Development West Coast

Viability of a commercially sustainable West Coast horticulture industry

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Chapter 1
Introduction

The aim of this report is to assess the feasibility of establishing a horticultural industry on the West Coast. The industry should be intended to be of sufficient size to facilitate the development of an infrastructure to support the ongoing development and evolution of horticulture on the West Coast. The industry development should also be in the relatively short term and therefore it is not intended that new markets should be explored but rather this industry to take advantage of exiting supply channels, some scoping of which had already been done by stakeholders on the West Coast.

The report initially outlines the physical characteristics of the West Coast which provide basis from which crops could potentially be grown. This includes the climate, climate change, soils type and current land use type. This is followed by the current size and extent of the horticultural industry in New Zealand as well as its importance in export markets. This section provides some context from which crops can be selected. The fact that crops already exist does imply that expertise in their growing and marketing is available in New Zealand.

The report then outlines the potential markets within which an industry could be developed and the issues surrounding this, followed by the identified key factors in developing an industry such as markets, leadership, policy and size.

A review of the potential crops is then undertaken. The report covered as wide a range of crops as possible however as many of these were not feasible for growing commercially on the West Coast or did not meet the criteria they are listed in the appendix whereas the potential crops are listed within the report for further comment and the basis from which four or five crops are to be selected.

In selecting the crops certain criteria have to be developed that include suitability of crop for West Coast; potential issues in producing eth crops; the issues around supporting the production of the crop (from provision of core infrastructure to expertise); and the market for the crop.

Chapter 2
West Coast

2.1 General

The West Coast region stretches from Karamea in the North to around 100km south of Haast while reaching inland to the Main Divide. The longest region in New Zealand (from latitude 40°50ô to 44°15ô south) its length is almost the same as the distance between Auckland and Wellington. It covers an area of approximately 600 x 70 km or 4,200,000 hectares, making up 8.7per cent of New Zealandôs land area (Nathan, 2009). Of this 266,250 hectares are considered usable land area with 200,126 hectares of this in agricultural production (Statistics New Zealand, 2007a).

2.2 Climate and soils

The West Coast has a noticeably milder climate than east coast regions of New Zealandôs South Island, with similar sunshine hours, but fewer extremes in climate. It receives a generous, reliable annual rainfall of 2,000ï 3,000 millimetres near the coast increasing rapidly closer to the mountains with the highest rainfall occurring near the Main Divide (Nathan, 2009). Valleys and other sheltered locations provide a range of different microclimates, with warm, moist north-westerly flows common (West Coast Regional Council, 2011).

Although rainfall is high compared to the rest of New Zealand, it often occurs as high-intensity downpours. This is seen in the main, coastal towns, where more than half the days each year are fine and without rain. Average sunshine hours range between 1,800 and 1,900 annually ï fewer than in Christchurch, but more than in Timaru (Nathan, 2009).

It has the lowest mean frost days of any South Island region, with 26 annual ground frosts being the mean for the 1971-2000 period (Plant & Food Research, 2009).

Although the region is primarily coastal maintaining similar temperatures, rainfall and sunshine averages, inland areas can experience greater overall annual temperatures with areas such as Reefton receiving significantly higher averages.

The NIWA predictions based on Climate Change Scenarios (see Appendix 1) suggest that the West Coast climate is likely to change in the next 90 years with significant temperature and precipitation increases. In taking the average of these Climate Change Scenarios we can observe a possible 2°C rise in temperature by the end of the century. This would be coupled with a projected 10-15 per cent increase in precipitation for the same period with southern and inland areas receiving the greater increases (Wratt & Mullan, 2008).

The West Coast features a wide range of soil types. However, the soils used for agriculture in lowland areas can be generalised into three broad groups (Nathan, 2009):

- Recent soils are located on river flats and valley floors, however in some areas these are still subject to occasional flooding and bank erosion which can be a constraint on their use. Despite often being deficient in lime, these soils have the highest natural fertility, are more productive and form an essential element in the regionôs agricultural economy (West Coast Regional Council, 2011), although continued fertiliser application is required for successful agricultural production (Nathan, 2009).

- Yellow-brown earths are found on lower terraces and rolling morainic (rocky) and hill country. These soils have been leached by the heavy rainfall, and are of lower fertility than recent soils. The only exception is the lower Grey Valley, in the rain shadow of the Paparoa Range, where rainfall is lower (Nathan, 2009).
- Gley podsols, which are waterlogged and nutrient-poor, are found on older terraces and moraines (glacial rocks). High rainfall over a long period has led to the formation of an impervious iron pan (layer) that impedes drainage. These unproductive flat areas, widespread around Westport, are locally known as pŪkihi (Nathan, 2009).

