SUSTAINABLE WINEGROWING BRITISH COLUMBIA

Inspired people growing outstanding wine

Sustainable Practices for BC Vineyards

Condensed Guidebook

February 2016

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CHAPTER 1
SETTING YOUR SUSTAINABILITY FOUNDATION

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1.0 SETTING YOUR SUSTAINABILITY FOUNDATION

INTRODUCTION

Before starting this program you must first understand what sustainability means and how it relates to wine production. You also need to collect together information about your operation that will provide the foundation for creating a sustainability mission statement and completing the other chapters of this program.

Sustainability is a broad topic that means different things to different people. A common definition of sustainability is "meeting the needs of the present generation without compromising the ability of future generations to meet their needs" (The Brundtland Commission, 1987). Sustainability is more than just environmentally-friendly; it integrates protection of the environment, profitability, and social values. **Sustainable winegrowing reaches from soil to shelf.**

Implementing sustainable winemaking practices and measuring results is an ongoing process that does not happen overnight. **Sustainability is a journey of continual improvement rather than an end point.** The Sustainable Practices for BC Vineyards self-assessment and guidebook will help you to choose practices to implement over time and teach you how to monitor and measure the results of these practices.

The Sustainable Agriculture Research and Education Program at University of California, Davis, points out that a systems perspective is essential to understanding sustainable agriculture. A systems perspective involves viewing multiple factors when making decisions on the farm and realizing that each farm is part of a complex community ecosystem, which in turn can impact or be impacted by global economics and global ecological processes (e.g. El Nino).

Timelines for sustainable viticulture practices are not measured in a few years, but in decades and even hundreds of years. The impacts of unsustainable viticulture practices may only be felt by future generations. On the flip side, implementing sustainable viticulture practices and measuring results is also an ongoing process that does not happen overnight. The Sustainable Practices for BC Vineyards assessment and guidebook will help you to choose practices to implement over time and teach you how to monitor and measure the results of these practices.

DEFINING YOUR RESOURCE BASE

You cannot manage what you don't measure. Defining your resource base will help you describe where you are now so you can judge whether you are making progress as you implement sustainable practices. The resource base of your vineyard is all of the resources you have available to you to operate and manage your property and business. The intention is to put on paper what you already know about your vineyard so you can effectively communicate

that information to others involved in your vineyard operations (e.g. auditors, consultants, contractors, employees, emergency first responders). Identifying your resource base can also give you new ideas on how to manage your business.

1.1. Land Base – Mapping and Description

A **site plan** of your vineyard and the surrounding land is a necessary and invaluable component of sustainable viticulture. You can use a topographical, PARC Summerland GIS map, survey, or hand drawn map, or a combination of these. Air photos or orthophotos are also handy.

The site plan will provide the foundation for creating the following specific maps:

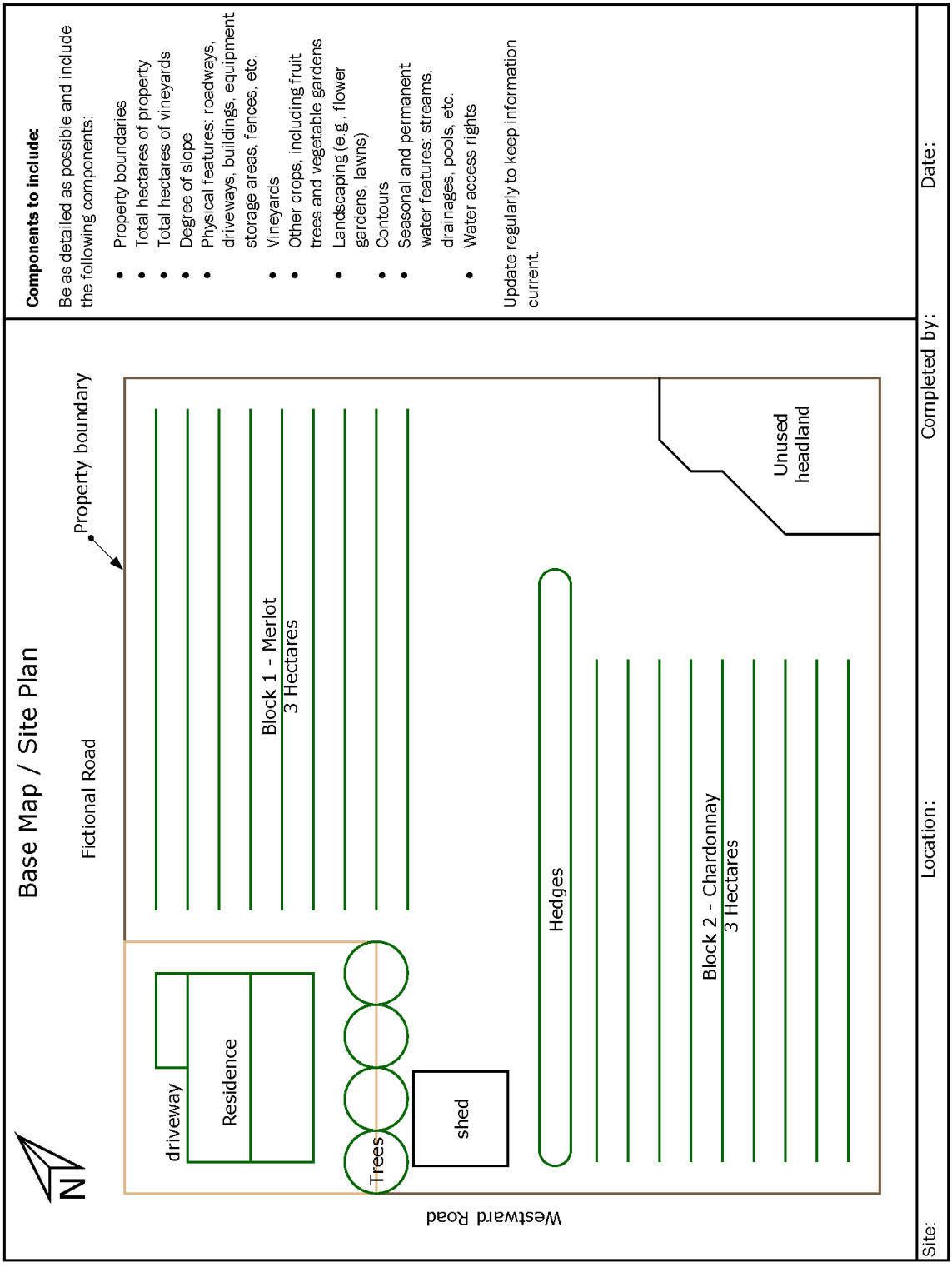
- Ecosystem management map, which will include environmentally sensitive ecosystems and features (Chapter 2)
- Soil management map (Chapter 4)
- Irrigation management map (Chapter 5)
- Pest management map (Chapter 6)

Your site plan should be accompanied by a written description. Be as detailed as possible and include the following components:

- Property boundaries
- Total hectares of your property
- Total hectares of vineyards
- Degree of slope
- Physical features: roadways, driveways, buildings, equipment storage areas, fences
- Vineyards
- Other crops, including fruit trees and vegetable gardens
- Landscaping (e.g. flower gardens, lawns)
- Contours
- Seasonal and permanent water features: streams, drainages, pools

Your mapping information will need to be reviewed regularly to ensure that the information is current. An example **site plan** of a vineyard is included below.

VINEYARD SITE PLAN EXAMPLE



1.2. Human Resources

List all people who have anything to do with the management or operations of your vineyard. **You can list the types of activities these people do rather than listing their names (e.g. fencing contractor, seasonal worker).**

This list will help you communicate with those who will be implementing the sustainable practices or whose activities could affect the sustainable operation of your vineyard. For example, say you made a significant effort to restore native vegetation along a property boundary only to have the fencing contractor bulldoze it because he or she did not recognize it as valuable habitat. Having the contractor listed as someone to whom you need to communicate your sustainable practices may have avoided the situation.

The list may include any or all of the following groups of people: family, friends, employees, contractors, stakeholders, neighbours, community members, bankers, agricultural advisory committees, agricultural regulators (governmental and private organizations), and environmental and conservation groups. Family members and friends should be listed so you can ensure they know how to react in case of an emergency or accident, for example.

1.3. Operational Resources

You may choose to develop two separate lists of operational resources – one that focuses on mechanical resources, equipment and buildings and one that focuses on financial resources and reference materials (e.g. manuals, guides). You may already have a list of equipment and machinery for insurance purposes. There will be some cross-over with your operational resources lists and your lists for land base and people.

CREATING A SUSTAINABILITY MISSION STATEMENT

A sustainability mission statement considers the fundamental ideas of how you wish to achieve sustainability of your vineyard. The mission statement will provide the framework for your viticulture management decisions.

1.4. Mission Statement

A **mission statement** is a formal, short, written statement of the purpose of a company or organization. You may already have a mission statement for your vineyard. If so, you do not need to write a new one, just incorporate sustainability into your existing mission statement.

A mission statement typically contains:

1. the purpose of the business or organization (e.g. to grow high quality grapes),
2. how this purpose is being filled (e.g. using sustainable techniques that protect the environment and provide social benefits), and
3. the principles and ideals that guide your work.

CHAPTER 2
ECOSYSTEM MANAGEMENT

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2.0 ECOSYSTEM MANAGEMENT

INTRODUCTION

Chapter objective: To encourage a balanced and holistic management approach that recognizes the vineyard as part of an interconnected system and adopts practices that reduce environmental impacts and contribute to biodiversity.

British Columbia is blessed with a rich variety of habitats and wildlife and distinct wine growing regions surrounded by stunning natural scenery. Some of the same factors of climate, soils, and geography that contribute to our healthy growing industry also support a diversity of unique ecosystems and plant and animal populations.

Although large areas of connected native vegetation support the highest levels of native biodiversity, smaller patches of native and semi-natural vegetation can also support many species. As the human population and development expands, many wildlife species increasingly depend on private land and working landscapes such as vineyards for all or part of their life cycle.

Ecosystem management is a balanced and holistic approach to managing natural resources that acknowledges all parts of the system as interconnected. Healthy and biologically diverse ecosystems provide many important goods and services to viticulturists that can reduce the need for inputs such as pesticides and fertilizers, increase the productive capacity of the land, and reduce production risks.

Viticultural activities can impact ecosystems and be detrimental to biodiversity. Impacts may include:

- Loss of habitat to land development;
- Altering the size and shape of habitats and the distances between them;
- Changes in surface and ground water levels from over-irrigation, which may negatively impact habitat and water quality, or dewatering of wetlands and riparian areas from water extraction;
- Reduction in nutrient uptake, cooling of soils, increase in erosion, and nutrient and chemical runoff into watercourses through over-irrigation;
- Soil, air and water pollution from improper use of production inputs; and
- Harming of pollinators such as native bees and natural predators such as hawks and snakes through the use of pesticides and rodenticides.

As a viticulturist, you have the unique opportunity to help support biodiversity on your vineyard and thus contribute to the resilience of ecosystems on your property and beyond. Vineyards provide habitat, food sources and breeding grounds for a variety of birds, amphibians and reptiles and can serve as corridors for wildlife as they move between habitats.

It is equally important to consider how an individual vineyard can contribute to biodiversity on a regional scale. Many animals and plant seeds and pollen move over large areas that extend well beyond the vineyard boundary. Meeting the needs of wide-ranging species requires management strategies that operate on a larger scale.

For more information on ecosystem management, see Chapter 7 and Chapter 11 of the EFP Reference Guide (https://www.bcac.bc.ca/ardcorp/program/environmental-farm-plan-program) and the EFP Planning for Biodiversity: A Guide for BC Farmers and Ranchers publication (https://www.bcac.bc.ca/ardcorp/program/biodiversity).

ENVIRONMENTAL FEATURES

This section will guide you through the identification of environmental features of your property; provide an overview of some of the ecosystem types you may encounter on or near your property; and outline best practices for protecting, restoring, and enhancing those ecosystems and the species that depend on them.

2.1. Identifying the Biogeoclimatic Zone

The Biogeoclimatic Ecosystem Classification (BEC) system divides British Columbia into fourteen biogeoclimatic or ecological zones. These zones are large geographic areas that share a similar climate within the province. You can use this classification system to learn more about the characteristics of the ecosystem your vineyard is part of. See www.for.gov.bc.ca/hfd/library/documents/treebook/biogeo/biogeo.htm for a map of the biogeoclimatic zones.

BEC zones where winegrapes are grown include:

Interior:

- Ponderosa Pine
- Bunchgrass
- Interior Douglas Fir
- Interior Cedar Hemlock (low elevations in Shuswap region)

Coast:

- Coastal Douglas Fir
- Coastal Western-Hemlock

You can download a brochure that describes the ecosystems, climate, wildlife, endangered species and special features of the BEC zone you are located in (links to and information from the brochures are provided below). Hard copies of the brochures can be ordered by calling Crown Publications at **1-800-663-6105.**

Ponderosa Pine

- ponderosa pine forests typify the area
- hot, dry zone (although not as hot and dry as the Bunchgrass Zone)
- consists of a mosaic of forests, grasslands, and wetlands
- home to a wide variety of birds, mammals, reptiles, and amphibians, some of which are relatively rare or threatened
- occupies a narrow band along the bottoms and lower side walls of a number of major river valleys, including the Fraser (in the

Lytton-Lillooet area), lower Thompson, Nicola, Similkameen, and lower Kettle
- also occurs in areas adjacent to Okanagan Lake and in southeastern BC near Cranbrook and Lake Kookanusa
- Brochure URL: www.for.gov.bc.ca/hfd/pubs/Docs/Bro/Bro60.htm

Bunchgrass

- covers less than one percent of the total area of BC
- supports a rich diversity of ecosystems and a wide variety of plants and wildlife, including many rare and endangered species
- dry and relatively mild low-elevation climate, together with an abundance of productive agricultural land
- one of the most populated and most developed areas in the BC interior
- consists mostly of narrow fingers of land centred on the major river valleys of the Okanagan, Thompson, and Fraser river basins
- these include the Okanagan Valley from Summerland south to the United States border, the Thompson River Valley from Kamloops to Spences Bridge, the Nicola River Valley, and the Fraser and Chilcotin river valleys south of Riske Creek to north of Lillooet
- zone occurs from the valley bottom up to elevations of approximately 900 m on the valley slopes
- Brochure URL: www.for.gov.bc.ca/hfd/pubs/Docs/Bro/Bro54.htm

Interior Douglas Fir

- lies in the heart of BC's southern interior
- often described as "cattle country"
- land of rolling hills and valleys covered by dry grasslands and open forests
- also supports a rich diversity of natural communities and wildlife species
- spreads across low- to mid-elevations in the east Kootenays, the Okanagan-Similkameen and Thompson region, the Shuswap region and southern parts of the Chilcotin and Cariboo
- Cranbrook, Vernon, Chase, Princeton, Boston Bar, Clinton, and Williams Lake all lie within this zone
- Brochure URL: www.for.gov.bc.ca/hfd/pubs/Docs/Bro/Bro47.htm

Interior Cedar Hemlock

- found at elevations of 660-1400 metres in the Shuswap region
- experiences cool, wet winters and warm, moderately dry summers
- productive coniferous forests that include Western red cedar or western hemlock characterize these forests
- A wide variety of birds find food and habitat in this zone's productive ecosystems.
- Brochure URL: www.for.gov.bc.ca/hfd/pubs/docs/Bro/bro48.pdf

Coastal Douglas Fir

- home to some of the province's most interesting and diverse ecosystems
- mild climate

- contains some of the province's rarest vegetation, which is seriously threatened by growing human settlement
- covers a small area of BC's south coast, including a band of lower elevation along southeastern Vancouver Island, the Gulf Islands, and a fringe of mainland along Georgia Strait
- Victoria, Nanaimo, and Powell River are major urban centres in the area
- Brochure URL: www.for.gov.bc.ca/hfd/pubs/Docs/Bro/Bro30.htm

Coastal Western Hemlock

- characterized by a towering forest canopy and thick underbrush
- one of Canada's wettest climates and most productive forest areas
- stretches in a broad swath along the province's entire coast
- covers most lower elevations west of the Coast Mountains, from the very wet and exposed outer coast to drier and more sheltered areas of the inner coast
- also extends east of the Coast Mountains along major river valleys
- Brochure URL: www.for.gov.bc.ca/hfd/pubs/Docs/Bro/Bro31.htm

2.2. Identifying Habitat Features

This section guides you through the identification and mapping of the habitat features of your property and its surrounding environment.

If you are considering establishing a new vineyard on a site, or are re-establishing areas of your current property, it is strongly recommended that you obtain a knowledgeable professional to conduct an environmental survey. The survey will identify potential environmental risks and the presence of sensitive areas in the property.

Preparation

The following materials will help you complete your assessment:

- The **site plan** of your property that you created in Chapter 1
- Coloured pencils for marking map
- A transparent grid overlay (optional)

Other resources you can use include:

- Your local Environmental Farm Plan Advisor
- Local government websites or hard copy mapping services (phone your municipality or regional district to request)
- GoogleEarth http://earth.google.com/download-earth.html
- Appendix D of Develop With Care: Environmental Guidelines for Urban and Rural Land Development in British Columbia www.env.gov.bc.ca/wld/documents/bmp/devwithcare/DWC-Appendices-A-F.pdf
- Overview of ecosystem types and information on wildlife (including species at risk) included in this section.

Mapping

To create your **ecosystem management map**, you will be adding habitat features to your **site plan**. Using your map and coloured pencils, divide your property into the eight categories listed below:

1. roads, driveways, buildings, equipment storage areas, lawns, greenhouses, and gardens,
2. cultivated areas (including vineyards),
3. treed or wooded areas,
4. native grasslands,
5. rock bluffs, cliffs, mountainous areas (rugged terrain),
6. wetlands and other water features, permanent and seasonal (streams, rivers, lakes, floodplains, seasonal pools, ditches, swales),
7. riparian areas, and
8. linear habitats (windbreaks, hedgerows, buffers, uncultivated fence lines, ravines, gullies, and other corridors of native vegetation).

Note: Fallow land should be mapped in the category which reflects its anticipated future use. Also indicate on your map any areas of weed infestation.

An overview of ecosystem types you may need to identify and include on your map is provided below.

Riparian Areas

Riparian areas are typically linear ecosystems alongside lakes, rivers, streams and ponds that are characterized by lush vegetation including trees, shrubs, cattails, sedges and grasses.

Riparian areas are highly valuable ecosystems that:

- provide habitat for important birds, animals, and insects,
- serve as a filter, preventing sediments and nutrients in surface runoff from entering waterways,
- buffer against flooding and erosion, and
- support shrubs and trees that shade watercourses.

Riparian areas play an important role in pest management in your vineyard. Areas of native vegetation provide refuge for beneficial insects that prey on agricultural pest species. Insect species that thrive in riparian areas are, in turn, food for birds such as owls that prey on vineyard rodents. Other birds, such as swallows, bluebirds and wrens, will also make riparian areas their home and will help to reduce insect pests.

Wetlands and Other Aquatic Habitats

An aquatic ecosystem is a group of interacting organisms dependent on one another and their water environment for nutrients (e.g. nitrogen and phosphorus) and shelter. Familiar examples are ponds, lakes and rivers, but aquatic ecosystems also include areas such as floodplains, wetlands, and vernal (seasonal) pools which are flooded with water for all or only parts of the year. Man-made ditches and swales may also be considered aquatic habitat.

Aquatic ecosystems support a wide variety of life forms including bacteria, fungi, and protozoans (single-celled organisms); bottom-

dwelling organisms such as insect larvae, snails, and worms; free-floating microscopic plants and animals known as plankton; large plants such as cattails, bulrushes, grasses, and reeds; and fish, amphibians, reptiles, and birds.

Wetlands are a particularly important aquatic ecosystem. They act like giant sponges; holding back water during floods and releasing it during dry periods. They play a very important role in minimising soil erosion and attenuating floods. They are also natural filters that purify water by trapping pollutants such as sediment, heavy metals and disease-carrying organisms. Wetlands also provide special habitat for many plant and animal species that depend on them for all or part of their lifecycles.

Trees and Woodlands

Trees provide a number of habitat functions for birds including areas for nesting, roosting, foraging, and refuge. They also provide habitats for other animals, reptiles, insects, bats and amphibians. Dead and dying trees, referred to as "habitat trees" or "wildlife trees", provide nutrients for the soil and important habitat and food for some insects and animals. By providing a healthy tree habitat, you will increase the biodiversity on your property and improve the area's overall health.

Trees will provide other benefits to your vineyard. Planting trees on bare hillsides will reduce erosion by increasing water penetration and infiltration rates and by helping to increase the nutrient cycle in the soil. Trees planted alongside a vineyard can also act as a windshield to reduce any impact to the vines by high winds. Healthy strong trees also add aesthetic value to any property. Trees also act as perches for hawks and owls that are important predators of rodents.

FACT BOX: GARRY OAKS AND ASSOCIATED ECOSYSTEMS

Garry oaks are gnarly shaped trees that, in Canada, are found almost exclusively within a narrow coastal strip of southeast Vancouver Island, in the nearby Gulf Islands, and in two areas of the Fraser River Valley. Garry oak ecosystems include woodlands with Garry oak, arbutus, and Douglas-fir trees, often combined with rock outcrops, wildflowers, grassy meadows, coastal bluffs, or seasonal pools.

Garry oak areas provide habitat for more than 100 species of birds, 7 amphibian species, 7 reptile species, 33 mammal species, more than 800 insect and mite species and about 700 plant species (GOERT, 2010). Many of these species occur nowhere else in Canada.

Land conversion for development has vastly reduced the extent of Garry oak ecosystems. Less than 5% remains in a near-natural condition.

Grasslands (Shrub-steppes)

Grasslands are open areas where grasses or grass-like plants are the dominant vegetation and where there are few trees. Grasslands are one of Canada's most endangered ecosystems. In BC, grasslands cover less than 1% of the land base. Grasslands are the main natural habitat of the Okanagan and Similkameen

valleys; and are home to many unique plant and animal species.

Grasslands also contain flowering plants, called forbs, and shrubs. Big sagebrush, antelope-brush, bluebunch wheatgrass, needle-and-thread grass, and rabbit brush are common in lower elevation grasslands in British Columbia.

FACT BOX: ANTELOPE-BRUSH GRASSLANDS

Antelope-brush needle-and-thread shrub steppe grasslands extend mainly from Osoyoos to Skaha Lake. They are characterized by the large, often gnarled looking Antelope-brush. In the spring, each shrub is covered with thousands of fragrant yellow flowers.

These grasslands are one of the most critically imperiled plant communities in Canada. Many endangered and threatened mammals, plants, birds, reptiles and amphibians are found in the Antelope-brush ecosystems.

The greatest loss has been due to intensive agricultural expansion and urban development. Identifying whether this type of grassland occurs on your property or in the surrounding area and implementing appropriate protection and/or restoration measures is extremely important to ensure the future health of this unique ecosystems and the species that rely on them.

For more information:
www.env.gov.bc.ca/wld/documents/antelope.pdf.

Rugged Terrain

Cliffs and mountainous areas that are the backdrop to many grape growing areas in BC provide valuable habitat for wildlife. This rugged terrain is an important movement corridor for large mammals and ungulates. The cliffs provide a nesting area for eagles and falcons and the talus slopes are winter hibernation habitats for snakes and lizards. This terrain is often a natural refuge for wildlife surrounded by urban development and cultivated land.

2.3. Identifying Wildlife (including Species at Risk)

Vineyards provide habitat for a variety of species. Some birds, rodents and mammals that eat vines and grape crops are considered pests (see Chapter 5 Pest Management) but many species have a positive or neutral effect on vineyards. Raptors and snakes keep rodent populations under control and most bird species eat insects in the summer while they are raising their young. Bats flying overhead in the evening eat thousands of flying insects and the rare Pallid bat eats insects on the ground.

Due to concern over low numbers of certain plant and wildlife species, provincial and federal environment ministries have developed a ranking system for the degree to which species are at risk of becoming endangered. The ranking goes from vulnerable, to threatened, endangered, and finally extirpated (no longer occurring in the wild in British Columbia). Each of these designations has a scientific and legal definition but for simplicity,

the term "species at risk" is used for any plant or animal that is of conservation concern.

There are many agency resources and websites that provide information about natural habitats and species at risk on your vineyard and the surrounding region (see section 2.14). Many of these websites also have information and suggestions on land management and stewardship practices that can benefit local habitats and species.

Identify wildlife (including sensitive species) that you have observed on your property. Mark a dot on the location where they were observed. If you have not observed the species but know that there is potential the species may use your property, list the species on the back of the map.

ENVIRONMENTAL MANAGEMENT PRACTICES

2.4. Choosing Your Site

The key to an environmentally viable vineyard depends largely on good site selection. Careful site selection can help you retain or restore important habitat features and ecologically sensitive areas and functions and will enable you to minimize soil, drainage, and pest problems.

Choosing previously developed agricultural land for a vineyard rather than converting natural habitat is the best option available to viticulturists.

Section 3.2 contains more information about determining site suitability.

2.5. Minimizing Land Clearing

Grape growers are often faced with the challenge of determining how much of their land to put into production and how much to leave as native land.

Land preparation activities, such as clearing and grubbing, have a severe impact on birds, small mammals and snakes. In general, the least altered areas of your vineyard property have the highest potential for conserving biodiversity. Once native areas are converted to production it can be very difficult, time consuming, and costly to restore them back to their native state.

Timing your land preparation activities to avoid particularly sensitive times life stages (i.e. nesting, breeding, rearing young) will minimize impacts to wildlife. Land clearing and preparation should be done between October and March, where possible. Consult your local conservation organization (see section 2.14) to learn more about what you can do at your particular site.

2.6. Encouraging Diversity

Structure diversity, the variation in physical structure of both native vegetation and crops, on your land provides an important contribution to biodiversity. Maintaining a mix of vegetation layers, such as forbs, grasses, shrubs, and trees provides a diversity of habitats for birds, animals, and insects.

FACT BOX: TINHORN CREEK VINEYARDS SNAKE HABITAT

With the help of the South Okanagan Similkameen Stewardship Program run by The Land Conservancy, Tinhorn Creek Vineyards erected a snake fence along a snake travel corridor to prevent snakes from entering the vineyard. Artificial cover was also provided outside the fence. This increased worker safety and significantly decreased snake mortality.

In agricultural landscapes a majority of the biodiversity occurs in the soil – in the form of micro-organisms, bacteria, fungi, ants, earthworms and many other species. A biologically diverse soil is more likely to show better structure, aeration, water infiltration, nutrient cycling and accessibility than a biologically-deficient soil.

2.7. Retaining and Restoring Habitat

Native areas (e.g. wetlands, aquatic areas, riparian areas, forest/woodlands, grasslands, and rugged terrain) provide the most important contribution to biodiversity. Native plants are uniquely adapted to local conditions and are home to many unique plant and animal species.

Semi-natural areas (e.g. shelterbelts, hedgerows, fencerows, buffers, and road margins) also contribute to the conservation of biodiversity.

