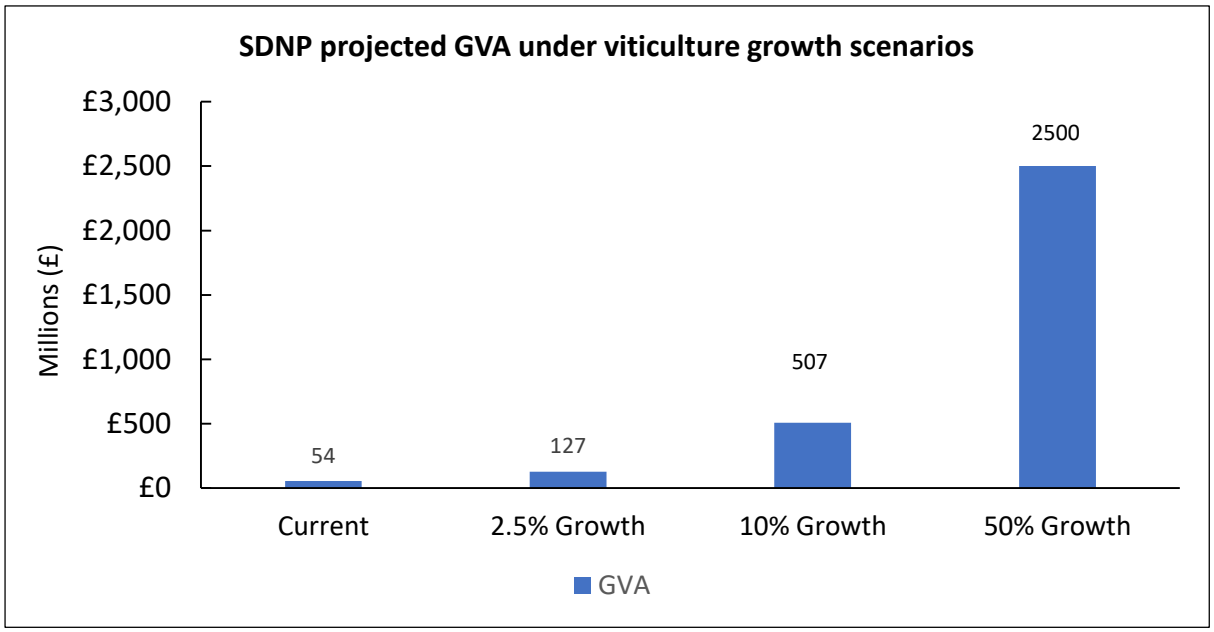


Figure 45. Projected economic contribution (GVA) under the viticulture growth scenarios.

13.4.2. Employment

Employment will expand under all growth scenarios. A near doubling of existing vineyard area (to 990 ha; see Section 8.4) could increase overall employment in the local area to approximately 800 (direct and indirect). That figure could reach 17,000 FTEs with an increase to 50% (approximately 20,000 ha) of potential area.

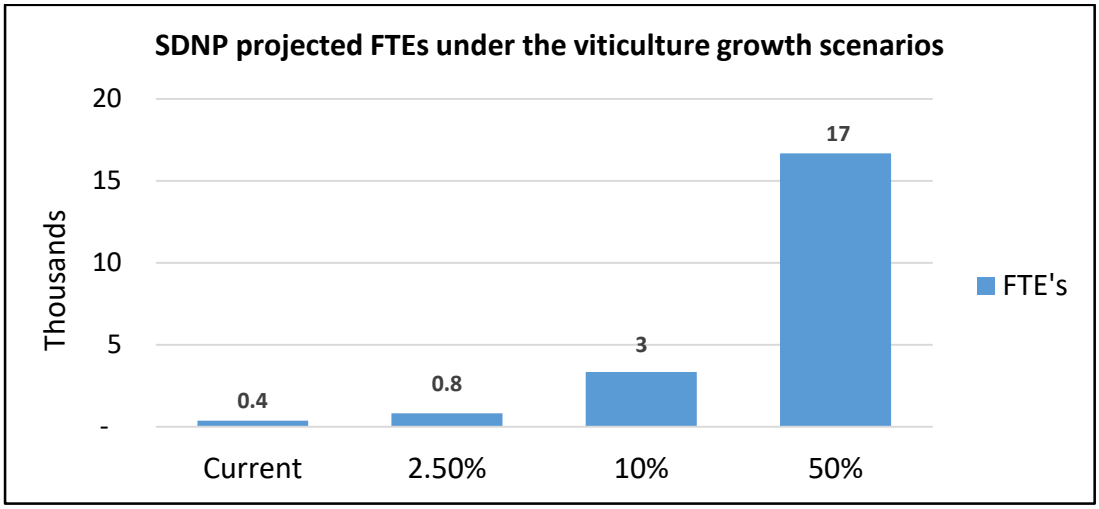


Figure 46. Projected FTE growth under the viticulture growth scenarios (direct and indirect).

13.4.3. Education

As employment expands in the SDNP it is anticipated that the education levels identified in Sections 13.3.3 and 13.5.3 will continue, providing skilled employment in the region. Around 18% of businesses are likely to have a majority of staff who are educated to level 4 or above and a further 27% of businesses with between 20–80% of their staff level 4 educated. A growth in viticulture is therefore anticipated to provide skilled employment in the region.

13.4.4. Tourism

Tourism is anticipated to be a significant part of any growth scenario. Based on a scenario of 990 ha of vineyards, it is estimated that wine related tourism would increase to 75,000 visits/year (more than double current numbers). This figure could reach 1.5 million visitors per annum with an increase to 50% (approximately 20,000 ha) of potential viticulture area.

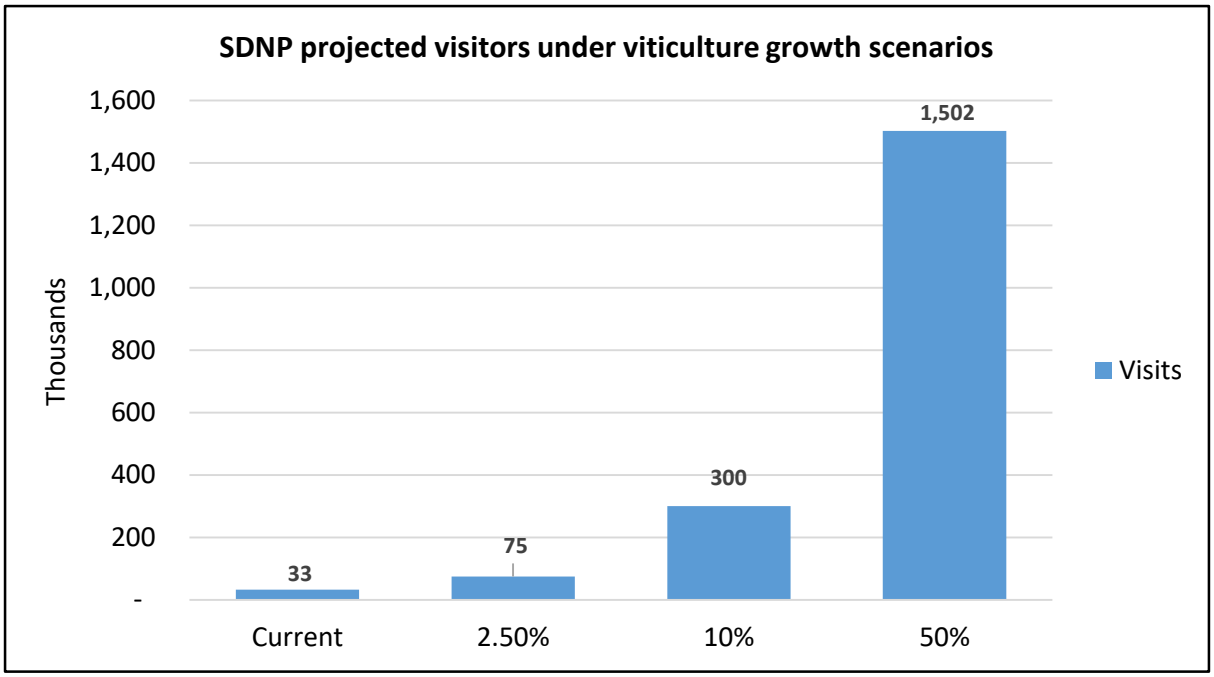


Figure 47. Projected visitor growth under the viticulture growth scenarios (direct and indirect)

13.5. Viticulture versus agriculture

There are 116,000 ha (950 holdings) of commercially farmed land within the SDNP (Defra, 2016). The key land uses are:

- Cereal, approximately 35,000 ha (227 holdings), predominantly winter/spring wheat and barley;
- Grazing, approximately 49,000 ha (holdings: 343 lowland grazing, 30 dairy, 25 pigs/poultry); and,
- Other agriculture, horticulture, mixed and woodland, approximately 32,000 ha (325 holdings).

Currently, vineyards in the SDNP cover less than 0.5% of the total farmed area.

13.5.1. GVA for viticulture versus agriculture

GVA for viticulture was compared with GVA for the most common forms of farming in the SDNP: cereals (winter/spring wheat and barley) and lowland grazing (see Section 13.2.6 for the methodology).

As shown in Figure 48, the GVA/ha for grapes is much greater than the GVA/ha for cereals and grazing. This variance is driven mainly by the price per tonne, with grapes attracting around £2k/tonne and cereals around £160/tonne – a significant difference. The gross margin (revenue less variable costs) for grazing beef and sheep is similarly low.

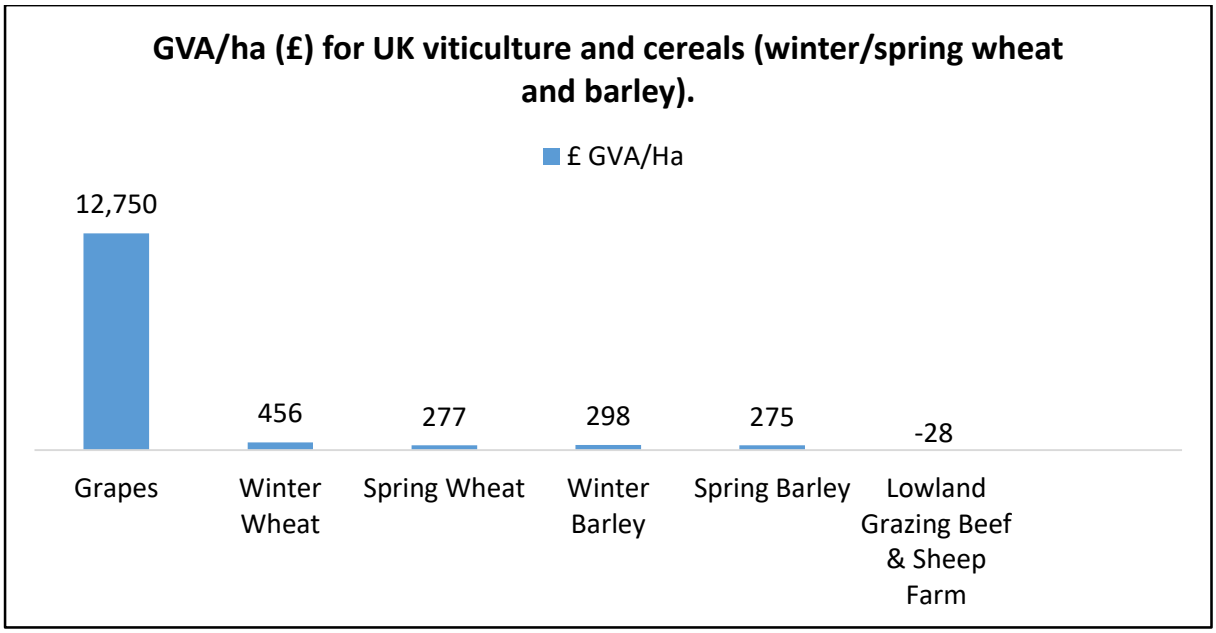


Figure 48. GVA/ha (£) for viticulture and UK cereals (winter/spring wheat and barley) (John Nix Pocketbook, 2019).

13.5.2. Employment for viticulture versus cereal and lowland grazing

As shown in Figures 49 and 50, vineyards have a much higher labour intensity than either cereal (winter and spring wheat/barley) or lowland grazing, with vineyards requiring 0.17 FTE/ha compared with 0.01 FTE/ha for cereal and 0.02 FTE/ha for lowland grazing. Vineyards also require a further 0.17 FTE of seasonal labour per annum (cereal requires minimal casual labour, around 8 hours/per annum/per hectare) (John Nix Pocketbook, 2019).

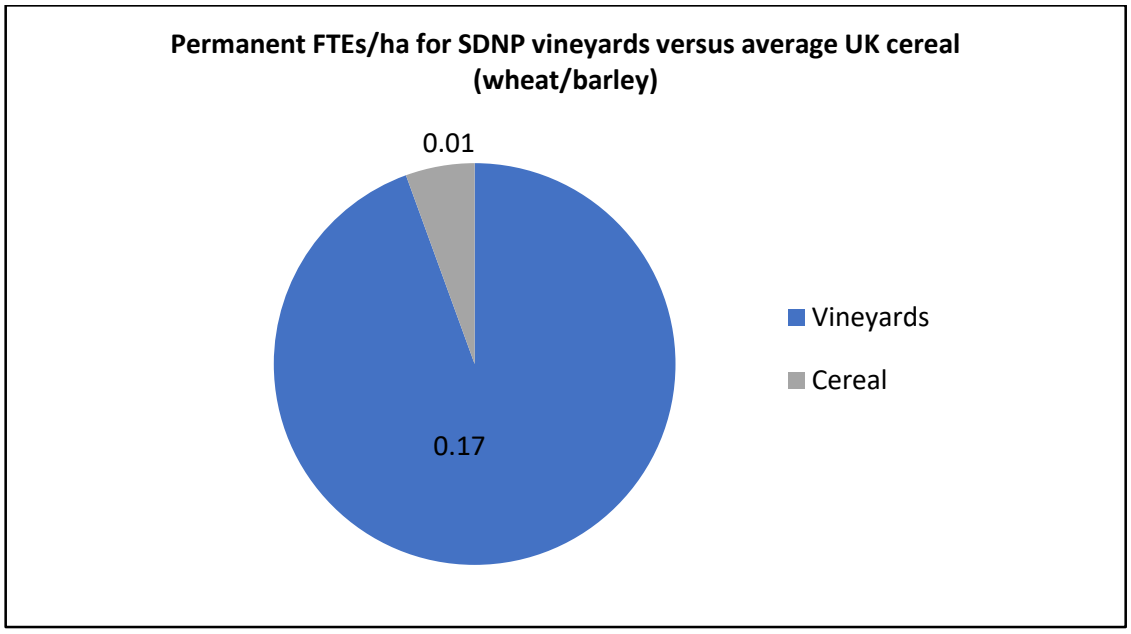


Figure 49. Permanent FTEs/ha in SDNP vineyards versus average UK cereal (wheat/barley) (John Nix Pocketbook, 2019).

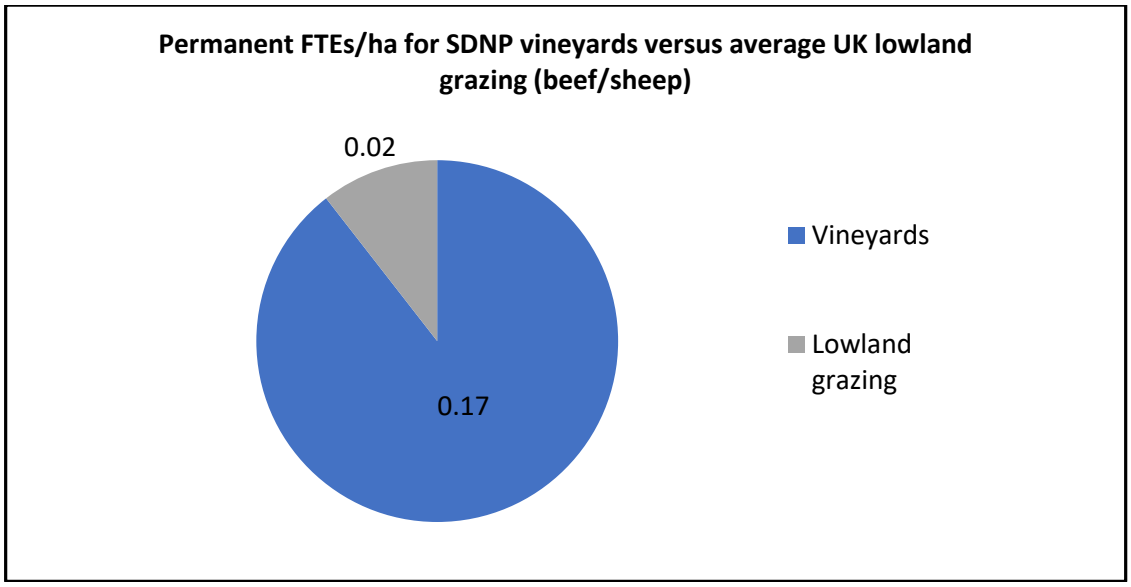


Figure 50. Permanent FTEs/ha in SDNP vineyards versus average UK lowland grazing (beef/sheep) (John Nix Pocketbook, 2019).