2.2.1 Suitability of West Coast for horticulture

The climate on the West Coast therefore does have the advantage of mild winters with few frosts and ample rainfall. This does make it attractive for the growing of some crops, in particular vegetative crops. It does have disadvantages that could affect the development of horticultural crops. These include the regularity of high intensity rainfall which can damage crops; lead to increased susceptibility to pests and diseases; leaching of nutrients in soil; deterioration of soil structure; erosion; and weed control. Thus higher rainfall characteristics require a greater understanding of soil development and management while being more prone to pests and diseases. Maintenance of soil organic matter and structure are of utmost importance in wet environments. The need for good drainage systems is essential; however caution must be taken to ensure these systems do not create excessive leaching of necessary nutrients requiring replacement. High temperature, moisture and humidity levels require more difficult and complex methods of pest and disease control (Crowder et al., 1978). This mitigation can be especially vital during flowering and fruit setting in certain crops such as kiwifruit (Williams, Personal Communication, March 11, 2011).

In the future, predictions under Climate Change Scenarios do have the potential to create new crop niches and opportunities. The temperature increases perhaps offer the greatest opportunities, especially in winter months as the potential exists to grow certain crops year round, unlike most other regions. This combined with readily available water could provide a significant advantage.

The increase in precipitation could have both positive and negative impacts. With many of the productive regions of the rest of New Zealand becoming more water scarce as the effects of global warming take hold, the West Coast looks set to receive more rainfall. This could enable the region to be more competitive in some crops, with limited irrigation investments and expenses once soil condition has been developed to optimise crop growth. Alternatively, this may also make certain regions less viable for production of certain crops. Some coastal areas which currently receive significantly less precipitation than inland areas look likely to increase in the next 40-90 years.

2.2.2 Current land use on the West Coast

The agricultural land use on the West Coast is predominantly agricultural grassland as is shown in Table 1. This is mainly land used for pastoral farming especially dairying which has grown considerably over the last decade or so. In 2009 there were 179,000 dairy cows; 46,000 beef and 43,000 sheep. Other less significant uses include grazed tussock, and mature or regenerating native bush with grain and seed crop areas being insignificant. Data on horticultural and forestry areas were unattainable for confidentiality reasons. It is assumed however that the major proportion of the 200,126 hectares not indicated in Table 1 is land

tied up in exotic forestry plantations with very little dedicated to horticultural crop production.

The West coast has an infant industry in horticulture. The following crops were grown on the West Coast in 2005: Hydroponic tomatoes, Australian tea tree, hydroponic lettuce, hydroponic sandersonia, callas lilies, black passionfruit, tamarillos, feijoas, blueberries, hydrangeas, carnivorous plants, native plants, lavender, limes, cranberries and nursery plants in general (Moynilhan & Moynihan, 2005).

Therefore, there are a number of specialist suppliers on the West Coast who have developed niche markets. The range and type of produce does lend itself to strategies for co marketing under West Coast branding but none of these are sufficient to develop a core infrastructure to support a large scale horticultural industry.

Table 1: West Coast agricultural areas in hectares by usage (June 2009))

Region	Tussock and danthonia used for grazing (whether oversown or not)	Grassland	Grain, seed and fodder crop land, and land prepared for these crops	Horticultural land and land prepared for horticulture	Plantations of exotic trees intended for harvest	Mature native bush	Native scrub and regenerating native bush	Other land	Total Land
West Coast	8,986	115,306	890	C	C	12,089	17,617	11,411	200,126
TOTAL South Island	2,844,675	3,238,474	301,164	54,948	479,008	170,508	273,669	252,505	7,614,952
TOTAL New Zealand	2,900,463	8,086,160	367,404	132,892	1,708,282	448,247	625,981	431,467	14,700,897
(1) Figures may not add to the totals due to rounding.									

Source: (Statistics New Zealand, 2007a)

2.2.3 Available land

Crowder *et al* (1978) suggested a number of locations which were believed to be highly suited to intensive broad acre production. Land was placed in Classes indicating its suitability for horticultural production. The West Coast has no Class I land which would be classed as ideal horticultural production. Class II and III land areas are most likely being considered highly suited for intensive broad acre production.