Maintaining or establishing areas of native vegetation in the vineyard has many advantages, including:

- shade and shelter from winds
- soil protection
- reduced salinity problem
- provide habitat for native plants and animals,
- improve property values,
- encourage beneficial insects and birds, and
- improve water quality.

Native vegetation can also shade vines, but this issue can be overcome by good planning of planting sites and the types of trees and shrubs that are planted. Advice on the potential for retention or restoration of native vegetation around your property is available from your local conservation organizations (see Section 2.14).

FACT BOX: ECOSYSTEM INITIATIVES AT SUMMERHILL PYRAMID WINERY, KELOWNA

Summerhill Pyramid Winery protects approximately 20 acres of streamside forest, a pond, a wide dry gully of pines and healthy bunchgrass, and a pocket of antelope brush.

Conservation Covenants

Conservation covenants, easements or agreements work to preserve an area of land for the purpose of conservation. This is a voluntary legal agreement between the current land owner and a land trust company aimed at conserving the land for natural habitats. Covenants may restrict future use,

development, or practices that could damage the natural or cultural features of the agreed upon land (Land Trust Alliance of British Columbia, 2002). This is an alternative way to ensure that habitats, ecological communities and species on your land are maintained, monitored and preserved. When you enter into a conservation covenant, you can work with the land trust company or group to custom design a conservation agreement for all or part of your land.

2.8. Protecting Wetlands and Aquatic Habitat

Three major objectives for the protection and management of wetlands and other aquatic habitats are: 1) protect and maintain water quantities, 2) protect and maintain water qualities, and 3) protect and maintain habitats and species (Wetland Stewardship Council, 2009). These objectives can be achieved by knowing what you have on your property (see Section 2.2), protecting with buffer zones, and minimizing impacts from viticultural activities.

Aquatic buffer zones are upland areas adjacent to the aquatic habitat. These areas may contain undisturbed natural habitat or have some level of disturbance caused by existing or past land uses. Well designed and maintained buffers can provide a wide range of benefits such as (Wetland Stewardship Council, 2009):

- Maintaining water quality by filtering out sediment, fertilizers and other toxic materials before they enter the aquatic area;
- Mitigating flood impacts and protecting downstream property by reducing the impacts from storm events;
- Improving human health by removing bacteria and other disease causing organisms;
- Preventing soil erosion by stabilizing banks;
- Providing habitat including wildlife corridors, shade, food and protection for fish and wildlife, including endangered species;
- Enhancing recreational opportunities; and
- Enhancing viewscapes and aesthetics.

Required buffer widths and composition are a function of (Wetland Stewardship Council, 2009):

- the pollution or nuisance potential of a given farm activity;
- the effectiveness of the vegetation to reduce pollution or nuisance;
- the time of year an activity is occurring;
- the sensitivity of an area to be protected; and
- the soil, topographic and climatic conditions associated with a site.

It is recommended that viticulturists work with an appropriately qualified professional to ensure decisions for wetland buffer distances are based on a review of the current scientific literature.

2.9. Connecting Your Land with Neighbouring Landscapes

When large, continuous areas of habitat are fragmented, many ecological processes that keep these systems functioning are disrupted and species become threatened or extinct. Connecting native and semi-natural areas on your land and between your land and neighbouring landscapes helps maintain continuous areas of habitat.

These connections may be used as travel corridors for animals during migration, when searching for food and mates, and when young are dispersing. Uncultivated corridors also provide routes for pollen and seeds to disperse.

There is no single figure available for suggested corridor widths or lengths because this depends on which animal or plant is in questions. However, generally wider corridors are better.

You are not expected to provide corridors that give problem wildlife (e.g. deer) easy access to your vineyard. Work with local conservation organizations and your neighbours to determine the best location, width and length of corridors to encourage wildlife movement but also protect your vineyard.

FACT BOX: MAINTAINING WILDLIFE TRAVEL CORRIDORS AT GOD'S MOUNTAIN ESTATES, PENTICTON

God's Mountain Estates placed their vineyard deer fence well inside their property boundaries, leaving natural habitat outside the fence but within their acreage. This allows wildlife to travel along all four sides of the vineyard to get to their water sources and up to the cliffs and forest for shelter.

2.10. Controlling Invasive Species

Invasive species include plants, animals, insect, and micro-organisms that are not native to the region but were introduced either accidentally or intentionally. Invasive species are generally detrimental to the conservation of biodiversity. Next to habitat loss, invasive species pose one of the greatest threats to biodiversity in BC.

Examples of invasive species in BC include Canada thistle, puncturevine, quackgrass, sulphur cinquefoil, knapweed, most of our agricultural insect pests, the European Starling, and the American bullfrog.

2.11. Managing Crop Damage Caused By Wildlife

Wildlife such as deer, bear, rodents and birds can develop a liking for grapes or the vine itself and cause significant crop losses. See the Wildlife Management section of Chapter 6 Pest Management for methods of controlling problem wildlife.

2.12. Preventing Pollution

Good chemical and waste management practices can make a profound contribution to retaining biodiversity. Pollution prevention, also known as P2, is about avoiding the creation of pollution and waste, rather than trying to clean it up or manage it after the fact.

Pollution prevention techniques and practices generally focus on the following areas (Environment Canada, 2010):

- substances of concern;
- efficient use and conservation of natural resources;
- material substitution;
- product design/product reformulation;
- process changes;
- reuse and recycling on-site;
- training;
- purchasing techniques;
- equipment modifications; and
- operating efficiencies/clean production.

Potentially polluting materials that cannot be prevented should be recycled. Recycling techniques often allow hazardous materials to be put to a beneficial use. Those that cannot be prevented or recycled should be treated. Disposal or other release into the environment should be employed only as a last resort. Whether you are recycling, treating or disposing, you should do it in an environmentally safe manner.

2.13. Communicating Practices to Employees & Contractors

Communicating your environmental practices to employees and contractors, including seasonal workers, is a key component of successful ecosystem management. These people conduct activities that can either harm or benefit ecosystems and the species they support.

2.14. Working with Environmental Organizations

There are three main types of environmental organizations that provide assistance and resources for an ecosystem approach to managing your vineyard.

Land trust organizations help private land owners with stewardship, purchase private land for conservation and manage conservation covenants on private land. They work with land owners under a strict code of privacy information. They often help find funds for landowners to assist with costs of fencing and restoration.

Stewardship groups encourage private land owners to restore and retain healthy habitat. They usually offer free advice for land owners, but a detailed biological assessment would likely have a fee attached.

Conservation organizations have education and outreach as their goals.

North Okanagan-Shuswap Region

The **North Okanagan Resource/Habitat Atlas** is a web-based mapping tool that brings together a variety of information about natural and cultural attributes and resources of the North Okanagan region. The contents of the atlas can assist people in creating a profile of the myriad of ecosystems with which they interact in the North Okanagan. It is available at www.shim.bc.ca/atlases/nord/index.cfm.

The **North Okanagan Parks and Natural Areas Trust** is registered to hold and administer covenants on lands. These covenants can control access to the lands and preserve them in their natural state in perpetuity. See www.nopnat.com/ for more information.

The mission of the **Shuswap Environmental Action Society** is to study environmental issues, inform the public about environmental problems and solutions, coordinate activities and share information with other local, provincial, and national environmental organizations, and take actions to improve our local environment. See http://www.seas.ca/ for more information.

Central and South Okanagan-Similkameen Region

The **Habitat Atlas for Wildlife at Risk: South Okanagan-Similkameen** focuses on 32 species considered "at risk" in the South Okanagan and Lower Similkameen. It is available at www.env.gov.bc.ca/okanagan/esd/atlas/index.html.

The **South Okanagan Similkameen Conservation Program** was created to protect the biodiversity of the Okanagan-Similkameen area, to maintain a viable ecological corridor between the deserts to the south and the grasslands to the north, and to effect recovery of endangered species to the extent possible. The program website is www.soscp.org.

The **Okanagan Similkameen Conservation Alliance** www.osca.org provides brochures on species at risk and guidelines designed for agriculture. They are available for free as laminated posters and cards designed to be posted in work yards and sheds.

The Okanagan Similkameen Stewardship Society has published many excellent fact sheets for land owners over the past 15 years. Many of these are available in print form from their office and all are on their website at www.okanagansimilkameenstewardship.ca/p/caring-for-your-space.html.

South Coast Region

The **South Coast Conservation Program** coordinates and facilitates the implementation of conservation actions to maintain and restore species and ecosystems at risk on the South Coast of BC. The program website is www.sccp.ca.

Vancouver Island and Gulf Islands

The **Garry Oak Ecosystem Recovery Team (GOERT)** coordinates efforts to protect and restore endangered Garry oak and associated ecosystems and the species at risk that inhabit them. Their website, www.goert.ca, contains extensive information about Garry oak ecosystems and how to protect them.

The Islands Trust is a federation of independent local governments which plans land use and regulates development in the trust area. The trust area covers the islands and waters between the British Columbia mainland and southern Vancouver Island, including Howe Sound and as far north as Comox. The Island Trust website, www.islandstrust.bc.ca/, provides detailed information on coastal ecosystems and wildlife.

The **Central Saanich Agricultural Resource Atlas** provides a comprehensive overview of the land base of the municipality, with a particular focus on the soils, groundwater resources and climate factors that influence agricultural production. Available at: www.centralsaanich.ca/hall/Departments/planning/planning/Agricultural_Resource_Atlas.htm

This **CRD Natural Areas Atlas** is a web-based mapping tool that facilitates well-informed and responsible land-use decisions. In the Atlas, you will find important information such as the locations of salmon bearing streams, spawning zones, old growth forests, endangered ecosystems, record-sized trees and shoreline habitats It is available at: https://www.crd.bc.ca/.

All of BC

The Stewardship Centre for British Columbia has done a great job at pulling together provincial species at risk information on the **Species at Risk & Local Government: A Primer for British Columbia** website located at http://www.speciesatrisk.bc.ca/. The website will help you to learn about species at risk and the threats they face, learn which species at risk are in your area, and search for species at risk by name or ecosystem type.

Other excellent sources of species and habitat information include:

- Grasslands Conservation Council of British Columbia www.bcgrasslands.org/
- Delta Farmland and Wildlife Trust www.deltafarmland.ca
- Ducks Unlimited www.ducks.ca/province/bc/index.html
- Wildlife tree stewardship www.wildlifetree.org
- Living By Water www.livingbywater.ca/

CHAPTER 3
VITICULTURAL MANAGEMENT

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3.0 VITICULTURAL MANAGEMENT

INTRODUCTION

Chapter objective: To provide practices that support due diligence and help the viticulturist make informed planning decisions when acquiring, establishing and managing a vineyard.

A viticulturist makes many decisions each day to produce grapes. In a sustainable vineyard, each decision considers the interactions between the various components of the vineyard system (e.g. soil, water, beneficial insects and wildlife) and focuses on producing high quality grapes with minimum inputs and adverse impacts on the environment and human health.

Careful planning before establishing or re-planting a vineyard will minimize soil, drainage and pest problems and help to retain or restore important habitat features and ecologically sensitive sites and functions.

Before selecting a site, a grower should study the economic realities of growing grapes in BC. Things to consider include:

- cost of production,
- cost of land or leasing,
- current market,
- market trends,
- government support programs, and
- overall management approach and corresponding costs.

Strategic selection of the grape variety that matches the conditions of the site, produces an economic yield, has a fair market value, is in demand, and meets the quality expectations of the client winery is key to economic sustainability of the vineyard.

Review chapters 2, 3 and 4 of the Best Practices Guide for more information on viticultural management.

PRELIMINARY CONSIDERATIONS

3.1. Business Planning and Market Research

Any business is highly competitive, and the grape growing industry is no exception. A thorough, accurate and well-researched business plan is essential to the success of your vineyard.

A business plan will provide you with a road map to setting up and managing your vineyard. It will help you to:

- organize your thoughts, clarify your goals, and measure progress;
- acquire knowledge and collect information about your industry, customers, and the marketplace;
- anticipate and avoid obstacles your business is likely to encounter;
- communicate your vision, goals, and strategies to management, staff, and

customers and be more persuasive to funding sources; and
- understand the financial aspects of your business, including cash-flow and break-even requirements.

Both internal users (e.g. management and key employees) and external users (e.g. lenders, investors, venture capitalists, attorney, accountant, and insurance agent) will be reading and using your business plan.

Elements of a successful business plan are listed below. Your plan will not necessarily include all of the components listed, and its length may range from a few pages to many pages depending on the size of your operation.

3.2 Site Selection

Whether or not a vineyard is environmentally and economically viable vineyard depends largely on good site selection. Major considerations should be climate, soil, topography, and water. You should also consider the current state of the property; whether it is undeveloped natural habitat or previously developed agricultural land and how close it is to existing amenities and to the winery you will be selling your grapes to. You will most likely need the help of industry professionals and government agencies and access to available resources (i.e. weather data).

You should answer the questions on the Vineyard Site Suitability Checklist below when considering a property for vineyard development.

Environmental Due Diligence

All forms of land development, including agricultural, involve changes to the landscape that may damage or put natural resources at risk and impact sensitive natural habitat. Development of land for a vineyard can include tree removal (including the possible clearing of orchards), land clearing and levelling, herbicide application, riparian vegetation removal, brush burning, grading, re-contouring, altering water sources and water drainage, putting in irrigation systems, excavating, installing erosion control measures, and construction of roads, wells, dams, fences, and buildings.

It is preferable to develop existing agricultural land instead of clearing unmodified sensitive ecosystems. Reusing agricultural land may also be more cost-effective than establishing a new site with the required infrastructure.

An environmental survey should be conducted by a knowledgeable person (e.g. Environmental Farm Plan advisor, environmental consultant or local conservancy group representative). This person should inspect the property and help owners identify potential environmental risks that may be subject to local, provincial or federal legislation. These environmental characteristics may include proximity to water, endangered species, and sensitive habitats. Local conservancy groups may be able to provide information on local environmental issues.

ELEMENTS OF A SUCCESSFUL BUSINESS PLAN

(Washington Association of Wine Grape Growers, 2006)

Title Page

- Contact information including name of vineyard and name, address, and phone number of owner(s)

Executive Summary

- Purpose of the plan
- Description of overall business concept including mission statement and company history
- Product(s) and/or service(s)
- Marketing and sales strategies
- Market analysis and description
- Organization and personnel
- Financial data

Table of Contents

- List of main sections, tables, figures, and appendices and corresponding page numbers

Purpose of Business

- What you want to accomplish (i.e. the ultimate purpose for starting the business)
- Mission statement
- Goals and objectives
- Description of business, including type of legal entity

Description of Product(s) and/or Services(s)

- Definition and benefits of product(s) and/or service(s)
- Ability to meet demands
- Competitive advantages
- Description of current position in life cycle
- Copyrights, patents and trade secrets
- Existing legal agreements
- Research and development activities

Market Analysis and Strategy

- Market research – industry description and outlook
- Distinguishing characteristics and key attributes of primary and secondary target markets
- Barriers to entry into the market
- Identification of key competitors and their strengths and weaknesses
- Regulatory environment
- Financial standards
- Marketing objectives and strategies
- Sales and distribution

Organization, Management and Staffing

- Organizational structure including management personnel, key employees, board, advisory committee, professional services, consultants
- Background and experience level of those who will run the business
- Management skills and professional services that are available in-house and that need to be hired or contracted
- Management compensation and incentives available

Milestones and Timelines

- Critical dates in the development and operation of the business
- Short-term and long-term plans to reach goals (e.g. planting schedules, openings, release dates)
- Barriers or risks and potential solutions

Financial Information

- Start-up and operating expenses
- Generated and required cash flow
- Funds required and their uses
- Financial statements
- Methods of financial reporting

Operations and Implementation

- Description of facilities, production, inventory control, quality control, capacity, productivity, labour, processes, equipment, supply and distribution, order fulfillment and customer service, research and development, financial control, and contingency planning
- Technology plan – software, hardware, telecommunications, personnel
- Operational issues essential to nature and success of your company, provide a distinct competitive edge and/or overcome frequent problems in a business such as yours

Appendices or Exhibits

- Resumes of key managers
- Pictures of products
- Professional references
- Market studies
- Significant contracts

VINEYARD SITE SUITABILITY CHECKLIST

What is the zoning of the site?

- ☐ Do local zoning bylaws limit farming?
- ☐ Do zoning bylaws prevent urban encroachment?
- ☐ What are the environmental regulations relating to site development?

What are the environmental values of the site?

- ☐ Is the site natural unmodified habitat?
- ☐ Does the site have species at risk associated with the habitat?
- ☐ How would the site biodiversity be affected by vineyard development?
- ☐ Has an environmental survey of the site been conducted by a knowledgeable person? (e.g. environmental consultant, knowledgeable local conservancy group representative) to:
  - ☐ Document potential environmental risks and the presence of sensitive areas in the property.
  - ☐ Ensure that during development of the site, damage to existing habitat is minimized by following the practices outlined in the guidebook under Habitat for Wildlife and Beneficial Organisms sub-section.

What are the water rights and water quality for the property?

- ☐ Are there available water and/or water rights? What is the water quality?
- ☐ For information on water quality testing see the Water Management chapter.

What is the site history?

- ☐ Was it used for agricultural purposes?
- ☐ Is the site compatible with grape production?
- ☐ List past irrigation history and systems used.
- ☐ List past crop and or animal use and management practices.
- ☐ List past insecticide, fungicide, herbicide use and residual carryover potential for each material.
- ☐ Have any fumigants been used at the site?
- ☐ Was past land use uniform or variable across the site?
- ☐ Has the site been levelled, eroded or altered in any significant way?

What is the neighbourhood like?

- ☐ Identify the land uses adjacent to the main property.
- ☐ Describe the general geography.
- ☐ What other crops are grown in the area? Is there potential for incompatibility issues from herbicides used in other crops, e.g. 2,4-D drift?
- ☐ Is there a winery nearby?
- ☐ Is the area susceptible to deer and elk predation? Will fences need to be erected to protect the vineyard?

What is the proximity to roads, suppliers and wineries?

- ☐ Distance to urban centres, residential properties, schools
- ☐ Is there a local market for grapes?

What utilities and infrastructure are already available?

- ☐ Roads
- ☐ Hydro, water, sewer

What are the local and micro climates of the site?

- ☐ Have I collected historical weather and temperature data for the site?
- ☐ Have I installed a weather station and monitored it for at least a year prior to planting?
- ☐ What is the average length of the growing season?
- ☐ What is the average precipitation?
- ☐ What is the accumulation of heat throughout the growing season (degree days)?
- ☐ What were the temperatures for my site from previous cold winter events?
- ☐ Is there enough slope to provide good cold air drainage? Slope greater than five percent is preferred.
- ☐ What is the elevation of the site?
- ☐ Is the site in a windy location? Windy areas tend to have less frost but wind can reduce vine vigour and growth.
- ☐ Is the site near a large body of water or large rock formation to help temper climate in the immediate vicinity?

What are the soil conditions like?

- ☐ Soil physical, chemical, and biological properties.
- ☐ See the Soil Management chapter for more information on identifying soil conditions.

What varieties are suitable for my site and are they the varieties desired by wineries?

- ☐ See Chapter 3 of the Best Practices Guide for a list of varieties.
- ☐ Obtain the services of an industry consultant.

Habitat for Wildlife and Beneficial Organisms

During vineyard establishment and development it is important to ensure damage to existing habitat (i.e. seasonal bodies of water (vernal pools), drainages, floodplains) is minimized.

This can be achieved by:

- Setting aside land and leaving or establishing these areas with native plant species. This land should be in addition to hard-to-farm areas (such as vernal pools, riparian areas, fence lines, rocky areas, and ditch banks).
- Maintaining a buffer with native vegetation between the habitat and the vineyard where possible.
- Integrated weed management for the control of invasive weed species in and around the vineyard is also recommended.

3.3. Site Preparation

Levelling the Vineyard Floor

In uneven (hummocky) terrain with notable depressions and gullies it is often advantageous to level the vineyard to create a more uniform working surface. Levelling can reduce or eliminate frost pockets, modify slopes to make machinery operation safer, or improve overall aspect and air drainage on a vineyard site. As a result, land levelling has become a common practice in many regions.

There are many risks involved in land levelling. Great care needs to be taken to preserve the topsoil (A horizons) layers of the natural soil profile (see discussion of the soil profile in Section 4.1). The A and B horizons are most favourable for plant growth because they contain the nutrient supplying organic matter and are generally leached of salts or excess lime that characterise the underlying unweathered parent materials of the C horizon.

In the silty soils found along the benchlands adjacent to Okanagan Lake, the chemistry of the soil profile changes rapidly with depth. Exposing C horizon material to the surface will result in long-term soil quality degradation and reduced productivity where this occurs. Coarser textured soils like those in the Oliver and Osoyoos areas do not have the same conditions in the C horizon. In the case of these sandy and gravely soils exposure of the C horizon to the surface is less critical than on the silty soils.

The ideal situation when land levelling from a soil perspective is to collect and stockpile the A and B horizon soil from the profile. The parent materials (C horizon) may then be levelled as needed. The final step is to replace the A and B horizon materials over the levelled surface to ensure none of the C horizon is exposed. While the thickness of the A and B horizons will vary over the landscape, a good rule of thumb would be to collect and stockpile the surface 20 to 40 cm of soil for re-distribution after levelling.

While the careful collection, stockpiling and re-distribution will minimize the impact of land levelling on the resultant soil quality, the

mechanical treatment of the soil material will invariably destroy soil structure, which in turn can reduce porosity and the soil's ability to supply air and water to plant roots. There will be disturbance to the topsoil biological community as well.

Fortunately, good soil management practices can, over time, see the re-establishment of soil structure and functioning biological communities in the soil if care has been taken in the levelling process. It may take decades to overcome the loss in surface soil quality if C horizon materials are left at the surface and in these cases, the land levelling activity would have to be considered an unsustainable practice.

Improving Compacted Layers

It is important to identify compacted soil layers within the potential rooting zone that could negatively impact vine growth. Where a compacted layer is identified, a number of techniques can be employed to break up the soil profile (see Table 3-1). The technique you choose will depend upon your soil type and level of compaction and safe machinery operation at your site (e.g. rollover risks).

Deep ripping should be carried out only when there is a hardpan soil that restricts roots and water to a shallow soil depth. Before undertaking any deep ripping it is important to determine the extent of the hard pans and/or compaction problem and decide whether deep ripping is necessary. If soil is deep and uniform, only surface tillage or disc plowing may be necessary.

Vineyards established on Vancouver Island and the Lower Mainland will often require deep ripping due to cemented subsurface layers. A recommended practice is to rip to approximately 1.1 metres at 3 metres intervals and lay drain tiles at that depth at some angle (e.g. perpendicular) to the ripping. Contact the Ministry of Agriculture and Lands for more information.

If surface tillage, disc plowing or deep ripping is required at your site, follow these practices:

- Do it during late summer or early fall when soil moisture is at its lowest;
- Ensure it does not introduce toxic factors to the roots (e.g. salt boron) by mixing subsoil layer up to the surface;
- Drop organic matter into the trench created so that organic matter and any soil amendments are placed deep into the soil profile

Table 3-1: Techniques that can be used to improve compacted soil layers.

Technique	Description
Spading	• Turns hard, compacted soils into deeply fractured structures while avoiding mixing sub-soils with surface soils • Leaves the bottom of the worked area rough and unglazed, ultimately promoting water percolation and root growth • Maintains the basic organic structure of the soil • Requires one pass only • Can effectively incorporate green manures and crop residues into the soil profile
Ripping	• Cracks or shatters hard layers at 2-7 feet, but does not mix the soil • Permanently improves soils with cemented hardpans • Temporarily improves tight or compacted soil, but • Does not improve claypan layers for long because they usually reseal • Minor effect on sand or gravel layers
Slip-plowing	• Rips, but also lifts and mixes the soil at 3-6 feet • Effective on claypans and sand or gravel layers • Makes a wide channel, creates some mixing of surface and subsoil layers • Causes more shattering than ripping
Chisel	• Relieves compaction and mixes the soil in the surface 2 feet • Best for loosening soil and breaking up surface compaction such as plowpans and wheel ruts

Adapted, in part from Dlott, *et. al,* 2006, p 3-15

3.4. Soil Management

Soil Survey

Thorough soil analysis is one of the best investments a grower can make because soil properties play a major role in vine health, vineyard growth and production.

A soil survey should be completed by a qualified professional the year before planting, prior to ordering vines.

Soil Physical and Chemical Properties

The soil's physical and chemical properties will greatly affect its ability to hold and transfer nutrients to the vines. Because of this, it is important to determine the following items to make the necessary amendments before tilling:

- Chemical properties,
- Soil composition (i.e. percent sand, silt and clay),
- pH,
- Organic matter content,
- Cation exchange capacity,
- Sodium Adsorption Ratio,
- Base saturation,
- Water-holding capacity, and
- Deficiencies or toxicities (i.e. boron, sodium, chlorides, zinc and phosphorus).

Many of these physical and chemical properties will also indicate site drainage and erosion potential.

The Soil and Nutrition Management chapter contains more information on the physical and chemical properties of soil.

Soils that do not possess all of the ideal components for establishing a vineyard can be amended somewhat. Examples of soil amendment methods include amending soil with lime if acidic, sulphur (or acids in drip) if alkaline, and compost/manure or cover crop if low in organic matter.

Section 4.10 of the Soil and Nutrition Management chapter contains more information on soil amendments.

In addition to soil amendments, cover crops may be used to address certain issues such as:

- reducing soil erosion due to wind and water,
- protecting soil surface during high traffic events during the growing season,
- increasing water infiltration,
- reducing insect populations (pests) or increase beneficial insect populations (predators),
- reducing chemical use,
- reducing weeds,
- reducing vine vigour,
- recycling nutrients within the soil ecosystem,
- preventing nutrient leaching,
- increasing organic matter, and
- altering microclimate.

The Soil and Nutrition Management chapter contains more information on cover crops.

Any soil amendments and modifications made on the site should be recorded for future reference.

Addressing Soil Biological Problems Pre-planting

Assessing the soil for biological problems is another crucial part of setting up a prosperous and sustainable vineyard operation. Nematodes can present a problem as they are ubiquitous organisms (present in all places). Some species of these organisms feed on the roots of plants and generally thrive on the roots of woody crops (especially grapes or trees). This is why it is important to sample the soil for nematodes prior to planting and it is especially important for the samples to include the roots of the previous crop or cover vegetation. When deciding on sampling locations, growers must consider the previous land use and soil variation.

Knowing the species type and population levels of nematodes on the site will be crucial in choosing a rootstock that is resistant to these pests. Alternately, lab results may show that no biological problems exist and warrant no further actions.

When biological problems are identified in a vineyard, they should be addressed by:

- Removing as many roots as possible from the previous perennial crop as some pests can survive on these (for up to 8-10 years in the case of grape roots);
- Using an appropriate resistant rootstock; and
- Carefully selecting and using a cover crop to deal with a specific issue (i.e. mustard for nematodes).

For more information on nematodes and phylloxera refer to Section 6.2 of the Pest Management chapter.