13.5.3. Education in viticulture versus agriculture

Government primary sector and utilities data were used to assess the general skill level in agriculture (Department for Education, Employer Skills Survey, 2017) against the data obtained from the SDNP Vinescapes Vineyard Survey, Q4 2019.

When comparing vineyard employees (SDNP) with employees in the UK primary sector and utilities, the education levels were comparable, with more than half of the vineyard employees not educated to level 4 (54% versus 55%, respectively). However, 18% of vineyards versus 9% of the primary sector had more than 80% of their staff qualified to level 4 or above, and this swing continues if wineries are included, showing that vineyards and wineries employ more staff who are highly skilled to support their viticulture and oenology businesses.

Table 23. Proportion of staff (per business) with a level 4 qualification or above; Vinescapes Vineyard survey (Q4 2019) and Department for Education (2017).

	<20%	20% – 80%	>80%	Total
UK primary sector and utilities (incl. agriculture)	54%	38%	9%	100%
Vineyard only (SDNP)	55%	27%	18%	100%
Vineyard and winery (SDNP)	46%	36%	18%	100%

13.5.4. Tourism from viticulture versus agriculture

Where agriculture provides open access and tourist facilities, e.g. farm days, farm shops and catering facilities, this will draw visitors/tourists to the area. However, tourism data for the agricultural sector in the SDNP was not available at the time of writing this report, therefore no comparison with vineyards and wineries was made. See Section 13.3.4 for specific vineyard and winery tourism information.

13.6. Socio-economic case studies from established wine regions: impacts of vineyards and wineries

From a wider review of socio-economic impacts, using case studies from more established, international wine producing regions, it is clear that there needs to be a balance struck between an increase in vineyards, wineries and wine destinations and the impact on local communities to create sustainable wine tourism. Sustainable growth requires careful planning and management, and it is recommended that this process should incorporate all interested parties, including local, regional and national governments, tourism operators, wine producers, other local business operators, and in particular the residents, who may be most impacted by any environmental, social and economic changes.

SOCIO-ECONOMIC IMPACT: CASE STUDY 1

Sustainable Wine Tourism: The Host Community Perspective (Oliver, British Columbia, Canada (Poitras & Donald, 2006)). This paper sets out some of the key impacts a growing wine production sector can have on the local community.

As noted in the paper: '*To ensure community and political support, wine tourism must demonstrate its benefits and deal proactively with potentially negative impacts. Various impacts on residents and host communities have been identified in the wine tourism literature. Hackett* (1998) *observed that conflicts can arise with host communities as a result of general tourism development and the following specific issues:*

- *Increased traffic in small towns and along rural roads, especially if tour buses are prominent.*
- *Annoyances and complaints arising from viticulture and winemaking processes.'*
- *Wineries competing with local businesses (e.g. food, entertainment, accommodation).*
- *A perception of inappropriate types or scale of development (e.g. large landmark wineries)'.*

Employment opportunities for local residents should improve as the sector grows, but this requires training and retraining opportunities. Those moving into the sector/area may take many of the new jobs, or the wineries might be small, family operated businesses. The

distribution of wealth might be an issue when outside capital dominates the wine production sector and locals feel excluded. Furthermore, 'local' residents may be unhappy if low-paying service sector jobs are all that arise from sector expansion, especially if they are largely part-time and seasonal in nature. These are just a few of the social impacts that require planning and consideration.

In rural and remote areas, where wine tourism can have profound impacts, small towns and rural communities may find amenities under pressure. Conversely, community amenity improvements have been made in other areas through tourism-related programmes (such as main street 'beautification' in Oliver, British Columbia, Canada, in Case Study 1), new entertainment and dining opportunities (especially at wineries), or the services that tend to follow.

SOCIO-ECONOMIC IMPACT: CASE STUDY 2

In California, USA, the *Code of Sustainable Wine Growing*, for the long-term sustainability of the wine region, was developed by the California-based Wine Institute: California Sustainable Wine Growing Alliance (2020). This included three key pillars, as set out below:

- Environmentally sound;
- Economically feasible; and,
- Socially equitable.

The code also includes Value Statements that stress, in addition to producing quality wines, the need to:

- Support the economic and social wellbeing of farm and winery employees;
- Respect and communicate with neighbours and community members; respond to their concerns in a considerate manner;
- Enhance local communities through job creation, supporting local business and actively working on important community issues;
- Honour the California wine community's entrepreneurial spirit; and,
- Support research and education as well as monitor and evaluate existing practices to expedite continual improvements.

Similar sentiments could and should be considered for the previously mentioned WineGB sustainability scheme and also be considered good practice for SDNP vineyards.

SOCIO-ECONOMIC IMPACT: CASE STUDY 3

In North Carolina, USA, a report focusing on growing tourism in the area – 'Are Neighbours benefiting from Wine Tourism Development?' (North Carolina State University, 2016) – identified that creating stronger links with the community improves local appreciation of the wine production sector and a greater understanding of the increase in tourism. Vineyards and wineries should therefore:

- Encourage their neighbours to visit their premises regularly, to increase awareness; and,
- Consider investing more effort into communicating to the public, and especially to their neighbours, about the range of benefits the wine production sector produces.

Similar community links should be encouraged within the SDNP vineyards and wineries to engage and communicate with residents and support greater understanding of the sector for the benefit of the SDNP residents.

13.7. Economic case studies from established wine regions: impacts of vineyards and wineries.

The economic and social impacts of the wine regions of Oregon (USA), Marlborough (New Zealand) and Champagne (France) have been reviewed for this SDNP Viticulture Growth Impact Assessment because of their similarities to the UK wine production sector: Oregon due to its premium price and focus on high quality wine; Champagne due to its geology, varietal and product similarities, and its regional proximity; and Marlborough due to its recent growth, scale, and focus on sustainability.

ECONOMIC IMPACT: CASE STUDY 1
Oregon (USA)

The Oregon wine sector has many similarities to the English and Welsh wine production sector. Oregon wine is seen as premium, high price and high quality. The state has low yields and a cool climate. WineGB referenced Oregon in their 2018 wine production sector report (Wine GB, 2018), as in 1992 they had a similar hectarage to the UK (2,400 ha producing 5.2 million bottles).

The wine production sector in Oregon is thriving. Since 2000, the number of vineyards has more than doubled and the number of wineries has increased nearly six-fold to service a current hectarage of 15,000 ha (University of Oregon & Oregon Wine Board, 2019). However, Oregon wines still account for just 1% of US domestic wine production.

The wine production sector's growth has made a positive contribution to Oregon's economy, particularly helping rural areas where much of Oregon's grape growing and wine production occurs. Full Glass Research (2018) estimated that in 2016, Oregon's wine production sector contributed $5.6 billion (direct and indirect) to the state's economy and supported around 30,000 jobs that paid around $1 billion in wages. Associated industries such as distribution, tourism and retail greatly benefit from Oregon wine business. There is also the multiplier effect created by purchases from suppliers and service firms as well as retail expenditure from an employed local workforce. Oregon wine producers retain more of their revenue stream locally than other US area as not only do they crush grapes and produce wine but also carry out the packaging, marketing and selling of wine to wholesalers or foreign importers within Oregon.

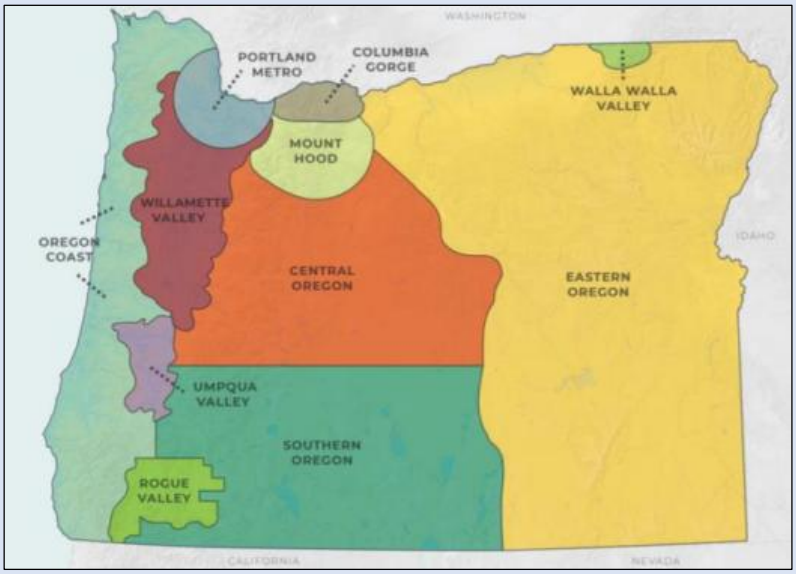


Figure 51. Oregon's wine regions.

Given the importance of this sector in Oregon, a Wine Tourism Study was undertaken by the University of Oregon's Institute for Policy Research & Engagement (IPRE) (2019) and the Oregon Wine Board. It involved surveying visitors to three of Oregon's major wine regions (Rogue Valley, Umpqua Valley and Columbia Gorge (see Figure 51, taken from the Oregon Wine Board, 2019 Oregon Winery Visitor Profile Study Report). We summarise the key information that may be relevant to the SDNP's wine production sector below.

Wine tourism complements agri-tourism: Agri-tourism is defined as an 'activity that generates supplemental income for working farms and ranches by connecting their resources and products with visitors'. Visitors engage in agri-tourism at wineries when they visit rural places where wine is grown and made, such as a vineyard or winery. Some common categories of wine agri-tourism include:

- Education, including wine tastings and winery tours;
- Entertainment, including dinners, live music, festivals and weddings;

- Hospitality, including farm stays, bed and breakfasts, and holiday rentals such as Airbnb; and,
- On-farm sales, including wine, food, merchandise and gifts.

A winery experience encompasses all the elements that visitors experience when visiting a winery or tasting room. The concept of a 'winescape' encapsulates all the potential elements of a winery experience: setting, atmospherics, wine products, complementary products, signage, layout, staff service (Thomas, Quintal, & Phau, 2018).

The effective marketing of agricultural clusters/regions as tourist destinations can be beneficial to vineyards and the local economy. Some examples in Oregon include the Fruit Loop in Hood River County, the four regional farm loops that together comprise the Oregon Farm Loop (an Oregon Agri-tourism Project), and the Oregon Food Trails (operated by Travel Oregon). Similarly, wine trails and clusters are popular ways to highlight regional wineries and vineyards. Interestingly, the Oregon Wine Board promotes an 'Oregon Wine Trail' that is in fact a travelling wine tasting event, bringing Oregon wines to consumers, rather than requiring consumers to visit wineries.

The Oregon Wine Board's 'Oregon Wine Touring Guide' serves to promote wine tourism by highlighting wineries in Oregon's wine touring regions. Studies of wine routes outside of Oregon have found that stakeholder participation and coordination are key elements to developing a successful wine route. Economist Michael E. Porter's cluster model refers to 'geographic concentrations of interconnected companies and institutions in a particular field' (Porter, 1998). In Porter's model, when one firm in a cluster prospers, so do its cluster neighbours. This theory can explain the popularity of wine region marketing and should further encourage cooperation among neighbouring wineries.

In the UK generally and the SDNP specifically it is anticipated that wine tourism will play a key role in sector growth and sustainability. Wine routes and producer groups are already being established to entice both local, national and international visitors, e.g. the 'Wine Garden of England' winery cluster in Kent, Hampshire's 'Vineyards of Hampshire' and the vineyards in the Surrey Hills, 'Surrey Hills Vineyards'.

ECONOMIC IMPACT: CASE STUDY 2
Marlborough (New Zealand)

New Zealand produces just 1% of the world's wine, but has an international presence and reputation that far exceeds this seemingly small proportion, due to its diversity and world-leading focus on sustainability.

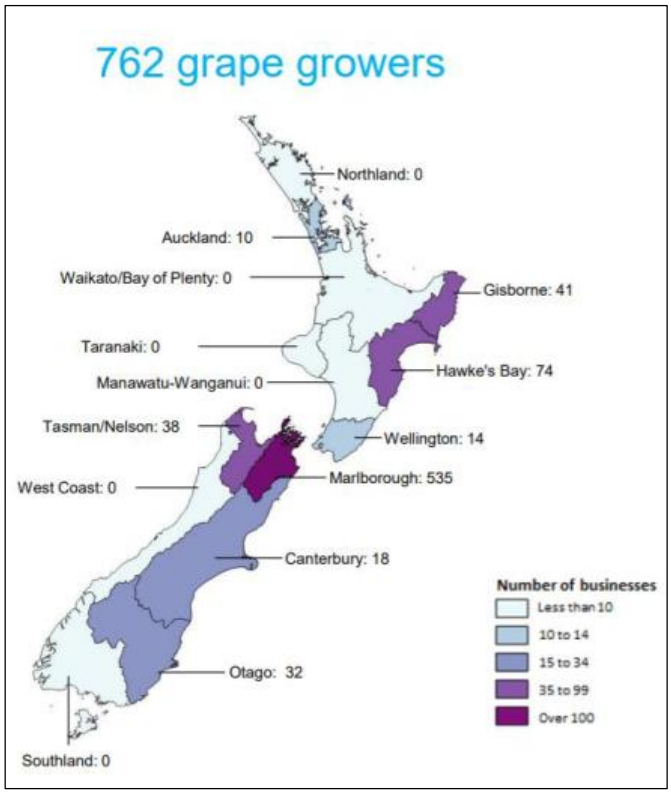


Figure 52. Number of grape growers in New Zealand, by region. Economic Contribution of the New Zealand Wine Sector 2015 (Economic Institute of Research, 2015a)

Marlborough (see Figure 52) put New Zealand on the international wine stage with its Sauvignon Blanc production in the 1980s. Marlborough, the country's largest wine region, has a combination of a cool yet high sunshine climate, low rainfall and free draining, moderately fertile soil. It has about 140 wineries, 535 grape growers and more than 26,850 ha (60 times larger than the SDNP) of vineyards mainly growing Sauvignon Blanc, Pinot Noir, Chardonnay, Riesling and Pinot Gris. (Economic Institute of Research, 2015a)

During the nineteenth century, large-scale sheep farming in the region gave Marlborough its unique identity, significantly different from the neighbouring Nelson province. Since then, farming has been the cornerstone of the regional economy. However, over the past 25 to 30 years there has been diversification into other sectors, most notably wine production, and by 1998 the Marlborough wine production sector had grown, making it the largest viticulture region in New Zealand.

During the early growth of the sector (1970s) there were significant objections, ranging from the morality of alcohol consumption, to the forestry sector who worried their livelihoods were at risk, to local farmers who felt the new wine production sector would impact on their ability to continue farming as they had for years. In the early 1970s, the Central Government had decreed that all local councils must produce a District Scheme Plan, which had to be open to public scrutiny. The Marlborough County Council, in charge of planning, were not favourable to anyone wanting to grow grapes. The early pioneers,

Chris and Phil Rose, fought for the right to plant grapes and in 1978 they won their battle; this opened the door for others to move into the wine production sector. The sector continued to grow until 1985, when oversupply impacted the industry; however, from 2000 onwards the industry has again grown significantly.

Wine contributes NZ$477 million (GDP) to the Marlborough economy and has grown by 300% since 2000. As much as 10% of local employment is provided by the viticulture industry (New Zealand Institute of Economic Research, 2015). When comparing tourists that visited vineyards/wineries with general tourists to the region, the wine tourists spent more than the general tourists and they also stayed in the country longer. Currently, 20% of international visitors to New Zealand visit a winery. The UK wine sector therefore has an opportunity to draw considerable international visitors.

ECONOMIC IMPACT: CASE STUDY 3
Champagne (France)

Grapes (predominantly the same varieties as grown in the SDNP for sparkling wine production, i.e. Chardonnay, Pinot Noir and Meunier) have been grown in Champagne for hundreds of years, with many of the Champagne houses established in the 1700s, including Moët & Chandon (1743) and Louis Roederer (1776). In 1927, the appellation of Champagne (production area) was set and defined by law at 35,280 ha (Comité Champagne, 2020). As a major player in French wine and spirit production, Champagne makes a vital contribution to the national economy. Champagne is also a major economic player in the export market of French wines and spirits, with 301.9 million bottles shipped per annum, of which 51.3% is exported with the top 4 importers being USA, UK, Japan & Germany.

The Champagne area, which comprises 0.5% of world vineyard acreage and 4% of France's total vineyard area, has 16,000 growers, 140 co-operatives, 4,600 producers and 340 champagne houses. It generates 20% of French wine revenue (Comité Champagne, 2018).