These areas were:

- Karamea River flats and associated areas
- Westport flats
- Barrytown area
- Greymouth flats
- Hokitika
- Kowhitirangi

- Waitaha River
- Harihari ï Wanganui River
- Whataroa River

Class IV and V is land that could be made productive but has greater limitations.

Suitable areas are:

- Area south of Karamea adjoining coastal sand dunes south to Wanganui River.
- Coastal strip North and South of Westport (includes Waimangaroa).
- Extension of Barrytown soils to Punakaiki.
- Large areas of Ahaura valley
- Hokitika Valley
- Waitaha River
- Small areas further south on Waiho and Cook rivers.

The region is equipped for small scale irrigation which could compensate for dry spells in specific regions. The actual irrigable area is unclear with some figures being confidential but available figures suggest it is insignificant at less than 600 hectares (Statistics New Zealand, 2007b).

Thus a number of West Coast locations have relatively desirable growing conditions, with some additional factors adding to their feasibility. These qualities suggest Karameaôs coastal Class II and III land as being the ideal location due to the lowest rainfall averages and the influences of the marine climate preventing the lower night minimums. Due to transportation costs to centres of processing, distribution and consumption, the Class II and III land areas around Westport and Greymouth may be also be possible. The area of similar class land around Barrytown would appear to have great potential due to the enhanced micro-climatic advantages associated with immediate shelter, sloping ground and proximity to both Greymouth and Westport.

Optimum locations within these areas would be elevated areas and terraces in close proximity to the coast. These would provide the longest growing seasons without the cooler temperatures of inland and lowland flats. The much greater areas of Class II and III land both inland and to the south could not be suitable for horticultural development due to severe winter frosts and significantly heavier rainfalls and associated drainage problems (Crowder et al., 1978).

The West Coast has the potential to make use of its relative climatic advantage in the production of many crops during winter months. These growing conditions may allow for supplementary production of many crops that cannot be grown in the remainder of the South Island during the colder winter months.

Chapter 3
Existing Horticultural Production, Markets and Infrastructure

3.1 New Zealand Horticulture Sector

The New Zealand horticulture sector is a key contributor to the New Zealand economy in terms of output and exports. The sectors exports were $3.2 billion in 2009 (StatsNZ), thus accounting for 7.8 per cent of exports. The sector has had a strong growth rate with exports only worth $115 million in 1980. The key crops are apples, kiwifruit, wine and onions. The main change in the industry over the last decade has been the increase in importance of kiwifruit and wine. Kiwifruit exports have increased from less than half a billion ($478m) in 1999 to over one billion ($1.043bn) in 2010; and wine exports have increased from $126m in 1999 to close to $1 billion ($985m) in 2010. Other key crops include apples ($346 million); processed vegetables ($167 million); onions ($91.5 million), squash/kabocha ($69.8 million), cut flowers and foliage ($38.3 million) with orchids, calla lilies, flowers, tulips and lilium bulbs and honey ($81 million).

Therefore, the horticultural industry in New Zealand is dominated by three crops but has significant exports in a wider range of commodities.

Table 2 shows the main fruit crops this shows that grapes have increased in area over last decade or so by around 50 per cent; apples have declined in area by 27 per cent and kiwifriut risen by 10 per cent.

Table 2: Main fruit crops - total New Zealand (Annual-Jun) hectares

	Total New Zealand		
	Wine grapes	**Apples**	**Kiwifruit**
2002	17,300	11,717	11,841
2003	19,646	12,150	12,271
2005	24,793	10,982	12,071
2007	29,616	9,247	13,080
2009	33,422	9,284	13,287

Source: Statistics New Zealand

Table 3 shows the main vegetable crops grown in New Zealand. The area of these has not changed much over the last decade apart from a decline in onions. Potatoes account for the biggest crop area followed by peas; sweetcorn; squash and then onions. Much of this supply is linked to processing factories such as McCains or Heinz Wattie and is also a reasonable export crop for NZ.

Table 3: Main vegetable crops – total New Zealand (Annual-Jun) hectares

	Total New Zealand						
	Potatoes	**Sweetcorn**	**Squash**	**Onions**	**Peas (fresh and processed)**	**Tomatoes, outdoor**	**Tomatoes, indoor**
2002	11,082	5,790	6,560	5,621	7,679	608	162
2003	10,931	7,041	6,804	5,748	9,708	600	-
2005	10,850	7,115	6,981	4,931	8,747	772	126
2007	10,050	6,210	7,774	4,594	6,791	757	100
2009	11,398	5,059	6,825	4,511	5,988	745	108

Source: Statistics New Zealand

Table 4 shows the main berry crops grown in New Zealand. This shows that blackcurrants are the main crop with small areas in the other crops. The main changes are the rise in blueberry area and the fall in raspberries.