3.5. Water Quality and Irrigation

Water quality can impact the soil, vine yields and fruit quality and food safety. Knowing what is in the water is the first step in mitigating any detrimental effects. For this reason, it is recommended that water to be used for vineyard irrigation be assessed for suitability and nutrient values, especially water obtained from groundwater wells or surface water bodies. Even if your water is supplied by a municipality or irrigation district, it is still important for you to know about your water quality.

For information on water quality testing please refer to section 5.3 of the Water Management chapter.

Some examples of water quality issues and how they may affect the vineyard include:

- pH affects acidity and alkalinity for grape growth;
- Sodium Absorption Ratio can affect water penetration;
- a range of parameters from pH, Suspended Solids, Calcium bicarbonate, and other minerals can affect clogging of drip emitters;
- spray tank water pH can either negatively or positively affect the efficacy of pesticides;
- total dissolved solids can affect water salinity; and
- sodium, chloride and boron can be toxic to vines.

Because of their toxicity to grapevines, it is important to know sodium, chloride and boron concentrations prior to planting. In cases where water quality is an issue, the relative sensitivity to toxic elements should be an important factor in selecting scion and rootstocks. You may need to install a proper filtration system to deal with water quality issues.

Your soil survey and water quality testing will also play a role in determining the appropriate irrigation system design (e.g. high levels of calcium bicarbonate or manganese may lead to clogging of drip irrigation emitters), and determining fertilization requirements (taking into account nitrogen levels in the water). For more information, refer to the Water Management chapter and the Soil and Nutrition Management chapter.

The irrigation system should be installed and be fully functional prior to planting. This is so the vineyard site can be irrigated before the planting begins and immediately after planting.

VINEYARD ESTABLISHMENT

Vine balance refers to the process of giving the vine the right inputs and conditions to grow, while at the same time preventing excessive growth. Excessive growth leads to a decrease in fruit yields. Some forms of stress trigger the plant's survival and reproductive

mechanisms, which lead to more fruit production.

Achieving a balanced vine is one of the most important factors in viticulture as it affects many other factors such as susceptibility to pests, air ventilation, sun exposure, and fruit yields. A balanced vine can minimize or eliminate the need for remedial measures such as hedging, leaf removal, shoot positioning or shoot removal.

Vine balance can be achieved through proper:

- vineyard design (spacing, trellising and training),
- pruning,
- crop load adjustments,
- irrigation,
- cover crop,
- fertilization, and
- distribution of shoots and fruit along the fruiting zone.

The following sections of this chapter, as well as subsequent chapters, will help you to achieve vine balance in your vineyard.

3.6. Variety, Rootstock, Scion, and Clone Selection

Variety

The variety you choose to grow will depend on your site characteristics, market demand, and other factors. Grape variety descriptions are included in the Best Practices Guide. Always consult a number of sources before selecting varieties to grow.

Rootstock

Selecting a rootstock that matches your site conditions is essential to vine balance, improved water and disease management, and optimal wine quality and will reduce the need for chemical or cultural intervention. It is essential that rootstocks are certified disease-free.

Growers are encouraged to seek the advice of an experienced consultant when selecting rootstock.

Scion

When selecting a scion to go with the rootstock, the grower should look for a plant that is visibly healthy and that has been tested and certified to be virus free and free from other known pathogens. Growers should ask for certificates from the nursery or source of scion material. The scion must also be appropriate for the rootstock, local climate and soil properties. Growers are encouraged to seek the advice of an experienced consultant when selecting scion.

Clone

Clone selection should be based on information from local trials where the soil, rootstock, trellis, irrigation were as close as possible to the grower's vineyard, or on broad-based province-wide experience and marketability. Clones of some varieties vary greatly in their bunch tightness and bunch rot susceptibility. Consulting with the wine maker, nursery and/or private consultant is encouraged when selecting a clone.

3.7. Plant Certification

The following information was provided by Ray Johnson, Section Head, Grapevine Diagnostic Program at the Centre for Plant Health, Sidney Laboratory, Canadian Food Inspection Agency (CFIA).

Prevention is the only practical cure for viruses, virus-like diseases, phytoplasmas and other diseases such as Crown gall. Starting with healthy plant material is essential for a sustainable vineyard.

The benefits of using healthy plant material include:

- easier and more successful propagation;
- reduced production costs and chemical inputs required to offset the harmful effects of these diseases;
- higher crop yields, better plant growth and crop quality, reduced disease and mortality; and
- increased international competitiveness and economic viability.

There are many benefits to buying certified grape plants for your vineyard. The advantages of certification programs include:

- Most effective approach for the production of healthy vegetatively propagated planting stock. Many viruses spread naturally via insect and nematode vectors. There is no cure once a plant has become infected;
- Increased assurance to growers that they are buying healthy plants derived from plants originally tested for specified viruses and other diseases, and that have been propagated under conditions that mitigate the likelihood of subsequently becoming infected during propagation;
- Certification is usually provided and monitored by a neutral party; and
- Reduced spread of damaging domestic pests and prevention of the introduction of damaging invasive foreign pests.

There are various types of certification programs:

- Phytosanitary only where the focus is on diseases & other pests.
    - Pest list may be comprehensive or limited;
    - May or may not include pest tolerance levels for different pests.
- May also include quality (such as grades) and variety (trueness to variety or clone) standards.
- For export or only domestic purposes.
- Mandatory or voluntary.
- Official (government run or approved) vs industry run vs nursery based (under a quality assurance program accredited under Standards Council of Canada or other association).

Sources of certified grapevines include:

- Canadian CFIA-certified nurseries.
    - Foreign pest risks eliminated;
    - Domestic pest risks greatly reduced;
    - Only official Canadian certification program.

- Imported from foreign CFIA-approved programs in the United States (California, Washington, Oregon) and Europe (France & Germany).
    - Reduces but does not totally eliminate risks of introducing both known and unknown foreign quarantine pests such as viruses, phytoplasmas, other diseases, and insects;
    - Some economically damaging non-quarantine viruses have been detected in samples tested from importations.

Even if you are purchasing from Canadian sources, it is important to purchase certified plants. Economically damaging viruses such as *Grapevine fanleaf virus*, *Arabis mosaic virus*, *Tomato ringspot virus*, Grapevine leafroll-associated viruses, and X-disease and Aster yellows phytoplasmas are present in some Canadian vineyards. Other, currently unknown pests may also be present in Canadian vineyards as a result of illegal importations. The unknown origin of uncertified plants is a main reason for purchasing certified plants. Both varieties and rootstocks should originate from certified nurseries. Viruses in either the variety or rootstock will spread throughout the plant after grafting. Whether you buy plant material or receive cuttings from a friend, always ask for the parentage and source of both rootstock and scion.

For more information on Canadian nurseries participating in the CFIA grapevine certification program contact your local CFIA office.

For information on import and domestic movement requirements for grapevine propagative material see www.inspection.gc.ca/english/plaveg/protect/dir/d-94-34e.shtml or contact your local CFIA office.

BC Coastal and Mainland Office
4321 Still Creek Dr., Suite 400
Burnaby, British Columbia, V5C 6S7
Tel: 604-666-6513
Fax: 604-666-1261

3.8. Vineyard Layout

Vineyard uniformity makes vineyard operations more efficient, leads to uniform crop development and ultimately leads to higher quality fruit. To achieve this, the grower must first:

- Determine row orientation based on site physical features (i.e. soil type, slope, aspect, prevailing winds);
- Divide the vineyard into blocks based on uniformity;
- Ensure vineyard design and row direction allow for safe and easy access;
- Ensure headlands are wide enough for equipment to make turns; and
- Ensure erosion is minimized.

A vineyard is best laid out when it is divided into blocks based on uniformity. It is generally not ideal to design the vineyard layout based on existing fence and property lines, to accommodate the fewest possible tractor turns or to make rows as long as possible.

The site's physical characteristics should be the most important factor in determining row orientation. These physical characteristics could be the result of:

- Environmental survey findings;
- Soil profile inspection and modification;
- Soil tested for physical and chemical properties and amended pre-planting; and/or
- Soil tested for biological problems pre-planting.

Additionally, the vineyard design should be safe and easy to farm with row directions that minimize erosion and trellises aligned according to regional wind patterns and sun exposure. For vineyards that are adjacent to a sensitive site such as a public highway, row orientation should be such that equipment (e.g. sprayers, dusters) turnaround is minimized next to the sensitive area.

Vine Spacing

Plant spacing is an important decision when planting a new vineyard. Row spacing determines the amount of fruiting area or the number of linear feet of fruiting surface per acre.

Row and vines should be spaced to accommodate the vigour of the clone, scion and rootstock, and take into consideration the fertility of the soil, quality of the water, the amount of available sunlight, the intensity of sunlight and the length of the growing season, with the purpose of creating a balanced vine to produce high quality fruit.

3.9. Trellis and Vigour

The trellis system supports the vine to achieve optimum production, which is dependent on capacity and vigour of the vine. Soil properties and the rootstock will have an effect on the capacity of the vine. The complexity of the trellis system will differ depending on the vine vigour.

The following items should be considered when selecting a trellis system:

- Site properties (e.g. soil fertility, slope)
- Quality of irrigation water.
- Growth habit
- Vigour
- Size
- Winter hardiness of vine
- Fruitfulness of basal buds
- Site selection
- Harvest and pruning methods

A good trellis system provides structural support that creates an open canopy with moderate fruit zone exposure to light and air, and allows for efficient farming while minimizing canopy manipulation. Wine quality should be the main outcome of selecting the appropriate trellis type.

3.10. Planting

Some recommended practices when planting new vines are:

- Planting material should be handled and stored according to nursery directions.
- The soil around the newly planted vines should be compacted to remove air pockets. For green growing vines, tamp soil moderately to avoid breaking the roots. For dormant vines, tamp more vigorously, as breaking of roots is less of a problem.
- For grafted vines ensure the graft union is kept well above the final level of the under-vine soil surface to prevent the scion from rooting.
- Support plant viability by increasing water holding capacity (i.e. with coir, bone meal). A disadvantage of this is that it could limit plant root growth.
- Monitor soil moisture around the vine roots and observe vine characteristics such as node length, cane diameter and shoot tips and tendrils.

VINEYARD MAINTENANCE

3.11. Maintaining Young Vines

Once the vine has been planted, care must be taken to ensure a healthy plant. The first shoots from a young plant are fragile.

3.12. Crop Estimation

Accurate crop estimation is critical for planning in both vineyards and wineries. Viticulturists require early season estimates to make decisions on canopy management, crop reduction and vine balance in order to optimize tonnages to maximize quality and productivity. Wineries rely on the crop estimate to ensure the grape intake requirements are sufficient, there is allowable tank space, and to order adequate enological supplies for the up-coming vintage.

3.13. Canopy Assessment and Management

To achieve uniform vegetative growth and fruit development in the vineyard block (Dlott, *et. al.,* 2006):

- prune vines differentially to match their vigour,
- remove weak and late blooming shoots,
- tailor irrigation blocks to the soil and rootstock requirements,
- drop slow ripening fruit at or after veraison, and
- harvest units from uniform sections of the vineyard.

A qualified professional should be retained to help you achieve appropriate vineyard uniformity.

3.14. Fruit Exposure

Special note: It is important to ensure the fruit is not exposed to too much sunlight, which will cause sunburn and splitting. Too much exposure may also lead to hail and bird damage and potential reduction in positive fruit aroma and flavour compounds.

3.15. Frost Protection

Several options are available for frost protection, including wind machines, helicopters, smudge pots, heaters, and irrigation systems. Crop value, expenses,

cultural management practices, and historical frequency and intensity of frost events should be considered when implementing cold protection strategies.

VINEYARD REMOVAL

3.16. Decommissioning a Vineyard

When decommissioning a vineyard, grind the above-ground portions of the vines, or sell them to a co-generation company that can use the vines as biomass for fuel (if one is available), and remove as many roots as possible.

Ensure the following refuse disposal practices are implemented:

Plastics

- Reuse or return all waste plastics to depots for recycling.
- The Waste Exchange Program has a Recycling Hotline 1-800-667-4321.
- Properly dispose of plastics that have contained or contacted toxic materials

Treated Wood

- Waste wood that was treated with registered preservatives is not considered hazardous waste.
- Wood waste can include pallets, boards or posts.
- Reuse treated wood products for other applications (i.e. landscaping).
- Take treated wood product to an approved landfill.
- Obtain a permit from the Ministry of Environment to bury the material on farm property.
- DO NOT burn treated wood as open fires cannot reach the temperature required to eliminate the preservatives, not to mention the toxic fumes that emanate from the burn pile.
- A proactive approach when implementing a vineyard is to look into other options such as metal, concrete or recycled plastic posts.

Metal Disposal

- Most commercial suppliers accept the return of metal containers.
- Recycling options exist for most types of metal containers.
- Taking the metal containers to an approved landfill is another option.

CHAPTER 4
SOIL AND NUTRITION MANAGEMENT

Table of Contents

4.0 SOIL AND NUTRITION MANAGEMENT

INTRODUCTION

Chapter objective: To provide soil and nutrition management practices that minimize impacts on the natural environment and reduce the need for inputs such as water and fertilizer.

Soil is the foundation of your vineyard. It provides nutrients and anchorage for your grapevines. Optimized monitoring and management of your soil and its nutrients produces healthier vines and ultimately better wine quality and reduces the risk of negatively impacting the surrounding environment.

This chapter guides you step-by-step through the completion of a **nutrient management plan.** The main objectives of a nutrient management plan are to supply crops with nutrients at the appropriate rate, timing, and with the appropriate method to produce an economically optimal crop in terms of both yield and quality and to minimize the risk of pollution by loss of nutrients via runoff, leaching, emissions to the air or other loss mechanisms.

The chapter also provides sustainable practices to maintain soil quality by reducing erosion and sediment transport on-site and minimize off-site movement of soil and water.

Review Chapter 4 of the Best Practices Guide and Chapter 8 of the EFP Reference Guide for more information on soil and nutrition management.

SOIL AND NUTRIENT CHARACTERISTICS

4.1. Important Properties of Vineyard Soils

The purpose of this section is to help you understand some of the terminology that will be used throughout the chapter and to provide you with general background information on soil.

The three main components of soil are:

- **Minerals:** derived from decomposed rocks (ideally 45% of soil makeup)
- **Organic matter:** decomposed plant and animal residues, living organisms (ideally 5% of soil makeup)
- **Pore spaces:** space between solid parts of the soil. Pore space is occupied by water and air. If the pore space is entirely made up of water the soil is considered to be saturated. If the pore space is entirely made up of air the soil would be completely dry and unable to support plant growth. An ideal soil pore space to support plant growth is about 50 / 50 air and water in the pore space (water at 25% of total soil makeup and air at 25% of total makeup).

These three components provide the physical framework to support plant growth and anchorage. The balance between each of these components as well as the chemical properties of the soil determines a soil's ability to support plant growth over the long term.

Other important characteristics of soil include texture, structure, porosity, organic matter, and bulk density. These characteristics are described in Table 4-1.

Soil Profile

A soil profile is examined to a depth of one to two metres. While your interest is normally concentrated on the topsoil because it lies directly under your control, grapevine roots penetrate into the lower horizons and are affected by the composition of these deeper layers. An accurate account of the soil must include not just the topsoil, but the subsoil as well. Knowing what type of soils you are dealing with is the first step to understanding how to properly care for your vines.

Description of Soil Horizons

A) Topsoil (A Horizon(s)) is the layer formed over time from which plants obtain water and nutrients. It most often varies from 5 to 20 cm in thickness. This zone is the most influenced by soil management and contains the most organic matter and biological activity. The amount of organic matter determines the fertility of the soil. Topsoil is easily lost when land levelling is done; it should be carefully removed and then replaced after grading the subsoil below.

B) Subsoil (B Horizon) contains less organic matter and generally fewer roots but is still an important zone for nutrient uptake. In fine-textured soils the B horizon may accumulate materials leached from the topsoil such as clay which can create a compact subsoil layer. In sand and/or gravely soils, the horizon is identified as having a brownish or reddish colour.

C) Parent Material (C Horizon) is basically unweathered, geologic parent material, often of glacial origin. There is limited biological activity. In fine-textured soils the C horizon is identified as a zone of lime accumulation and sometimes hard concretions composed of calcium carbonate. In coarse-textured soils the C horizon lacks the colours as seen in surface horizons.

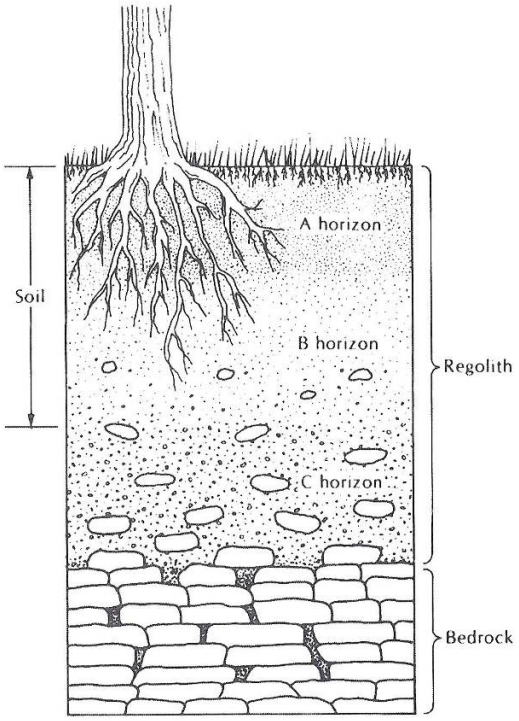

Figure 4-1: Well-developed soil, showing the typical sequence of horizons.
Adapted from Brady (1990, fig. 1.3).

Table 4-1: Important physical properties of vineyard soils.

Property	Description
Texture	• the relative proportions of sand, silt and clay particles found in a soil sample • affects nutrient and water holding capacity and aeration of the soil • grouped into 12 classes (see Figure 4-2) o sandy soils (those dominated by sand sized particles and are referred to as having coarse texture): water enters at a rapid rate, does not retain water and nutrients well, good aeration and easy penetration by plant roots, often low in organic matter and nutrients o silty soils (those dominated by silt-sized particles and referred to as having medium texture): holds more water and nutrients than sand, but less than clay, has less drainage than sandy soils, but more than clayey soils o clayey soils (those dominated by clay-sized particles and referred to as having fine texture): good water and nutrient holding capacity, may have poor drainage and little aeration, compaction may be a problem o loamy soils (those dominated by a mixture of particle sizes): considered best for grape growing because of the desirable properties of a sand, silt, and clay mixture, which allows for ease of cultivation, adequate water-holding capacity and nutrient-storage capacity and good drainage
Structure	• the way soil particles clump together into larger units called soil aggregates • naturally occurring soil aggregates are called peds • affects the availability of air and water in soil • classified according to 3 groups of traits: o type: the shape of the soil peds (granular, blocky, platey or structureless) o class: the size of the peds (very fine, fine, medium, coarse or very coarse) o grade: how distinct and strong the peds are (weak to strong where the peds are easily visible and can be handled without breaking) • ideal soil structure for plant growth is well aggregated soil that contains large, continuous pores • takes a very long time to develop naturally but can be damaged very quickly by mechanical operations and compaction
Porosity	• amount of pore space in the soil • these pores convey oxygen, water and dissolved nutrients and provide the space in which roots grow • nature of the pore space will vary depending on: o texture: sand (relatively large pore spaces, good aeration) and clay (relatively small pore spaces, holds water but can have poor root aeration) o structure: aggregation of particles creates larger pore spaces o mixing of the soil particles: excessive cultivation, for example, will decrease porosity by destroying natural soil structure, compaction will reduce total pore space due to compression
Organic Matter	• made up of living microorganisms and plant and animal residues in various stages of decomposition • plays an important role in many beneficial soil functions, including o source of nitrogen, sulphur and phosphorus. o contains chemical exchange sites that increase the ability of the soil to “hold onto” nutrient compounds o maintains soil structure and stability o increases soil water holding capacity; humic substances can hold up to 5 times their weight in water o provides a major energy source for soil microorganisms o increases soil temperatures due to darker soil, which also promotes biological activity • excessive tillage, soil erosion and poor cover crop management will speed the loss of organic matter
Bulk Density	• measures, for a given volume of dry soil, how much is occupied by solids and how much by pore space (i.e. how compact a soil is)

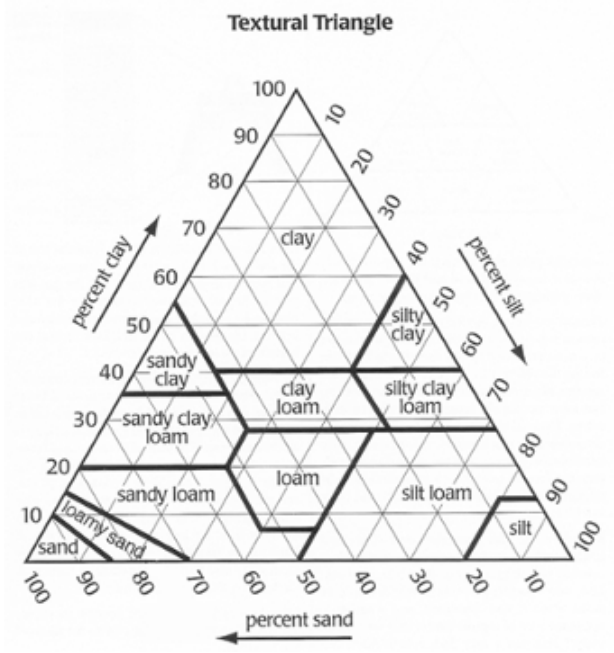

Figure 4-2: Soil textural classes (outlined in bold lines) are defined by percentage of sand, silt, and clay (fine lines parallel to arrows).
Adapted from Brady (1990, fig. 4.6).

4.2. Nutrients Necessary for Grapevine Growth

The purpose of this section is to help you understand some of the terminology that will be used throughout the chapter and to provide you with general background information on nutrients.

Macronutrients and Micronutrients

Nutrients come from the soil and are absorbed through the root system. They can be divided into two types:

- **Macronutrients:** essential elements that plants use in large amounts (nitrogen, phosphorus, potassium, calcium, magnesium, sulphur).
- **Micronutrients:** essential elements that plants use in small quantities (zinc, iron, manganese, copper, boron, molybdenum, chlorine, nickel).

Table 4-2 provides information on some of the macronutrients and micronutrients essential to grapevine growth and common effects of deficiencies or excesses.

Nutrient Cycles

Each nutrient element has its own cycle, the process by which the nutrients required by living organisms move through the living (biotic) and non-living (abiotic) components of an ecosystem.

Major plant nutrients include nitrogen, phosphorus and potassium. These nutrients follow cyclical patterns as they are used and reused by living organisms. Organic materials, like plant litter, decompose and are reincorporated into the soil as nutrients by decomposer organisms. Some physical processes, such as oxidation, mechanical breakage, lightening, fire and wind are non biological contributors to the nutrient cycle.

How nutrients are cycled is important in agricultural health and can be directly influenced by soil and nutrition management practices. A complete nutrient management plan (see Section 4.3) should take into consideration methods of managing and taking full advantage of the natural nutrient cycle.

Table 4-2: Nutrients essential to grapevine growth and common effects of imbalances.

Macronutrients	Use and Effect on Grapevine
Nitrogen	• Of all soil nutrients, nitrogen is the most likely to be deficient • Makes up 1% to 2% of the dry matter of a grapevine • Used as a component of proteins, and in energy transfer and photosynthesis • Deficiency symptoms include: loss of vigour, yellow leaves, red petioles • Excess causes vigour, reduced fruit set, reduced bud fertility, bud necrosis, bunchstem necrosis
Phosphorus	• Makes up 0.1% to 0.3% of the dry matter of a grapevine • Used in the fatty portion of cell membranes, carbon fixation, sugar metabolism, energy storage and genetic material • Deficiency symptoms include: reduced shoot growth, yield, and fruit set, low bunch numbers, basal leaves that turn pale or yellow and fall before flowering time, and red dots near the edges of mid or terminal lobes of basal leaves
Potassium	• Makes up 3% of dry weight of a grapevine • Required to form sugars, starches, proteins, acids, colouring materials, odour and taste for grapes • Increases the hardiness of the plant for winter and makes it more drought resistant • Deficiency symptoms include: yellow leaves in centre of new shoots starting at edge and moving into the centre, necrotic spots, holes, brittle leaves, uneven ripening of fruit, scorched leaves, reduced shoot growth, low vigour, reduced berry set and yields, and delayed growth of shoots and reductions in initial yield of young vines. • Excess reduces calcium and magnesium and produces high pH wines
Magnesium	• Essential for chlorophyll and is linked to phosphorus uptake • Deficiency symptoms include: yellowing between the veins of older leaves, red pigmentation in red varieties, grape stem drying, and yellowing of basal leaves
Calcium	• Plays a part in root, protein and carbohydrate formation • Controls the uptake of water into the vine • Deficiency symptoms include: dead buds and tips, necrotic leaf edges • Excess can affect the uptake of other nutrients, especially magnesium, boron, and potassium, and result in high soil pH
Micronutrients	**Use and Effect on Grapevine**
Zinc	• Component of enzyme catalyst reactions • Deficiency symptoms include: reduced fruit set, reduced internode length and small leaves, hen and chick berries • Deficiency symptoms usually occur at the shoot tip
Iron	• Used for chlorophyll development, enzyme system activation, and the formation of organic compounds • Deficiency symptoms include: chlorophyll loss starting between the small leaf veins, fading beginning at the leaf margins and progressing interveinally, reduce set, and dry leaves • Deficiency often referred to as iron chlorosis, lime chlorosis, or lime-induced chlorosis
Manganese	• Used in the formation of chlorophyll and works to activate enzymes • Deficiency symptoms are similar to iron or zinc deficiency symptoms
Boron	• Regulates plant hormones • Influences cell differentiation, cell growth, pollen germination and growth of pollen tubes • Deficiency symptoms include: reduced fruit set, puckered leaves, brown necrotic spots on leaf margins and base of shoots • Excess can cause toxicities

4.3. Nutrient Management Plan

The main objectives of a nutrient management plan are to:

1. supply crops with nutrients at the appropriate rate, timing, and with the appropriate method to produce an economically optimal crop in terms of both yield and quality; and
2. minimize the risk of pollution by loss of nutrients via runoff, leaching, emissions to the air or other loss mechanisms.

Nutrient management planning is included as a component of the Environmental Farm Plan. The nutrient management plan outlined in the EFP is more appropriate for large-scale farms than it is for vineyards. With this in mind, a nutrient management planning process has been developed here that is more appropriate for vineyards. Some technical components of the EFP Nutrient Management Reference Guide will be essential to preparing your management plan, and are referred to in the appropriate sections below.

Please download the EFP Nutrient Management Reference Guide from www2.gov.bc.ca/gov/content/industry/agriculture-seafood/agricultural-land-and-environment/soil-nutrients/nutrient-management/reference-guide

Acknowledgement: The structure and content recommended for your nutrient management plan in the following sections is based, in part, on the Lodi-Woodbridge Winegrape Commission's Soil Management – Companion Document.