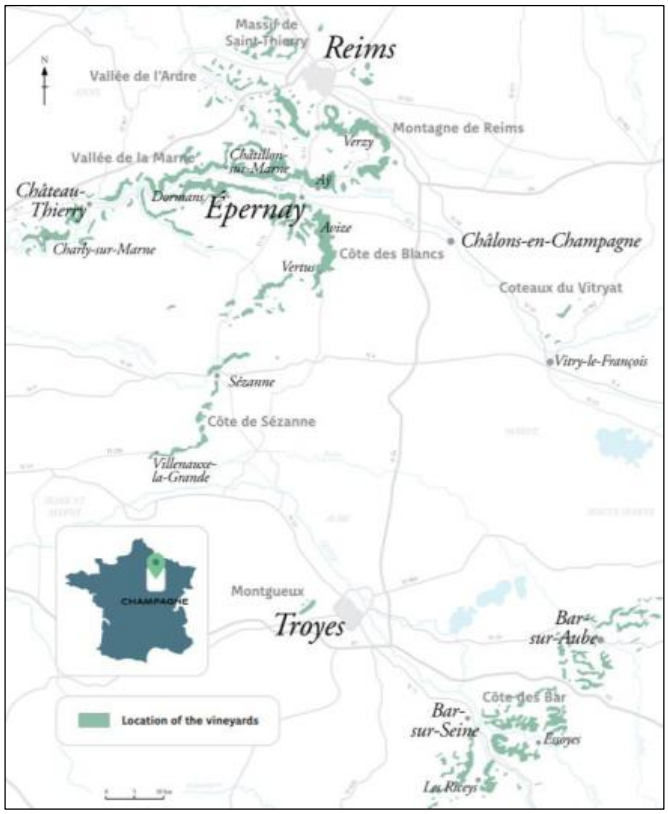


Figure 53. The Champagne region (Comité Champagne, Champagne - A major economic player, 2018).

The wine production sector in Champagne directly employs 30,000 people, of whom 15,000 are salaried staff, plus some 120,000 seasonal workers at harvest time. Champagne exports its wine to more than 190 countries. It has a strong trade organisation, overseeing four key areas: economic management, technical development, global protection (of the appellation) and education (about the appellation area) (Comité Champagne, 2018).

The Champagne region is set up differently to many wine producing areas, with a distinction between the vineyards/farmers who grow grapes (16,000 of them) and the Champagne houses and Champagne producers/co-ops, who buy grapes from growers (Comité Champagne, 2018).

Sustainability: Champagne is a wine producing sector committed to sustainable development. Interestingly, 20% of the wine area has environmental certification, including 15% certified Sustainable Viticulture in Champagne, with great strides having been made over the past 15 years in a region that even boasts the largest fleet of electric straddle tractors in France.

Tourism: There were 10 million wine tourists in France in 2016, with 17.2% of them visiting the Champagne vineyards (Visit French Wine, 2016). Key statistics for France's wine tourism include:

- 4.2 million foreign visitors; 5.8 million French visitors;
- Growth of 33% since 2009;
- €1,256 on average spent on a wine tourism visit (for all those participating in the visit), comprising any activity linked to wine and the discovery of the vineyards;
- €240 average spend related to the purchase, ordering or consumption of wine in situ and associated spending (visits, tastings, courses and other); and,
- An estimated total spend of €5.2 billion Euros by wine tourists in France in 2016.

The negative socio-economic impacts within the Champagne region are not clear, as the wine production sector has grown over hundreds of years with residents becoming used to the vineyards and Champagne houses. From a purely economic perspective, the industry brings additional income into the region through jobs, supplies, accommodation, on-trade sales etc.; however, local communities must manage the millions of tourists that frequent their area.

There are both similarities and differences between England and the Champagne region, from a viticulture and wine production perspective. The same seam of chalk found in Champagne runs under the English Channel and informs the geology in much of south-eastern England. Champagne and English sparkling wines are made from the same grapes (Chardonnay, Pinot Noir and Meunier) and predominantly produced the same way (traditional method). However, one of the key differences is yield, partly driven by climate and partly (although significantly related) by training system and vine densities. Champagne produces between 10.4 and 15.5 tonnes/ha (capped at 15.5 tonnes/ha for AOC - Appellation Origin Contrôllé) (Comité Champagne, 2020) of grapes whereas yields in the UK are closer to between 6 and 7 tonnes/ha (Skelton, 2014).

13.8. Economic conclusions

The economic benefits of viticulture and wine production in the regions referred to above are clear; all provide significant employment and income to regional and national economies, largely through associated business revenues and tourism. However, the socio-economic benefits and implications for new, establishing regions are less obvious. What can be deduced from the case studies and the Community perspectives (see Section 14) is that engagement, support through training and employment, and targeted economic uplift through multiplier effects, with and for local communities is paramount to realising local and regional economic benefits.

Recommendations regarding GVA, employment and education, tourism and socio-economic impacts are set out in Section 15.

14. SDNP community perspectives on viticulture growth and wine production impacts

Section 14 – Key findings:

SDNPA Citizen Panel survey results

- Survey respondents thought that a growth in vineyards and wine production within the SDNP would positively benefit the local community.
- More than half (53.5%) of the respondents also thought an increase in vineyards in the National Park would provide a positive impact on the views and general character of the landscape.
- 11.8% of respondents thought vineyards would have a negative visual impact on the National Park.
- Many respondents thought vineyards could bring positive economic benefits through training and employing more people (84%), diversifying and regenerating rural areas (76%) and enhancing the National Park as a tourist destination (52%).
- 3.9% of respondents did not see vineyards as positively contributing to the local economy.
- There were significant concerns in relation to environmental impacts, i.e. pesticide/herbicide use, water use, noise and increased vehicle movements.
- Only 26.4% of respondents had no concerns in relation to the environment.

Workshop results

- Overall, the Parish Council, community groups and SDNPA members anticipated more challenges for local communities, although some benefits were anticipated.
- From a social perspective, their key concern was vineyards/wineries being used as tourist attractions and associated reduced tranquillity.
- From an economic perspective, it was thought that most employment was filled from 'overseas', therefore not increasing the opportunities for National Park 'residents'.
- From an environmental perspective, many attendees were concerned about the increased use of pesticide and herbicides – especially leaching into chalk aquifers – and also spray drift and its impact on neighbouring land and people.
- Concern was also raised about the potential loss of access to open land.
- From a visual impact perspective, concerns were raised that vineyards increasing on a large scale would result in a monoculture landscape, with straight lines of vines and trellising.
- Viewsheds are important to the local communities and vineyards should avoid being planted on high ground where their potential to impact views is greater.
- It was felt that development scale is very important in weighing up associated risks and opportunities, as this will often determine how significant the 'impact' could be.
- Opportunities for education – from school children through to Vineyard managers – was deemed very important.
- It was recognised that mitigants could be put in place by the SDNPA or local councils, to address some of the concerns raised.

An increase in viticulture and wine production within the SDNP may impact those living and working within the National Park. To more fully contextualise, understand and assess the economic, social, environmental and visual impacts of viticulture growth, the perspectives and perceptions of local people were sought.

14.1. Approach

To gather this valuable input, two stakeholder engagement exercises were undertaken with 1) the SDNPA Citizen Panel, and 2) SDNP Parish Councils, local community groups and SDNPA members.

The first exercise was conducted via an online survey in Q4, 2019. The SDNPA Citizens Panel, set up in 2017, is a group of SDNP residents (between 1,000 and 2,000 people) who are regularly surveyed about their opinions on a particular issue or sets of issues. They are not necessarily representative of the wider SDNP community, as they have not been randomly selected, but they have chosen to take part in the Panel and chose to respond to the questionnaire. There were 383 responses from the Panel in response to this exercise, which provided valuable input in relation to their reactions to any growth in viticulture and wine production in the SDNP.

The second stakeholder engagement exercise was a workshop, held with Parish Councils, local community groups and SDNPA members, on 6 March 2020 at the SDNP offices in Midhurst. The workshop was run by Vinescapes with support from the SDNPA. All SDNP Parish Councils, many community groups and SDNPA members were invited to the workshop. There were seventeen attendees, ten were from Parish Councils, four were SDNPA members and three were from community groups. The workshop attendees were provided with:

- High level data and information on the UK wine industry;
- SDNP vineyard and winery numbers;
- Early economic, environmental and visual impact information regarding vineyards and wine production in the SDNP, developed through this study;
- High-level findings and comments from the Citizen Panel 'feedback'; and,
- Artists impressions of additional vineyards within the SDNP landscape at Devils Dyke, Kingston Ridge, Firle Beacon and Temple of the Winds (see Section 11).

The attendees were split into three groups: 1) environment, 2) visual, and 3) social and economic. Perspectives, perceptions and feedback were sought from each of these groups regarding their opinions of an increase in viticulture and wine production within the SDNP. The group's views were collected, reviewed, discussed and developed at the workshop.

Questions put to the Citizens Panel can be seen in Appendix F.

14.2. Findings

The stakeholder views were captured and analysed and are summarised below. It is important to note here that Parish Councillors in particular could not be expected to represent the wide

range of opinions or views of all their residents, but they were selected to provide a flavour of local opinion in relation to vineyard growth.

14.2.1. Citizen Panel findings

The responses to the Citizen Panel Autumn Survey were analysed by the SDNPA (2020b), with the summary information provided here and further information in Appendix F. In response to the questionnaire, a large number of respondents provided free text comments to support their answers to questions, demonstrating an interest in and engagement with this topic. A selection of responses have been included below and full details of the Citizen Panel Autumn 2019 Survey Results are available from the SDNPA (2020b).

When assessing the levels of awareness of vineyards, the vast majority of respondents (93%) indicated an awareness of vineyards within the South Downs National Park.

Awareness of vineyards varied across the National Park:

- Those residing in the GU postcode area were most aware of vineyards (95%), while those in the SO postcode area least aware (89%).
- Those residing in the BN postcode area were the most likely to have seen a vineyard (56%) and included the lowest percentage of respondents (14%) who were aware of vineyards in the South Downs National Park, but had not visited or seen any, suggesting vineyards may be more visible or prolific in this geographic area.
- A total of 30% of all respondents had visited a vineyard within the National Park, with a further 15% intending to visit a vineyard in the National Park within the next 12 months.
- Those aged 65 years or more were the most likely to have visited, or be planning to visit, a vineyard, with younger demographics decreasingly so. Males were also more likely to visit a vineyard (18%) than females (11%).

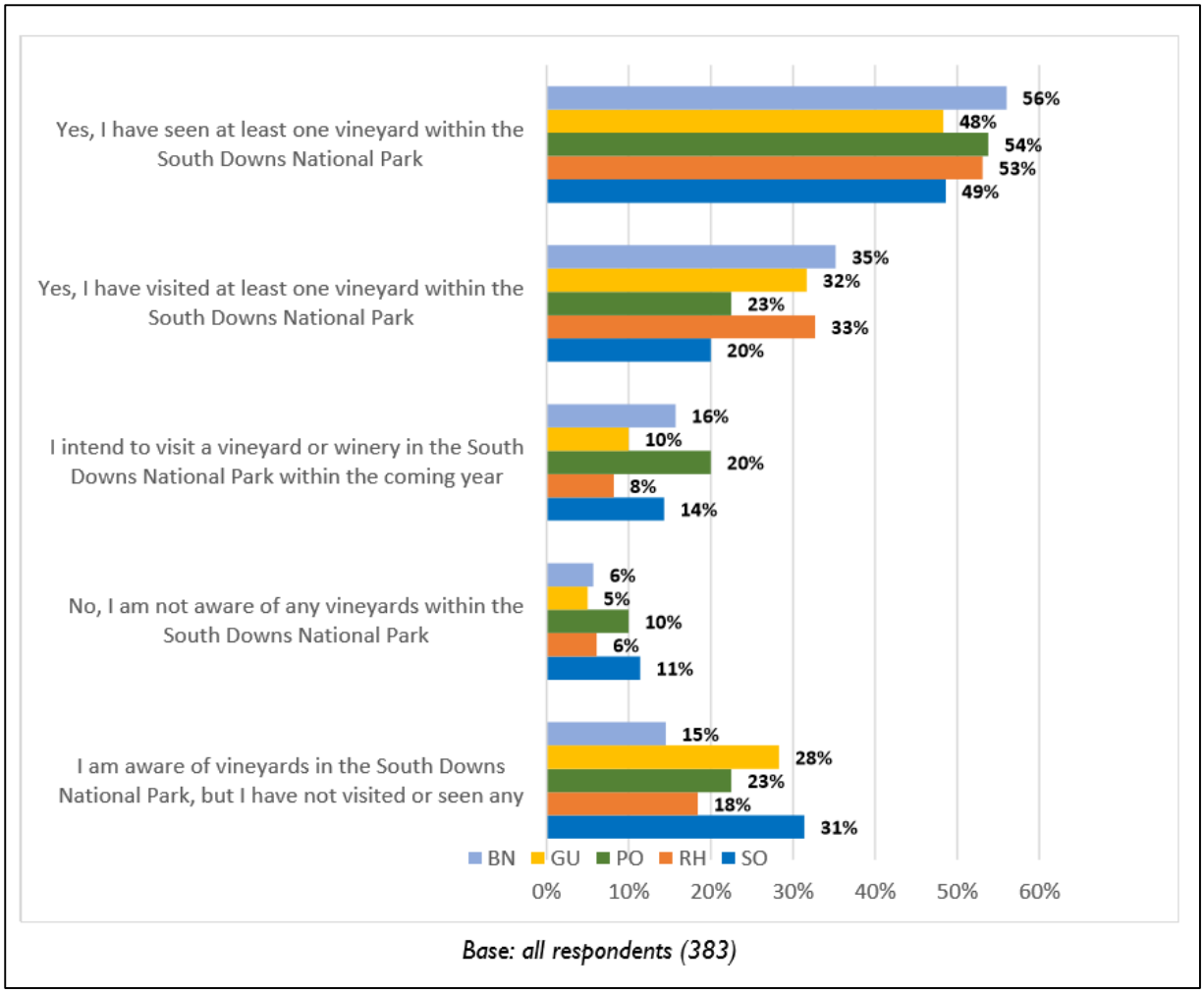


Figure 54. SDNPA Citizen Panel, Viticulture Question 1 responses.
By Postcode (BN, GU, PO, RH, SO) - Have you seen or visited any vineyards within the South Downs National Park area? Citizen Panel, Autumn 2019 Survey Results (SDNPA, Citizen Panel, 2020b).

Comments from respondents regarding the increasing number of vineyards within the National Park were largely positive. Of the 33 individuals who expressed an opinion, 25 (76%) made positive comments while just 8 (24%) expressed concern or made negative comments.

Positive comments included:

- 'This is a very important development sector to support, providing income to otherwise challenged farms and businesses and valuable employment and training for young job market entrants.' (Male aged 65+ from the GU postcode area.)
- 'Viticulture may provide new income to farmers who may be losing existing grant aid.' (Male aged 55–64 from the PO postcode area.) 'Further publication of the vineyards and tours available will be great for future resilience of the national park.'

Less positive comments included:

- 'I have some concern that vineyards seem to be a monoculture, rows upon rows of vines, no weeds, no hedges. I don't object to vineyards but wouldn't like to see a massive increase.' (Female aged 65+ from the BN postcode area.)

- ‘Should the possible impact of increasing the number of vineyards on biodiversity be investigated?’ (Female aged 65+ from the BN postcode area.)

When assessing impact, 54% of respondents thought that an increase in vineyards in the South Downs National Park would have a positive or very positive impact (69% positive or no impact) on the views and general character of the landscape. This finding was consistent across all demographics. A further breakdown by postcode has been provided below.

Overall, 12% of respondents thought an increase in vineyards would have either a negative or very negative impact on the views and landscape. These responses were most apparent in the BN (17%) postcode area.

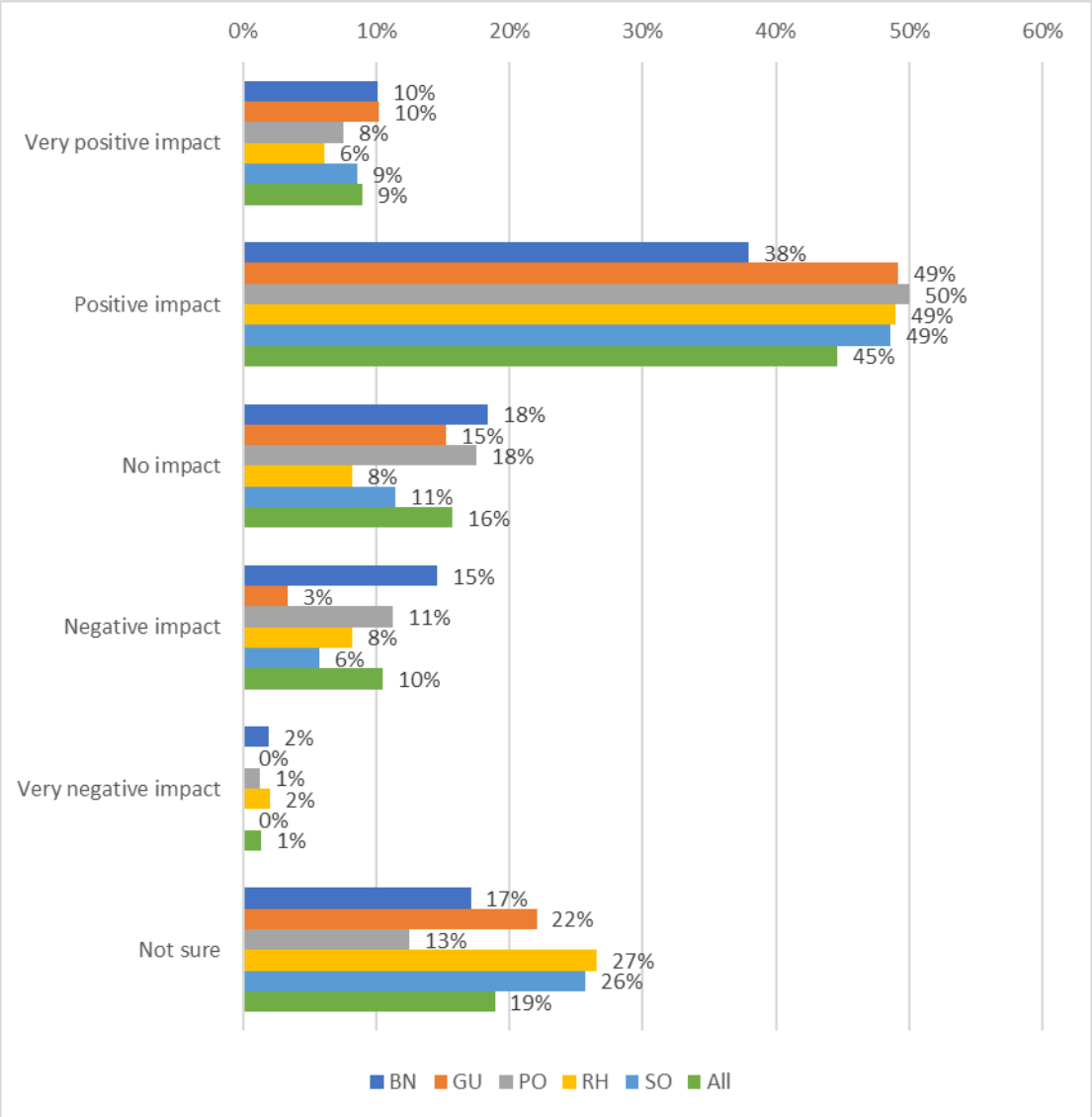


Figure 55. SDNPA Citizen Panel, Viticulture Question 2 responses By postcode (BN, GU, PO, RH, SO) - What impact (if any) do you think an increase in vineyards in the SDNP would have on the views and general character of the landscape. Citizen Panel, Autumn 2019 Survey Results (SDNPA, Citizen Panel, 2020b).