Table 4: Berryfruit total New Zealand (Annual-Jun) hectares

	Total New Zealand					
	Boysenberries	**Blackcurrants**	**Blueberries**	**Strawberries**	**Raspberries**	**Blackberries**
2002	239	1,308	450	311	302	94
2003	238	-	449	-	204	58
2005	196	1,311	567	219	190	58
2007	277	1,155	522	216	150	-
2009	268	1,268	539	256	115	-

Source: Statistics New Zealand

Table 5 shows the minor vegetable crops in New Zealand that may also be suited to growing conditions on the West Coast. The largest of these is broccoli followed by lettuce and then cauliflower and cabbage.

Table 5: Minor vegetable crops total New Zealand (Annual-Jun) hectares

	Total New Zealand				
	Silverbeet/ Spinach	**Broccoli**	**Cabbage**	**Cauliflower**	**Lettuce**
2002	396	1,780	774	1,175	1,287
2003	437	-	-	-	-
2005	-	1,717	808	979	1,207
2007	-	2,247	768	860	1,309
2009	-	2,059	765	836	1,241

Source: Statistics New Zealand

Table 6 shows the tree crops in New Zealand this shows the importance and growth in avocados from over three thousand in 2002 to over four thousand in 2009. Olives are the next most important crop. Data on nursery trees, shrubs and plants was only available in 2002 but this covered over 2 thousand hectares.

Table 6: Tree crops total New Zealand (Annual-Jun) hectares

	Chestnuts	Macadamias	Hops	Nursery Trees, Shrubs and Plants	Olives	Pears	Avocados	Feijoas	Tamarillos
2002	615	358	-	2,192	2,612	-	3,106	198	270
2003	-	-	-	-	2,732	905	3,235	-	-
2005	-	322	-	-	2,433	719	3,400	181	206
2007	310	242	254	-	2,173	694	4,004	251	194
2009	-	207	-	-	2,016	636	4,117	254	137

Source: Statistics New Zealand

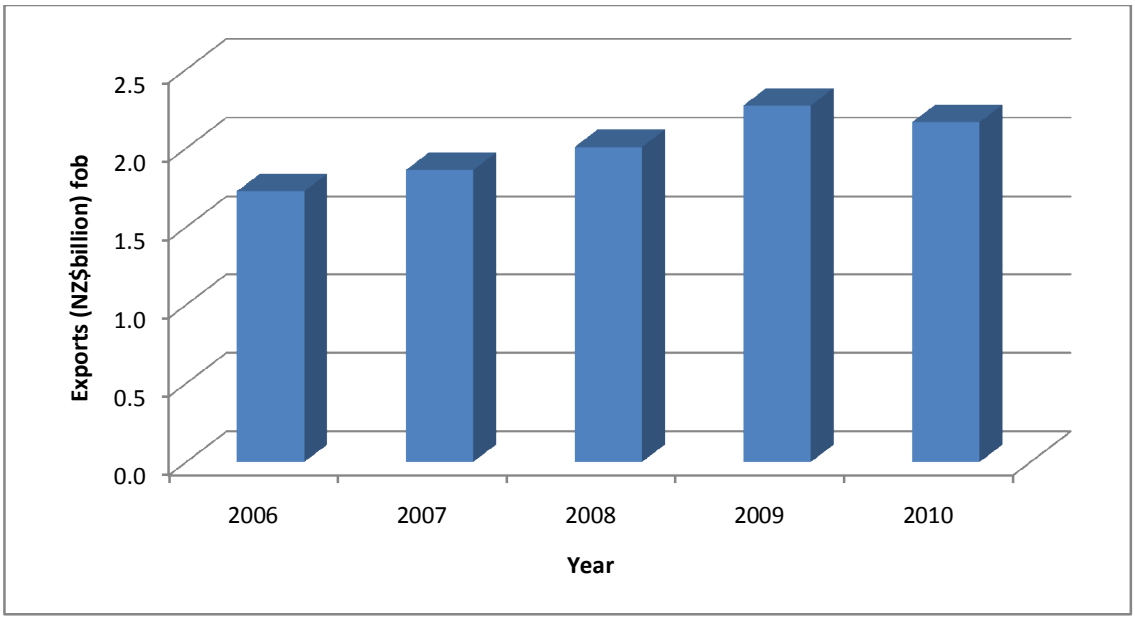
The data above shows the extent and type of crops grown in New Zealand that could potentially be considered for the West Coast especially as they will have some kind of marketing structure and outlet as well as an infrastructure and knowledge about how they are grown.