A recommended structure for your nutrient management plan includes:

- Field Parameters
- Petiole Analysis
- Soil Analysis
- Water Analysis
- Sources and Forms of Nutrients
- Areas of Concern
- Rates of Fertilizer Application
- Timing of Fertilization
- Methods of Application
- Environmental Considerations with Fertilizer
- Fertilizer Storage
- Annual Review and Update

Nutrient management planning is an ongoing process. Your nutrient management plan must be kept in a form that will make it easy for you to find information and record new information as necessary. There are various ways to organize your plan, but the best is by placing it in a binder and using tabs to separate the different sections of the plan and the different vineyards if you have more than one. Organize the tabs of your nutrient management plan to match the guidelines above. Not all of the guidelines may apply to you, but try to be as thorough as possible.

A template is included below.

NUTRIENT MANAGEMENT PLAN TEMPLATE

Title Page

The title page identifies the vineyard name and all pertinent contact information for the vineyard.

Table of Contents

The Table of Contents gives an outline of all the sections of the plan. It should be inserted immediately after the Title Page but prior to Tab 1.

Tab 1: Field Parameters

- Information related to your soil classification
- Size of your property
- Soil site history, answers to questions on page 4-10 of the Guidebook
- This information can also be used in your Soil Conservation Plan

Tab 2: Identifying Areas of Concern

- Site plan with areas of concern identified
- Accompanying written description
- Records of predominant wind direction, water table depth, vineyard irrigation system, and potential for leaching based on soil type and water table

Tab 3: Petiole Sampling and Analysis

- Test results and analysis from lab

Tab 4: Soil Sampling and Analysis

- Test results and analysis from lab

Tab 5: Water Sampling and Analysis

- Test results and analysis from lab

Tab 6: Cover Crops

- Species of cover crops that you are or will be using in your vineyard
- Reasons for use (e.g. managing nitrogen excess in soil, reducing erosion)

Tab 7: Fertilizers

- Specific environmental considerations for fertilizer use on your property
- Type of fertilizer you are or will be using
- Reasons for use

Tab 8: Rates and Timing of Fertilization

- Amount of fertilizer you will be applying
- Timing of that application (i.e. what time of year and how many times during the year

Tab 9: Methods of Nutrient Application

- Where the fertilizer will be applied (e.g. below dripper, row middles)
- What method will be used to apply the fertilizer
- Who will apply the fertilizer
- What equipment will be used
- Factors you will use to adjust the application date or method (e.g. slope, rainfall patterns, soil type)and how they will be changed based on those factors

Tab 10: Review and Update

To be completed periodically throughout the season and formally before starting your fertility program for the following year.

- Actual application rates
- Actual application dates
- Actual material that was used
- Tonnage
- Outcome of application (i.e. enough, too much, too little for crop and quality goals)
- Events that caused deviation from the plan (e.g. weather, lack of labour, crop maturity)

You can start a new binder each year or add data from multiple years into the same binder. If the same binder is used for the second year, all new reports for year 2 should be inserted within the same tabs as in year 1 and placed immediately behind the year 1 reports.

For subsequent years, the same process should be repeated. A new binder should be started after the fifth year.

If using a new binder each year, the information in the binder should be inserted in the same order each year.

4.4. Field Parameters

For each vineyard, the nutrient management plan requires information on soil classification, size, and history.

Soil Classification

The interaction of the climate, physiography, geology, and vegetation ecology is what creates soil on the earth's surface. Because these factors can vary so greatly, they create many types of soils with different properties. The soil types that make up the grape growing regions of BC are diverse and may vary in pH, depth, texture and organic matter content, among other things. You will need to use soil maps to determine the soil series that occur on your vineyard.

Soil Maps

The Canadian System of Soil and Soil Climate Classification is a taxonomic system used to categorize soil in Canada. The levels of soil categories descending from broad to more specific are: Order, Great Group, Sub- Group, Family and Series. Because soil series is a more specific level of classification, it is the best to use for local and site specific information. The soil series is the name of the soil (example Penticton silt loam) and will include information on soil texture (proportions of sand, silt, clay and gravel), pH, organic matter content, and soil depth to water table or bedrock if these occur near the surface. However, the regional soil surveys were conducted many years ago and so the descriptions of soil series that may be available for your vineyard may not reflect the current condition of the soil, particularly if the soils have been intensively managed (irrigated, fertilized, levelled, amended) over the last 20 years.

The soils of interior BC vineyards are generally alkaline (pH >7.5) and low in organic matter. Many fine-textured soils contain abundant free lime which promotes high pH (>8.0). Most of the soils of the south Okanagan are sandy and/or gravely in texture, mildly alkaline but very low in organic matter. pH values exceeding 8.0 occur in some of the calcareous fans of the Similkameen. By contrast soils of coastal regions are acidic (pH <7.0) and tend to be higher in organic matter.

The soil properties at a given site are the product of natural soil forming factors like climate and parent material origin but also past management history. In particular, a history of poor land levelling may result in long term management challenges for grape growers particularly where free lime subsoil has been exposed on the surface.

The Viticulture Research Program at the Summerland federal research station has conducted surveys of grower vineyards in the Okanagan and Similkameen valleys and produced variety block maps with soil series information from published soil surveys listed. In most cases a soil scientist has field checked and validated this information. All participating growers should have this information. It is planned that this information will be collected and updated as new vineyards are established or existing vineyards change as funding allows. For more information about the availability of soil information for the Okanagan and Similkameen valley vineyards contact Carl Bogdanoff at (250) 494-2124.

While the same format of information does not exist for vineyards in other parts of the province, detailed soil survey maps do exist for most agricultural areas where grapes are grown in the province. For soil information for other areas of the province contact Elizabeth Kenney at (604) 796-2221.

Soil Pits

A soil map is a good starting point in identifying your soil types, but the best way to get to know your soil is to dig a pit and have a look. At pre-planting, it is necessary to dig to a minimum of 1 to 2 metres deep. In an established vineyard your soil pits should be 1 metre deep.

Based on your own knowledge of soil variation in your vineyard, or from information from the soil map, make observations using a soil pit of each soil series (type) on your vineyard. Starting from top of the pit, observe profile to determine properties and differences between horizons. Place golf tees or markers at the top and bottom of each horizon to clearly identify it. Look for and record: different colors, shapes, roots, the size and amount of stones, small dark nodules (called concretions), worms, or other small animals and insects, worm channels, and anything else that is noticeable. Periodically observing your soil will help you to plan and interpret your soil management outcomes. A soil professional or viticulture consultant can help you with interpreting soil features as you observe them in the field.

Hectares of Property/Vineyard

Record the size of your property in its entirety and the size of each of your vineyards.

Soil Site History

Consider the following when documenting your soil site history (adapted, in part, from Washington Association of Wine Grape Growers, 2006):

- How long has this site been a vineyard?
- List any past irrigation history and the systems used.
- List any past crop and/or animal management practices.
- List any past herbicide usage and carryover potential for each material.
- List any past fertilizers and soil amendments used.
- Was the past land use uniform or variable across the site?
- Has the site been levelled, eroded, or altered in any significant way?
- What is the native vegetation on the site or in the surrounding area?

4.5. Identifying Areas of Concern

Areas of concern include adjacent areas that may be impacted by your vineyard operations (e.g. wetlands, streams, residences, schools) and areas on your vineyard that may require extra attention. Use the **site plan** you created in Chapter 1 to record areas and provide an accompanying written description. Refer to this new map as your **soil management map**.

For adjacent areas of concern identify the following attributes:

- type,
- why it is of concern,
- proximity to vineyard, and
- size and type of buffer present

To identify areas on your vineyard that may need extra attention consider the following:

- unproductive regions of the vineyard,
- overly vigorous regions of the vineyard,
- regions with poor water drainage,
- areas with very shallow top soil,
- areas that have variations in canopy colour, and
- areas where there is a variation in cover crop.

Also record the predominant wind direction, water table depth, vineyard irrigation system, and potential for leaching based on soil type and water table.

4.6. Petiole Sampling and Analysis

An annual petiole (leaf stem) sample and analysis will provide an accurate determination of the nutritional status of your grapevine and help you to develop a nutritional and fertilizer regime.

Contact the lab in advance to discuss packaging and timing of sample and results.

Interpreting Petiole Test Results

Nitrate-nitrogen (NO_3) can also be used as a guideline to determine nitrogen levels, but ambiguity exists in defining critical values. NO_3 is highest at bloom, and progressively decreases until stabilization several weeks after bloom; therefore sampling should be done at full bloom. Below 350 ppm is considered deficient, above 500 ppm adequate, and above 2000 ppm excessive. **It is important to note that if vines display high vigour, additional nitrogen is not needed, regardless of NO_3 or nitrogen lab results.**

It may be appropriate to obtain a second, independent interpretation (e.g. from a consultant or soil expert) of the petiole analyses and their application to your nutrient management plan, even if you understand how to interpret and apply the results.

4.7. Soil Sampling and Analysis

Soil tests provide reliable information relating to organic matter content, pH, degree of salinity, and relative quantities of available plant food.

Soil sampling and analysis should be done every 5 years or every 2 to 3 years if undergoing a soil amendment program or if fertigation is the soil's primary source of nutrients. Fall (post harvest) is the best time to sample soils.

Soil tests are not reliable for determining fertilizer requirements because of the volume of soil that grapevines can mine, differences in nutrient uptake rates among rootstocks, soil variability, root health, nutrient interactions, and other factors. Soil testing is useful in identifying nutrient imbalances, deciding the form of fertilizer to apply, and tracking soil changes in your vineyard over time.

Make a map of your vineyard that separates varieties and indicates areas that are different from each other (e.g. slope, surface soil colour, drainage, soil texture). Add these characteristics to the **soil management map** you began creating in section 4.5.

Contact the lab in advance to discuss sample packaging, how quickly you should deliver the sample to the lab after taking it, and when to expect results. **Avoid contamination of the samples.** Make sure to store the samples in a cool place and mail or deliver them to the lab as soon as possible.

Interpreting Soil Test Results

Some of the most important soil parameters are described in Table 4-3.

Table 4-3: A description of important soil parameters and guidelines for interpreting lab results

Parameter	Description/ Importance	Interpreting Lab Results
pH	• Measure of acidity (low pH) or alkalinity (high pH) of the soil • Influences the plant availability of macronutrients and micronutrients	• 6.0 to 7.0 ideal because all nutrients available at this pH • Vines can grow in soil that is pH 4.0 to 8.5 • pH greater than 8.0 indicates high calcium carbonate and salts • pH greater than 9.0 indicates high levels of salinity • Low pH can be caused by years of fertilizer and sulphur use and may induce aluminum toxicity • Low pH can also create fungi problems • High pH can be accompanied by iron chlorosis
Cation Exchange Capacity (CEC)	• Also known as the buffer index • Measure of the electrical charge of the soil • Measure is used to calculate the amount of lime needed to raise the pH • CEC can be altered with soil organic matter	• Varies widely with soil type • The more negative the charge of the soil, the greater its ability to attract and hold positively charged nutrient ions (cations) including (magnesium (Mg^{++}), calcium (Ca^{+}) and potassium (K^{+})) • As the amount of base cations increases, so does the pH
Base Saturation	• Indicates the ratio of base cations in the soil to total cation exchange capacity	• For all alkaline soils, base saturation will typically be greater than 50% and many will approach 100%
Electroconductivity (EC)	• Measure of soil salinity	• Values < 0.7 mmho/cm indicate no salinity present • 0.7 to 2.0 mmho/cm indicate minor salts present, potentially problematic • 2.0 to 4.0 mmho/cm indicate moderate salinity that will affect plant growth and fruit yield • over 4.0 mmho/ cm can result in major yield reductions
Chlorides	• A small amount of chlorides are essential for grapevine growth but chlorides can be toxic at low concentrations	• < 300 ppm are good • 300 to 700 ppm are acceptable • > 700 ppm are problematic

4.8. Water Sampling and Analysis

The purpose of water sampling and analysis is to determine what your water is contributing to the nutritional balance of the soil.

Section 5.3 of the Water Management chapter contains information on water sampling and analysis.

4.9. Cover Crops

A cover crop is any plant that improves the soil on which it grows. The use of cover crops in a vineyard is a long term cost effective way to regulate the amount and persistence of soil organic matter. It takes approximately three years from the initial planting of cover crops to see nutrient cycling benefits in the soil organic matter whereas the changes in soil tilth and water penetration and infiltration can occur within one or two years.

Cover crops are featured predominately in this section because they are a very effective way to manage soil and nutrients in your vineyard. Cover crops can consist of grasses or legumes, but are typically planted together for their complimentary benefits; the grass makes up the bulk and the legumes provide additional nitrogen.

Choosing the correct cover crop requires the consideration of a number of factors, as outlined in Table 4-4.

Table 4-4: Factors to consider when choosing a cover crop.

Consideration	Questions
Growth Habits	• What kind of growth habit is needed? • When is the growth required, e.g. lots of vigorous late fall growth or rapid early spring growth?
Tendency to Compete with Vines	• Rooting depth • Water requirements • Nutrient requirements
Overwintering	• Does the cover crop need to survive over winter? • Would it suit the cropping schedule and soil type if the cover crop winter killed and dried out by spring?
Control Options (Tendency to spread)	• Will the cover crop become a weed concern? • How is it controlled? • What options are there for control?
Sensitivity to herbicides	• How sensitive is the cover crop to herbicide residues?
Seed cost and availability	• What is the seed cost and is the seed available in your area?
Environmental impact	• Can the cover crop damage natural habitat (e.g. orchard grass)?
Establishment	• What is the best way to plant the seed? • Is different equipment required? • How easy is it to establish?
Nutrient Management	• Is the cover crop a nitrogen producer or does it require nitrogen to grow well?
Pest Management	• What crop family is the cover crop in? • Is it related to other crops in the rotation? • Are there pest concerns?

Source: adapted from Ontario Ministry of Agriculture, Food and Rural Affairs, 2002.

4.10. Fertilizers

A fertilizer is a substance used to supply essential elements. Two major questions people ask about fertilizers are what specific fertilizer to use and how much to use. There are no universal answers to these questions.

The ability of roots to take up nutrients depends on the nutrient supply, but it also depends on other factors, such as soil structure, the availability of air and water, and the population of soil organisms surrounding the roots. After the initial nutrient application, a grower should be prepared to make appropriate modifications later in the season or in the following year, considering the weather and how the grapes are growing.

Grapes can often be grown without added fertilizers. A sustainable vineyard will use nutrients released through the decomposition of inherent soil organic matter, nitrogen fixed by leguminous cover crops and contained in irrigation water to maintain nutrient levels as much as possible.

All types of fertilizers can have negative impacts on the environment if not managed properly. Rather than promoting the use of certain fertilizers over others, this program promotes the "responsible use" of any fertilizer, whether organic or inorganic (synthetic). The following sections provide best practices for fertilizer use that will minimize environmental impacts, enhance energy and other cost savings, and benefit society.

Environmental Considerations

Some of the environmental concerns to be aware of when working with any kind of fertilizer are:

- **Water pollution (nitrogen and phosphorus leaching):** occurs when the fertilizer washes into surface water (streams, lakes or rivers) or leaches into groundwater. A cover crop that establishes quickly in the fall and stays throughout the winter can prevent/reduce nitrogen leaching by taking up added nutrients as can careful use of irrigation water to avoid adding excess water to the root zone that will facilitate leaching of any soluble nutrients.
- **Air pollution:** a problem primarily with dry, powdery fertilizers or when fertilizers are applied by spraying. Avoid air pollution problems by only spraying on days when there is no wind.
- **Habitat and animal risks:** proper storage and application of fertilizers can reduce the risk of natural habitats and animals being adversely affected by fertilizers.
- **Energy costs:** some fertilizers have a high energy cost. The mining and processing of phosphate and potash fertilizers consume some energy but the highest energy cost is involved in making ammonia.

Organic Fertilizers

Organic fertilizers include manure, mulch and compost. Many are considered "slow release" because nutrients are released gradually over the growing season as the organic matter decays.

The responsible use of organic materials as soil amendments also benefits society because other options for disposing of the materials, such as landfilling and incineration, often carry greater risks to the environment. That said, organic fertilizers are usually bulky and expensive to transport (both financially and environmentally) so it is important to look at locally-sourced options first.

Many organic materials contain low amounts of nutrients. Although organic fertilizers are not always a quick fix for immediate nutrient requirements, they can be applied to balance the nutrient levels over time.

Animal Manure

Animal manure is the oldest known fertilizer. Throughout history, people have long relied on animals as a source of soil nutrients. To realize the potential value of manure and to avoid pollution problems, well-planned manure handling and storage systems are essential.

Manure has several benefits:

- it has good amounts of nitrogen and potash, fair amounts of other micronutrients, and traces of several micronutrients;
- it adds organic matter to the soil – 20 to 40 percent of manure is made up of organic solids;
- it is low in phosphorus but it helps prevent phosphorus from being tied up in the soils, thus making it available for plants; and
- it has longer-lasting effects than an equivalent amount of chemical fertilizer.

Table 4-5 provides an estimate of the average nutrient content of several types of animal manure. Manure includes both solids and liquids, which are for the most part the feces and urine of the animal. The solid part may also include bedding. Most of the potash in manure is contained in the urine, and the phosphate is contained primarily in the feces. Nitrogen is distributed equally between the two parts. The nutrient content of manures is low compared to commercial fertilizers.

Table 4-5: Nutrient content of several animal manures, in pounds of nutrients per ton.

Animal	Pounds/Ton					
	N	P_2O_5	K_2O	S	Ca	Mg
Dairy cattle	10	4	8	1	6	2
Beef cattle	11	8	10	1	3	2
Poultry	23	11	10	3	36	6
Swine	10	3	8	3	11	2
Sheep	28	4	20	2	11	4
Horse	13	5	13	--	--	--

Source: Plaster, 1997.

Table 4-5 is provided as a guideline – the nutrient value of manure can vary considerably depending on several factors, including the feed, the age and productivity of the animal, and the amount and type of bedding in the manure. Always be sure the manure added to your vineyard meets the nutrient need of your vineyard. Although it is not always practical, testing your manure at time of application will be very helpful in determining its nutrient content.

Proper handling of manure reduces nutrient losses and lowers the chance of polluting surface or groundwater. The best way to

handle manure is to spread it on unfrozen ground and turn into the soil immediately. If it is not practical to mix it into the soil immediately, the manure should be stored short-term in a storage structure with a concrete floor and walls and a roof to stop drainage losses and slow down the drying of the manure. Sharp nitrogen losses occur if it begins to decay before it is spread. The losses occur when urea changes to ammonia gas during decay – the loss is most rapid when it is warm and the concentration of urea is highest. Covering manure piles with straw, hay or tarps will reduce N loss.

Raw manure might contaminate the soil with E. coli bacteria, so it is better to use properly composted material.

Green Manure

Green manure is a cover crop that is grown to be tilled and turned under while still green.

Green manure reduces erosion, weed growth and increases organic matter and nutrients in soil. Legumes, grasses, or other plants can be grown for green manure, depending on the soil nutrient requirements. The turning under of the cover crop can increase the nutrient and water holding capacity and aeration levels of the soil.

Green manure crops can be planted in March or April, after the fall cover has been removed. A good time to consider green manuring is prior to vineyard establishment.

Green manuring is generally not practiced in dry climates where water is chronically a limiting element to plant growth. Considerable soil water is lost in transpiration from the green manure plant, lowering the water table.

Mulch

Mulch is an organic matter material (e.g. straw, leaves, vine and grape waste) that is spread on the soil surface. Mulch decomposes and provides the soil with increased nutrients and soil aggregation. Mulches also block evaporation of water from the soil, moderate soil temperatures, slowing down soil drying, and help control the growth of weeds

Compost

Composting is the decomposition of waste products by aerobic means (i.e. through microorganisms that require oxygen). The successful production of compost depends primarily on the moisture content, air supply and quantity of material.

The unique feature of compost as a fertilizer is its usually predictable and ideal C/N ratio, combined with a high concentration of minerals. Compost also contains high levels of microorganisms that aid in the decomposition and may increase pest and disease resistance of the vineyard. Composting also destroys viable weed seeds that may be present in uncomposted manures.

Compost made up of manure or food waste can have quite high concentrations of salt. Grapevine growth can be affected if salinity levels of the compost are greater than 2.5 ds/m and certainly will be impacted if salinity

levels exceed 4.0 ds/m. Therefore, it is advised not to use manure or food waste compost if your vineyard soil is somewhat saline (soil test results for EC > 3.0 ds/m).

If using compost in high quantities or for specific nutrient needs, have the compost tested to find out what levels of nutrients are in it. Because compost can be made up of such a variety of materials, it can vary greatly in nutrient content and salinity levels. If your compost is from an Okanagan landfill, be sure to test for boron levels as they are higher than desirable in many cases.

The pros and cons of various types of compost and manure are included in Table 4-6.

Table 4-6: Compost and manure pros and cons (characteristics may vary per product, especially from mixed sources).

Material	Pros and Cons
Green waste compost	High carbon and low nitrogen, potassium, and phosphorus. Good choice for building stable organic matter. May immobilize nitrogen if incorporated (particularly a problem with high C/N ratio material). Recycles urban yard wastes. Typically low in salt content. Source and quality is important because it can be a source for undesirable chemical residues.
Dairy manure compost	High nitrogen (slow release) and low carbon.
Steer manure compost	High nitrogen (slow release) and low carbon. May contain high levels of salts.
Grape pomace compost	High potassium and nitrogen (slow release). Recycles winery waste products.
Chicken manure	High nitrogen (slow release) and very high phosphorus.
Dairy manure	Moderate nitrogen, but needs incorporation for maximum contribution because of ammonia volatilization. May contain numerous weed seeds.
Steer manure	Moderate nitrogen, but needs incorporation for maximum contribution because of ammonia volatilization. May contain numerous weed seeds and high levels of salts.
Chicken manure	Very high nitrogen and phosphorus, but needs incorporation of maximum contribution because of ammonia volatilization. Has strong odour, can burn young vines, and can tie up zinc if includes bedding.
Raw grape pomace	High potassium and moderate nitrogen. Recycles winery waste.

Source: Ohmart and Matthiasson, 2008

Special note: do not apply fermented grape pomace to vineyard soils because it can be highly toxic.

Synthetic Fertilizers

Synthetic fertilizers are manufactured in labs and are composed of synthetic chemicals and/or minerals. Some fertilizers contain one main nutrient source, while others contain multiple sources. Different nutrient compositions suit different crops and soil types.

Advantages of synthetic fertilizers include:

- nutrient amounts can be tweaked depending on what is lacking in the soil,
- quickly available to the plant upon application,
- cost effective,
- easily transported, and
- can be bought in quantities needed.

Over-application of synthetic fertilizers may lead to burning of the root, plant death, leaching due to rain or irrigation, increased salinity to toxic levels, and excessive vigour.

The production of synthetic fertilizers uses large amounts of energy. The bulk of energy use is not consumed directly at the agricultural site, but indirectly during the production, packaging and transportation of the fertilizer. Additional energy is then used on site during application.

4.11. Rates and Timing of Nutrient Application

This section of your nutrient management plan should outline the amount of fertilizer you will apply and the timing of that application (i.e. what time of year and how many times during the year).

The amount and type of fertilizer applied should be based on the results of your petiole and soil tests, the nutrients available to the vines, the amount removed with harvest, the nutrients incorporated into root and trunk growth (5-10% of that removed with harvest), and the vineyard vigour. It is important to ensure vines are balanced, leaching is minimized, and nutrients are not over or under applied.

Knowledge of deficiency symptoms (see Table 4-2), good record keeping, and experimentation with quantities and timing of fertilizer applications will also aid in assessing the soil capability and determining the appropriate rates and timing of applications.

The timing of fertilization is important to maximize the positive effects of the fertilizer to the soil and to minimize its potentially negative effects to the grapevines and the surrounding environment.

General best management practices for fertilizer timing and application include:

- Add fertilizers in small amounts and in multiple doses to decrease the possibility of leaching into the groundwater or of creating excessive nutrient levels;
- Add fertilizers during the growing season when the uptake of nutrients by the grapevines is at its peak, or at post harvest to allow the grapevines time to take up the nutrients for the next growing season;
- Do not apply nutrients on excessively wet soils and soils which are cold, frozen or snow covered as these soils are less likely to absorb nutrients; and
- Never add fertilizers when the grapevines are dormant.

4.12. Methods of Nutrient Application

This section of your nutrient management plan should address the following questions:

- Where will the fertilizer be applied (e.g. below dripper, row middles)?
- Will the irrigation system be used to apply the fertilizer?
- Who will apply if someone from your operation won't be doing the application?

- What equipment will be used?
- What factors will you use to adjust application date or method and how will they change (e.g. slope, rainfall patterns, soil type)?

Fertigation

Fertigation (or chemigation) is the process of applying highly soluble inorganic fertilizers using an irrigation system for application. Fertigation is only as effective as the irrigation system it is used in. Fertigation works best in a trickle/drip system but can also be used through sprinkler or surface irrigation.

Advantages of fertigation include distribution uniformity, reduced fertilizer use, minimal off-site movement, flexible in timing fertilizer application and significantly less labour intensive, all of which reduce overall costs.

An alternative to fertigation is the use of a biological source to add nutrients to the soil. A biological source may be compost, pomace or a cover crop. As the crop is irrigated, water transports nutrients from the biological source into the root zone of the plants.

Soil Surface Applications

Some fertilizers are added directly onto the soil and then worked into the soil for optimal results. This includes the organic fertilizers such as manure and compost and some synthetic fertilizers as well.

Topical application is one of the simplest methods of fertilizing, it is the easiest method of applying organic fertilizers (i.e. manure, compost), and it can be used to apply bulk blends rapidly.

The disadvantages of topical application are:

- Some nutrients do not leach very far into the soil, and if left on the surface may not reach the root zone;
- Runoff can occur if rainfall or irrigation rates exceed the infiltration capacity of the soil. Some moisture is needed to solubilise the nutrients and transport them downward into the root zone so they can be utilized by the plant;
- Nutrients can have an adverse affect on animals that enter the vineyard too soon after application; and
- Light and powdery fertilizers can blow away on a windy day. Be sure to work the fertilizer into the soil as soon as possible.

Foliar Spraying

Foliar feeding involves spraying solutions directly on the leaves of the vines. The nutrients are absorbed through the stomata (openings in leaves that allow gases to move in and out). The most practical use of foliar sprays is to solve trace element shortages. Spraying the leaves bypasses any soil problems (e.g. trace elements being tied up in the soil).

The advantage of foliar spraying is that it often provides the quickest response of any method of fertilization so may be used as a quick cure for a deficiency.

The disadvantages of foliar spraying are:

- Results are usually short-lived so it may be necessary to repeat feedings several times;
- Difficult to supply enough of the major elements; and
- Sprays strong enough to supply much nutrient value can burn the leaves and damage application equipment.

Nutrient Application Equipment Calibration

In order to manage nutrients effectively, both manure and fertilizer spreaders need to be maintained and calibrated to ensure uniform distribution. Calibration is a determination of the amount of solid or liquid applied to a given area for a specific piece of application equipment. Uniformity is the evenness of application across the band spreading width from the beginning to end of each pass.

4.13. Review and Update of Nutrient Management Plan

Your nutrient management plan should be reviewed periodically throughout the season and a formal annual review and update conducted before starting your fertility program for the following year.