When assessing the environmental impact, respondents were most concerned about the impact of pesticide and/or herbicide applications (64% of respondents) as a result of an increasing number of vineyards in the National Park, followed by concern about an increase in water usage (43% of respondents).

Just over a quarter of respondents (26%) said they had no concerns, but this was not consistent over all age demographics, as older respondents exhibited less concern than younger respondents.

Respondents were invited to list 'other' potential environmental impacts of increased vineyards. Of the 19 comments provided, the main issues raised related to impacts on biodiversity (5 comments), monoculture farming methods (4 comments) and changes in or to the landscape (3 comments). Other areas of concern included an increase in tourist numbers and the potential loss of access land.

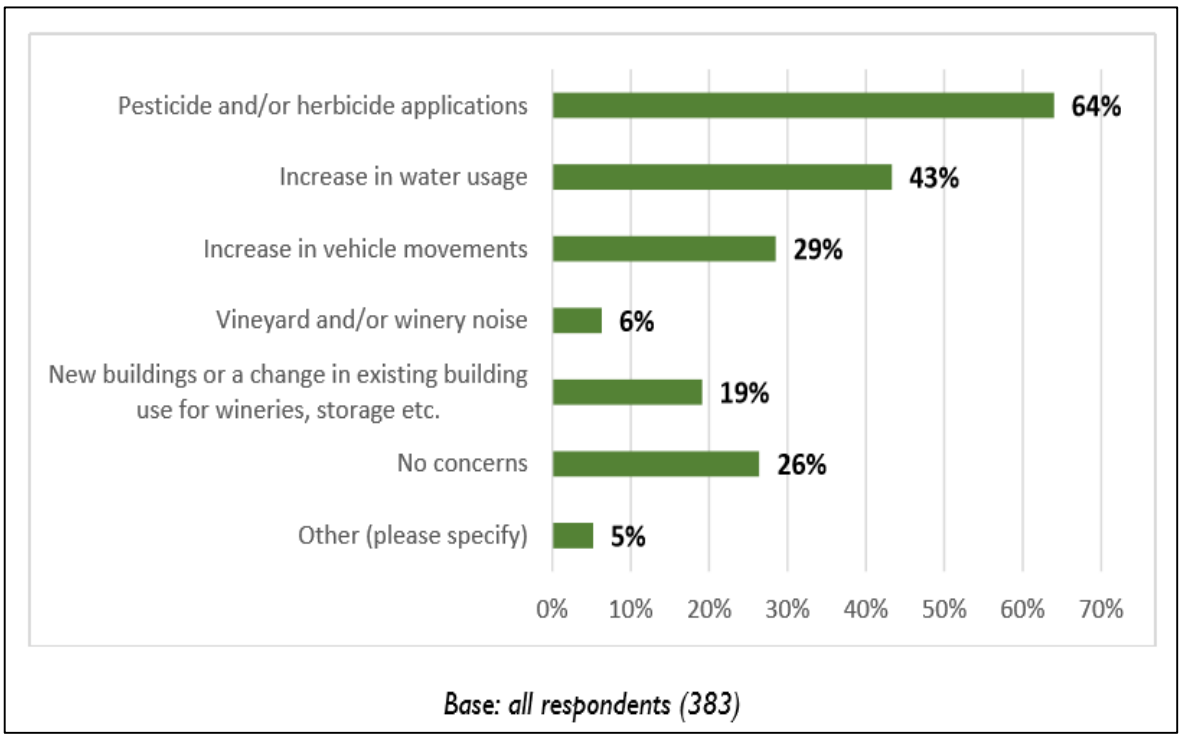


Figure 56. SDNPA Citizen Panel, Viticulture Question 3 responses.
Relating to the environmental impacts of an increase in grape growing or winemaking what would your concerns be? Citizen Panel, Autumn 2019 Survey Results (SDNPA, Citizen Panel, 2020b).

A large majority (84%) of respondents thought that training and employing more local people was an important economic benefit that vineyards and wineries could provide within the SNDP. This was followed by diversifying and regenerating rural areas (76%) and enhancing the SNDP as a tourist destination (52%). Only 4% of respondents did not want to see an increase in vineyard or winery numbers.

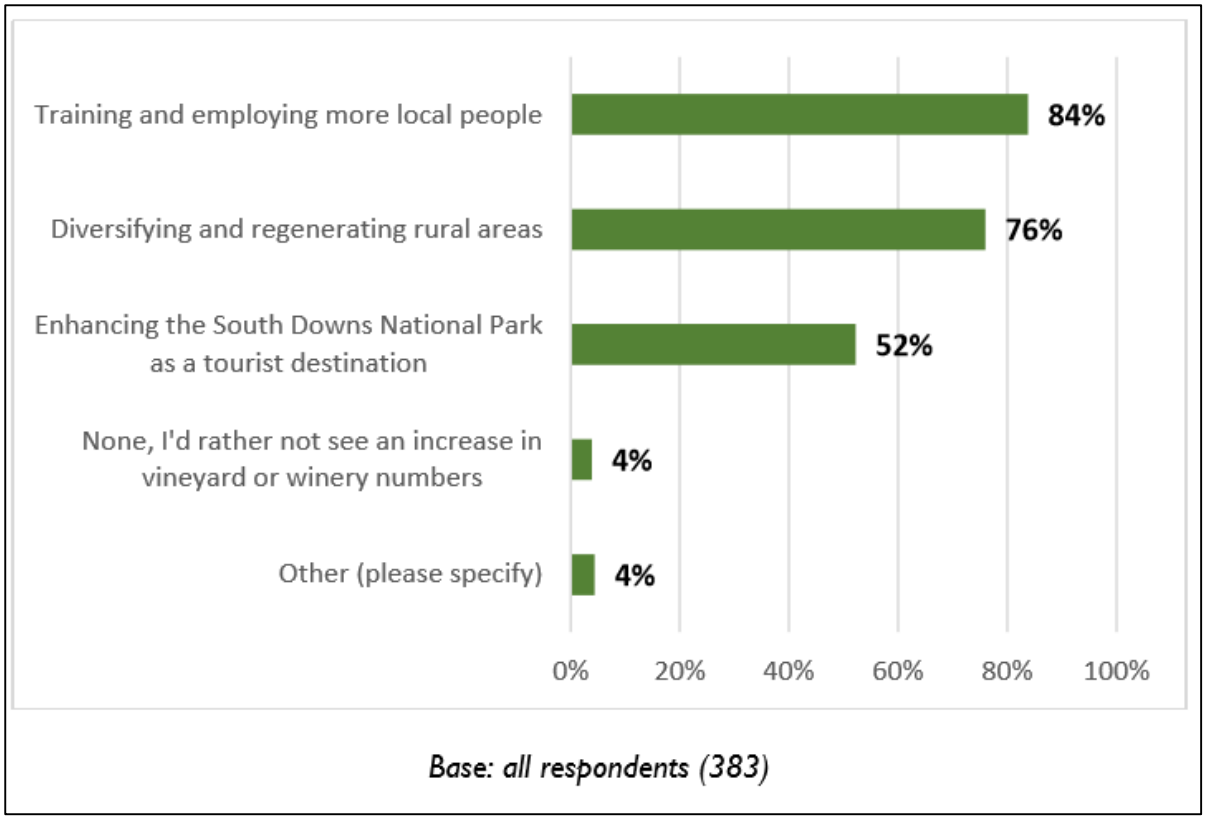


Figure 57. SDNPA Citizen Panel, Viticulture Question 4 responses

Vineyards and wineries are labour intensive and vineyards in particular employ more people per acre than most other common types of agriculture. What other economic benefits could vineyards and wineries provide within the South Downs National Park that would be important to you?

Citizen Panel, Autumn 2019 Survey Results (SDNPA, Citizen Panel, 2020b).

With hindsight, the survey (Appendix F, Question 3) should have included additional options allowing people to respond 'I don't know what the environmental impacts are' or 'I don't think there are any environmental impacts', as the question seems to imply that the options are all categorical negative impacts of the viticulture industry, which may not be the case.

Given the high-level nature of the questions, it is understood the responses could change depending on the scale of viticulture and wine production increase.

14.2.2. Parish Council, community groups, and SDNPA member findings

Overall, the Parish Council, community groups and SDNPA members anticipated challenges for local communities resulting from an increase in viticulture within the SDNP, although some benefits were anticipated.

From a social perspective, the key concern was in relation to vineyards/wineries used as tourist attractions. This was seen to have a significant impact on the local population, with reduced tranquillity. It was suggested reductions in tranquillity would come from increased noise from functions (e.g. weddings), increased traffic movements from visitors on roads, and

light pollution. However, it was acknowledged that these concerns are generally managed through planning restrictions.

From an economic perspective, it was generally agreed that vineyards employ more people than general agriculture (per ha); however, it was thought that most employment was filled from 'overseas', therefore not increasing the opportunities for National Park residents. In reality, however, most vineyard work is provided by local residents (whether British citizens or not), who live within or in the proximity of the National Park and who are either employed directly by vineyards or contracted through local Vineyard Management businesses. Positive impacts noted were from farms diversifying (allowing them to stay in business), potential for increased returns per ha, and foreign investment being brought into the UK.

From an environmental perspective, as with the Citizen Panel findings, many attendees were concerned about the environmental impact any increase in viticulture and wine production would have on the SDNP. These concerns specifically included the increased use of pesticides and herbicides, especially risks associated with chemicals leaching into chalk aquifers, and also spray drift and its impact on neighbouring land and people living near vineyards (see Section 7). Other concerns expressed included impacts on biodiversity, increased irrigation (note, this is only used for watering in SDNP vineyards), and plastic grow tubes littering the countryside and not degrading.

Concern was also raised about the loss of access to open land. However, it was clarified that current designated footpaths must continue to be provided, unless legally moved. Access could also increase, with vineyards increasingly open to the public for visits and walks.

From a visual impact perspective, concerns with regards to large-scale increases in vineyards were related to a monoculture landscape, with straight lines of vines and trellising and no colour variation (see Sections 7 and 11.). Single-variety tree or artificial windbreaks were also deemed to be undesirable. Current viewsheds are important to the local community, and the planting of vineyards on high ground, where the potential to impact views is higher, should be avoided.

It was felt that the scale of development scale was very important in weighing up associated risks and opportunities, as this will often determine how large any 'impact' could be.

An interesting theme that emerged from all breakout groups was education – from school children through to Vineyard managers – summarised as follows:

- Educate the next generation (in schools) about jobs within the viticulture sector – providing knowledge is key to enticing new entrants into the job market;
- Provide increased viticulture education availability across the National Park, including in horticultural educational facilities (at present this is only available at Plumpton College in the local area, but nationally there is a lack of such facilities); and,
- Ensure the Vineyard managers are well educated in relation to sustainable practices to ensure the best mitigation strategies are used to minimise impacts.

It was also recognised that mitigants could be put in place by the SDNPA or local councils, to address some of the concerns raised. Below is a summary of the key mitigants proposed and discussed at the workshop:

- **Social:** Winery tourist destinations reduce tranquillity.
  - Mitigant: Strong planning mitigants required to minimise potential noise, light and increases in traffic.
- **Economic**: There is an increase in employment provided by viticulture and wine production but a lack of training access.
  - An increase in viticulture and wine production education facilities to upskill and increase knowledge of the sector, beyond Plumpton College, could be very valuable. Also, increase local advertising and have recruitment fairs for vacancies.
- **Environmental:** Increased use of pesticides – specifically chemicals leaching into chalk aquifers and significant concerns over spray drift; impacts on biodiversity; and the use of plastic grow tubes/rabbit guards 'littering the countryside' and not degrading.
  - Mitigant: Increased education about regulations and sustainable practices (see Sections 10 and 15), and a greater focus for vineyards on being good neighbours to people and the local environment.
- **Visual impacts:** Vineyards increasing on a large scale will result in a monoculture landscape with straight lines of vines and trellising, with no colour variation (trellising and landscape). Single-variety tree or artificial windbreaks were also deemed to be undesirable.
  - Mitigants: Increased education of, and strong relationships with, vineyards (or Vineyard managers) to support the implementation of practices that lower visual impact, for example, cover crops, native vegetation, 'appropriate' trellis posts, the colour of grow tubes, etc.

15. Mitigants, opportunities and recommendations

Section 15 – Key findings:

Key recommendations for the South Downs National Park Authority include:

Policy and guidance:

- Following on from this document, it is suggested that a planning guide for viticulture related development is produced by the SNDPA, along with a sustainability guide for vineyard owners and managers. Both documents should aim to support the vineyards and wineries of the National Park in line with its purposes and duty.

Support services (ecosystem services):

- Work with vineyards and advisory organisations, such as the Farming and Wildlife Advisory Group (FWAG), to establish a consistent approach that can be applied for ecology and biodiversity benchmarking and monitoring in vineyards.
- A simple visual impact assessment toolkit should be developed and provided as a helpful guide for those designing vineyard(s) in the protected landscapes.

Cultural services (ecosystem services):

- Undertake further, specific research into economic and tourism benefits from vineyard and winery clusters and how these opportunities can maximise ecosystem service benefits whilst reducing risks to local communities.
- Provide the public and tourists with further information regarding vineyards and/or wineries that are open to the public and/or offer tours or visitor experiences.
- In conjunction with other local authorities, review and optimise public transport links to wine destinations.

Regulating services (ecosystem services):

- Signpost producers to schemes such as the Voluntary Initiative, the Good Neighbour Initiative and the Sustainable Wines of Great Britain sustainability scheme.
- Produce research regarding the potential for pesticide leaching (particularly into chalk aquifers), and guidance to inform risk mitigation strategies.

Wineries, winemaking and associated activities:

- The SDNPA pre-application enquiry process, the Farmer's Guide to Permitted Development, and relevant planning policy should be clearly signposted through a proposed TAN for vineyards and wineries.

Education and sharing best practice:

- Foster closer engagement between the ‘authorities’ and producers, where an open dialogue may lead to more structured support including, but not limited to:

    - The creation of a dedicated protected landscape vineyard group to discuss and share best practice and initiatives that are mutually beneficial;
    - Engagement through Farm Clusters, Rangers or other conservation orientated bodies;
    - Review and promote training opportunities to offer education and upskilling for local residents in particular.
    - An introductory guide (possibly as part of a Technical Advice Note) to risks, risk mitigation and opportunities, for those thinking of establishing vineyards or wineries within protected landscapes.

More detailed recommendations, including those for producers, are set out in this Section.

One of the core aims of this study, beyond assessing viticulture and wine production impacts and providing an evidence base from which the SDNPA, AONBs and New Forest National Park Authority could start to address their knowledge gap, was to deliver recommendations for enhancing opportunities and mitigating risks presented by viticulture and wine production in these protected landscapes.

Within this section, therefore, recommendations for growers and producers are made, and a prospective assessment is undertaken of what the impact of any interventions might be. Tactics, functions and strategies are suggested that could be employed by the South Downs National Park Authority to 1) further inform a consistent approach and viewpoint on viticulture growth, and 2) provide a means of engaging with sustainable initiatives undertaken by vineyards and/or prospective vineyards and wine producers. In turn, and when taken together with this study, these should enable the SDNPA to produce a Technical Advice Note and Environmental Measures Best Practice Guidance for viticulture.