Thus New Zealand horticultural production levels continue to expand every year with constant investment in infrastructure, research and development, and land to cater for this growth. It is estimated that on-farm investment is around $16 billion and off-farm investment to exceed $29 billion[1].

As stated above a considerable proportion of New Zealand horticultural products are exported and contribute to New Zealandôs overall exports. Figure 1 shows the total exports of fruit and vegetables from 2006 to 2010. This shows they have increased from $1.7 billion in 2006 to $3.2 billion in 2009 and $2.1 billion in 2010.

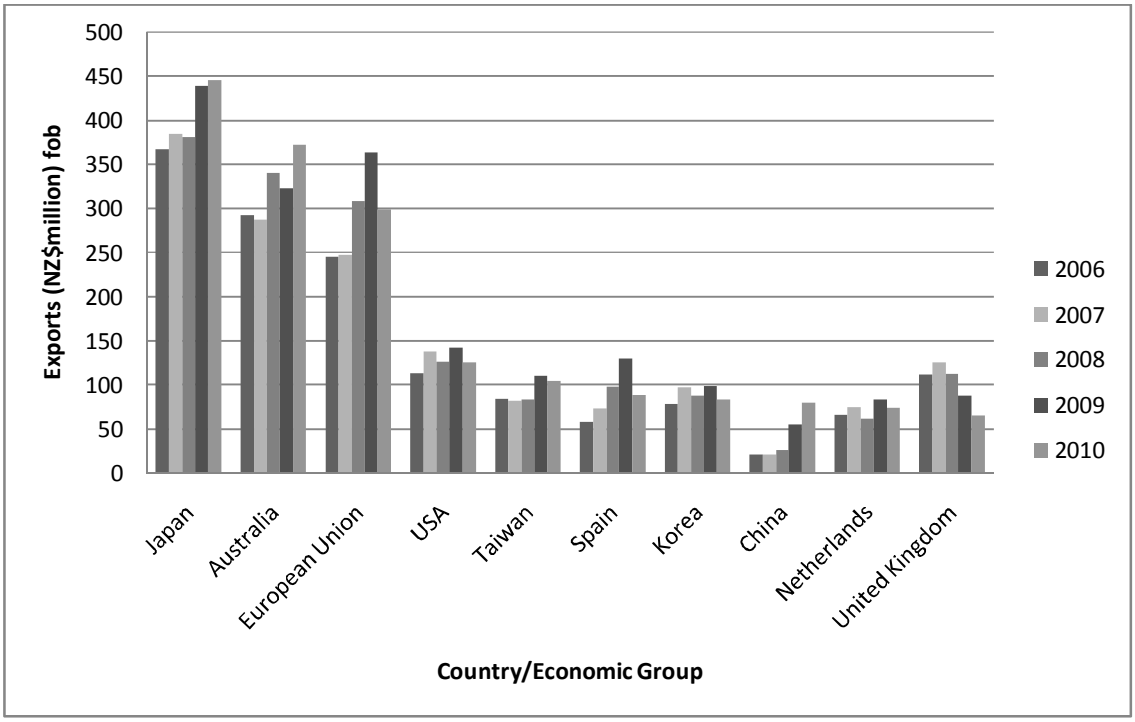
[1] http://www.plantandfood.co.nz/page/news/media-release/story/earnings-from-new-zealands-horticultural-industries-exceed-6billion/

Figure 1: New Zealand fruit and vegetable exports



Source: Statistics New Zealand

Figure 2: New Zealand fruit and vegetable exports by destination



Source: Statistics New Zealand

Figure 2 above shows the destination of exports by country. This shows the biggest market for exports is Japan followed by Australia and then the EU. These key markets have all grown in importance with growth rates of between 21 and 27 per cent over the five years reported here.

Chapter 4
Influences on the Growth and Development of Individual Industries

There are a number of influences related to the specific characteristics of a particular industry that impact on the extent and rate of its development. A better understanding of these with respect to a specific industry will assist in identifying sources of risk, and characteristics which may increase the rate of development, or limit the total size of particular industries.