The questions to consider during your reviews are:

- What were your actual application rates?
- When did you actually apply?
- How did you actually apply?
- What material was actually used?
- What was your tonnage?
- Was the fertility enough, too much, or too little for your crop and quality goals?
- What events caused deviation from the plan (e.g. weather, lack of labour, crop maturity)?
- Reflect on these deviations from your plan and update or change components to better predict next season.

SOIL MANAGEMENT

4.14. Soil Erosion Due to Water, Wind, or Equipment

Agricultural lands lose surface soil every year to different types of erosion.

Water erosion happens when rainfall or melting snow or even excess irrigation washes valuable topsoil away. Water erosion can be limited by ensuring your soil has good water infiltration, good water holding capacity (by the addition of organic matter to your vineyard). If possible and necessary, you should consider a drainage system for your vineyard. (Although some larger vineyards use a tile drainage system, this can be costly and not feasible for many viticulturists. Drainage ditches or gullies to catch excess water are another alternative.) Cover crops will help protect the surface soil and prevent water erosion as well. Drip irrigation will minimize water use and runoff.

Mass movement erosion occurs when a large amount of soil moves and takes more soil with it. This is like a landslump or small landslide and occurs on a slope. Generally mass

movements will be caused by concentrated runoff flows that saturate soils on sloping terrain. If possible, avoid planting on steep grades. Sandy or clayey textured soils are more likely to be carried away in mass movement erosion. Add organic matter to your soil to help limit mass movement erosion. Planting cover crops will also work to reduce the possibility of mass movement erosion.

Tillage erosion occurs through plowing and discing the soil on sloping and hummocky (uneven hilly) landscapes. On most cultivated soils this is the major factor in soil movement usually resulting in removal of topsoil from convex landform positions and deposition in concave or depressional positions. The impact is to greatly reduce soil health on the eroded slopes and knolls. The object should be to minimize tillage on hummocky landscapes. In some high-value vineyards in Europe it is not uncommon for vineyard managers to transport soils moved downslope through tillage back onto upperslope positons to maintain soil health and productivity.

Wind erosion occurs when wind blows away surface soil. Cover crops will help protect the soil from wind. Also, planting trees and shrubs on the perimeter of your vineyard will act as a windbreak and help to protect you vineyard from wind.

Air quality is an important consideration when working with soil. Dust particles in the air can be considered air pollution. Particulate matter (PM) in the air is measured in diameter. PM10 means particulate matter less than 10 microns in diameter. At this size, the particles can be inhaled and enter the lungs and it is very difficult for the body to get rid of them. If enough of these particles accumulate in the lungs, they can create health problems.

It is important to be aware of PM10 and how you can reduce them in your vineyard. Using dust suppression materials (paving, oil, roadmix gravel, organic matter) on roadways and shifting soil only when it is moist and not on windy days are two measures to reduce your impact on air quality.

Breaks in water supply lines or irrigation lines can result in large volumes of water being discharged over a small area. In fine textured soils (clayey and silty soil classes) considerable erosion can occur very quickly. Water supply lines must be inspected and maintained on a regular basis to prevent such erosion events from occurring.

4.15. Soil Erosion from Roads, Ditches, and Culverts

It is important to limit erosion associated with roads and their infrastructure and to prevent erosion that does occur from reaching adjacent waterbodies.

Important sediment reduction measures for roads, ditches and culverts include (Horwath et. al, 2008):

- *Outsloping unpaved roads* minimizes surface erosion by rapidly moving water from the roadbed. Outsloping also disperses eroded sediments along the hill-slope, where it can be filtered by cover

crops or natural vegetation, rather than concentrating sediment in the ditch.

- *Vegetating unpaved roads* with grass or other vegetation reduces erosion and dust.
- *Grassing and hardening ditches* to prevent erosion and downcutting. For low to moderate slopes use perennial grasses to stabilize ditch surfaces and filter sediments from unpaved road surfaces. For steeper slopes and points of potential high scour, hardening with stone or cement may be necessary.
- *Stabilizing culverts* at both the inlet and outlet by ensuring soil is well compacted and points of scour hardened (e.g. with stone or cement); sizing culverts to accommodate high flow events; installing culverts at a slope matching the downstream grade; and installing energy dissipaters below the culvert outflow.

4.16. Tillage of the Vineyard Floor

Tillage or discing (tilling which cultivates only the top few inches of soil) should be used sparingly. Once a vineyard is established, tillage of the vineyard floor should not be done more than once every five years, if at all. Tilling can break down soil structure, deteriorate soil organic matter, and adversely affect soil aggregation. Tilling can also break down mycorrhizae fungi and contribute to soil compaction.

Tilling can be necessary if you use green manure as part of your nutrient management plan. Tilling is then used to turn under these plants for decomposition in the soil for specific nutrient requirements. This practice of tilling should still be done only when required and the adverse affects of soil compaction should be considered in your soil management practices. Use a spader or cultivator to minimise the impacts of tillage.

4.17. Soil Compaction

Soil compaction occurs when heavy traffic such as tractors or other farming equipment, compresses soil, causing it to lose pore space. The loss of pore space makes the soil less able to absorb and hold water, causing an increased likelihood of water erosion. Vine roots require a certain amount of water and oxygen in order to take in nutrients and grow and soil compression makes less space for both water and oxygen in the soil and can have an impact on vine growth.

To avoid soil compression:

- Do not use heavy equipment on wet soil;
- Use lighter equipment when possible;
- Use equipment with tracks or wide diameter tires to reduce ground loading;
- Keep tire pressure on equipment as low as possible (tracked tractors have the lowest psi);
- Plant cover crops (the roots create space in the soil to reduce compaction); and
- Use equipment that can do 2-4 rows at a time.

4.18. Soil Water Storage and Movement

Soil should have good infiltration rates and a high water holding capacity to soak up surface water to minimize run off and maximize the amount of water that can be made available to vine root systems.

Water stress on the vine will affect the growth of leaves, shoots and fruit. Good soil structure is important for creating optimal levels of water infiltration, water holding capacity and drainage.

If water from irrigation or rain puddles on top of the soil and runs off when the soil underneath is dry, measures to improve the infiltration capacity of the soil should be taken.

- **Water infiltration**: affected by how prone the soil is to crusting. Covering soil with mulch or compost will improve the ability of the soil to absorb water.
- **Water holding capacity**: affected by the soil structure, texture and organic matter content. Inside the soil aggregates are water holding micro pores. Soil with good water holding capacity will store water during rainfall for use by the vines roots. Grow cover crops or add compost or mulch to create well aggregated soil.
- **Sufficient drainage:** affected by internal porosity, which can be enhanced by adding organic matter, or by landscape position whereby runoff water collects at a site. In this later case, artificial drainage may be required.

CHAPTER 5
WATER MANAGEMENT

Table of Contents

5.0 WATER MANAGEMENT

INTRODUCTION

Chapter objective: To promote responsible use of water through monitoring, proper irrigation system design and scheduling, efficient technologies, and runoff control.

Effective irrigation management can help growers reduce their water consumption, minimize the likelihood of excess nutrients leaching beyond the plant's rooting depth, increase crop yield, improve fruit quality, and capitalize on related cost savings. Consequently, the environment and society also benefit: reduced water consumption in the vineyard means more water is available for the future or for other needs; reducing or eliminating runoff and nutrient leaching means less impact on streams, lakes and aquifers.

Not only will water conservation save water, but in many cases energy use will be reduced, thus having a significant impact on operating costs for the vineyard.

To be effective, irrigation management must be tailored to suit site conditions, plant characteristics, vine size, spacing and variety, and must be compatible with other management goals such as cover crop maintenance, frost protection, and disease and pest control. Growers should use a varied set of tools to help them make more informed decisions. These tools may include monitoring equipment, weather stations, online data banks (i.e. evapotranspiration data) and calculators (i.e. irrigation calculator).

Chapter 4 of the Best Practices Guide and Chapter 9 of the EFP Reference Guide should also be reviewed to learn more about water management in the vineyard.

IDENTIFYING LOCAL CONDITIONS

Soil type, land features, and irrigation water source are examples of local conditions unique to every vineyard that should be considered in any water management scheme, as they will influence how the crop objectives can be achieved. Local parameters and conditions should be monitored on an on-going basis, to identify shortfalls in the strategy and to take the necessary corrective actions.

Some monitoring tools may include:

- soil monitoring devices,
- weather stations, and
- other information resources (e.g. www.irrigationbc.com and www.farmwest.com).

Some local parameters to track may include:

- visual plant stress,
- leaf water potential,
- soil moisture, and
- evapotranspiration (ET) estimates.

The data should not only be collected but also recorded and interpreted to support irrigation scheduling decisions. Other considerations such as energy efficiency should also be taken into account when relevant.

5.1. The Water Cycle

The water cycle is an essential component to agriculture and life in general. It is important for all water users to optimize the water received from the natural cycle, especially as water becomes a scarcer resource.

During precipitation, moisture is stored as both surface and ground water. Some of this water is lost through evaporation back to the atmosphere or runs off the site as surface flow. Additionally, some water is taken up by plants, where it is stored in the plant and transpired back into the atmosphere. The plant communities on the vineyard and particularly the vine and cover crop selection can have a significant impact on how water is cycled, as various plants use and store water differently.

To take full advantage of natural water resources you should have a basic understanding of the water cycle and of how practices such as monitoring evapotranspiration, increasing the water holding capacity of your soil, improving soil filtration, and managing runoff fit into the cycle.

5.2. Your Watershed

Your vineyard is located in a watershed. A watershed is an area where surface water captured by precipitation, filtration and stored water, drains into the same water source. Watersheds can be large areas that drain into an ocean or smaller areas that drain into a lake. All living things in a watershed area depend on their common water source and therefore all have a vested interest a healthy watershed. Activities on the land in a watershed can have both a local environmental impact and an impact downstream.

Knowledge of the local watershed is important in understanding what issues a region faces regarding their water resources. To find out which local watershed your property is located in, contact your water purveyor or local government (i.e. municipality or regional district).

WATER QUALITY

5.3. Water Quality Testing and Analysis

Water quality is an important aspect in irrigation planning. Water of poor quality can carry pollutants, pathogens and salts that can negatively impact the vineyard and the environment.

Irrigation water suitability is greatly influenced by the concentration of salts. The long-term growth of a crop and health of the soil will be greatly influenced by salinity and the proportion of sodium relative to magnesium in water. It will also depend on soil type, irrigation practices, grape variety and rootstock. High levels of salts can affect the osmotic effect at the root zone, meaning that

greater tensions are needed within the roots to extract water in higher salinity soil.

Additionally, some of the salts may be in a form that is toxic to vine roots (i.e. chloride and sodium), which can affect shoot growth and yield potential. High levels of boron can cause leaf damage (cupping and spotting), defoliation and depressed growth.

Methods of dealing with salt toxicity include:

- Ensuring good drainage. Soil type has a large effect because good drainage results in leaching of salt out of the root zone.
- Adding calcium to the soil.
- Water filtration may be necessary as carbonate and bicarbonate ions in water can combine with calcium and magnesium, precipitate and block drippers and emitters.

Most vineyards in BC are supplied with water by irrigation districts, municipalities or regional districts. These water purveyors carry out regular water testing and usually treat water to drinking-water standards prior to distribution. Where this is the case, growers may not need to test their water for irrigation suitability, however, growers should request test results from their water purveyor at least once every five years.

Where private groundwater wells are the source of water, testing for irrigation suitability and nutrient content should be performed every three years. Where dynamic water sources such as streams are the source, a more frequent monitoring scheme is recommended as water quality can change more often. Growers should inspect wellheads and water sources on an annual basis to identify potential contamination, and additional water testing should be carried out when a cause for concern is identified.

Table 5.1 shows parameters according to the BC Approved Water Quality Guidelines. In all cases the values shown are maximum limits. In case of dispute, the original document (available from BC Ministry of Environment) must be consulted.

In addition to the parameters listed in Table 5-1, it may be beneficial to analyze for bicarbonate, calcium, magnesium, manganese and total suspended solids (TSS).

Table 5.1: Test parameters for irrigation water for wine grapes.

Analysis	Irrigation Parameters**	Comments
pH	7.0 – 8.7	8.5 or greater suggests possible sodium hazard
Aluminum	5mg/L dissolved	
Boron	0.5 - 1.0 mg/L	
Chloride	100 mg/L	
Copper (sheep)	200ug/L	
Faecal coliform	1000/ml	
Lead, neutral and alkaline – fine textured soils	400ug/L	
Lead, all other soils	200ug/L	
Sodium	300mg/L	
Sulphate	500mg/L	
Nitrate	No level	
Nitrite	No level	
Iron	0.3mg/L	Aesthetic objective only.
Total dissolved solids (salinity)	500mg/L	Objective level: Higher values indicate high salt content
Hardness	-	For information only
Zinc for irrigation water with pH <6	1000ug/L	
Zinc for irrigation water pH >7	5000ug/L	
Zinc for irrigation water with pH 6-7	2000ug/L	

**Irrigation parameters are for systems that do not provide public access and do not provide overhead irrigation to crops that are eaten raw.

Source: BC Approved Water Quality Guidelines

5.4. Backflow Prevention

Fertigation is a way of distributing fertilizers, soil amendments or other water soluble products through an irrigation system. The process involves injecting fertilizer into irrigation lines and delivering it to the plant along with the irrigation water. See Section 4.12 for more information on fertigation.

Backflow prevention devices are essential in a fertigation system to prevent water source contamination.

WATER USE EFFICIENCY

5.5. Types of Irrigation Systems

Irrigation systems used in BC vineyards include high-volume, high pressure sprinkler systems and low pressure systems such as drip or trickle and micro-sprinklers.

Regardless of the irrigation system type, it is important to know the rate of water application per area to calculate the amount of time required to wet through the root system. Water delivery rates will be influenced by site and crop characteristics such as terrain, slope, cover crops and the rate of water absorption, and percolation within the soil.

Most vineyards in BC are irrigated by overhead sprinklers, which are used not only to supply water but to provide frost protection. While overhead sprinklers are the predominant method of irrigation, drip and microjet systems are also being used.

5.6. Irrigation System Design and Operation

The irrigation system must be designed to provide vines their maximum water requirements. Also, the system design must take soil characteristics into consideration. Irrigation companies can help growers determine flow rates, sprinkler sizes, pipe and pump needs for the land and crop to be irrigated.

Irrigation systems must be designed and installed correctly. You should use a Certified Irrigation Designer (CID) to help you design and install your system. CIDs are held to a code of ethics that require the selection and design of irrigation systems that meet standards and specifications outlined in industry adopted irrigation design manuals. They also provide scheduling information to the property owner to ensure that the systems are operated correctly. Visit www.irrigationbc.com to find a CID in your area.

The irrigation system designer must set water application rates that are ideal for the local soil characteristics and vine vigour. Equally important are the number of emitters and their spacing from each other; these should be set to deliver a water rate adequate for the vine size and soil texture.

An irrigation system should include certain basic components:

- back-flow preventers
- flow controls
- filtration and injection equipment
- pressure compensation
- energy efficiency
- accommodation for site variation.

To prevent plugging of irrigation emitters, a filtration system and regular inspections of the emitters are recommended. These components and controls can enhance safety and energy efficiency.

5.7. Flow Meters

Water metering in an irrigation system helps by providing a visual representation of water consumption and can help detect leaks in the system. Metering usually leads to water conservation efforts, including a reduction in wasted water.

Flow meters can be installed on wells and other pumps to provide an accurate measure of water usage. Monthly checks and recording of flows are recommended.

5.8. Delineating Irrigation Management Zones

An important component of irrigation management is the identification of zones of the vineyard that have similar plant-available water storage and similar crop-water extraction patterns. Zones will have significantly different water and nutrient requirements that will affect irrigation scheduling.

To delineate irrigation management zones you can follow these steps, which consist of creating different layers of drawings (using tracing paper) and overlaying these on top of the site plan of your site (FAO, 2005):

Step 1:

- Make a copy of the **site plan** created in Chapter 1.

Step 2:

- Make a copy of the **soil management map** created in Chapter 4 on tracing paper.
- Ensure the drawing identifies the dominant soil types and key soil properties that affect soil-water storage.
- Mark areas with similar irrigation requirements.

Step 3:

- Draw your irrigation system plan on a new sheet of tracing paper, and overlay on top of the **soil management map** and **site plan**.
- Mark areas watered by each valve and in each irrigation shift.

Step 4:

- Overlay a planting plan of grape varieties.
- Integrate this information to draw up irrigation-scheduling units.
- Delineate areas that have similar irrigation requirements according to soils, aspect, topographic location and vine type/cultivar.
- Some modification may be required to the irrigation system.

Refer to the resulting map (or maps) as your **irrigation management map(s)**.

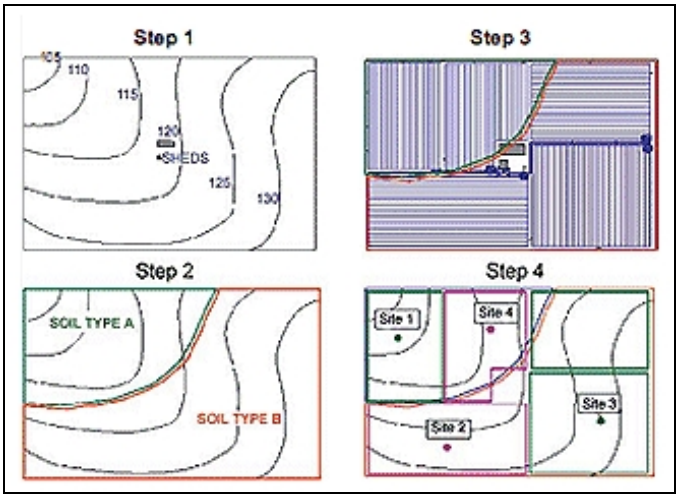

Figure 5-5: Steps in delineating irrigation management zones. (FAO, 2005)

5.9. Distribution Uniformity and Application Efficiency

Distribution Uniformity (DU) is a measurement of the evenness of water application over a field, and is expressed as a percentage. Application efficiency is an indication of the percentage of water applied by the irrigation system that is actually available to the crop. It is important for irrigation water to be distributed evenly throughout the vineyard so the vine canopy, yield and fruit quality are uniform throughout the block. The goal should be to avoid overwatering one area and not watering enough in another, since this will affect crop uniformity -- one of the most important parameters influencing wine quality. Table 5-2 lists the impacts of irrigation extremes.

Table 5-2: Impacts of irrigation extremes

Over-Irrigation	Under-Irrigation
• Drowns roots, stressing plants	• Reduces crop yield
• Leaches nutrients and pesticides from the root zone to groundwater	• Reduces crop quality (fruit and vegetable size)
• Reduces nutrient uptake	• Reduces plant growth
• Cools soil, thus reducing root growth	• Weakens plant
• Encourages root disease	
• Reduces crop quality	
• Increases system operating costs	
• May impact unnecessarily on water resources and impact fish and wildlife resources that rely on adequate and sustained water quality and quantity	

Source: Nyvall and Tam, 2005, p. 4

Simple catch can trials can be conducted on any type of irrigation system and the data used to calculate the distribution uniformity for the system. Yearly testing and recording of distribution uniformity of the irrigation system is recommended, unless subsurface drip irrigation is employed, in which case relief valves should be checked weekly. Testing can be done by monitoring emitter outflows and pressure differences across the block and make corrections where needed.

Irrigation systems should be assessed for distribution uniformity and application efficiency before scheduling is developed.

5.10. Pump Efficiency

An irrigation system can be made more efficient firstly by having a custom designed distribution system with adequate pump and pipeline sizes, and by irrigating according to crop requirements.

Energy efficiency of pumps can be optimized by having a pump operate at or close to its "Best Efficiency Point", accomplished by:

- Ensuring that the correct impeller is used
- Improving friction loss in fittings at pump discharge.
- Replacing worn nozzles as these can apply more water than desired and can throw off your irrigation schedule (water budget).
- Replacing pump with a more efficient model.

Pumps fed by electricity produced from clean alternate sources of energy such as wind or solar photovoltaic, have become an economically viable option for many vineyards in North America and are considered the most sustainable.

5.11. Routine System Maintenance

Once your system is designed and installed it is up to you to make sure it is being used (scheduled) and maintained properly. Irrigation scheduling takes into account the location, landscape, soil and irrigation system operation parameters. The IIABC provides an online irrigation calculator that can be used to help develop watering times and amounts for

landscape irrigation. The scheduling calculator is integrated with the climate network so that current evapotranspiration data is used in the calculations. See www.irrigationbc.com for the calculator and instructions on how to use it.

Routine checks of your entire system will help ensure proper functioning and reduce water waste.

Low-Volume Surface Systems

Sprinkler systems can be expensive to install and can have many components. These may require a significant amount of maintenance to continue operating at maximum efficiency. Irrigation system leaks waste water and can result in significant off-site movement of water, contributing to non-point source pollution.

For proper performance it is necessary that filters, lines and sprinkler heads are operating as designed without interference from clogging, leaks or breaks. A backflushing or self-cleaning filter is ideal for this application.

Routine maintenance should include:

- checking for leaks,
- backflushing filters,
- flushing lines,
- chlorinating (if needed),
- acidifying (if needed),
- cleaning or replacing clogged emitters, and
- inspecting or replacing other parts.

Low-Volume Subsurface Systems

Low-volume sub-surface systems may require a significant amount of maintenance to continue operating at maximum efficiency.

Routine maintenance should be done while irrigating, and should include:

- checking for leaks,
- backflushing filters,
- flushing lines,
- chlorinating (if needed),
- acidifying (if needed),
- cleaning or replacing clogged emitters, and
- inspecting or replacing other parts.

High-Volume Sprinkler Systems

Routine maintenance should be done while irrigating, and should include:

- checking and fixing head rotation problems,
- checking and fixing nozzle clogging, and
- repairing line leaks and breaks.

IRRIGATION SCHEDULING

High quality fruit depends on an irrigation schedule that is started at the right time of the season and continued at optimal intervals. The definition of 'adequate' will depend on soil, crop, atmospheric, irrigation system and operational factors. The decision making process can include simple things, such as making decisions based on personal experience or following neighbours' practices, or more complex methods, such as using soil water measurements, forecasts/meteorological data, climate projections, plant stress indicators, and monitoring leaf turgor pressure, trunk diameter and sap flow.

The goal of any irrigation program should be to supply the vine with enough water to survive and produce high quality fruit, while minimizing loss due to percolation and runoff.

Irrigation scheduling is a systematic way of determining when and how much to irrigate. Its purpose is generally to replace the amount of water lost from the soil over a specified period of time, although other considerations exist (i.e. winter hardiness).

Benefits of irrigation scheduling include (Prichard, nd):

- reduced costs (energy and water,
- control of excess vegetative growth,
- reduced cost of hedging and multiple leaf removal,
- reduced disease susceptibility,
- increased fruit quality,
- reduced environmental risks (off site and percolation movement, and
- reduced fertilizer losses (deep percolation.

FACT BOX: IRRIGATION SCHEDULING CALCULATOR

The Irrigation Industry Association of BC (www.irrigationbc.com) has developed agriculture irrigation scheduling and landscape irrigation scheduling calculators. The calculators use real time climate data to determine an irrigation schedule and information on when to apply the next irrigation. They are tools to help the system operator make quick decisions without having to do numerous hand calculations. User guides are available to help you through the process.

5.12. Soil Moisture-Based Approaches

As the vine canopy expands and temperatures rise, the evapotranspiration rate increases, which can deplete the soil of surplus water reserves from winter rain and irrigation. Vine water stress generally occurs when half of the root-available water has been depleted and stress increases as the dry point is reached.

To manage irrigation effectively, the scheduling of irrigation events should be based on direct measures of soil moisture, which will help determine what is available for the plant, and what needs to be supplied. Monitoring frequency will depend on the rate at which soil dries.

Soil water measurements are easy to apply in practice and can be quite precise. Many commercial systems are available and some sensors can be readily automated. Disadvantages include the fact that soil heterogeneity requires many sensors (often expensive) or an extensive monitoring program and selecting a position that is representative of the root-zone can be difficult. (Jones, 2003).

Water Holding Capacity of Soil

During irrigation or rainfall, gravity pulls water through large pores in the soil and approximately 50% of it ends up being 'held' in the smaller pores of typical soil. Sandy soils have larger pores and therefore hold on to less water, while clay soils have smaller pores that can hold more water per unit volume.

However, the smaller pores hold on to water more tightly and leave less water available for the vine.

Knowing your soil's water storage capacity, along with annual rainfall, cover crop water use and soil variation, is essential in developing a water budget, and in conducting proper irrigation initiation in the spring/summer and irrigation scheduling later in the growing season.

Methods and Instruments for Measuring Soil Moisture Content

Soil water potential and soil water content can be measured using a variety of techniques. Soil moisture testing techniques and devices have advantages and disadvantages depending on the use of the measurement. For example, tensiometers, conductivity blocks, time domain reflectometry probes, and the soil feel method are useful for monitoring soil moisture status; however, these may not be sufficient if employing a deficit irrigation strategy.

Equipment should be professionally calibrated to ensure accurate readings.

5.13. Plant-Based Approaches

Irrigation scheduling can also be done based on sensing of the plant response to water deficits. Plant stress sensing includes both water status measurements and plant response measurement.

Visual Cues

Visual cues are easy to detect, but often not precise. They should be used in combination with one or more other irrigation scheduling techniques.

Pressure Chamber ("Pressure Bomb")

The pressure chamber, also called a pressure bomb, is an invaluable tool for monitoring winegrape vine water status and is available commercially at a reasonable cost. It is portable and the measurements are done in real time in the vineyard, so irrigation management decisions can be made as data is collected.

Two disadvantages of this method are that it is slow and labour intensive (and therefore can be expensive) and it is unsuitable for automation.

There are basically three ways a pressure chamber can be used to measure vine water status. These include: predawn leaf water potential, mid-day leaf water potential, or mid-day stem water potential. The three methods vary mainly in the timing of the measurement and the preparation of the leaf to be sampled.

<u>Leaf water potential (LWP)</u>

- Taken in the one-hour period from 30 minutes prior to and 30 minutes after solar noon (time can be lengthened in a practical field situation to 1 hour before and 1 hour after solar noon).
- Fully expanded leaf exposed to direct sunlight is chosen for measurement.

- Leaf is covered with a small plastic bag that is wrapped tightly around leaf and secured before cutting from shoot.
- Petiole of bagged leaf is cut from shoot with sharp razor as close to shoot as possible.
- Petiole is quickly placed in chamber with cut edge of petiole facing outside and bagged leaf blade inside chamber.
- Operator carefully watches exposed edge of petiole for appearance of drop of water – as soon as it appears the operator reads the corresponding pressure from the chamber gauge.
- Main limitation is the time frame allowable to ensure consistency, which limits the number of vines that can be measured in one day.

Stem water potential (SWP)

- Taken in the one-hour period beginning 30 minutes prior to solar noon and ending 30 minutes after solar noon.
- Leaf on the shaded side of canopy is chosen to minimize any possible heating effects.
- Leaf is wrapped in black plastic bag that is covered with aluminum foil.
- Leaf is left in bag for 90 to 120 minutes (allows LWP to come into equilibrium with SWP).
- Leaf is then excised and tested in pressure chamber using same method as LWP.