These recommendations respect the context of the special qualities of the SDNP, which define its sense of place and attract people to live, work and visit. They also acknowledge that the rural economy, which significantly influences the landscape, is diversifying and that future climate change is likely to further increase the pressure on sensitive ecologies and resources. By their nature, vineyards and wineries highlight active human intervention in the landscape – a managed, somewhat regimented and controlled landscape, but one where most nature can, should be and indeed is a welcome influence. Whilst most stakeholders engaged with during this study were generally very supportive of vineyards and wine production in the SDNP (see Section 14), their potential harmful influence on the landscape and environment was of concern to many. Vineyards were described by some stakeholders as 'industrial', 'polluting', 'scarring' and were associated more with harm than good. Whilst these connotations may not be without cause in some cases, in the main it was found that good practice and positive contributions to the environment, ecosystems and landscape can be made and do exist. Furthermore, from an economic perspective, vineyards and wineries are a net contributor compared with the contribution of other land uses that they replace. They also represent an adaptation to climate change (Section 9; 25-year Environment Plan, (2018); the SDNPA Climate Change Adaptation Plan (2016b)) and an attractive form of rural diversification and enterprise to landowners. However, 'best practice' is not universally adopted and there are a multitude of activities that could (and it is recommended should) be undertaken to reduce potential harm, maximise opportunities and better integrate vineyards and wineries within the protected landscapes that this study was concerned with.

The recommendations and opportunities set out below, for vineyards, wine producers and authorities, are based within the context of policy presented in Section 5.4. Their potential adoption, adaptation or expansion, application, assessment, and monitoring are all matters for the South Downs National Park Authority to consider and to act on. The sentiments expressed by the Vineyard managers who were interviewed and surveyed through this work are to be commended – they care about the environment and they want to learn and do more to preserve and enhance the special qualities of the National Parks and AONBs, and protect the wider regional, national and global environment.

The mitigants, opportunities and recommendations are provided using ecosystem services and natural capital contexts as a useful structure, which relates to the SDNPA's Local Plan (2019) (Section 5.4.5).

15.1. Supporting services

15.1.1. Soil formation

Soil is the foundation of all terrestrial ecosystems and viticulture's provisioning services, as well as being the structural medium for supporting the terrestrial biosphere and human infrastructure. Soil condition and type determine its ability to function and to provide ecosystem services. Degradation may be reflected by declines in soil fertility, organic matter and organic carbon content, loss of biodiversity, loss of water retention capacity, disruption of water, nutrient and gas cycles, and reduced capacity to degrade contaminants. Soil degradation reduces its ability to provide ecosystem services.

Each soil forms as a unique expression of five soil-forming factors (climate, vegetation, topography, parent material and time) that work through soil processes. These soil processes can be considered in the following four groups: additions, losses, transformations and translocations.

Soil quality and its maintenance is addressed in Section 15.4.4. Ground cover and vines reduce erosion risks post-establishment of a vineyard, as well as improving the stability of soil aggregates and soil structure. However, soil formation can be negatively affected in vineyards through lack of vegetation and exposure to erosion, often limited in the UK to pre- and immediately post-planting of new vineyards. To reduce these risks, the following recommendations are made:

a. Pre-planting soil analysis and profiling should be undertaken using in-house expertise or viticulture or agronomy consultants proficient in this area. Professional soil analysis can provide valuable information on soil type, structure, nutrient (macro and micro) status, organic matter, fertility and drainage (amongst other variables). Such an assessment not only provides essential information regarding suitability and likely amelioration requirements for viticulture but also critical information on its potential ecosystem services or risks that could be realised through poor management.
b. Ground cover should be established over winter, pre-planting. Agronomy advice should be sought to determine which species could/should be established.
c. Drainage ditches should be established at the tops of vineyards, where higher land, above a vineyard site, may result in surface water entering a vineyard and eroding soils.
d. Windbreaks should be established at an early stage to help reduce wind-induced soil erosion. Where windbreak trees are not established in time, temporary alternatives such as straw bales could be considered.
e. Ground cover/swards (grasses and other plants) should be established inter-row and in headlands post-planting (usually later in year 1 or early in year 2).
f. Under-vine strips should be kept to a minimum and managed with a view to having some (limited) cover that reduces erosion risk (see Section 15.4.5).

g. Unlike the annual soil cultivation that occurs with most arable farming, cultivation in UK vineyards normally only takes place pre- and soon after planting, and is not performed again until vineyards are re-planted (potentially 35 to 45 years post-establishment). Cultivation within this period, if required, should be kept to an absolute minimum.
h. Cuttings, prunings and waste (grape marc) should be spread and/or mulched back into vineyards to contribute to soil formation through organic matter and carbon content, thus reducing losses. Note, disease pressure may restrict the potential to mulch prunings in some years.

15.1.2. Primary production

Vines and grapes are an obvious source of primary production (the production of chemical energy in organic compounds by living organisms), and their production to commercially viable yields and quality will depend largly on Vineyard Management skill as well as environmental factors. It should be remembered that wine-grape yields in the UK are still relatively low compared with international comparators – largly a reflection of the UK's very cool climate (in viticulture terms). However, vineyards often offer opportunity for additional primary production. This may be through vineyard flora and fauna or more pro-active exploitation such as the growing of legumes or other crops inter-row or within the vineyard vicinity. In terms of extracting potential ecosystem related benefits, we recommend that as per the recommendations in Section 15.1.1. ground cover is maintained and production opportunities maximised. A small study to identify and quantify additional primary production opportunities on vineyard land in the UK would be of value to growers and help provide further guidance here.

15.1.3. Nutrient cycling

As with the recommendations in Section 15.1.1., nutrient cycling in vineyards can be improved through ground cover, mulching vine prunings back into the vineyard and adding winery pomace/marc back onto vineyards as compost. Additionally, it is recommended that:

a. Vine nutrient requirements should be regularly assessed through soil and petiole analysis (timing to be advised by a viticulturist or agronomist if the Vineyard manager is uncertain) and additions applied as and when required.

15.1.4. Water cycling

Competition from vines for water is limited in a relatively wet growing environment, such as the UK, particularly where vines are established on chalk-based geology. However, competition could potentially increase during very dry seasons – and this may be the case under future climate change scenarios (see Section 9). The ability of ground cover to improve rainfall infiltration and enhance soil water storage is valuable; therefore, ground cover is again recommended (and is the case) in vineyards. Additionally:

a. Winery wastewater can be treated (although this incurs a costly infrastructure requirement) and re-used in the vineyard (for spraying) or in the winery itself.

b. All vineyards should be aware of LERAP requirements (see Sections 7 and 10) and take appropriate action to protect watercourses or bodies of water.
c. Pesticides or other chemicals leaching from vineyards into groundwater or aquifers could reduce water quality. It became apparent, through this study, that more research in this area is required to fully understand these risks (within different areas of the protected landscapes) and it is recommended that expertise is sought to study and more fully elucidate these risks. Notwithstanding potential risks, it is recommended that in protected landscapes, vineyards fully consider the value of recycling, electrostatic or other sprayers that reduce drift, waste and improve contact – with a view to limiting potential impacts on water cycling.

15.1.5. Biodiversity

Globally, biological diversity (biodiversity) is low in many wine-growing regions and in no way corresponds to their potential. Vineyards in the SDNP, AONBs and New Forest National Park often have significant opportunities for enhancements in biodiversity, sometimes as a net gain relative to the land use (conventional arable farming) they often replace. Only around 15% to 20% of a vineyard's area is taken up by vines themselves. Inter-row alleys, headlands and non-plantable areas provide significant areas for other species (see Section 10). Vineyard managers surveyed for this study were enthusiastic to implement measures to promote biodiversity, but often lacked the practical knowledge to do so, and there is a lack of advisory services and tailor-made support programmes. Research and practice must work hand in hand to develop sustainable solutions to protect and enhance biodiversity in vineyards. Base level recommendations and mitigants arising from this study include:

a. Vineyards should establish an ecology and biodiversity baseline/benchmark of their land through an ecology survey/study, from which an action plan can be developed and implemented. This can encourage a balanced management approach that recognises the vineyard as part of an interconnected system and adopts practices that contribute to biodiversity and habitat improvements. This process should be supported by ecology experts or consultants and draw on ecological reports from the Biodiversity Records Centre. It is recommended that protected landscape authorities work with vineyards and advisory organisations such as the Farming and Wildlife Advisory Group (FWAG) to establish a consistent approach/methodology (template) that can be applied and which captures local ecological pressures, mitigants and opportunities. Part of this exercise could be compatible with or facilitate the environmental impact assessment requirements as set out in Section 7.2.
b. Where vineyards are on larger estates, their viticulture and wine production related activities and mitigants (drawn from the above recommended study Section 5.4.10) should form part of wider Whole Estate Plans.
c. When planning or designing a vineyard, the surrounding and internal hedgerows, trees and other vegetation should be kept in situ and managed, as they provide food, shelter, a natural habitat and wildlife corridors.
d. Ground cover in vineyards (see Figure 58) should be maintained to provide rich habitats and biodiversity, which deliver beneficial ecosystem services.

Figure 58. Vineyard ground cover (in an AONB vineyard).

e. Establish a multi-species grass sward/cover inter-row (not necessarily every row) and in unplanted vineyard areas to provide a habitat and food for predatory insects and pollinators.
f. If sown, use a slow-growing seed mix to reduce the number of cuts/mows required.
g. Use a native (to the landscape area) seed mix as ground cover. One vineyard interviewed as part of this study established a chalk downland flower (20%) mix the year after planting. The mix included 2.2% agrimony, 1.0% bird's foot trefoil, 1.4% black medick, 0.2% cowslip, 0.6% dropwort, 0.5% goatsbeard, 0.8% hedge bedstraw, 1.2% knapweed (common), 1.2% knapweed (greater), 1.2% lady's bedstraw, 0.1% meadowsweet, 0.4% marjoram (wild), 1.0% oxeye daisy, 0.4% plantain (hoary), 1.6% salad burnet, 2.0% sainfoin, 1.0% scabious (field), 0.6% scabious (small), 1.0% selfheal, 0.2% toadflax, 0.6% vetch (kidney), 0.4% wild carrot, 0.4% yarrow, 14.4% fescue (slender creeping red), 17.6% chewings fescue, 4.0% common bent, 6.4% smooth stalked meadow grass, 4.0% creeping bent, 16.0% crested dogstail, 16.0% sheep's fescue, 1.6 % quaking grass and yellow rattle (see Figure 59).

Figure 59. Wildflower mix established in a chalk landscape vineyard.

h. Mow only alternate rows to a manageable height and to keep the vineyard as dry as possible to reduce disease and aid day-to-day management (see Figure 60).

Figure 60. Alternate row mown vineyard.

i. Beyond inter-row cover, promote species biodiversity and habitats in unplanted areas of the vineyard. Introducing indigenous plants into vineyards has been successfully undertaken in other more established areas such as Waipara in New Zealand. The Greening Waipara programme has been shown to enhance:

- Biological control of pests and diseases (reducing fungicide and insecticide use);
- Weed suppression;
- Biodiversity;
- Soil fertility; and,
- Eco-tourism and conservation.

It is likely this recommendation will require a period of research before application.

j. Reduce pesticide use. The loss of surface biodiversity through pesticide use was a concern to grape growers interviewed for this study. Presently, beyond current pesticide application training/licence requirements and annual National Register of Sprayer Operators (NRoSO) CPD courses, or schemes such as the Voluntary Initiative (2020), there is little, if any, in-field training or monitoring of activities regarding vineyard pesticide use. The number of pesticide applications per year in vineyards in the SDNP ranged from 6 to 15 (mean: 10.5/year) and up to 20 applications per year in an AONB vineyard. Whilst pest/disease pressure and pesticide requirements vary between vineyards it is clearly plausible that, with improved training, skills and

knowledge, pesticide application rates could be significantly reduced in some vineyards. Furthermore, unlike arable farming, vineyards do have the opportunity to use recycling/tunnel or electrostatic sprayers that decrease 'wastage' and spray drift and increase efficiency (see Section 10.4).

k. Focus on Integrated Pest Management. There is an opportunity to develop a more integrated approach to plant protection, using a range of different pest management methods and using pesticides only when justified, through monitoring the pest, host and environment. Some of the growers interviewed were not aware that, since 2014, there has been a legal requirement for them to have a written Integrated Pest Management (IPM) plan (a cornerstone of the EU's Sustainable use of pesticides directive, implemented in the UK National Action Plan for the Sustainable Use of Pesticides (Plant Protection Products), 2013). Beyond training and research into IPM we recommend that protected landscape authorities encourage sharing of knowledge and best practice regarding IPM (and other strategies to reduce pesticide use) among growers through forums such as the farm clusters which vineyards could be encouraged to join.
l. It was noted that one of the vineyards interviewed for this study used a drone to survey vine vigour, with the aim of targeting operations such as foliar fertiliser applications to more precise areas of the vineyard. The adoption of such precision viticulture techniques should be encouraged as an integral part of improving efficiency and, as in this case, biodiversity protection.
m. Reduce or eliminate under-vine herbicide use. When growers were asked about herbicide use several replied that they had plans to stop using them and switch to under-row cultivation. Areas under-vine in vineyards can be effectively managed (to reduce weed growth) through cultivation, strimming, establishing beneficial flora, herbicide use, or a measured combination of any of these. Trials and research into non-herbicide methods of under-vine weed and soil management are continuing at pace. A research-based document that assessed the effectiveness of activities employed elsewhere and provided information about different techniques would be well received by protected landscape vineyards. It is useful to note that the Comité Champagne (in the Champagne region of France) has recently announced it wishes to end herbicide use in the region's vineyards by 2025, as part of its sustainability plan, which runs alongside the French government's 'EcoPhyto' initiative to make agriculture less reliant on artificial fertilisers, herbicides and pesticides. Some producers, such as Moët Hennessy, are introducing the ban in 2020 to force a focus on alternative practices.
n. Where windbreaks are established, these should also be viewed as wildlife corridors. It would therefore be useful to look at introducing lower growing vegetation and using a variety of native tree species to create the windbreaks, rather than simply using the default species, Italian alder (regardless of the wildlife corridor value, this recommendation also stands alone in terms of landscape benefit). It would be beneficial to conduct a relatively small study, involving growers (and potential growers), the protected landscape authorities, the Farming and Wildlife Advisory Group (FWAG), and other local conservation groups, to look at suitable options for native trees and vegetation.
o. In conjunction with an ecologist and/or local ornithology groups, it would be useful to identify local beneficial birds, such as owls, and establish bird and owl boxes.

p. The maintenance or promotion of a vineyard's potential ecological infrastructure beyond the vineyard floor/ground should be considered. This includes management of surrounding hedges, trees/woodland, grassland, meadows, and other habitats. All should be mapped and have associated management recommendations made by conducting an ecology survey. Additionally, species of earthworms, beetles, butterflies, birds, spiders, grasshoppers, insect pollinators and predatory vertebrates that exist in and/or around a vineyard could be attracted to the vineyard's environment should be sought, protected and encouraged, by drawing on expert advice. This may involve, for example, establishing beehives, owl boxes or wood piles.
q. Beyond an initial baseline ecology study and a subsequent action plan to protect and promote biodiversity in vineyards, protected landscape authorities should seek greater engagement with vineyards through forums, their Rangers, or other relevant officers. A structured relationship that provides a network of support and collaboration with growers will be of significant help in monitoring and supporting best practice with regards to biodiversity, and it is recommended that the SDNP and others seek to establish such relationships.

15.2. Provisioning services

15.2.1. Water supply

Winery and other related buildings should be used for rainwater collection/harvesting (from roofs) which, if treated, can be used in wine production and spray operations.

The risk to water supply from viticulture is very limited since, in the protected landscapes studied, vineyards are not irrigated and, except for the occasional need to water-in vines post-planting in drier years such as 2018, water use is restricted to spray operations. There is a handful of small vineyards in the UK that use overhead sprinkler systems for frost protection (although not in the summer season when water resources are under most pressure), but water requirements and costs make this prohibitive on a large scale, and it is not a routine frost protection strategy in the UK. Climate change modelling work with regards to viticulture (Section 9) in the SDNP and other relevant climate change adaptation work, such as the ADVICLim project (2020), show that irrigation is very unlikely to be required over the next 50 years. However, if irrigation became a requirement in the future this would put increased pressure on water supplies, particularly in the Chalk Valleys, where water supply has been identified as being at risk from climate change and agricultural intensification (see Table 17).

15.2.2. Food production

Although not an essential foodstuff, wine produced from grapes is the result of multiple ecosystem services. Opportunities for viticulture expansion within the SDNP are significant (approximately 40,000 ha of suitable land); the associated economic and socio-economic benefits of the sector were presented in Section 13.

There is limited potential for other food production in vineyard environments, although the co-production of legumes was referred to in Section 15.1.2. It is also not uncommon to find beehives and sometimes sheep in vineyards, as part of a wider food production benefit.

Notwithstanding the above opportunities, it should be noted that vineyard land often replaces arable or pasture land and therefore opportunities for these farming types are reduced where land is converted. Furthermore, whilst rotated cropping provides variety year on year, vines are perennials and so crop/food production variety is further limited.

15.2.3. Energy

Within vineyards, opportunities for energy production are limited. Winery buildings and related infrastructure do have potential for renewable energy production through solar, wind and ground (thermal) sources. Opportunities to maximise these benefits should be sought by wineries/producers.

15.2.4. Genetic diversity

Significant opportunity for genetic diversity exists in vineyard environments, through grapes (varieties) themselves, the diversity of flora and fauna (Section 15.1.5) found in vineyards, soils, microbial communities, diseases and yeasts. Good soil management and the promotion of biodiversity goes a long way to sustaining this diversity.