Predawn leaf water potential (PDLWP)

- Same basic method as LWP except readings are taken beginning at 3:30 am and ending before sunrise.
- Questionable practicality due to timing

To ensure appropriate and consistent results, it is imperative that technicians be well-trained in the use of the pressure chamber and the choice of leaves to sample.

Evapotranspiration

Weather records and evapotranspiration estimates can also be used to help to determine how much water to apply to the vineyard.

Evapotranspiration is an estimate of the amount of water lost through the evaporation of water from the soil surface and the transpiration of water vapour from the plant. This estimated amount can help determine how much water to apply to the crop to replace the water that was lost.

Frequent irrigation, wetting a larger area, high temperatures, low humidity, and wind increase evaporation from the soil surface

Plant transpiration is mostly affected by wind, temperature, humidity, light intensity, root depth, soil-water availability, soil texture and structure, and plant physiological characteristics.

Evapotranspiration can be estimated using an evaporation pan (atmometer or evaporimeter)

or climatic data obtained from weather stations. Real time evapotranspiration estimates are available from numerous weather stations across BC and can be found at www.farmwest.com or www.irrigationbc.com.

The evapotranspiration estimate provided by the weather office (ET_0) is based on a reference grass, so growers must use a formula to estimate the evapotranspiration value for their crop.

The quantity of water applied can be based on replacing all (no deficit) or a portion (deficit irrigation) of the estimated evapotranspiration.

Section 5.14 describes in more detail deficit irrigation techniques aimed at reducing water consumption while still maintaining a high quality crop.

5.14. Deficit Irrigation and Dry Farming Methods

Regulated Deficit Irrigation

Regulated Deficit Irrigation (RDI) is the practice of applying mild water stress at different phenological stages of growth to influence vine growth, improve berry quality and to reduce the incidence of bunch rot.

RDI can be a component of a "standard" irrigation strategy or utilized in a "drought strategy" to limit vine water use during periods of limited water availability. For RDI to be effective, accurate measurements of soil and/or plant water deficits must be taken, as opposed to simply replacing the amount of water lost, which relies mainly on estimates of evapotranspiration.

Successful RDI programs have been known to cut vine water consumption by 50%-65%, although the risk of delayed harvest and poor quality fruit is higher. Clay soils and deeper root zones can sustain vines at lower RDI levels due to the better water-holding capacity of clays and the longer reach of the roots.

RDI is not ideal for young vineyards, low vigour vineyards from rootstock/scion selection, limited soil resource or vineyards with nutrition or pest related issues. RDI may not be feasible or advantageous (or more difficult to implement) on coarse textured soils.

While much is known to date, there is still a lot to learn about successfully applying RDI concepts to different regions, site conditions, varieties, rootstock, soil types and trellis systems. Ultimately, it is up to the grower to fine-tune the system for their own vineyards.

Partial Root Zone Drying

The basis for PRD is that the positive effects of mild water stress and high vine water status can be achieved simultaneously by having part of the vine root system in moist soil and the other part in relatively dry soil.

Important Note on Irrigation Scheduling During Vineyard Establishment

It is important for newly planted vines to receive enough water to maintain full evapotranspiration, which allows the plant to

establish a healthy root system and canopy. Even mild water stress should be avoided in young vineyards. Make sure the soil in the root zone is well drained and has sufficient porosity. Also, the young vines may need frequent, low rate applications of fertilizer since over-application of water can leach nutrients from the root zone.

SURFACE WATER MOVEMENT

Surface water run-off from excess irrigation or precipitation events, can collect and carry pollutants to nearby watercourses and degrade water quality. Pollutants can include pesticides, fertilizers and sediment. A properly designed drainage system can go a long way in reducing or preventing negative environmental impacts.

5.15 Stormwater Runoff

Stormwater originates from roofs, paved and non-paved areas within the vineyard. Unmanaged stormwater flow can substantially increase the risk of overloading the wastewater storage and treatment system.

Runoff quality degrades as it moves and collects pollutants, and ends up in surface water or groundwater bodies. It may form rills or gullies on unprotected soil, which can lead to channel and stream bank degradation.

Areas bordering water bodies such as streams, lakes, ponds and wetlands should be protected from pollution by setting up a buffer strip of undeveloped land, preferably with native vegetation, between the water body and human activity or development.

Look into the feasibility of using separated non-contaminated stormwater in your vineyard for irrigation.

Make sure to inspect banks along streams for erosion during and after heavy storm events, especially if they are unstable. Any erosions problems that are identified should be fixed on a timely basis.

The following is a list of practices that can be adopted to prevent excessive runoff on your site:

- soil and water conservation,
- planting of cover crops,
- vegetation filter strips separating vineyard from water bodies,
- conservation tillage,
- installing subsurface drainage that is built for the specific soil conditions and plant rooting requirements,
- ditch banks,
- unpaved roadways,
- increasing channel capacity to higher-than-normal levels ,
- restricting access and use of critical riparian areas, and
- addressing soil permeability problems.

5.16 Drainage

Adequate drainage can help increase soil strength, control salinity and alkalinity in some cases, and improve nutrient uptake. Significantly higher volumes of precipitation

on the BC coast make subsurface drainage necessary to control saturation of the root zone, soil compaction, overland flow (run-off) and erosion.

Inadequate drainage can lead to flooding, which can lead to increased amounts of pollutants being washed into water bodies. Flooding can be an issue in BC coastal areas, especially if they also experience runoff from neighbouring, uphill areas.

Consider implementing the following practices:

- Install receptor drains to reduce overland flow and erosion potential.
- Obtain a sketch of where your drains are and where they lead to. Make sure the stormwater system is not cross-connected with the sanitary or septic systems.
- Make sure your drainage system directs runoff away from sensitive water bodies.
- Where drains may be susceptible to pollution, install catch basin inserts, drain covers or other protective devices.
- Keep waste away from drains to prevent water pollution.
- Keep floatable material (e.g. branches, plastic materials) located away from any drains.
- Grade land to reduce shallow surface ponding that attracts unwanted wildlife (not wetlands!).
- Install permanent drop structures in channels to allow water to flow gently without causing erosion.

Surface water run-off, from excess irrigation or precipitation events, can collect and carry pollutants to nearby watercourses and degrade water quality. Pollutants can include pesticides, fertilizers and sediment. A properly designed drainage system can go a long way in reducing or preventing negative environmental impacts.

CHAPTER 6
PEST MANAGEMENT

Table of Contents

6.0 PEST MANAGEMENT

INTRODUCTION

Chapter objective: To encourage integrated pest and weed management practices that minimize economic, health and environmental risks associated with pesticides and herbicides.

A vineyard, like any other agricultural ecosystem, attracts a range of organisms. Some are beneficial, some are neutral, and some are counterproductive to an economically sustainable operation.

The incidence, frequency, and severity of pest impacts vary depending on the vineyard location, climate, soil type, ecological conditions and other factors.

For thousands of years, humans have used pesticides in one form or another in an attempt to destroy, repel or mitigate pests.

Synthetic pesticides were developed in the 1940s, and their widespread use led to a "green revolution" that saw increased yields and crop viability. By the 1950s and 1960s, it became apparent that pesticides and their application practices were responsible for the contamination of soil and water, human health problems, and the emergence of pesticide resistant pests.

As a response to this new reality, a new approach was developed to manage pests while reducing or eliminating the use of pesticides. Integrated Pest Management (IPM) is an essential component of a sustainable viticulture program.

Chapters 5 and 7 of the Best Practices Guide and Chapter 5 of the EFP Reference Guide should be reviewed to learn more about pest management in the vineyard.

INTEGRATED PEST MANAGEMENT

Integrated Pest Management (IPM) is a systematic ecosystem-based approach that uses biological, cultural, physical and chemical tools to manage pests. While the use of chemicals form part of an IPM program, its main goal is to use a variety of management practices to reduce the need for chemicals, and when they are needed, to use products that are least damaging to the crop, non-target organisms, humans, and the environment.

IPM relies on an understanding of pests; their lifecycles, feeding and reproduction patterns, and natural enemies. IPM discourages relying solely on calendar sprays without regard for the effects of the control materials used.

Its goal is not to eradicate pests, but to control them. That is to keep their populations at levels that are not detrimental to the ongoing sustainability of the vineyard.

6.1. Avoid Pest Problems

The first step in any IPM Plan is to identify and implement practices that will help you to prevent pests for establishing in your vineyard in the first place.

6.2. Identify and Understand the Pest

In agriculture, a 'pest' is an organism that damages crops or impedes operations through feeding, parasitizing, infecting, attacking. However, it is possible for an organism to be a pest for one crop and beneficial or neutral for another, which is why accurate identification and understanding of pests and their natural predators is important.

In order to plan and manage crop production to avoid pest problems, growers need to understand the ecology and dynamics of the crop, along with its common pests and their natural predators (beneficial organisms). Learning about common pest life cycles, the timing of pest activities, their natural predators, and ways of affecting their populations, enables growers to plan and manage production in economical and environmentally-friendly ways that focus on pest prevention.

The following actions should be completed regularly in order to identify and understand the pests that may occur in your vineyard:

- Identify pest damage - use the Best Practices Guide for Grapes for British Columbia Growers and other reference material as needed.
- Identify pests - use 10 to 20x hand lens or photograph and match against reference material.
- Identify beneficial organisms (natural enemies) - use hand lens or photograph and match against reference material.
- Research the life cycles, natural predators, and other relevant information of identified pests.

Insects and Mites

Fewer insect pests attack grapes grown in British Columbia compared with most other major grape producing regions of the world. For this reason, growers in BC are able to pursue programs that preserve populations of beneficial insects and predacious mites that help regulate numbers of pests.

Pests that may cause problems in your vineyard include leafhoppers, cutworms, wasps, spider mites, thrips, grape mealybug, scale insects, grape erineum mite, snailcase bagworm, wood boring beetles, grasshoppers, and whitefly.

Beneficial organisms can help keep pest numbers under control, but the vineyard must be generally hospitable for them to thrive. An environment that is friendly to beneficial organisms can be kept by limiting pesticide and other chemical applications to a minimum, and by providing natural habitat for them to live in.

Beneficial organisms may include bacterial and viral diseases and vertebrates such as toads, bats and birds. However, predators such as spiders, mites and other insects can be singled

out as the most important natural control agents for pest insects and mites.

Plants that help to increase beneficials include (examples only, not a comprehensive list):

- nectar producing plants,
- aromatic plants,
- flowering plants, and
- roses.

Soil-borne Pests

Soil-borne pests and diseases are caused by organisms that live in or on the surface of the soil. The most common soil-borne pest management strategy is fumigation of the soil prior to planting or using pest-resistant rootstock. However, other management methods exist that are crucial in developing a productive vineyard. Nematodes are an example of a typical soil-borne pest.

Pathogens and Diseases

Diseases can be very damaging to grape production as they negatively impact fruit quality. As with insects and mites, accurate diagnosis of diseases is an important component of integrated pest management. Correct identification of a disease and an understanding of its life cycle will enable you to select the most appropriate control method.

The most common diseases in BC include Powdery Mildew, Botrytis Bunch Rot, Sour Rot, Crown Gall and viruses. Other diseases being watched closely (but do not currently present economic challenges) include Pierce's disease, Eutypa dieback, and young vine decline.

6.3. Monitor Populations and Damage

Finding an organism that is known to damage crops does not automatically mean that pest control is required. You need to know how many of them there are, and whether the numbers are static, increasing or decreasing as the season progresses in order to determine the potential damage to the crop and decide if and what control measure is needed.

The following monitoring methods should be conducted if a pest is found in your vineyard. Observations should be noted on an annotated map (use the **site plan** you created in Chapter 1).

- Use sampling and detection methods to estimate the abundance and distribution.
- Examine for damage symptoms and determine if the damage is spreading.
- Examine for beneficial organisms (natural enemies) and determine if their populations are healthy.
- Estimate potential cost of damage.

Sampling is a disciplined, reliable and repeatable approach to measuring pests so that samples taken in different vineyards or at different times can be meaningfully compared.

Sampling techniques are the specific methods used to collect the information. Pest numbers are usually monitored either by using beating trays, sweep nets, or insect traps and collecting parts of the grapevine and counting pest numbers. The technique will depend on the pest.

6.4. Establish Action Thresholds

To determine when pest control is required, growers have to estimate the point at which the cost of remedial action is less than the cost of tolerating the pest. This point is referred to as an action threshold (sometimes referred to as a spray threshold or economic threshold). Establishing an action threshold for each pest in the vineyard is critical in guiding pest control decisions.

Acceptable action thresholds for spraying should be set for each vineyard based on:

- past experience,
- vine vigour,
- numbers of beneficial insects present,
- potential damage to the crop,
- cost of control methods,
- value of production,
- impact on other organisms and the environment,
- what has already been applied, and
- potential impact on neighbours.

Generic threshold data for the majority of pests does not exist, making it crucial for growers to develop their own based on careful observation and experience.

Ideally, preventive measures are taken before the action threshold is ever exceeded.

6.5. Choose Appropriate Control Methods

The first line of defence in an IPM is *prevention*, which means managing the crop in such a way that discourages the proliferation of pests while maintaining optimal crop production (see Section 6.1). Preventive measures are often cost- effective and pose little to no risk to humans or the environment.

When preventive measures are no longer sufficient and action thresholds are exceeded, a grower may employ various strategies to bring pest population levels under control.

Effective control methods are used from less risky (e.g. pheromones that disrupt pest mating or mechanical control such as trapping or weeding) to most risky (e.g. pesticide broadcast spraying). Riskier pest control methods should be used only if further monitoring, identification and action thresholds indicate the less risky control measures have not been effective.

To prevent pests from reproducing to levels where they will cause problems, consider the following:

- Examine alternate control strategies.
- Evaluate effectiveness and risk of each strategy.
- Explore **biological** controls such as pheromone use, predator enhancement strategies, alternate food sources for beneficial insects.
- Explore **cultural** (physical) controls (including mechanical, behavioural and physical) such as pest-resistant crop varieties, weeding, encouraging natural competition, reducing the number of potential hiding places, canopy management strategies.

- Explore **chemical** controls (such as insecticides, fungicides) after other options have been explored.
- Record your mode of action.

Growers should select least disruptive or organic chemicals first and avoid using broad-spectrum, persistent materials that are harmful to beneficial insects and the environment. Table 6-1 lists chemicals whose use is discouraged under this program.

Growers using any of the pesticides listed in Table 6-1 must provide written documentation that demonstrates a clear need for the use of the pesticides, that no safer alternatives exist, and that describes the application details (such as timing, location, and amount used). Please note that the list in Table 6-1 does not override legislation or organic standards.

Growers should consider the impact of chemicals applied for the control of one pest on the natural enemies of secondary pest. Eradicating natural enemies may lead to an outbreak of other pests (e.g. most mealybug outbreaks appear to be induced by insecticides applied against other pests).

For some pests, the best action is the early use of safe, non-persistent and selective pesticides that can be less damaging than other practices. Disruptive chemicals, on the other hand, not only damage the environment, but can also cause outbreaks of secondary pests that require additional insecticide applications.

While some cultural and biological controls can be applied when pests reach the action threshold, most need to be applied months or even years earlier to prevent pests reaching the action threshold. For example, increasing groundcover diversity is an ongoing process, while sticky tape in areas heavily infested with leafhoppers needs to be applied in spring.

Table 6-1: Pesticides (listed by chemical group and active ingredient) whose use is discouraged under the Sustainable Winegrowing British Columbia.

Avoid use of	Reason
methyl-bromide	highly toxic to humans, contributes to destruction of the ozone layer
azinphos-methyl	neurotoxin, harmful to beneficials, banned in the European Union since 2006
Use strongly discouraged	**Reason**
paraquat	highly toxic to humans and wildlife, high risk to salmon and aquatic life
organophosphates (diazinon, malathion)	nerve agent, toxic to other insects, wildlife, pets and humans, high risk to salmon and aquatic life
endosulfan	highly toxic to humans and wildlife
neonicotinoides (acetamiprid, clothianidin)	harmful to beneficials, particularly bees develop resistance
pyrethroids (permethrin, cypermethrin)	permethrin harmful to all beneficial arthropods cypermethrin harmful to all beneficial insects and mites, high risk to salmon and aquatic life
carbamates (carbaryl)	moderate to high impact on all beneficials, high risk to salmon and aquatic life

A note on copper formulations: Copper build-up in the soil – in some cases to toxic levels – has been experienced in areas where it has been used extensively to control downy mildew. This is not a problem in BC because there is no downy mildew here; copper is used sparingly and mostly for hardening off the plants in the fall or for prevention of sour rot. Some organic standards limit the amount of actual copper applied per year per acre. Use with caution in your vineyard.

6.6. Review and Assess Effectiveness

IPM depends on continual improvement through learning about the crop, pests and beneficial organisms. Keeping accurate records of observations and actions taken in the vineyard is very important. Records will be invaluable in identifying changes in pest and beneficial organism prevalence and their weaknesses, which should aid in evaluating the effectiveness of your treatment options, and for planning adjustments for the next growing season.

IPM RECORDS CHECKLIST

The following records should be kept in a notebook or computer.

When identifying and monitoring pests and beneficial organisms, record the following:

- ☐ Date of monitoring sampling
- ☐ Location of sample
- ☐ Sample size (how widespread)
- ☐ Pest/disease identified
- ☐ Number found
- ☐ Block/variety
- ☐ Growth stage of vines (phenology)
- ☐ Crop yield and quality (and any other observations related to crop condition)

When applying control methods, record the following:

- ☐ Application date
- ☐ Block
- ☐ Vine growth stage
- ☐ Pest controlled
- ☐ Technique used
- ☐ Weather conditions
- ☐ Observations

If applying pesticides, also record the following information:

- ☐ Product used (trade name) and amount per tank
- ☐ Rate used per hectare
- ☐ Spray volume per hectare
- ☐ Pre-harvest interval
- ☐ Re-entry interval (as stated on label)

6.7. Integrated Weed Management

For the purposes of this program, weeds are defined as plants that grow in the vineyard that are unwanted and have a detrimental effect on vineyard production. Weeds are unwanted because they compete with crop plants for soil nutrients, light and water. In severe cases, weed infestation can lead to crop production delays and even crop failure. Many weed species are also considered "invasive plants" by provincial and regional governments, and as such, there is legislated control required on private lands.

Growers should be aware of the distinction between unwanted 'nuisance' weeds (as discussed here) and invasive weeds (noxious) as classified by the province, which landowners have an obligation to eliminate.

Growers can learn more about invasive weeds by visiting the following websites:

- Regional District Okanagan-Similkameen: Invasive Plant Program: http://www.rdos.bc.ca/index.php?id=122.
- Invasive Plant council of BC: http://www.invasiveplantcouncilbc.ca/.

An Integrated Weed Management (IWM) approach that uses a combination of different practices to manage weeds is the most sustainable approach a grower can use. The goals of IWM are to maintain weeds at manageable densities and to prevent more aggressive weeds from taking hold in your vineyard. Relying on a variety of prevention and control techniques keeps weeds from becoming resistant to one control method.

The focus of IWM should be prevention, keeping chemical methods as a last resort to control the spread of weeds. Combinations of different mechanical, cultural, biological and chemical methods may be necessary for different species. For example, experts no longer recommend pulling knapweed, but cutting it down and leaving the roots to support the biological control agent. It is now preferable to sustain a small population of the biological agents who keep the weeds in manageable numbers.

An effective IWM program relies on three main sets of practices.

- Practices that limit the introduction and spread of weeds (prevention).
- Practices that help the crop compete with weeds (help "choke out" weeds).
- Practices that keep weeds "off balance" (make it difficult for weeds to adapt).

To create an IWM plan, refer to the Ministry of Agriculture and Lands: Weed Management Planning section (part of the Integrated Weed Management Introductory Manual) at www.agf.gov.bc.ca/cropprot/weedman.htm#PLANNING.

The manual helps growers create a plan by going through the following essential steps in detail:

Diagnosing the problem (identifying the weed and possible causes):

- More often than not, weeds are a symptom of a problem, and this should be addressed first. Causes may range from poor seedbed, land, or drainage preparation, soil pH, diseases/insects, herbicide-resistant weeds, weed population shifts, microbial degradation, weather effects on herbicide activity, and lack of an integrated management plan.
- Learn to identify weeds or contact your local Ministry of Agriculture and Food office to assist you. This will be crucial in selecting the right control strategy.

Preparing a plan of attack (planning the control program):

- Record relevant information (i.e. crops, cropping sequence and weeds that are present) on your **site plan** (created in Chapter 1). Are the weeds caused by underlying factors such as poor drainage, poor fertility or pH? If so, correct these first.
- Learn about weed control strategies and write them on the map along with notes on timing of control operations. Is the herbicide you plan on using registered for use on your crop? Is the target weed listed on the herbicide label? What is the cost per hectare?
- How will my control program impact the environment? If using herbicide, how persistent, and how toxic is it to fish and wildlife?
- Choose a control method based on effectiveness, cost and environmental considerations.

Implementing the program:

- Strictly follow the timing outlined in your plan.
- If using herbicides, ensure accurate herbicide application to (1) avoid over-application, which could result in crop damage, environmental impacts and wasted money and (2) avoid under-application, which can lead to lower crop yields and waste money.

Monitoring Success/Failure:

- Keep good records of actions taken and record the effectiveness. This will help in making improvements in the future.

WILDLIFE MANAGEMENT

Wildlife such as deer, bear, rodents and birds can develop a liking for grapes or the vine itself and cause significant crop losses. Some of these animals are managed as pests (e.g. rodents and some birds) while others are managed as "problem wildlife" (i.e. deer, elk and bear).

It is important to balance the need to protect your vines and grapes with the need to maintain healthy local ecosystems and support the species that depend on them. Refer to the Ecosystem Management chapter for more information.

Good wildlife management requires using an integrated approach (like that discussed earlier in the Integrated Pest Management section). Your approach should include prevention of conflict, identifying and learning about the species, monitoring them and the damage

they cause, choosing appropriate control methods and reviewing the effectiveness of your actions.

Most wildlife issues can be managed through preventative measures. For example, habitat alteration and exclusion strategies can reduce the number of pests and problem wildlife frequenting your vineyard. These strategies may include using grow tubes around young vines to discourage chewing by rodents; selecting cover crops that are less desirable to wildlife, locating compost heaps away from forests and thickets; and clearing away brush piles that create habitat for birds.

Your Integrated Pest Management plan should include a section on wildlife management. The following information will help you determine when and what control methods to use for birds, rodents, snakes, deer and elk, and bears.

6.8. Birds

Birds can be divided into invasive bird species (e.g. starlings) and other birds that may be unwanted but are native. Some birds are protected by the *Migratory Birds Convention Act* (e.g. bluebirds) and the *Species at Risk Act* (e.g. Lewis's Woodpecker).

Starlings, robins, house finches and other birds feed on grapes. Starlings, however, cause the most damage. Ensure that starlings are not able to nest in farm structures, or destroy their nests before the young fledge. Creating nest traps can be effective in controlling starlings but care should be taken not to trap other cavity nesting birds (e.g. bluebirds, flickers).

If birds begin to attack the crop, act immediately and implement a combination of two or three control methods.

FACT BOX: AUDIBLE BIRD SCARE DEVICES – INTERIOR AND SOUTH COAST BC

Audible bird scare devices can be a nuisance to nearby residents. The Ministry of Agriculture has developed guidelines for the use of audible bird scare devices.

See the *Interior BC Wildlife Damage Control* fact sheet at: www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/agricultural-land-and-environment/strengthening-farming/farm-practices/870218-60_wildlife_damage_interior_bc.pdf

See the *South Coast BC Wildlife Damage Control* fact sheet at: www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/agricultural-land-and-environment/strengthening-farming/farm-practices/870218-59_wildlife_damage_south_bc.pdf.

It is illegal to kill or harass most native birds and their nests in Canada as detailed in the *Migratory Birds Convention Act* and the *BC Wildlife Act*.

Note: The European Starling is a non-native bird for which there is an aggressive campaign of extermination and netting to prevent fruit loss. Starlings compete with native birds for nest sites.

6.9. Rodents

Rodents can damage young vines by gnawing on grape shoots, roots and crowns. While the damage they cause in vineyards is usually minor, they can also attract animals such as badgers, snakes and coyotes, which can become problem wildlife.

In addition to the control methods listed in the Best Practices Guide, consider the following:

- Manage food and water supplies:
  - Avoid spilling farm animal feed (if applicable),
  - Store feed in covered containers, and
  - Eliminate water sources such as leaky, and taps, sweaty pipes and open drains;
- Rodent-proof buildings and eliminate nests:
  - Keep building doors in good condition,
  - Keep areas around buildings free of weeds, long grass and debris, and
  - Install screens on ventilation ports and other openings;
- Maintain good general sanitation and cleanliness through the vineyard;
- Rake under vines to prevent mice; and
- Promote the predators of rodents, which include owls, raptors, weasels and snakes.

If rodenticides are used in and around manure or compost piles, be sure to collect the traps before any manure or compost is removed to prevent spreading to unwanted parts of the property where they could pose a risk to pets, birds, farm animals and wildlife.

6.10. Snakes

Snakes are not an agricultural pest but can become a nuisance or a danger to vineyard workers. In fact, snakes are beneficial to crops because they are significant predators of rodents. Provincial and federal laws make it an offence to harass or kill snakes.

Recommend snake management practices include:

- Maintain natural buffer of at least 100 m from rocky slopes.
- Leave draws/ravines as migration corridors; use culverts or bridges where roads cross these corridors.
- Maintain or enhance existing debris/cover features to which snakes are drawn to reduce accidental encounters and for easy relocation of snakes.
- Provide artificial cover (e.g. small pallets, rock piles) away from frequented work places and clearly identify them. In this way the snakes can reside in the cover areas and forage all night for rodents in the crop and are rarely encountered by people.

- Install snake barrier fencing along the perimeter of an agricultural area, where this is needed and practical.
- Develop irrigation-fed ponds outside the snake barrier to reduce the attraction of snakes to irrigated crops.
- Inform workers if snakes are found in the vineyard, how to avoid encounters and how to respond to an encounter.
- Avoid accidental killing of snakes during vineyard activities such as driving, mowing, tilling, and haying.
- Contact your local conservation officer or another qualified person if you need help relocating snakes.

6.11. Deer and Elk

Deer and elk can severely damage vines. They eat buds, spurs, shoots, fruit and leaves and/or rub their antlers against the plant, breaking branches and removing bark in the process.

In addition to the control methods listed in the Best Practices Guide, consider the following:

When dealing with deer and elk, the following practices should be considered:

- Scare devices
  - Cracker or whistler shells, propane exploders and electronic Av-Alarm or Phoenix Wailer Systems.
  - Short term solution as animals become tolerant of the noise.
- Allow hunters (especially bow hunters) access to your land during hunting seasons, where this is permissible.
- Plant “lure crops” or crops less desirable to wildlife.

6.12. Bears

Bears can be a nuisance in some vineyards and can pose a threat to workers. The only long-term, proven and effective method for keeping bears out of vineyards is properly constructed electric fencing.