15.3. Cultural services

15.3.1. Inspiration/spiritual values

Vineyards can provide inspiration/spiritual cultural services but not necessarily to a greater or lesser degree than the land use they are replacing. The degree of inspiration and spiritual value is somewhat subjective.

New and expanding vineyards bring about changes to the landscape character and whilst scale, location, previous land use and business models are likely to be key factors in determining acceptability, there are many other factors that could be taken forward in any technical note or guidance the SDNPA should choose to develop.

Even if not bound by a requirement for planning permission or environmental impact screening, the same issues that are studied with a landscape and visual impact assessment (LVIA) should be best practice for new and existing vineyards.

15.3.2. Tranquillity (and wider landscape impacts)

Vineyards are generally more intensively managed compared with the management of the land they often replace and can therefore impart a reduction in tranquillity. The sense of tranquillity may be further diminished by winery related developments/infrastructure and operations due to equipment noise, management activities and vehicle movements and lighting, which could also negatively impact the SDNP's dark skies at night. The Chalk Valleys, Dip Slope, Scarp Slope, Western Downs and Western Weald (areas with the most viticulture

potential) could all be negatively affected in terms of tranquillity by viticulture and wine production.

As set out in Sections 7 and 10, vineyards in the SDNP are managed to varying degrees of intensity which will impact relative tranquillity.

Within Section 11.4 of this study, both subjective opinions and objective statements were made about the impact of vineyards in the landscape and on the landscape character. There are both general recommendations regarding all vineyards (potential and established) and specific recommendations based on the sensitivity of a particular landscape character, which should be considered by both vineyards and the SDNPA, in relation to visual and character impacts. To reduce potential landscape and tranquillity related impacts the following recommendations are made:

a. When 'designing' a vineyard in the National Parks or AONBs, due care and consideration should be made to its visual impact to inform mitigation actions. A simple visual impact assessment for vineyards could be devised and provided as a helpful tool by the protected landscape authorities. This may include, for example, a viewpoint or visibility/visualisation assessment (see examples in Section 11.4.) that influences the choice of trellising materials (colour, type, etc.) or the colour of grow tubes, or which helps aid decisions over row orientation (best-fit) or, within reason, areas for establishing screening or biodiversity alongside the need for the optimum viticulture locations.
b. For both viticulture and landscape impact purposes it is not recommended that vineyards are planted above elevations of approximately 150 m, nor on north-facing slopes or slopes with inclines of more than 15%. Vineyards above 150 m elevation are likely to have a significant impact on the top of the Downs in particular – that high plateau where true remoteness and 'escape' can be experienced. Other landscape character areas each have their own sensitivities:

    i. The open downland character area is hugely visually sensitive and has a large recreational audience. The South Downs Way (SDW) is an obvious highly sensitive route, but there are many others.
    ii. The same applies to the Wooded Estate Downland – there are large, open areas, including Amberley Mount and South Harting Hill, which would be completely changed by the presence of vineyards. However, there are also large arable fields away from the SDW, to the south, where viticulture could easily be accommodated in landscape terms.
    iii. Major valleys and valley floors often share many characteristics, but once they are explored in detail their unique riparian characteristics manifest very quickly. Many are unsuitable for viticulture.
    iv. Greensand Hills are likely to be quite sensitive due to their remote character, high degree of wildness (probably the highest in the SDNP) and a predominantly pastoral, still landscape with much historic intactness. Large areas of common land and uncultivated open access exist, as does a network of sunken lanes vulnerable to increased traffic and with poor transport links. This is a somewhat 'secretive' and enclosed landscape where scale is likely to

be of significant importance when considering viticulture and potentially associated activities.

v. Upper coastal plain areas are potentially less sensitive, and there are vineyards already established in these areas.
vi. The Hampshire Downland Mosaic and Clay Plateau areas, owing to their higher levels of enclosure and undulating topography, would potentially better accommodate viticulture. As with the Low Weald, sensitivities exist with regards to the thinning or lopping of boundary trees to reduce shading or increase viable area, and these must be considered.
vii. The Low Weald is a variable landscape, although quite viable for viticulture in landscape terms owing to its undulating and enclosed character. The Milland Basin would be potentially more sensitive due to its quiet, still and enclosed nature. It is also extremely wet; roads are on causeways and in winter it is a watery landscape.
viii. Sandy, arable farmland areas are well established as intensive agricultural land and vineyards also already exist there, so these areas would seem to comprise a less landscape-sensitive location, with the additional benefit of also having good transport links.

c. Surfacing, drainage, contours and distant views can affect whether access tracks appear 'natural' and 'acceptable' in the landscape. Tracks straight up and down slopes are usually less successful in landscape terms and, through a visual impact assessment, optimal locations for tracks, that do not impact productivity or operational effectiveness, can be integrated into vineyard designs.
d. Where open to the public, vineyards and wineries should provide walking routes and benches or viewpoints from which people can enjoy the countryside, vineyard views, and rural environment, often with associated peace and quiet.
e. A slow-growing seed mix should be used to reduce the number of cuts/mows required in a vineyard, which in turn reduces noise.
f. Mowing should only be carried out when necessary. This activity could be combined with others, such as spraying, where possible by simultaneously using both the front and rear power take-offs of a tractor.
g. Wineries should use chiller units with a low noise output and position them in areas where the greatest noise attenuation can be achieved.
h. Deer, rabbit and badger fencing should only be erected where essential.
i. Existing and natural features may be used for screening of buildings or to help reduce visual impact.
j. Winemaking operations should be planned with impacts on highways and traffic in mind. General site access and servicing, access for large vehicles and the delivery of oversized items (e.g. wine tanks, offsite construction items) should be considered. Where any form of wine tourism is planned, appropriate allowances will be required for car (and potentially coach) parking. Sensitive landscape designs may need to be considered to mitigate the visual impact of large areas of parking and access roads.
k. Mitigate potential sources of noise and light pollution from wineries. Wineries are not generally a source of significant noise in day-to-day use. However, seasonal activities such as bottling, the pressing of grapes, and vehicular movements are potential issues that may need to be considered. Heat pumps, which are required to maintain a constant temperature in the wine tanks, may be a source of nuisance if they are

located without due consideration to adjacent properties or sensitive locations such as a Public Right of Way.

l. Light pollution from artificial lighting is a sensitive issue in the countryside, particularly within a National Park or AONB. Dark Skies policies provide helpful guidance as to what is acceptable.

15.3.3. Cultural heritage values

Vineyards and wineries can promote local and regional cultural heritage, and indeed often integrate elements of this into their brands and products. Vine growing and wine production are part of the heritage of the protected landscapes, and opportunities exist to further integrate them into local and regional identities, cultures and traditions. Marketing, events, pride and socio-economic benefits all build heritage value, and it is recommended that where vineyards and wine production deliver these aspects in line with the protected landscapes' purposes and duty, they are supported to deliver these values.

The '*terroir*' (sense of place) that reflects the unique aspects of a wine producing region and its winemaking traditions is a key component of wine marketing.

15.3.4. Recreation and tourism services

Vineyards and wine production businesses can provide significant recreation and tourism related opportunities. These are evidenced in the protected landscapes through:

- Vineyard walks and tours;
- Catering facilities and cellar door experiences;
- Accommodation;
- Car parking and bicycle racks;
- Cycle rides;
- Meeting spaces (including wedding venues);
- Wine routes and visitor guides;
- Shops; and,
- Sports opportunities, e.g. running races etc.

Using case studies from elsewhere, as set out in Section 13.7, it can be seen that effective marketing of winemaking areas as tourist destinations can be beneficial to both vineyards and the local economy. However, these ecosystem related benefits can lead to increased traffic, noise and nuisance. In the Dip Slopes and Scarp Slopes in particular (see Table 17), visitor numbers have already been identified as a key pressure on natural capital.

Only about 20% of vineyards in the SDNP that were surveyed for this study were open to the public. There are significant opportunities to learn from those who are open and to explore opportunities to provide access, education and wellbeing within a vineyard environment. See Figure 61, for example, showing walkers enjoying a Surrey Hills AONB vineyard.

Figure 61. Walkers enjoying a Surrey Hills AONB vineyard.

Whilst not all vineyards have the resources or desire to open to the public all or part of the time, where they do the potential for education, from school children to adults, is great. The Greening Waipara project, in New Zealand, provides visitors with noticeboards and talks about viticulture, native vegetation, ecology, biodiversity, ecosystems and natural capital (see Figure 62). Such an approach could be extended in the UK to include education around climate change impacts, adaptation and mitigation, as vineyards are so closely linked to this topic.

Figure 62. Greening Waipara education board.

Furthering the theme of education, there are examples of vineyards in the UK that encompass community, volunteering and ecotherapy opportunities within their businesses, for example at Capel Manor College and Rathfinny Estate (in the SDNP). Genuine connections between the community and the land can be facilitated in this way.

Tourism opportunities are significant in viticulture and wine production and are of benefit to both the local and wider economy (see Section 13), and to producers' sustainability. Whilst

sensitivities require careful planning and management, vineyards and wineries can provide opportunities for residents and visitors alike to enjoy, appreciate and better understand the landscapes, history and environments within National Parks and AONBs.

It is recommended that further, specific research be undertaken into the economic and tourism benefits from vineyard and winery clusters, and how these opportunities can maximise ecosystem service benefits whilst reducing risks to local communities. Other related recommendations are:

- Provide the public/tourists with further information regarding vineyards or wineries that are open to the public and/or which offer tours (guided or self-guided) or visitor experiences.
- In conjunction with other local authorities, review and optimise public transport links to wine destinations.

The amenity experience of Public Rights of Way (PROW) is protected within the SDNP Local Plan (2019). PROWs need to be maintained but could be fenced through vineyards or along vineyard boundaries, creating a hitherto sense of enclosure and constriction which would be a change from walking through or around an unfenced pasture or arable field. Views may be blocked or channelled in such cases and the experience of using the PROW considerably changed. It is recommended that vineyards are designed with PROWs taken into consideration, potentially providing wider field/fence margins or accommodating PROWs within the vineyard environment.

15.4. Regulating services

15.4.1. Pollution (and public impacts)

Pollution can be produced by vineyards and wineries, for example through tractor and machinery use (unless they are electric), by visitors, through pesticide leaching (see Water Quality and Sections 7 and 10), wastewater and winery energy consumption.

However, pollution and the wider environmental impact of viticulture goes beyond the vineyard, and this point was not missed by those interviewed and surveyed for this study. One of the concerns expressed by stakeholders was that of spray drift. In addition to the recommendations regarding spray reduction and spray optimisation, it is recommended that vineyards should:

a. Spray only in suitable weather conditions (no rain and low or no wind) and only when necessary.
b. Be considerate of neighbouring properties and people who live and work in areas where spray drift may impact. Schemes such as the Good Neighbour initiative (National Farmers Union, 2018) exist to help sprayer operators adhere to legal requirements, as set out in the Code of Practice for Using Plant Protection Products and other guidance from the Health and Safety Executive, but also to highlight extra steps they can take to help relationships with neighbours, bystanders and the general

public when carrying out spraying operations. These initiatives and guidance should be followed by anyone spraying in vineyards.

Comments were also made by stakeholders during this study about vineyard sundries 'littering the landscape', with particular reference to grow tubes becoming detached from vines or being left unused/discarded within vineyards, blowing beyond vineyard boundaries or remaining loose in the countryside, i.e. as litter. It would seem reasonable (and is in fact a legal duty) that vineyards do everything they can to prevent this happening and be open and receptive to collecting any such 'lost' grow tubes, or indeed any other litter. Additionally:

c. Vineyards could further explore obtaining B Corp Certification to demonstrate verified high standards of social and environmental performance, public transparency, and legal accountability to balance profit and purpose.

15.4.2. Pest and disease management

Sections 7 and 10 provide further guidance on pest and disease management. It was not the aim of this study to provide a comprehensive manual or training on such a core component of viticulture. However, it is recommended that there is a focus on Integrated Pest Management techniques, which reduce the need for pesticide use, and that they should be adopted as part of a knowledge sharing forum between growers and experts in protected landscapes. The WineGB sustainability initiative may be a suitable medium for this.

Sprayers that are more efficient (whilst still being effective) at targeted applications and reducing drift are of course beneficial. Schemes such as the Voluntary Initiative and the Good Neighbour Initiative should be more actively promoted to vineyards.

15.4.3. Water quality

Further research is needed into pesticide leaching and run-off potential from vineyards, but leaching may be reduced by using a cover crop. Likewise, nitrogen leaching may be reduced by the direct uptake of residual soil nitrogen by cover crops, but also by decreasing runoff and stimulating microbial activity that could promote nitrate immobilization and recycling.

15.4.4. Soil quality

Soil formation is addressed in Section 15.1.1, and there is some overlap with this soil quality Section, so the two should be read in conjunction with each other. Section 10.1.1 identified that vineyard soils are critical to vine health and vine performance and that the preservation and enhancement of vineyard soils are of benefit to the wider environment.

We recommend that professional agronomists and/or viticulture scientists with expertise in soil are consulted by vineyards to advise on soil preparation and management pre- and post-planting. Both initial soil preparation and ongoing management should be informed by the proposed ecology/biodiversity baseline study recommended in Section 15.1, which would identify local and wider sensitivities and risks to soil quality. To facilitate this, and prior to planting, a thorough soil profiling (down to a depth of 2 m), soil sampling (within the top 40

cm) and analysis (by an approved laboratory) exercise should be undertaken across all potential vineyard areas. The results would inform site suitability, amelioration requirements, and risks to soils from, for example, erosion or nitrate vulnerability. Guidance on specific profiling and analytical requirements should be provided by an agronomist/viticulturist, but the process should involve assessments of, at a minimum, erosion risks, drainage capacity, soil texture/structure, pH, organic matter content, macro- and micro-nutrient availability and active calcium rates.

The following additional recommendations are not to be considered a comprehensive guide to vineyard soil management and should be further informed by agronomy or viticulture soil science advice. To help preserve and enhance the soil quality in vineyards in the protected landscapes it is recommended that:

a. Winter cover crops should be established on land prepared for vineyard planting the following spring, to reduce water- and wind-derived erosion risks.
b. Where viable (determined by expert advice), cultivation and soil preparation pre-planting should be restricted to the narrow strips of land to be planted with vines, i.e. rather than cultivating whole fields. This is not common practice (although one producer interviewed for this report had done so) and sharing of knowledge about this technique is limited. Further research to inform a potential technical advisory note, that considers both the advantages and disadvantages of this approach, should be undertaken, potentially through the WineGB sustainability initiative.
c. Soil and petiole testing (via an approved laboratory) should be regularly undertaken across a vineyard site (approximately every 2 years; petiole testing more frequently if vine nutrient deficiencies are apparent), to determine soil quality changes, amelioration requirements (in conjunction with an agronomist/viticulturist) and plant nutrient needs, so that applications can be targeted. Improved awareness of specific vineyard areas that are at risk will aid better adoption of precision management/viticulture techniques.
d. Organic matter should be returned to the soil by mulching winter prunings onto the vineyard floor (unless the risk of disease is deemed too high); where possible grape marc/pomace from wine production should also be returned to the soil.
e. Compost (especially PAS100 compost) should be used when and where required, instead of artificial fertilisers, as it replenishes ground organic matter and improves soil carbon.
f. There are pros and cons to both under-vine cultivation and herbicide use to suppress weeds. Cultivation aerates the soil, thus increasing the rate of soil organic matter mineralisation by microorganisms, leading to the loss of soil organic matter. Herbicide use reduces biodiversity potential. Both can expose soils to erosion risk. Once a vineyard has been established, growers should carry out trials, strimming under-vine growth (where competition is not problematic) or using low-growing indigenous cover crops to reduce the need for either cultivation or herbicides. In the UK, more research is needed in this area (some is underway at the time of writing), but similar research to find plant-based and economically viable solutions has been successfully undertaken in other viticulture regions, such as Waipara, New Zealand (see also Sections 15.1.5 and 15.3.4).

g. All-terrain vehicles (ATVs) should be used instead of tractors when possible, to reduce soil compaction. The use of wider tractor tyres and/or the combination of multiple operations (e.g. trimming and mowing) when operating machinery in the vineyard can also reduce compaction.
h. Using vineyard cover crops (as discussed previously) in inter-row (usually every other row or every third row) and non-planted vineyard areas can aid biodiversity (see Sections 10 and 15.1.5) and reduce mowing requirements, which in turn reduces soil compaction. If deep-rooting cover crops are used, they also aid water infiltration. Winter cover crops, such as peas, clover and mustard, will help to significantly increase nitrogen content in the soil (if required) and contribute to soil biomass (if used as a green manure). In turn, this also aids water holding capacity and reduces risks associated with run-off, e.g. erosion.
i. Where and when appropriate (more commonly in the winter months), sheep grazing in vineyards is compatible with most cover crops and can reduce mowing requirements and associated soil compaction.
j. The number of tractor operations should be kept to a minimum in vineyards with wet or moist soils, to avoid soil compaction.

15.4.5. Erosion

Recommendations regarding the reduction of soil erosion are set out in Section 15.1.1.

15.4.6. Water flow and flood

Vineyards in the protected landscapes are generally not established in flood prone areas. Ground cover in vineyards improves rainfall infiltration and reduces run-off.

15.4.7. Climate and carbon storage

As has been set out in this report, viticulture and wine production within the protected landscapes has significantly benefitted from changing climate conditions over the last 20 to 30 years. Projections presented in Section 9 indicate significant future warming, which, all else being equal (including market demand), will further boost yields, offer potential for variety and wine style expansion and is likely to attract further interest and investment in the sector. Simultaneously, viticulture offers a form of climate change adaptation for other land uses.

However, although vines and vineyard ground cover provide a valuable route for carbon sequestration (Winkler, Viers, & Nicholas, 2017), there is more that vineyards and wineries could do with regards to climate change mitigation:

a. Efforts to measure and reduce fossil fuel usage and greenhouse gas (GHG) emissions should be adopted by growers. There is an effort underway (the WineGB sustainability initiative) to devise a process/tool by which growers can measure their carbon footprint and GHG emissions and learn about means of reducing them. None of the managers surveyed for this study calculated their carbon footprint or GHG emissions per ha of vineyard.

b. CO_2 is emitted as a by-product of fermentation, and the technology exists to capture this CO_2. Such opportunities should be investigated by wine producers.
c. Electric vehicles for use in vineyards are increasing in popularity and availability. As the technology advances it is likely that we will see greater uptake within the sector, and this should be encouraged.
d. Tractor operations should be reduced by combining them, e.g. by trimming vines and mowing alleys in the same pass.
e. Winery buildings and related infrastructure offer significant potential for energy generation from renewable sources (wind, solar and ground); again, these should be encouraged through incentives and planning policy.

15.4.8. Air quality

Air quality in vineyards and from wineries could be improved through a migration to equipment and vehicles powered by renewable energy. Air quality can also be improved through better management and a reduction in pesticide use. There are significant opportunities for technological adaptation and adoption in viticulture (precision viticulture). Automated mowers (that are quiet and clean), drones, robotic implements, remote sensing, etc. all provide avenues for green technology that contribute to cleaner air.

15.5. Wineries, winemaking and associated activities

New or expanded facilities for wine production, storage or ancillary activities are likely to require planning permission. The process through which this permission is sought provides the framework and structure for recommendations regarding building style, size, setting, etc. (see Section 5.4. for the planning policy context). The SDNPA planning pre-application process should be referred to for any potential planning applications.

15.6. Education and sharing best practice

All the Vineyard managers surveyed confirmed they would welcome more dialogue with representatives concerned with environmental conservation in their protected landscapes. Recommendations to foster an open dialogue that may lead to more structured support include:

a. An introductory guide should be produced for those thinking of planting a vineyard, along with guidance for consultants and land agents advising clients about land suitability and viticulture.
b. A dedicated protected landscape vineyard group should be established to discuss and share best practice and initiatives that are mutually beneficial. Potentially, a group could also be set up to seek collective support for relevant research or trials work.
c. Rangers could be encouraged to attend these, to learn about vine cultivation and subsequently work with growers in supporting best practice. The SDNPA could train specific rangers to specialise in viticulture, who would liaise with the vineyard managers and champion best practice.
d. Broaden out existing farm clusters (groups comprising farmers, land managers, foresters and other local partners who join to secure funding and benefit the

environment) to include vineyards and wineries. This concept may well be suitable for extension to include vineyards and wine producers. It may also be beneficial to form new viticulture clusters.

e. Interactions with education and relevant research offerings for viticulture and wine production within the UK should be encouraged, such as at Plumpton College, NIAB East Malling Research, Brighton University, Sussex University, the University of East Anglia and others. It is also recommended that training and retraining requirements and opportunities in the National Park are reviewed, so residents can take advantage of the skilled roles in this sector, as has been seen in other growing and established wine regions.

15.7. WineGB sustainability scheme

The recommendations set out above that relate to vineyards or wineries could be adopted (partially or collectively) and put into practice with support from sustainability schemes, such as Linking Environment and Farming (LEAF) or Red Tractor, organic or biodynamic schemes, or through the new WineGB sustainability scheme (Sustainable Wines of Great Britain; SWGB). This scheme provides guidance for how producers can improve biodiversity across their vineyards without detrimental effects on economic viability and be certified as environmentally sustainable.

SWGB publishes six e-bulletins a year, with information on sustainability issues such as vineyard soil management, water use in wineries and crop management. These bulletins are sent directly to WineGB members and form the basis of the sustainability information area on the WineGB members' website. The scheme encourages and enables WineGB members to achieve the following vineyard objectives:

- Maintain and improve soil health;
- Optimally manage vineyard canopies and yields;
- Reduce and optimise pesticide inputs;
- Conserve the vineyard (and surrounding) environment and promote biodiversity; and,
- Reduce vineyard energy inputs, greenhouse gas emissions and carbon footprint per hectare.

To comply with the Scheme, members follow recommended guidelines. They must observe, measure and record data relating to the sustainability objectives described earlier, which will then be benchmarked against those of other members. Run by WineGB members for the UK wine industry, members will then be tasked with developing new guidelines, so that all scheme members can work together to achieve the core objectives. The scheme is validated by an independent auditor, and wines produced in scheme-approved wineries, using grapes produced in approved vineyards, will bear a Certification Mark (Figure 63).

Figure 63. WineGB Sustainable Wines of Great Britain Certification Mark

15.8. Policy and guidance

It is hoped that this report will provide the context and baseline knowledge that will enable the South Downs National Park Authority to establish an informed view on vineyards and wine production. It is also hoped that the Authority will now be able to forge stronger links with growers and producers and vice versa, which may result in guidance and relevant policy.

Heritage preservation is a guiding principle of the SDNPA and, the changing climate and evolving landscape of the National Park notwithstanding, the working landscapes of vineyards are not new. Indeed, the growth of commercial viticulture since the 1950s has been a positive contributor to local economies, a 'good farming story' to tell, and is generally supported by central Government. When combined with good, careful and considered practices, viticulture environments can be enhanced beyond those possible in the arable or pastureland that they replace.

Some grape growing regions of the world have adopted vineyard planting planning regulations, for example in Santa Monica, California. UK industries such as forestry have also established standards for sustainable management, which are applied to all woodland, regardless of who owns or manages it. However, no such regulations exist in the UK for viticulture. Indeed, beyond spray-related regulations and environmental impact assessment requirements, there is little active regulation of vineyard activities. Yet, there are a multitude of opportunities presented herein that protected landscape authorities could adopt or foster (subject to resources) that would promote best practice, knowledge and understanding for the mutual benefit of their areas and vineyards.

16. Conclusions

The recent significant expansion of viticulture and wine production within the SDNP has raised questions over associated environmental, economic and social impacts. The SDNPA is objective and open in its view on the challenges and opportunities that viticulture and wine production expansion could bring. They commissioned this study to better understand the impacts, to inform a consistent approach and to meet their strategic, statutory and policy objectives.

Through stakeholder engagement, policy driven impact assessments, modelling, and expert knowledge and analysis, this study establishes a benchmark of existing common viticulture practices and begins to identify best practice that should be adopted where possible to reduce risks or harm. It also assesses future growth potential, climate change and landscape impacts, and the economic and socio-economic opportunities that viticulture and wine production could bring. Opportunities for employment and economic contributions are set out more fully in Section 13, and they should not be underestimated within a changing and challenging agricultural landscape. Recommendations are made (Section 15) for authorities and production businesses. These are not exclusive, but they include suggestions for a framework through which research, engagement and policy-system harmonisation could be explored further. Within the contexts of preservation and enhancement, changing landscapes, working landscapes, agriculture change, climate change, a rural economy and social interaction and wellbeing, the notion of guided adaptation seems central to informing next steps.

Whilst not all findings are repeated or concluded here, those of key significance are:

- There has been a significant recent expansion of vineyard area in the UK (>300% between 2005 and 2019), including within the protected landscapes this study is concerned with, and English wines are receiving significant acclaim for their quality. Whilst climatic suitability is likely to increase under climate change scenarios, the degree of diversification or investment into viticulture at different spatial and temporal scales remains unknown, as socio-economic factors are likely to be of significant influence. However, in the medium-term at least, vineyard area can be expected to increase, as can yields and the range of varieties grown. There is likely to be expansion and pooling of production facilities (as found elsewhere in more established wine producing regions). Combined, these factors may well drive further vineyard and winery investments and a desire to establish in the National Parks and AONBs.
- Vineyard area currently comprises 0.26% (436 ha) of SDNP land area yet there is approximately 40,000 ha of terrestrially and climatically suitable viticulture land in the SDNP. However, all the SDNP landscape character areas are sensitive to land use change – perhaps unsurprising for a nationally protected landscape. Within each character type, these sensitivities (environmental, visual and capacity related) must be considered by those establishing vineyards and wineries. Local variability may offer more capacity for change (from a landscape perspective) to viticulture in areas classified as: sandy arable farmland, some Hampshire (western) Downland, the Low Weald, some of the Scarp footslopes, some lower elevation Chalk Downland and Wooded Estate Downland. The Chalk Downs, especially at mid to high elevations, are

very sensitive and one of the defining characteristics of the SDNP, and in these and other areas vineyards above elevations of around 150 m are likely to have a significant negative effect on the landscape character and impact iconic views within the National Park.

- The environmental and landscape impact of vineyards and wine production in sensitive landscapes has the potential to be high unless well managed. However, where best practice is employed, as in many of the vineyards surveyed and interviewed for this study, vineyards can mitigate, to varying degrees, many of the associated risks. Promoting biodiversity, for example, can readily be achieved in vineyards. Conversely, their landscape impact is harder to mitigate – linear rows of vines and trellising are of course different to pasture or arable landscapes, and notwithstanding mitigants such as vegetative screening and the use of trellising materials that better integrate into the landscape, there is a limit to what can be achieved to reduce this impact.
- A majority (53.5%) of the SDNPA Citizens Panel survey respondents thought that an increase in vineyards in the National Park would provide a positive impact on the views and general character of the landscape, while 11.8% thought they would have a negative visual impact.
- Most thought a growth in vineyards and wine production within the SDNP would positively benefit the local community, through training and employing more people (84%), diversifying and regenerating rural areas (76%) and enhancing the National Park as a tourist destination (52%). Results from Section 13 show that currently the sector contributes £24.5 million (gross value added (GVA)) to the economy, employs 358 FTEs (including seasonal labour) and attracts approximately 33,000 visitors to SDNP wine destinations each year. A modelled growth scenario, based on 2.5% of suitable land area in the SDNP being established with vines, shows contributions to the economy of £127 million (GVA) and employment of 800 FTEs, and potentially more than 75,000 visitors to the SDNP each year.
- Significant concerns in relation to environmental impacts, for example pesticide/herbicide use and risks regarding leaching into chalk aquifers and spray drift, water use, noise and increased vehicle movements, were raised by the Citizens Panel, representatives of the Parish Council and community groups, and SDNPA members. This report makes recommendations (Section 15) for reducing these potential impacts.
- This study has reviewed, at a high level, the ecosystem service benefits that viticulture and wine production can bring, and also the risks they pose to these benefits. It has reviewed the concepts of natural capital to produce a roadmap to developing a natural capital account for viticulture. In this context, it is important to recognise that viticulture expansion needs to be assessed alongside other pressures on natural capital. Findings presented earlier in this report suggest that although vineyards can present significant opportunities for biodiversity, climate and carbon storage, and recreation and tourism, their net gain is often dependent on the status of land they are replacing and how they are managed. Likewise, nutrient cycling and soil quality benefits and risks are very much dependant on practices employed in vineyard management. Comparative potential benefits and risks associated with genetic diversity, pollution, inspiration and cultural heritage require further research. Possible risks associated with pesticide leaching were also identified as requiring further

research. Tranquillity, one of the key features of the protected landscapes, was deemed to be lower with viticulture compared with that of the land uses it often replaces. Section 12 also identifies that there are certain areas within the National Park (i.e. the Chalk Valleys, Dip Slope and Western Downs) where the underlying natural capital could be especially sensitive to change.

- Some vineyards and wineries could be better neighbours and landscape custodians than they are, and several initiatives are recommended in Section 15 to facilitate improvements in these areas.
- Education is a recurring theme from this study, and recommendations are made in Section 15 to establish processes and schemes that facilitate the evolution and adoption of best practice and good environmental stewardship, particularly considering the limited regulation and oversight of viticulture by third parties.
- There are clear opportunities for exemplary winery design and the sensitive development of winery related infrastructure within protected landscapes. However, recommendations for such are restricted to guidance and process offered through planning policy (Section 5.4.). Development scale (of vineyards and winery related infrastructure) is very important in weighing up associated risks and opportunities, as this will often determine how significant the 'impact' could be.

Viticulture and wine production in marginal climates are not for the faint hearted. Capital investment requirements are high, returns a long way off (if ever!) and challenges to achieve and maintain commercial viability are not to be underestimated. However, this adaptation to climate change and the pressures on and opportunities for protected landscapes are broadly well received and supported by local populations and by central Government. The 'success story' talked about by WineGB is one that local populations can be proud of. This success is largely due to the investments and dedication of vineyard and winery owners, but also to the unique environment that provides vineyards and wine producers with the special sense of place and character, which makes such an important contribution to the wine and evolving wine culture and heritage.

Recommendations and findings presented herein are now for vineyards, wine producers and the South Downs National Park Authority to consider, adapt and potentially adopt. There is partial synergy between these recommendations and the new WineGB sustainability initiative, which should be explored further. What is apparent is that there is a real desire for the National Park Authority to adopt a closer interface with producers.

Appendices

Appendix A – Authors' biographies

Dr. Alistair Nesbitt (*Vinescapes*): Primary author and editor

Alistair is a leading viti-climatologist with 20 years' experience in the wine production and viti-climate research sectors. He holds a PhD in viticulture and climate science and lectures internationally on viticulture – climate – environmental relations, consults to new vineyards, governments and the global wine industry. Alistair is CEO of Vinescapes (vinescapes.com), a research-based consultancy that provides the viticulture (grape growing) and wine production sectors (internationally) with a bespoke portfolio of research, environmental risk management, suitability modelling, grape growing and wine business consultancy.

Alistair has previously worked and lectured within the Plumpton College Wine Department (near Lewes, East Sussex) and was responsible for managing the sector-wide (WineSkills) sustainability initiative in 2012 – 2013 to establish guidelines and training resources for sustainable viticulture and wine production in the UK. These have been adopted by many producers to improve best practice within the sector and are currently being used as the basis for a certified English sustainable wine production scheme.

Prof. Steve Dorling (*University of East Anglia & Weatherquest Ltd*): Contributing author – Climate Change Impacts, and sub-editor

Steve is Professor of Meteorology at the University of East Anglia and a Chartered Meteorologist specialising in food, water and energy security. He is highly experienced in working with stakeholders to capitalise on meteorological knowledge and data and in the co-production of decision support tools and climate services. In the agriculture sector, Steve works with a wide array of industry and research collaborators including KWS, British Sugar, BBRO, John Innes Centre, Wines of Great Britain, NIAB-EMR, Berry Gardens and VegPro. Steve is also Chief Executive of Weatherquest Ltd (weatherquest.co.uk), a weather forecasting and analytics SME which has delivered £7M of weather and climate business-to-business services. Weatherquest is a partner on two active InnovateUK- and DfID-funded agri-tech projects concerned with fruit and vegetable production.

Chris Foss (*Chair of WineGB's sustainability scheme*): Contributing author – Environmental Impacts

Chris was head of the Wine Division at Plumpton College (UK) for more than 30 years, prior to which he managed his family's vineyard in the Entre-Deux-Mers and worked in Sauternes (Chateau d'Yquem) and St Emilion (Bordeaux, France), becoming winemaker for the GFA Leclerc vineyard group.

Whilst at Plumpton College (since 1988) Chris developed an international centre of excellence in wine training, education and research. Chris lectured principally in vineyard establishment

and management, vine protection, soil and vine health, and sustainable viticulture. He also established and managed Plumpton's 10-ha vineyard. His principal research interests lie in climate change and vineyard sustainability. He publishes regularly in industry journals and has presented at conferences in France, Austria, Germany, Spain, Australia, China, Romania, New Zealand and the USA. He was Chair of the South East Vineyards Association (and a Council Member of the UK Vineyards Association) and led the team that co-ordinated the programme for the highly successful ninth International Cool Climate Wine Symposium, held in Brighton (UK) in May 2016.

Chris is now actively encouraging and supporting grape growers and winemakers in producing sustainable wine through chairing the WineGB Environmental Sustainability Workgroup.

Lionel Fanshawe (*terra firma landscape architects*): Contributing author – Landscape and Visual Impacts

Lionel is Managing Director at terra firma and is a landscape architect and elected fellow of the Landscape Institute. He has worked for private practices and public bodies in the UK, USA and New Zealand (where he was Project Landscape Architect for the 1990 Commonwealth Games Village). He is well versed in environmental impact assessments and has frequently appeared as an Expert Witness. Lionel is also Chair of his local Parish Council and co-ordinated the production of its Parish Plan; he sat on the East Hants District Council's Architect's Panel, was a founder member of the South Downs National Park Design Review Panel 2012 – 2016 and currently sits on the NE Hants Design Panel.