PESTICIDE MANAGEMENT

A pesticide is any material used to kill, control or manage pests, including products to manage the growth of plants.

The main environmental concern with pesticides is the direct or indirect impact their use may have on the soil, water, air, fish, wildlife, pets and humans. Pesticide pollution can result from the inappropriate application of pesticides (due to wrong volumes or bad timing), spills, backflow and improper disposal of chemicals and/or containers. Short-term and long-term effects on wildlife that come into contact with treated crops are also an issue.

6.13. Reducing Environmental and Health Risks

The primary environmental concern related to pesticides is any unwanted movement to sensitive environmental areas such as watercourses, ground water, and fish or wildlife habitat. Pesticides can move by:

- drift – movement of spray droplets or vapour in the air,
- runoff – movement in the water or bound to eroding soil,

- leaching – movement in water through the soil, and
- direct transport – movement of soil, vegetation, and other materials that contain pesticide residues.

Special safety precautions must be taken when handling pesticides. See Chapter 7 of the Best Practices Guide for more information.

6.14. Pesticide Transport

Refer to Chapter 7 of the Best Practices Guide and Chapter 5 of the EFP Reference Guide.

6.15. Pesticide Storage

Refer to Chapter 7 of the Best Practices Guide and Chapter 5 of the EFP Reference Guide.

6.16. Mixing and Loading Pesticides

Refer to Chapter 7 of the Best Practices Guide and Chapter 5 of the EFP Reference Guide.

6.17. Pesticide Application

Application characteristics affecting the movement of pesticides include:

- Application methods – direct applied pesticides (wipe-on) have a lower risk than sprayer applied.
- Droplet size – coarse droplets are less prone to drift than fine droplets (although they are also less effective so a balance must be achieved).
- Application rate – lower rates decrease the risk of runoff and leaching.

6.18. Pesticide and Pesticide Container Disposal

Refer to Chapter 7 of the Best Practices Guide and Chapter 5 of the EFP Reference Guide.

CHAPTER 7
SOCIAL SUSTAINABILITY

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7.0 SOCIAL SUSTAINABILITY

Chapter objective: To provide practices that will contribute to a positive working environment for you and your employees and enhance your relationship with your neighbours and community.

INTRODUCTION

Recruiting, training and retaining good employees, promoting a safe work environment, and building positive employee relations play a major role in the level of productivity, competitiveness, innovation, liability and profitability of your vineyard.

Implementing sustainable practices at your vineyard requires willing, dedicated and skilled employees that feel committed to the vineyard and care about its success. In other words, your employees are critical to achieving tangible environmental results from your sustainable practices program.

Your vineyard can contribute to social equity through job creation, bringing tourism and other revenue to your community, and educating the public about sustainability through vineyard tours and other events.

The better you are at anticipating conflict and educating and communicating with your neighbours and community the less likely you and/or your employees will have to spend valuable time responding to complaints. A good reputation with your neighbours and community will go a long way - these same people could also be your customers!

HUMAN RESOURCES

Whether you have 5 or 75 employees, clear, consistent and documented human resources (HR) policies and practices are fundamental to maintaining positive employee relations. The next sections will help you learn more about these topics and the practices that can be used to promote HR sustainability.

7.1. Staffing and Recruiting

Understanding Staffing Needs and Labour Availability

A strategy that analyses your staffing needs for 2 to 5 years into the future will help you hire the correct number of employees with the appropriate skills to successfully operate your vineyard. Understanding your staffing needs will enable you to prepare budgets for wages and salaries, recruiting costs, and employee education and training.

Consider the following questions when developing your staffing strategy:

- What type of labour do you need (i.e. skilled, unskilled or highly skilled; seasonal or permanent)?
- When are your peak periods? When are your slower periods?

- Do your peak periods coincide with another local industry and, if so, how will that affect your potential labour pool?
- Can any of the work be moved to avoid peak labour demands?
- Are there any major activities in the region that could affect your ability to get the right people at the right time?
- Can you accomplish the same amount of work with fewer people over a longer period of time (i.e. full-time, long-term employees)?
- Can you round up instead of down for the number of employees you need? For example, if you determine you have enough hours and budget for 4.5 employees, can you round up to 5 employees instead of down to 4?

Flow charts and schedules are useful when planning your staffing needs on a long term, annual, and seasonal basis.

Having clearly defined job positions you are looking to fill and profiles of the backgrounds needed for key employees will help you in identifying and fulfilling your staffing needs.

Standard Job Description

Clear, concise, and realistic individual job titles and descriptions will help employees understand what is expected of them and provide them with a sense of direction. Standard job descriptions will also help to alleviate conflict among staff and management and will ultimately increase productivity.

Consider including the following points in your standard job descriptions:

- how to complete the job,
- why the job must be completed a certain way,
- when the job needs to be completed,
- why the job needs to completed within a specific time frame,
- what the job performance expectations are, and
- what the employment conditions and terms are.

Publish your standard job descriptions in an employee handbook (see section 7.2). Make sure to update them on an annual basis.

Recruiting

Recruitment is the process of identifying and hiring the best-qualified candidate for a job vacancy, in a most timely and cost effective manner.

Your recruiting methods may differ depending on whether you are looking for temporary or full-time employees. You will need to establish a budget for recruiting that is based on your evaluation of staffing needs.

Examples of recruiting methods include:

- relationships with labour contractors or temp agencies,
- word of mouth,
- keeping contact information on those seeking work for use at a later date,
- advertising in local and regional newspapers and industry publications,
- advertising on the Internet,
- attending job fairs, and
- relationships with community colleges or universities

It is important to use consistent messaging in your job descriptions and to coordinate your hiring, especially if you have different managers hiring for different job positions.

If a position comes available make sure to look internally first before going through the recruiting process.

Standard Interviewing Format

Your job position descriptions and employee background profiles will help you to fairly and quickly screen resumes and applications that you receive and determine who is most suitable for an interview.

A standard interviewing format will help you to:

- provide consistent and fair interviews,
- ask all of the pertinent questions needed to fully evaluate the potential employee,
- avoid questions that are inappropriate, and
- effectively evaluate people applying for the same position against each other to choose the best person for the job.

Interview questions should be related to the job description and generally fall into five categories:

1. Previous work experience that may be relevant to the position
2. General skills and aptitudes related to job criteria
3. Education
4. Attitudes and personality
5. Career goals and occupational objectives

Exit Interviews

An exit interview is a meeting between at least one representative from a company and a departing employee. An exit interview will help you gather information for improving working conditions and retaining employees.

Exit interviews are most commonly conducted with employees who have voluntarily resigned, but are also useful to conduct with casual employees to learn how the employee enjoyed his or her term and whether or not he or she is planning on returning next season.

In small operations it may not make sense to track statistics of number of employees leaving because the numbers may be very small. However, it is still important to determine why an employee leaves and to document the reason in the employee file.

7.2. Employee Orientation

The orientation of new employees to their work environment and associated task(s) is an essential component of due diligence on behalf of the employer. An Employee Orientation Checklist is included in below. Your employee orientation should include most or all of the following components.

Orientation is an ideal time to introduce employees to your company's sustainability policies and practices. Also, make sure that your company's health and safety policies and practices are included in the orientation and that applicable employees are given WHIMIS and First Aid training.

EMPLOYEE ORIENTATION CHECKLIST

Employee Handbook

- ☐ Provide Employee Handbook to the new employee and use it to guide orientation

Overview of Company

- ☐ Organizational structure
- ☐ Mission and values
- ☐ Goals and objectives
- ☐ Products, priorities and strategies
- ☐ Sustainability philosophy and practices

Overview of Position

- ☐ Job description review (provide copy to employee)
- ☐ Specific performance standards and expectations
- ☐ Probationary period and probationary review process (if applicable)

Company Policies and Procedures

- ☐ Work procedures such as timekeeping, dress code, work schedule, time off, overtime, breaks
- ☐ Grievance and complaint system
- ☐ Discipline policies, including for specific issues such as tardiness, absenteeism, drug and alcohol use, violence, harassment
- ☐ Process for performance evaluations
- ☐ Benefits and eligibility requirements
- ☐ Transportation and travel policies
- ☐ Health and safety policies

Health and Safety

Your health and safety training will vary depending on the job description. It may include the following:

- ☐ Availability and interpretation of Material Safety Data Sheets (MSDS)
- ☐ Hazardous materials handling
- ☐ Solid waste handling
- ☐ First aid
- ☐ Importance of personal hygiene
- ☐ Prevention of heat stress
- ☐ Equipment operational and confined space safety
- ☐ Fork lift
- ☐ Personal protective equipment
- ☐ Fall protection
- ☐ Respiratory protection
- ☐ Hearing loss protection

Work Site Familiarization

- ☐ Tour of operations
- ☐ Introduction to immediate supervisor
- ☐ Introduction to other employees and others she/he will regularly interact with in her/his job

Employee Documentation

- ☐ Employee signing of required documents such as employment contract, handbook receipt

7.3. Employee Handbook

Having an accurate, clear, and up-to-date employee handbook enables the employee and employer to have a firm understanding of their relationship and various responsibilities. It results in less worker confusion, mistakes and complaints and can reduce the risk of potential costly legal suits.

An employee handbook serves to inform employees about company policies, procedures and practices and to communicate expected standards of performance and conduct. The size, format and content of your employee handbook will vary depending on the size and operations of your vineyard. For a small owner-operated vineyard, a few pieces of paper stapled together may be sufficient; however a larger operation may require a fully developed, bound handbook or an outline format on the company website

Common employee handbook contents include:

- Welcome and Purpose
- Disclaimer (specify that handbook is not a contract of employment)
- Company Strategy and Values
- Sustainability Philosophy and Practices
- Employee Definitions (distinguish between full-time staff and contract employees)
- Communication and Grievance Policies
- Work Schedules and Compensation Policies
- Benefits and Time Off Policies
- Transportation and Travel Policies
- Performance Management and Discipline Policies
- Environmental Health and Safety Practices

Important legal considerations regarding employee handbooks include:

- Have your handbook reviewed by a lawyer to ensure your policies are clear and consistent and cannot be misconstrued
- Update your handbook as needed to reflect the actual practices of the company
- Implement handbook policies and procedures because if you do not implement them as outlined in the handbook, your company can be held legally liable
- Ensure that your handbook is regarded as a resource of policies and guidelines rather than a contract or employment
- Obtain written acknowledgement of Employee Handbook receipt and of any revisions or updates by having your employee sign a document.

Below is an example acknowledgement of receipt.

I, _____, acknowledge that I have received a copy of the (Your Company Name) Employee Handbook dated: (date).

By my signature below, I acknowledge, understand, accept and agree to comply with the information contained in the Employee Handbook. I understand that this handbook is intended as a guide only, and is not intended to be a complete description of employer's policies and procedures. Furthermore, I understand that this handbook is neither a contract of employment nor a legally-binding agreement.

Employee signature:_____
Date:_____

7.4. Internal Communications

Clear, continuous lines of communication throughout all levels of employment, from supervisor to seasonal workers, are critical to a well-functioning workplace. The more employees know, the more they feel part of the company.

Communication methods include:

- regular staff meetings,
- one-on-one meetings with each employee,
- newsletters or bulletins,
- informal, brief "tail-gate" sessions to discuss safety and/or sustainable practices,
- company Intranet,
- email and phone calls,
- bulletin board with current information,
- posters promoting safety, health, and good housekeeping procedures, and
- Employee handbook (see Section 7.3).

Communication is as much about listening as it is about talking. Make sure you pay attention to your employees when they speak about their ideas, problems, needs or suggestions. If managers are accessible and encourage staff to share their thoughts, both the business and employee will benefit.

Conduct all verbal communications in the primary language of the employees, or ensure a translator is present. Also, translate communication materials (e.g. job descriptions, applications) into primary language.

7.5. Employee Relations

This section provides information on policies that you should consider in order to create a positive company culture, increase employee job satisfaction and productivity, and decrease the risk of legal liability issues.

The following topics are covered: complaints and grievances, performance evaluation, discipline and recognition, and compensation and benefits.

Your policies related to these topics may differ for casual versus long-term employees.

Complaints and Grievances

A step by step employee grievance process avoids uncertainty and anxiety that may arise from uncomfortable situations and demonstrates that the communication channels are open and issues will be dealt with in a professional, confidential, and timely fashion.

Performance Evaluation, Discipline and Recognition

A performance management system should document the following information:

- How employees will be evaluated for job performance (e.g. one-on-one meetings, written performance reviews).
- How often their performance will be evaluated and when (e.g. once per year at the end of the year, every six months).
- How the performance management system is linked to pay and promotions.

Work with your key employees to develop annual goals and assess their progress at their performance reviews. Train your managers and employees on how your performance management system works.

Consider having a post-production wrap-up meeting to discuss things that went well during the year and those that did not. Use the results of this meeting to improve your operations the next year.

Employee recognition can enhance job satisfaction and performance, promote cohesiveness among employees, and promote sustainable practices. Recognition may be given to acknowledge good work ethic, good safety performance, contribution to sustainable practices, length of service, teamwork, or community service.

Incentives work extremely well when the employer acknowledges employees before they ask for time off, salary increase. Provide the incentive close to when the employee did the task that you are recognizing.

Prepare a written discipline policy and explain it to your employees before you need to use it. The policy should include stepped and progressive procedures and must be uniformly implemented.

Compensation and Benefits

Questions to address when documenting your compensation and benefits philosophy and strategy include:

- Do you pay all employees competitive wages at or above the average wage for your region?
- How do you determine salaries for each job or job family? How often do you update your salary structure? How is it organized and documented?
- Do you participate in wage surveys?
- What benefits do you provide to employees? Document complete list, including government required benefits such as workers compensation. Describe why you offer each benefit and how the benefits administered (i.e. who does it, when, and what are the eligibility requirements)?
- How are wages and benefits communicated to employees?
- How is payroll administered (i.e. who does it, when, and what methods are used)?

Family Support Services

Examples of family support services include, but are not limited to, the following:

- housing opportunities referral information and resources,
- community resources referral information,
- childcare referral program,
- nutrition, health and wellness resources and/or referrals,
- employer participation in groups dedicated to increasing housing opportunities, and
- employer donating money and other resources to local housing groups.

7.6. Education and Training

Your employees are an integral part of the team that successfully works together to produce quality wines. They need basic education and training required to complete their job to a satisfactory level. They should also be provided with opportunities to enhance their understanding and skills in the workplace, especially if that training covers sustainable practices.

An effective training and professional development program ensures that employees that have the skills needed to accomplish their work, increases employee satisfaction, and enhances job performance.

You should develop an annual education and training plan for you and your employees. The plan should include specific training that is required for each major job category, based on what you can afford. Consider where your grape growing and business knowledge is lacking and consider how your business can improve by providing education to key employees.

A good understanding of your employee's career goals and aspirations is key to ensuring job satisfaction and reducing turnover rates.

Your training plan will need to consider the different job categories at your vineyard. Management staff will require different education and training than regular employees. Managers need to be well versed in all areas of your vineyard operations and share your vision. They need to have the skills, management style, personality, and value system conducive to managing employees in this type of employment situation. They also need to be clear on all job titles and expectations and be knowledgeable of labour laws and compliance issues.

You may also want to provide different opportunities for key employees than for casual or seasonal workers. That said, your casual staff are more likely to come back year after year if they are rewarded with exciting professional development opportunities that enhance their job satisfaction.

You will need to establish an annual education and training budget that includes required training and also funds for additional, more expensive professional development opportunities for key employees. If you are not willing or able to cover all education and training costs, you can consider providing paid time off or other incentives instead.

Education and training ideas include:

- academic or industry workshops, seminars, and continuing education courses,
- wine and grape associations annual meetings and other events,
- membership in local vintners' associations,
- grape growing publications, technical bulletins, and newsletters,
- in-house education by inviting a speaker or teaching your employees yourself,
- organizing tours through suppliers (e.g. tour of glass factory that makes bottles),
- visiting other wine regions,
- cross-training (having employees work in different parts of the business for a day or so), and
- attending industry conferences and other networking opportunities.

Document all education and training provided to employees.

7.7. Health and Safety

Worker health and safety is a major contributor to the social equity component of your sustainable business.

The kind of program you have depends on the number of regularly employed workers in your workforce ("regularly employed" means those who work at least one continuous month in a year, whether full time or part time).

Vineyards with more than 20 workers must have a formal written program, while vineyards with less than 20 workers must have a more informal program based on regular meetings with workers.

Resources to help you prepare your health and safety plan include:

- The *Health and Safety for Small-and Medium-Sized Wineries,* published by the BC Wine Grape Council.
- WorkSafe BC www.worksafebc.com.
- FARSHA's Vineyard and Orchards Coordinator and the Regional Safety Coordinator for your area. Contact information is available from the main FARSHA office http://www.farsha.bc.ca/contact-us/

7.8. Succession Planning

In BC, family-owned estate wineries and vineyards are common and many will soon be faced with a transfer of ownership. Succession planning is a continuous process to plan for the transfer of knowledge, skills, labour, management, control and ownership of the business between one generation and the next or to new owners outside the family (Coughler, 2004). Succession planning is usually only done at the top management team level.

Each vineyard is unique and no single approach works for everyone. However, succession planning can be thought of as a six-step process. The steps are not necessarily completed in a sequence or in a set order. A description of the six steps is included below. The format of your written succession plan will vary, but you should consider all of the components described below.

STEPS IN THE SUCCESSION PLANNING PROCESS

(Coughler & Anderson, Ontario Ministry of Agriculture, Food & Rural Affairs, 2004)

Step 1: Open the Lines of Communication

- Define personal, family (if applicable) and business objectives and goals
- Identify successor:
  - Does the next generation wish to be involved in the business?
  - If yes, the process moves forward within the framework of transitioning to the next generation.
  - If no, the discussions and decisions will focus on preserving family wealth and the transition out of farming.
  - Assess the compatibility of objectives and goals.
  - Work towards reaching consensus between the founder(s) and the successor(s) on major objectives and goals.
  - Consider hiring a trained outside facilitator to assist in these discussions.
  - Identify a team of advisors to help you through the process.

Step 2: Collect and Analyze Information

- Collect relevant technical information (particularly financial)
  - Compile and review documents such as the legal will, the power of attorney, property deeds, mortgage and loan information, tax returns, bank account information, financial statements, current financing arrangements, retirement savings position, business and legal agreements, current list of suppliers and service providers, production and performance records
  - Identify missing pieces
- Analyze financial viability and profitability of the business
  - Compare the financial performance of the vineyard to industry benchmarks
  - Develop projected cash flow and income statements
- Review additional specific technical information
  - This includes details related to methods of transfer, financing options, tax and legal implications, business structure options, business agreements, and tenancy issues

Step 3: Generate Options

- Address the various issues related to, but not limited to:
  - Ownership transfer options- purchase, rent, gifts, bequests
  - Financing options
  - Business organizations/structure (i.e. sole proprietorship, partnership, corporation)
  - Legal considerations (e.g. will, power of attorney
  - Tax strategies and implications
- Generate numerous options that consider the information gathered in Step 2
- Investigate different "what if" scenarios and develop contingencies to address such things as disagreement, disaster, death, disability and divorce

Step 4: Make Preliminary Decisions

- Start narrowing down your options and make preliminary decisions on the direction of the plan

Step 5: Design, Develop and Review

- Write the succession plan
- As decisions are documented, your team of advisors should review the plan and provide detailed feedback, advice and comments

Step 6: Implement and Monitor

- Provide copies of the plan to all those involved
- Follow the timetable laid out in the plan
- Monitor progress as the plan is implemented
- Modify the plan as needed
-

COMPONENTS OF A WRITTEN SUCCESSION PLAN

(Coughler & Wenger, Components of a Farm Succession Plan, 2010)

A. Business Overview

- Executive Summary of the overall plan
- Action points to implement the plan
- Description of current business, including relevant points such as:
  - Size and location of the operation
  - Products
  - Production amounts
  - Organizational structure
  - Type(s) of business arrangement(s)
- Include enough detail to set the stage for the rest of the plan, but not so much that it is overwhelming

B. Description of Business and Personal Goals and Expectations

- Describes the business and personal goals and expectations of the founder(s) and the successor(s)
- The rest of the process and the resulting plan should flow from this section

C. Retirement Plan

- Deals with two issues – financial and lifestyle
- Lifestyle includes how the founder(s) will be involved in the business, living arrangements, desired activities for the founder(s)
- Financial component includes where retirement money will come from, an explanation of any retirement-income strategies and how the money will be spent

D. Training and Development Plan for Successor

- Outlines the necessary skills and knowledge required by the successor(s) to successfully operate a winery
- Includes a "skills profile" of the successor compared to the founder, a gap analysis and an action plan to address those gaps
- A "skills profile" breaks down common activities to operate a winery and the skills needed for each
- The action plan may include such things as additional training, responsibility sharing, job shadowing, etc.
- A performance review process is also outlined under this component; it helps identify both strengths and where improvements are needed
- In all cases a regular meeting should take place to review the successor's progress. It should focus on what has worked, what has not, why, and what could be done differently. This should be a two-way discussion and a positive experience for both the founder and the successor — a chance to share and learn.

E. Business Plan

- Describes how the winery business will meet the needs of both the founder and the successor
- Includes a financial analysis of the business – past, present and future – to determine if it is profitable and viable
- Describes the future direction of the business (e.g. maintaining the same scale, downsizing, expansion, diversification, etc.) and how this direction will affect the business

F. Operating Plan

- Outlines how to manage everyday business activities
- Identifies the roles, responsibilities and authorities related to day-to-day operations and how decisions are made
- Outlines the plan for family business meetings to discuss the transfer process, including how they will function, who will be involved, who will be responsible for what, where the meetings will take place

G. Management, Control and Labour Transfer Plan

- Related to the operating plan [F]

- Describes how the transfer of management, control and labour to the successor will take place
- Includes a timetable for transition (linked to implementation timetable[I])
- Also needs to be closely connected to the successor development plan [D]

H. Ownership Transfer Plan

- Outlines how the business is currently structured and how it will change during the transfer process, including a description of the business arrangement that will be used (e.g. sole proprietorship, partnership, corporation)
- Link to business overview [A]
- Explains how the transfer of asset ownership will be handled, including a description of the transfer mechanism (e.g. purchase, gift, bequest, combination)
- Also may include:
  - an explanation of the financing required, the various sources available and the preferred financing option(s)
  - an inventory and valuation of assets and liabilities
  - an explanation of the tax implications of the proposed transfer process along with a description of how these items will be addressed
  - an outline of the insurance requirements related to life, disability, disaster and related insurance tools and a description of the legal agreements (e.g. employment contracts, partnership agreements, shareholder agreements, buy-sell agreements). Copies of these could be attached as appendices for reference purposes.
  - A copy (or copies) of the legal will(s) and any prenuptial agreements could also be attached for reference.

I. Implementation Timetable

- Provides a timetable to complete key activities that are prioritized with deadlines

J. Communications Plan

- A description of how those involved communicate about transition and succession planning (link to operating plan [F])
  - Rules of meetings and discussions
  - Schedule for regular meetings
  - Outline of who will participate in the meetings
  - Meeting locations and meals
  - Meeting responsibilities and decision making processes (e.g. who will set up the meeting and agenda, chair meetings, take minutes)
  - an outline of the ground rules for the discussion (e.g. everyone has a turn to talk, not interrupting, no blaming, stay focussed on the agenda item).
- A discussion of how disputes are managed and resolved (e.g. voting, third-party mediation)

K. Contingency Plan

- Outlines what will happen and who will ensure the implementation of contingency measures in such situations as illness, death, disability, divorce, disagreement, disaster, business downturn or failure
- Includes reference to the insurance requirements and selected mechanisms (link to ownership transfer plan [H])

7.9. Documentation and Record Keeping

Proper documentation is important throughout the employment process, from hiring to disciplinary action to job termination. Documentation helps you review and evaluate your HR plans and policies and make necessary improvements. Certain documentation is also required for compliance with federal and provincial labour laws.

Consider the following regarding documentation and record keeping:

- Ensure supervisors are aware of what should be documented, and when and how it should be documented.
- Determine the roles and responsibilities for record keeping.
- Record the list of employee records and documents you maintain (e.g. employee applications, performance appraisals, discipline records).
- Describe where you keep the records and how long you keep each document.
- Make sure you are complying with legislative requirements for length of time you need to keep records and what records you need to keep.
- Describe your process for preparing and submitting required documents to government.
- Make sure your documentation is completed in a timely, consistent manner, and using a comprehensive format that will stand up in court and is free of personal opinion.

NEIGHBOUR AND COMMUNITY RELATIONS

Many vineyards in British Columbia are located in rapidly changing areas, where competition for land can bring agriculture/rural areas and urban/suburban areas close together. Rapid population growth in many winegrowing areas of BC is putting a strain on resources such as water, energy, and on air and environmental quality. There is also increasing public concern and awareness about environmental and social issues and more interest in how businesses address these issues. For these reasons it has become imperative for vineyards to establish good neighbour and community relations.

To maintain a harmonious relationship with your neighbours and community, it is important to take the time to research local issues and learn various perspectives, anticipate and minimize nuisances, and educate the public about your processes so they understand how and why you do certain things through the year.

There are many potential positives to the community from your vineyard practices and operations. It is important to maximize these benefits by informing your neighbours and community about your sustainable values, initiatives, production practices, products and technologies.

The purpose of this section is to identify potential issues that can arise at the agricultural-urban interface and to help you

better understand, communicate about, and engage in positive problem solving solutions.

7.10. Identifying Potential Concerns

A proactive plan that emphasizes education and communication will minimize conflicts and maximize the potential benefits of your vineyard to society. The first step in proactive planning is to anticipate potential concerns and sources of conflict and develop solutions before they occur.

Potential concerns of your neighbours and/or the community may include the following:

- transportation and traffic
  - increased traffic at peak labour times
  - traffic on vineyard roads and ancillary roads
- water quality and supply
  - competing uses
  - water pressure
  - sedimentation of water supply due to erosion
  - chemicals and pesticides affecting water quality
- noise and vibrations
  - vineyard groundwork
  - wind machines for crop protection
  - wind turbines for electrical generation
  - engine driven irrigation pumps
  - cropping equipment
  - night time grape harvest
  - bird control devices
  - traffic
- visual impacts
  - lighting: lights in greenhouses, grape harvester and equipment lights during harvest, yard security lights
  - viewsheds
- air quality
  - dust (traffic on unpaved roads, soil erosion by wind from laneways and bare fields, livestock ventilation fans, field tillage)
  - chemical spraying
  - odours (manure, pomace or other organics storage and field application, compost piles, pesticide applications, livestock pasturing)
  - smoke (burning prunings, farm wastes, organic materials for heating shops, greenhouses)

7.11. Outreach and Communication

Formal and effective outreach and communication is essential to identifying and addressing potential concerns and to developing positive relationships with your neighbours and community. Consider the following when developing your outreach and communications plan.

Get acquainted with vineyard neighbours and your local community and generate goodwill:

- Get to know those that may be impacted by your operations in a friendly setting. Invite them to tour your vineyard (for example).
- Be involved in community events and civic and charitable groups to work alongside community members.