Terra firma has worked closely with the SDNPA over a number of years, undertaking work including: providing landscape advice to the SDNPA Development Management team and members; producing landscape assessments for a number of Strategic Housing Land Availability Assessment sites within the National Park; providing specific landscape and visual assessments for proposed developments affecting the National Park and assisting with the SDNPA Settlement Context Study, which contributed to the landscape evidence base for the South Downs Local Plan. As well as undertaking this work for the SDNPA, terra firma has extensive experience of working in and around the National Park for various clients including Parishes, local action groups and developers.

Paula Nesbitt (*Vinescapes*): Contributing author – Economic and Social Impacts

Paula is an ACCA chartered accountant and Fellow of the Chartered Certified Accountants with more than 20 years' experience in senior project management roles working across multiple disciplines, including finance, internal audit and risk. Paula joined Vinescapes in 2017 as Finance Director and Project Manager. Paula also works with clients in modelling and de-risking wine production businesses.

Prof. Andrew Lovett (*University of East Anglia*): Contributing author – Natural Capital Asset & Risk Register

Andrew is a Professor of Geography in the School of Environmental Sciences at the University of East Anglia. His academic background is in human geography and he has been involved in a range of projects concerned with applications of geographical information systems (GIS), landscape visualisation software and statistical techniques. Andrew has particular interests in issues of rural land-use change, natural capital and ecosystem services, future energy pathways and catchment management.

Appendix B – Vineyard interview questions

a) General conservation:
    I. How important is vineyard environmental conservation?
    II. What aspects of environmental conservation particularly concern your vineyard?
    III. Are you aware of any important natural habitats on, or around your vineyard?
    IV. Do you have a map of significant habitats or other conservation features on your vineyard?
    V. Have you taken any specific steps towards environmental conservation in your vineyard?
    VI. Do you discuss environmental conservation with your fellow workers?
    VII. Do you have a written policy?
    VIII. Do you regularly measure and record any aspects of environmental conservation?
b) Vineyard operations:
    I. The managers were asked to list the annual vineyard operations that they perform and state the number of times that they perform them.
    II. Which vineyard operations (outside of pesticide and herbicide application) present the greatest risk to the vineyard environment?
    III. How do you mitigate against these risks?
    IV. How do you maintain your soil's health and promote biodiversity in your soil?
    V. How do you maintain above-soil biodiversity?
    VI. Are you aware of the need to conserve target native species?
    VII. Are you aware of the need to control of non-native invasive species?
c) Vineyard inputs:
    I. The managers were asked to list the annual inputs (pesticides, herbicides & fertilisers) that they used in their vineyards and state the number of times that they applied them.
    II. Which vineyard inputs present the greatest risk to the vineyard environment?
    III. How do you mitigate these risks?
    IV. Do you have a LERAP assessment for your vineyard?
    V. What steps do you take to meet requirements for the nitrate vulnerable zone regulations (storage & application)?
d) GHG emission & carbon footprint:
    I. Do you calculate your greenhouse gas emissions per hectare of vineyard?
    II. How could you reduce your GHG emissions?
    III. Do you calculate your carbon footprint per hectare of vineyard?
    IV. Are you aware of the need for and methods of carbon sequestration?
e) Conclusions:
    I. What plans do you, or could you have for reducing the impact of your vineyard on the natural environment of the SDNP?
    II. How could SDNP support you in these plans?

Appendix C – Vineyard survey questions

1. General information

1.1. Your name
1.2. Vineyard Name
1.3. County
1.4. Postcode
1.5. Hectarage of planted grapevines
1.6. What are your % splits in terms of varieties that you grow?
1.7. What is your production volume (hector-litres/annum)?
1.8. What is your % split in terms of sparkling and still wine production?
1.9. Is your vineyard organic, biodynamic or conventional?
1.10. Do you have a winery within the SDNP? If so, what is its production capacity (in hector-litres, tonnes or bottles)?
1.11. If you have wine made by a contract producer, where is it made?

2. Vineyard Staff

Vineyard permanent employees (Full Time Equivalents):
2.1. How many full time equivalent (FTEs) are employed in your vineyard?
2.2. Please list the main roles performed by each member of vineyard staff.
2.3. How many years of experience does each member have, in similar roles?
2.4. What viticulture qualifications, if any, do your vineyard staff have?

Vineyard seasonal labour:
2.5. If you use seasonal vineyard labour approximately how many weeks per year are they 'on-site'?
2.6. How many seasonal labour vineyard staff are 'on-site' on average at any one time?
2.7. What is your source of seasonal vineyard labour? For example, local people, students or contracted labour?

3. Winery Staff

Winery permanent employees (FTEs)
3.1. How many full-time equivalents are employed in your winery? (if applicable)
3.2. Please list the main roles performed by each member of winery staff.
3.3. How many years of experience does each member have, in similar roles?
3.4. If any, what winemaking qualifications do your winery staff have?

Winery seasonal labour:
3.5. If you use seasonal labour in the winery, approximately how many weeks per year are they 'on-site'?
3.6. How many seasonal labour winery staff are 'on-site' on average at any one time?
3.7. What is your source of seasonal vineyard labour? For example, local people, students or contracted labour?
3.8. Please list the main roles performed by each member of seasonal winery staff.

3.9. What are your accommodation requirements and arrangements for seasonal staff?

Business employment:

3.6. What additional employment roles do you have as a business? E.g. office staff, shop staff, admin, management etc?

4. Vehicle movements

4.1. What are the total number of vehicle movements to and from your vineyard, and winery if applicable, on an average weekly basis, **excluding harvest**?

4.2. What types of vehicles visit your vineyard (and winery if applicable)?

4.3. What is the total number of vehicle movements to and from your vineyard, and winery if applicable, on an average weekly basis **during harvest**?

4.4. Approximately how many hours of tractor work is undertaken per ha per annum?

5. Social and environmental considerations

5.1. Is your company engaged in any local social inclusion or community interest activities?

5.2. Do you have an environmental impact/awareness strategy? If so, what does it cover?

5.3. Do you practice any environmental impact mitigation activities or strategies?

6. Tourism

6.1. How many visitors do you have to your premises on average per year?

6.2. What percentage of your production do you sell through your cellar door?

6.3. What is the approximate average spend per visitor (£)?

Appendix D – Data sources used in the characterisation of natural assets for the SDNP.

Table 24. Data sources used in the characterisation of natural assets for the SDNP.

Source Name	Indicator Details	Source Web Address (URL)
British Geological Survey	Bedrock geology, hydrogeology and soil parent material	https://www.bgs.ac.uk/opengeoscience/downloads.html
Soil Erosion by Water	Modelled soil erosion risk based on rainfall, soil, topography and land use information	https://esdac.jrc.ec.europa.eu/content/soil-erosion-water-rusle2015
Water Framework Directive	Information on boundaries and WFD water body status measures	https://data.gov.uk/dataset/wfd-river-waterbody-catchments-cycle-2
Water Resource Availability	The extent to which additional water may be available for consumptive abstraction	https://data.gov.uk/dataset/water-resource-availability-and-abstraction-reliability-cycle-2
CORINE Land Cover 2018	44 categories grouped into 8 Habitat Classes based on details in Mace et al. (2015)	https://land.copernicus.eu/pan-european/corine-land-cover
Agricultural Land Classification	Five categories of land quality, plus non-agricultural and urban land.	https://data.gov.uk/dataset/provisional-agricultural-land-classification-alc2
Carbon in Soil and Vegetation	Mean estimates of carbon density in topsoil and vegetation (tonnes per hectare)	https://eip.ceh.ac.uk/naturalengland-ncmaps/reportsData
Priority Habitats	Habitats of principal importance under Section 41 of the Natural Environment and Rural Communities Act (2006)	https://data.gov.uk/dataset/priority-habitat-inventory-england2
Chalk Rivers	Chalk rivers and streams recognised as Priority Habitat	https://data.gov.uk/dataset/f478556e-9eb5-4d4a-a0c6-78654860ebda/chalk-rivers
Nature Conservation Areas	Information on LNRs, NNRs, SSSIs, SACs, SPAs and RAMSAR sites	https://ckan.publishing.service.gov.uk/dataset and then search for site type
CROW 'Open Access' Land	The Countryside and Rights of Way Act 2000 (CRoW Act) gives the public right of access to land mapped as 'open country'	https://naturalengland-defra.opendata.arcgis.com/datasets/crow-act-2000-access-layer
OS Open Greenspaces	Locations of publicly accessible parks, playing fields, sports facilities, play areas and allotments	https://www.ordnancesurvey.co.uk/business-government/products/open-map-greenspace
Public Rights of Way	Rights of way data for most local authorities in England	https://www.rowmaps.com/

Carbon in Soil and Vegetation	Mean estimates of carbon density in topsoil and vegetation (tonnes per hectare)	https://eip.ceh.ac.uk/naturalengland-ncmaps/reportsData
Risk of Flooding from Rivers and Sea	Modelled risk of flooding published by the Environment Agency	https://data.gov.uk/dataset/bad20199-6d39-4aad-8564-26a46778fd94/risk-of-flooding-from-rivers-and-sea

The following points should be noted about the characteristics and processing of the datasets:

- CORINE land cover data for 2018 were used to provide information on the extent of habitats rather than the (Centre of Ecology and Hydrology (CEH), 2015) Land Cover Map. The CEH data have higher spatial resolution but, unlike CORINE, are not open data.
- Details of carbon sequestration in soil and vegetation were obtained from two separate datasets created by the CEH. These data did not include values for urban land, so information from the literature (Edmondson, Davies, & McCormack, 2014) was used to assign averages for soil and vegetation in these areas. In addition, the soils information only referred to topsoil (0–15 cm depth), so underestimates the extent of carbon storage in deeper layers of peat. However, there is little peat in the SDNP, so this is not a major issue.
- The Environment Agency data on water resource availability provide classifications of water bodies at a number of different flow percentiles. For this study, the Q95 details were used, which represent the flow that was equalled or exceeded for 95% of the flow record. Since Q95 is an indicator of low flow conditions it provides a relatively wide definition of where restrictions on abstraction might occur.

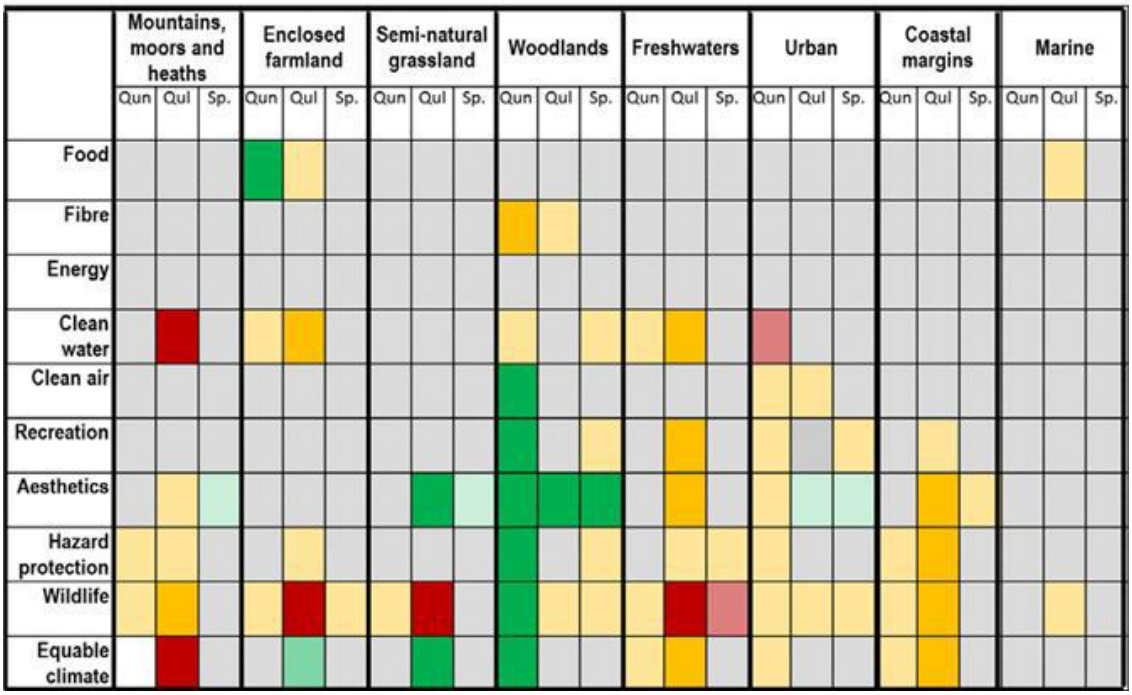
Appendix E – Development of a Natural Capital risk register; additional information.

Mace et al. (2015) constructed the first natural capital risk register for the UK, using a combination of existing data and expert judgement to highlight those natural capital assets whose current condition was such as to put at risk a sustainable flow of ecosystem services into the future. The register used eight Broad Habitat types (as adopted in the UK National Ecosystem Assessment and Follow On, (2014; 2011) and ten major benefits. These categories were as follows:

- Habitats – Mountains Moorlands and Heaths, Semi-Natural Grasslands, Enclosed Farmlands, Woodlands, Freshwaters, Urban, Coastal Margins and Marine.

- Benefits – Food, Fibre, Energy, Aesthetics, Freshwater, Recreation, Clean Air, Wildlife, Hazard Protection and Equable Climates.

For each habitat–benefit relationship, Mace et al. (2015) explored the influence and modification of quantity, quality or spatial configuration of habitat on the identified benefit (i.e. the provision of a usable service or good to human populations). Quantity was defined as 'the amount of an asset, its area, volume or mass'; quality as 'a range of more specific conditions of the natural asset [that] will be critical where the nature of habitat management or the presence of certain components or processes affects benefits'; and spatial configuration referred 'to the location of the asset and/or its spatial patterning and fragmentation' (Mace, Hails, Cryle, Harlow, & Clarke, 2015). This created a total of 240 relationships (8 x 10 x 3), as shown in Figure 64.



		Status		
		Above, at or just below target	Below target	Substantially below target (>50%)
Trend	Positive or not discernible	A	B	B
	Negative	B	B	C
	Strongly negative	C	C	C

	High confidence	Low confidence
Low risk	A	A
High risk (or risk unknown)	B	B
Very high risk	C	C

Figure 64. National risk register matrix (Mace, Hails, Cryle, Harlow, & Clarke, 2015).

The matrix describes the impact of modifying habitat quantity, quality and spatial configuration upon the capacity to provide a usable service or good to human populations. During the assessments, priority was given to 73 relationships where it was thought society had some influence (e.g. on the extent or management of a habitat) and the benefits involved were non-trivial. The assessed relationships were then placed in an institutional context and evaluated against existing societal targets, regulatory limits and policy commitments to derive scores of high, medium or low risk. Grey shading denotes relationships that were assessed not to be significant or where there was no information on which to base an evaluation.

The register in Figure 64 identifies seven relationships classed as high risk. These were cases where there was reasonable confidence that the current status of the natural capital assets in the relevant habitats was poor and/or the trends in quantity, quality or spatial configuration were strongly negative. Examples include risks to clean water and wildlife. In general, it was the quality of habitats that was most often the cause of a high-risk classification, and the Mountains, Moorlands and Heaths and Freshwaters categories had the most high or medium risk ratings. However, another feature of the analysis was the substantial degree of uncertainty, either because of substantial gaps in the knowledge base (e.g. regarding marine habitats) or low confidence in assessments (e.g. for urban areas).

Appendix F – Citizen Panel questions and responses

Four questions were asked of the Citizen Panel. The results are shown below. The respondents were able to tick all that apply.

Question 1. Have you seen or visited any vineyards within the South Downs National Park area? (The National Park runs from Winchester in the West to Eastbourne in the East). The respondents were able to select multiple rows.

Response Options – Tick all that apply	**Total**	**%**
Yes, I have seen at least one vineyard within the South Downs National Park	204	53.3%
Yes, I have visited at least one vineyard within the South Downs National Park	116	30.3%
I intend to visit a vineyard or winery in the South Downs National Park within the coming year	56	14.6%
No, I am not aware of any vineyards within the South Downs National Park	27	7.0%
I am aware of vineyards in the South Downs National Park, but I have not visited or seen any	78	20.4%
Total respondents	**383**	

Question 2. What impact (if any) do you think an increase in vineyards in the South Downs National Park would have on the views and general character of the landscape?

Response Options – Tick all that apply	**Total**	**%**
Very negative impact	5	1.3%
Negative impact	40	10.5%
No impact	60	15.7%
Positive impact	170	44.6%
Very positive impact	34	8.9%
Not sure	72	18.9%
Total respondents	**381**	

Question 3. Relating to the environmental impacts of an increase in grape growing or winemaking what would your concerns be?

	Total	**%**
Pesticide and/or herbicide applications	245	64.0%
Increase in water usage	166	43.3%
Increase in vehicle movements	109	28.5%
Vineyard and/or winery noise	24	6.3%
New buildings or a change in existing building use for wineries, storage etc.	73	19.1%
No concerns	101	26.4%
Other (please specify)	20	5.2%
Total	**383**	

Question 4: Vineyards and wineries are labour intensive and vineyards in particular employ more people per hectare than most other common types of agriculture. What other economic benefits could vineyards and wineries provide within the South Downs National Park that would be important to you?

	Total	**%**
Training and employing more local people	321	83.8%
Diversifying and regenerating rural areas	291	76.0%
Enhancing the South Downs National Park as a tourist destination	200	52.2%
None, I would rather not see an increase in vineyard or winery numbers	15	3.9%
Other (please specify)	17	4.4%
Total	**383**	

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