Educate your neighbours and community and yourself:

- Share your sustainable vineyard goals and how they benefit the surrounding community.
- Inform your neighbours and community about your company outlining the sustainable practices you use, when, and why.
- Find out what issues are important to neighbours and fellow community members and learn and understand various perspectives.
- Pay attention to local and regional zoning laws and growth management plans.
- Attend meetings and workshops with community members to ensure that your perspective is represented.
- Host neighbour/community events at your vineyard and be involved in community events and civic and charitable groups.

Communicate with your neighbours and local community:

- Be open to discussing their concerns and questions and respect their views.
- Find a neutral setting to discuss their concerns.
- Seek common areas of interest.
- Alert them to upcoming potential nuisances before they begin.
- Ensure that your neighbours know how to contact you and consider providing an after hours phone number.
- Communicate with neighbours often through such methods as periodic visits, phone calls, community parties, postcards to alert of spraying
- Explore changes to practices that could smooth tensions (e.g. rescheduling objectionable activity to when neighbours are at work and not on weekends when they are likely to be outside.
- Make sure your employees are educated and trained to answer questions and speak on your vineyard's sustainability initiatives with consumers and community members.

Develop a relationship with local media:

- Invite reporters to your vineyard and give them newsworthy information.
- Share your sustainable practices and explain what your operation is doing to reduce pesticide use, water use
- Respond promptly if media does call. If you do not have the information they are asking for then contact them with the name of someone who can help.

7.12. Responding to Complaints

Even the best proactive planning may not entirely avoid complaints from your neighbours. The following practices should be used to deal with complaints:

- Develop a written procedure for addressing complaints from neighbours.
- Train all employees in the procedure.
- Delegate one person to managing the complaints process.
- Document all complaints with understanding and tact.
- Ensure all complaints are followed up on.

REFERENCES

Barrios, A. (2000). Agriculture and Water Quality. CAE Working Paper Series. WP00-2. June 2000. American Farmland Trust's Center for Agriculture in the Environment, DeKalb, Illinois.

BC Agriculture Council. (2008). Planning for Biodiversity: A guide for BC Farmers and Ranchers. The Canada – British Columbia Environmental Farm Plan Program.

BC Ministry of Agriculture and Lands and BC Wine Grape Council. (2006). Best Practices Guide for Grapes for British Columbia Growers. British Columbia: BC Wine Grape Council.

BC Ministry of Agriculture, Food and Fisheries. (2004). Strengthening Farming Right to Farm: Farm Practices and Habitat Management. URL: www.agf.gov.bc.ca/resmgmt/fppa/refguide/activity/870218-39_Habitat_Management.pdf. Accessed February 20, 2009.

BC Ministry of Environment. (2006). Develop with Care: Environmental Guidelines for Urban and Rural Land Development in British Columbia.

BC Ministry of Forests and Lands. (2007). Mountain Pine Beetle in BC: A Growing Problem. URL: www.for.gov.bc.ca/hfp/mountain_pine_beetle/bbbrochure.htm. Accessed March 3, 2009.

BC Ministry of Forests. (2002). Understanding Ecosystem Processes: Rangeland Health Brochure 3. URL: www.for.gov.bc.ca.hfp/range/reange.htm. Accessed February 20, 2009.

BC Ministry of Sustainable Resource Management. (2001). Inventory Methods for Raptors (version 2): Standards for Components of British Columbia's Biodiversity No. 11. Integrated Land Management Bureau of BC. URL: http://ilmbwww.gov.bc.ca/risc/pubs/tebiodiv/raptors/version2/rapt_ml_v2.pdf. Accessed February 20, 2009.

Bogart, K. (nd). Measuring Winegrape Water Status Using a Pressure Chamber. URL: http://pmsinstrument.com/Kay%20Bogart%20Article%2001132005.pdf. Accessed March 3, 2010.

Brady, N.C. (1990). The Nature and Properties of Soils, 10th ed. Macmillan, New York.

Brown, L., Hughes-Games, G., Van Kleeck, R. (eds.). (2005). The Canada- British Columbia Environmental Farm Plan Program: Reference Guide. BC Agriculture Council. URL: www.bcac.bc.ca/EFP_pages/documents/index.html. Accessed February 20, 2009.

Canadian General Standards Board. (2009). Organic Production Systems Permitted Substances Lists. Canadian General Standards Board, Gatineau, Canada. URL: www.tpsgc-pwgsc.gc.ca/cgsb/on_the_net/organic/032_0311_2006-e.pdf. Accessed December 10, 2009.

Canadian General Standards Board. (2008). Organic Production Systems General Principles and Management Standards. Canadian General Standards Board, Gatineau, Canada. URL: www.tpsgc-pwgsc.gc.ca/cgsb/on_the_net/organic/index-e.html. Accessed December 10, 2009.

Canadian Ministry of Environment. (2005). Hinterland Who's Who: Build a Bat House. URL: www.hww.ca/hww2.asp?id=323&cid=43. Accessed February 20, 2009.

Canadian Vintners Association. (2005). URL: www.canadianvintners.com. Accessed February 12, 2009.

Capital Regional District. (2009). Watershed Basics website. URL: www.crd.bc.ca/watersheds/protection/watershed-basics/index.htm. Accessed September 15, 2009.

Center for Irrigation Technology, The. (2003). Agricultural pumping efficiency program. Cal. State Univ., Fresno, CA.

Central Coast Vineyard Team. (2004). Positive Points System: Self-assessment tool for evaluating sustainable management practices used in vineyards. Central Coast Vineyard Team, Paso Robles, CA.

Christensen, P.L., Kasimatis, A.N., Jensen, F.L. (1978). Grapevine and Nutrition Fertilization in the San Joaquin Valley. University of California Division of Agriculture and Natural Resources. California: Agriculture and Natural Resources.

College of Agriculture, Human and Natural Resources. (2006). Cover Crops as a Floor Management Strategy for Pacific Northwest Vineyards. Washington State University.

Coombe, B.G. and Dry, P.R., eds. (1992). Viticulture Volume 1 Resources. Winetitles, Underdale, South Australia.

Coombe, B.G. and Dry, P.R., eds. (1992). Viticulture Volume 2 Practices. Winetitles, Underdale, South Australia.

Coughler. (2004). Components of a Farm Succession Plan. Ontario Ministry of Agriculture, Food & Rural Affairs.

Dakis, P., Hayes, P., Noon, D., Whiting, J., and Everett, M. (2001). The Profitability of Investing in a Small Vineyard and Winery. Department of Natural Resources and Environment, Victoria.

Di Guilio, M., Edwards, P.J., and Meister, E. (2001). Enhancing Insect Diversity in Agricultural Grasslands: The Role of Management and Landscape Structure. Journal of Applied Ecology (38):310-319.

Dlott, J., Ohmart, C. P., Garn, J., Birdseye, K. and Ross, K., eds. (2006). Code of Sustainable Winegrowing Practices Self-Assessment Workbook. Wine Institute & California Association Winegrape Growers. 477pp.

Ducks Unlimited. (2009). URL: www.ducks.ca/province/bc/index.html. Accessed February 27, 2009.

Earnshaw, S. (2004). Hedgerows for California Agriculture: A Resource Guide. Community Alliance with Family Farmers. URL: www.caff.org/programs/farmscaping/Hedgerow.pdf. Accessed February 20, 2009.

Egan, B. BC Ministry of Forests. Ecosystems of BC. URL: www.for.gov.bc.ca/hfd/pubs/Docs/Bro/Bro01.pdf. Accessed February 15, 2009.

Environment Canada Freshwater Website. URL: www.ec.gc.ca/Water/en/nature/prop/e_cycle.htm. Accessed April 15, 2009.

Environment Canada. (2009). The Hydrologic Cycle. URL: www.ec.gc.ca/Water/en/nature/prop/e_cycle.htm. Accessed September 15, 2009.

Fish Friendly Farming. (2009). URL: www.fishfriendlyfarming.org. Accessed April 15, 2009.

Fretzer Vineyards. (2008). Philosophy. URL: www.fretzer.com/philosophy. Accessed February 10, 2009.

GOERT. (2010). Garry Oak Ecosystems Recovery Team website. URL: www.goert.ca/. Accessed March 3, 2010.

Goodwin, I. (1995). Irrigation of Vineyards: A Winegrape Grower's Guide to Irrigation Scheduling and Regulated Deficit Irrigation. Institute of Sustainable Irrigated Agriculture, Tatura, Victoria, Australia.

Hall, L.S., Krausman, P.R., and Morrison, M.L.. (1997). The Habitat Concept and a Plea for Standard Terminology. Wildlife Society Bulletin 25(1):173-182.

Hellman, E. W. (ed.). (2003). Oregon Viticulture. Oregon State University Press. Corvallis, Oregon.

Horwath , W., Ohmart, C.P., Storm, C.P. (2008). Lodi Winegrower's Guidebook: A Self-Assessment of Integrated Farming Practices. Lodi-Woodbridge Winegrape Commission and US Environmental Protection Agency.

Ingels, C.A., Bugg, R.L., McGourty, G.T., and Christensen, L.P. (1998). Cover cropping in vineyards: a grower's handbook. Univ. Calif. Div. Nat. Res. Res. Publ. 3338. 162 pp.

Integrated Production of Wine: Guidelines for Farms. (2009). South African Wine & Spirit Board.

Jackson, D.I. and Lombard, P. B. (1993). Environmental and Management Practices Affecting Grape Composition and Wine Quality.

Jackson, D. and Schuster, D. (2001). The Production of Grapes and Wine in Cool Climates. Gypsum Press and Daphne Brasell Associates Ltd., Wellington, Aoteroa, New Zealand.

Jackson, D. (2001). Monographs in Cool Climate Viticulture – 1, Pruning and Training. Daphne Brasell Associates and Lincoln University Press, Wellington, Aoteroa, New Zealand.

Jackson, D. (2001). Monographs in Cool Climate Viticulture – 2, Climate. Daphne Brasell Associates Ltd. Wellington, Aoteroa, New Zealand.

Jones, K. (nd). The Australian Wine Industry's Environment Strategy: Sustaining Success.

Klinkenberg, B. (2008). E-Flora BC: Electronic Atlas of the Plants of BC. URL: www.eflora.bc.ca. Accessed February 15, 2009.

Land Trust Alliance of British Columbia. (2002). Preserving Natural and Cultural Features of Land with a Conservation Covenant. URL: www.landtrustalliance.bc.ca/options.html. Accessed February 28, 2010.

Lavkulich, L.M. (2007). Soil Landscapes of BC Part 2: The Major Soils and Soil Processes of British Columbia. Ministry of Environment of British Columbia. URL: www.env.gov.bc.ca/soils/landscape/part2.html. Accessed March 2, 2009.

Loukidelis, D. (1992). Using Conservation Covenants to Preserve Private Land in BC. Westcoast Environmental Law. URL: www.wcel.org/wcelpub/2986_1.html#con. Accessed February 22, 2009.

Luvkulich, L.M. and Valentine, K.W.G. (March 2007). Soil Landscapes of BC Part 3: The Canadian System of Soil and Soil Climate Classification. Ministry of Environment of British Columbia. URL: www.env.gov.bc.ca/soils/landscape/part3.html. Accessed March 2, 2009.

Macqueen, R.W. and Meinert, L.D. (2006). Fine Wine and Terroir: The Geoscience Perspective. Geological Association of Canada, Memorial University of Newfoundland. St. John's, Newfoundland and Labrador.

McGourty, G. (2004). Cover cropping systems for organically farmed vineyards. In Practical Winery and Vineyard Magazine. URL: www.practicalwinery.com/septoct04/septoct04p22.htm. Accessed February 27, 2009.

Meffe, G.K., Nielsen, L.A., Knight, R.L. and Schenborn, D.A.. (2002). Ecosystem Management: Adaptive Community-Based Conservation. Washington, DC: Island Press.

Mitchell, P.D. and Goodwin, I. (1996). Micro-irrigation of Vines and Fruit Trees. AG Media. East Melbourne, Victoria, Australia.

Mollah, M. (1997). Practical Aspects of Grapevine Trellising. Hyde Park Press, Adelaide, South Australia.

Morgan, T. and Nelson, B., (eds). (1992). Oregon Winegrape Grower's Guide 4th Edition. The Oregon Winegrowers' Association. Portland, Oregon.

Natural Resources Canada. (2006). Atlas of Canada: Watersheds Map. URL: http://atlas.nrcan.gc.ca/site/english/maps/environment/hydrology/watershed. Accessed February 26, 2009.

Nyvall, J. and Tam S. (2005). Irrigation System Assessment Guide. Companion Document to the Canada – British Columbia Environmental Farm Plan. BC Agriculture Council.

Ohmart, C. P. and Matthiasson, S. K. (2000). The Lodi Winegrower's Workbook: A self-assessment of integrated farming practices. Lodi-Woodbridge Winegrape Commission, Lodi, CA. 135 pp.

Ohmart, C. (2008). Why Discing is Bad for Your Vineyard Soil. Wines and Vines. URL: www.winesandvines.com/template.cfm?section=columns_article&content=59882&columns_id=41&ctitle=Why%20Discing%20Is%20Bad%20For%20Your%20Vineyard%20Soil. Accessed March 15, 2009.

OMAFRA Staff. (2002). Soil Management and Fertilizer Use: Cover Crops. Ontario Ministry of Agriculture, Food and Rural Affairs. URL: www.omafra.gov.on.ca/english/crops/pub811/2cover.htm. Accessed March 3, 2009.

Ontario Ministry of Agriculture, Food and Rural Affairs. (2002). Choosing the Right Cover Crop. URL: www.omafra.gov.on.ca/english/crops/hort/news/hortmatt/2007/18hrt07a2.htm. Accessed February 15, 2009.

Oregon Low Input Viticulture & Enology Inc. (2009). URL: www.liveinc.org/forms. Accessed February 7, 2009.

Parnes, R. (1990). A Grower's Guide to Organic and Inorganic Fertilizers. agAccess, Davis, California.

Pitwirny, M. (2006). Organization of Life: Species, Populations, Communities and Ecosystems. Fundamentals of Physical Geography, 2nd Edition. URL: www.physicalgeography.net/fundamentals/9d.html. Accessed February 22, 2009.

Plaster, E. J. (1997). Soil Science and Management (3rd Edition). Scarborough, Ontario: Delmar Publishers.

PRBO Conservation Science. (2009). Safe Nest Boxes for Owls in the West. URL: http://ilmbwww.gov.bc.ca/risc/pubs/tebiodiv/raptors/version2/rapt_ml_v2.pdf. Accessed February 20, 2009.

Prichard, T. (1996). Modification of Wine Characteristics through Irrigation Management. Final Report to Lodi-Woodbridge Winegrape Commission, Lodi CA. 15pp.

Prichard, T. (2000). Management of Zinfandel to Modify Vine and Wine Characteristics. Final Report to Lodi-Woodbridge Winegrape Commission, Lodi CA. 23pp.

Prichard, T. (2000). Management of Merlot to Modify Vine and Wine Characteristics. Final Report to Lodi-Woodbridge Winegrape Commission, Lodi CA. 17pp.

Prichard, T., Hanson, B., Schwankl, L., Verdegaal, P. and Smith, R. (2004). Deficit irrigation of quality winegrapes using micro-irrigation techniques. Univ. Calif. Coop. Ext. Dept. Land, Air and Water Res. Davis, Ca. 90 pp.

Prichard, T. (nd). Winegrape Irrigation Scheduling Using Deficit Irrigation Techniques. University of California Davis. URL: http://cesanjoaquin.ucdavis.edu/files/13563.pdf. Accessed February 23, 2009.

Proffitt, T., Bramley, R., Lamb, D., and Winter, E. (2006). Precision Viticulture: A new era in vineyard management and wine production. Winetitles Pty Ltd., Ashford, South Australia, Australia.

Reimchen, T. (2001). Salmon Nutrients, Nitrogen Isotopes and Coastal Forests. Ecoforestry Magazine, 13-16.

Rice, T.J. (1999). Liming of Vineyard Soils. Practical Winery. URL: www.practicalwinery.com/julyaug99/liming.htm. Accessed March 15, 2009.

Schwankl, L., Hansen, B. and Prichard, T. (1993). Low-volume irrigation. Univ. Calif. Irrigation Program. Davis, CA. 116pp.

Smart, R. and Robinson, M. (1991). Sunlight Into Wine: A Handbook for Winegrape Canopy Management. Winetitles, Underdale, South Australia, Australia.

Scott, L., and Delesalle, B. (2003). The Value of Riparian Habitat and How to Care for It. South Okanagan Similkameen Stewardship Program. URL: www.conservancy.bc.ca/attachments/okanagan/sosstewardship/The%20Value%20of%20Riparian%20Habitat-single.pdf. Accessed May 3, 2009.

Sheldon, D., Hruby, T., Johnson, P., Harper, K., McMillan, A., Granger, T., Stanley, S., and Stockdale, E. (2005). Wetlands in Washington State, Volume 1: A Synthesis of the Science. Washington State Department of Ecology. Publication #05-06-006. Olympia, Washington.

Shepherd, G (ed). (2004). The Ecosystem Approach: Five Steps to Implementation. World Conservatory Union (IUCN). Switzerland and Cambridge, UK: Gland.

Smallwood, K.S, Nakamoto, B.J, and Geng S. (1996). Association Analysis of Raptors on a Farming Landscape. In: Bird, D.M, D.E Varland and J.J Negro (eds). (1996). Raptors in Human Landscapes: Adaptations to Built and Cultivated Environments. Academic Press. San Diego, California.

South Australian Wine and Brandy Industry Association Inc. (2002). Sustaining Success: The Australian Wine Industry's Environment Strategy. URL: www.wfa.org.au/files/what_we_do/Sustaining_Success.pdf. Accessed March 15, 2010.

Stimson, D., and O'Conner, K. (2005). Multiple Benefits in Vineyard Erosion Control. Practical Winery and Vineyard Magazine.

Strachan, G. (2009). Cool Climate Viticulture. Okanagan College Course Presentation.

Styles, S. W. and Burt, C. M.. (1999). Drip irrigation for trees, vines and row crops. Cal. PolySan Luis Obispo Irrigation Tech. and Res. Center., San Luis Obispo. CA.

Sustainable Winegrowing New Zealand Working Group and Charles, J (Ed). (2008). Sustainable Winegrowing New Zealand (5th Edition). New Zealand: New Zealand Winegrowers.

Sustainable Winemaking Ontario. (nd). Viticulture Addendum to the Canada-Ontario Environmental Farm Plan Program, Third Edition.

Thrupp, L. (2002). Fruits of Progress: Growing Sustainable Farming and Food Supplies. Washington, D.C: World Resources Institute.

Thrupp, L., Costello, M.J., McGourty, G. (2008). Biodiversity Conservation Practices in California Vineyards: Learning from Experience. Bulletin from the California Sustainable Winegrowing Program. URL: www.sustainablewinegrowing.org/docs/2008-Biodiversity_in_Vineyards.pdf. Accessed February 15, 2010.

Traynor, J. (2003). Leaf vs. Petilole Analysis to Find 'N' in Grapes. Grape Grower Magazine. URL: www.beesource.com/pov/traynor/ggmfeb2003.htm. Accessed March 13, 2009.

Vernal Pool Association. (nd). URL: www.vernalpool.org/vpinfo_1.htm. Accessed February 23, 2009.

VineBALANCE New York. (2009). Guide to Sustainable Viticulture Practices. Workbook Sections. URL: www.vinebalance.com/workbook_sections.php. Accessed October 15, 2008.

Washington Association of Wine Grape Growers. (2006). Vinewise: Washington Guide to Sustainable Viticulture. URL: www.vinewise.org/245.html. Accessed October 15, 2008.

Westcoast Environmental Law. BC Guide to Watershed Law and Planning. Watersheds of BC. URL: www.bcwatersheds.org/issues/water/bcgwlp/d1.html. Accessed February 19, 2009.

Wetland Stewardship Partnership. (2009). Wetland Ways: Interim Guidelines for Wetland Protection and Conservation in British Columbia. URL: www.env.gov.bc.ca/wld/BMP/bmpintro.html/. Accessed March 15, 2010.

Wild Farm Alliance. (2005). Biodiversity Conservation: An Organic Farmer's Guide. Watsonville, California.

Wrysinski, J. (2002). Monitoring on Your Farm: A Guide to Tracking and Understanding the Resources and Wildlife on Your Farm. Woodland, CA: Yolo County Resource Conservation District.

Yalumba Wine Company (2009). Yalumba's Viticultural Code of Practice. Yalumba Wine Company. Angaston, SA. URL: http://www.yalumba.com/library/enviro_viticodeofpractice.pdf. Accessed October 15, 2008.

GLOSSARY

Annual: a plant that goes through the process of germinating, flowering and dying in one growing season. They need to be replanted each spring. Winter annual plants germinate in the fall and mature the next season.

Application rate (pesticide): the rate at which the pesticide should be applied over a given area. It is normally found on the product's label and is based on things such as target pest, weather conditions, soil conditions and plant development stages.

Beneficial organisms (beneficials): is a subjective term given to organisms that enhance crop production by contributing to pest control, pollination or maintenance of soil health. A beneficial organism for one crop may be detrimental to another and vice versa.

Biodiversity: the richness and variety of all life forms plus the habitats and natural processes that support them.

Biogeoclimatic zone: An ecosystem spread over a large geographical area that can be characterized by its climate, vegetation, soils and animal life.

Cover crop: vegetation that is planted (e.g. grass), or allowed to grow (e.g. native plants) between rows of grape plants. A cover crop is a sustainable tool that can be used to effectively manage soil quality, water use, weeds and pests.

Drift (pesticide): Pesticide drift refers to pesticide droplets or dust that are transported by the wind and deposited outside of target areas.

Ecosystem processes: the physical, chemical and biological actions or events that link organisms and their environment. Ecosystem processes regulate the climate, clean freshwater, regulate and clean soils, maintain genetic diversity, maintain the water cycle, recycle nutrients, and pollinate crops.

Ecosystem services: resources and processes that are supplied by natural ecosystems. Collectively, these benefits are known as ecosystem services. These services are extensive and diverse, affecting the quality of our land, water, food, and health. Ecosystems provide "services" that:

- contribute to climate stability and moderate weather extremes
- disperse seeds
- mitigate drought and floods

- cycle and move nutrients
- protect stream and river channels and coastal shores from erosion
- purify the air and water and detoxify and decompose wastes
- control agricultural pests
- support diverse wildlife populations
- maintain biodiversity
- generate and preserve soils and renew their fertility
- contribute to climate stability
- purify the air and water
- regulate disease carrying organisms
- pollinate crops and natural vegetation
- enhance aesthetic appeal
- provide habitat

Ecosystem: a community of plants, animals, and microorganisms that live, feed, and interact in the same area or environment. People are part of ecosystems. Ecosystems develop and exist at different scales: in a drop of water, within a single tree, within a field, across a farm, and across a large region like a major river basin.

Evapotranspiration (ET): The combined loss of water to the atmosphere from a given area by evaporation from the land and transpiration from plants; used in determining crop irrigation needs.

Fertigation: the application of fertilizers, soil amendments, or other water soluble products through an irrigation system.

Foliar spraying: Application of liquid fertilizer by spraying on the leaf of the plant.

Grafting: It is a form of asexual plant propagation where the scion of one plant is encouraged to fuse with the rootstock of another. Grafting is a method most commonly used for the propagation of commercial trees and shrubs.

Green manure: a cover crop that is grown to be tilled and turned under while still green for the purpose of adding nutrients and organic matter to the soil.

Habitat: the living area of a community of plants and animals. It includes the air, soil, water, food and cover components upon which plants and animals depend upon to carry out their life processes.

Invasive (noxious) weed: Noxious weeds are typically non-native plants that grow uncontrollably because of a lack of local predators or plant pathogens that would keep their populations under

control. They are detrimental to crops because they are highly competitive and difficult to control.

Invasive species: Invasive species are plants, animals, aquatic life and micro-organisms that out-compete native species when outside of their natural environment and threaten Canada's ecosystems, economy and society.

Leachate (pesticide): Pesticide leachate is pesticide in solution that gets transported by rain or irrigation down into or through the soil to unwanted areas.

Macronutrient: Macronutrients are soil nutrients consumed by plants in large quantities, and are necessary for the healthy development of a crop. These are nitrogen, phosphorus, potassium and sulphur. In areas that lack one or all of these nutrients, the soil can be amended by applying these as fertilizer.

Micronutrient: Micronutrients are those nutrients utilized by plants in small quantities but that are crucial to their development. These are boron, copper, chlorine, iron, manganese, molybdenum and zinc. In areas that lack one or all of these nutrients, the soil can be amended by applying these as fertilizer.

Mycorrhizae: beneficial fungi that form a symbiotic relationship with the root of a plant, which facilitates nutrient intake for the plant.

Organic matter: Decayed material that was once part of a living organism usually rich in nutrients.

Perennial: a plant that returns year to year, meaning it does not die in the winter.

Pest: is a subjective term given to organisms (including plants, animals or pathogens) that are detrimental to crop production. A pest for one crop may be beneficial to another and vice versa.

Pesticide: Any material used to prevent, destroy, repel, attract or reduce pest organisms. Insecticides, herbicides, fungicides and rodenticides are some of the more well-known pesticides. Less well-known pesticides include growth regulators, plant defoliants, surface disinfectants and some swimming pool chemicals. Under federal legislation, all pesticides used in Canada must be registered by Health Canada.

Petiole: The small stalk that attaches the leaf blade to the stem of a plant.

Rootstock: A rootstock is an established healthy root system used for grafting a cutting or budding

from another plant.

Runoff (pesticide): Pesticide runoff refers to pesticide solution transported by rain or irrigation outside of the target areas.

Scion: A scion is a plant cutting that contains desirable genes for things such as stems, leaves, flowers, or fruit. It is normally grafted onto the rootstock of another plant.

Soil amendment: Any material added to a soil to improve its properties (e.g. water holding capacity, drainage, aeration)

Soil compaction: Loss of pore structure and aggregate stability with soil caused by traffic and tillage, particularly in wet soil; reduces the movement of water, air, nutrients and soil microbes in soil.

Species at risk: are indigenous species, subspecies, and distinct populations that are at risk of becoming extinct at a local or global level.

Vine vigour: Vine vigour refers to the amount of vegetative growth produced by a vine in a single growing season. It has a direct effect on nutrient transport and fruit quality. It is affected by environmental factors such as water availability, climate, soil quality, as well as vineyard practices.

Water holding capacity: Soil holds water in the space between its particles due to capillary action, ionic forces and surface tension. Water holding capacity refers to the water remaining in a soil when the downward water flow due to gravity becomes negligible.

Watershed: the region draining into a river, river system, or other body of water. Other terms used interchangeably with watershed include *drainage basin* or *catchment basin*.

Weeds: native or invasive (noxious) plants that grow and reproduce aggressively, and compete with crop plants for soil nutrients, light and water.

Wilting point: When the plant goes into irreversible distress as the force required to remove water from the soil exceeds the plant's ability to do so. The permanent wilting point occurs at a higher (total) water content in clay soils than in sandy soils because the particles are smaller and water is more tightly bound to clay soils.