4.1 The establishment, growth and development of Horticultural industry on the West Coast[2]

The aim of this is project is to select possible horticultural crops from which an industry could be developed in a relatively short period of time on the West Coast. The development of this is industry would be assisted to provide core infrastructure from which further industry development could occur.

The development of industries has been subject to many studies and there have been many cases of industries being started and failing or not developing beyond a small scale. In the case of many of these industries this is due to the development of new crops which do not have existing New Zealand capability in marketing. This clearly increases the risk enormously in the development of an industry as well as the costs of its development. It is envisaged here than an existing marketing chain will be used for the potential crops chosen. This does not preclude in the future specialist marketing but to attempt to develop all the infrastructure for a new industry at once as well as the marketing channels for a new crops is putting a new industry at high risk of failure in its development.

In any selection of potential crops two factors must be paramount, these are, does the West Coast have a comparative and/or competitive advantage in these crops compared to other regions both in NZ but also overseas. This could be in terms of climate, seasonality, isolation (being free from pests and diseases) among other factors. The West Coast does have advantages from its climate being relatively mild and also reasonable rainfall. This does lead to disadvantages in that high rainfall areas can limit the choice of crops, as stated earlier, due to rain damage and water logging among other factors.

The other factors in selecting crops are the existence of sufficient infrastructure for their development and the existence of established marketing outlets. As stated above the choice of crops on the West Coast must build upon a comparative or competitive advantage for the West Coast for them to be sustainable. Comparative advantage implies some advantage in resources which could be natural (climate), labour and policy. Competitive advantage tends to refer to advantage in product differentiation. These can be driven importantly by innovation across all levels of production, processing, value chain and infrastructure.

Clearly any product has to suit the environment and climatic conditions on the West Coast to be feasible but there are a number of other influences related to the specific characteristics of a particular industry that impact on the extent and rate of industry development. A better understanding of these with respect to a specific industry will assist in identifying sources of risk, and characteristics which may increase the rate of development, or limit the total size of

[2] The following sections have drawn upon Greer et al 2000

particular industries. There are a range of possible opportunities that arise from combining knowledge about market opportunities and production technologies, which can be used to define broad categories of market opportunities that have been exploited in the past. These include:

Products for established markets that are not currently grown in scale on the West Coast possibly comprise the greatest potential opportunity for the development of new industries. Thus products need to be identified that are not currently grown in the West Coast, but for which there are existing markets. The most important requirement in this situation is the development of a production technology that produces a higher quality product than existing suppliers, different seasonality, or involves lower costs of production. The major focus of the industry is on developing production technologies suited to the West Coast environment and establishing distribution channels into existing markets. If markets are large there is often little competition between producers and strong incentives to co-operate to resolve technical problems. This can create an environment that is conducive to co-operative and supportive marketing efforts. The major difficulties faced by industries in this situation are the instability of markets and the continued reliance on maintaining low costs of production or obtaining quality premia in highly competitive markets. The West Coast has already scoped the potential of this track by developing relations with supply chains such as those in Nelson which produce juices. However, in taking this further the scale of production from the West Coast and how this would compete with other supply would have to be assessed. Clearly if this is substituting for imports or feeding into export market then this would reduce pressure on domestic markets.

The fact that there is an established domestic industry often means that there are fewer technological issues to be resolved than is usual with a new crop, although there may be technical difficulties encountered in dealing with the large-scale expansion of production required to establish an industry. However, these must ensure that the industry is competitive and the West Coast has an advantage. This includes the fact that in world markets many products are heavily protected, especially rice, thus small changes in policy can have large impacts on trade and markets.

Products for established markets that are not currently grown in New Zealand possibly comprise the most common opportunities for the development of new industries. Producers or exporters in New Zealand identify products that are not currently grown in New Zealand, but for which there are existing international markets. Examples of New Zealand industries that have developed in response to such opportunities include the wine and olive industries. In the case of the West Coast this could include cranberries, rice and/or Wasbi. The most important requirement in this situation is the development of a production technology that produces a higher quality product than existing suppliers, or involves lower costs of production. The major focus of the industry is on developing production technologies suited to the New Zealand environment and establishing distribution channels into existing world markets. However, as stated above this kind of market opportunity is probably beyond the scope of the study.

Products unique to New Zealand for which there are no existing international markets appear to provide the classic environment for a new industry. In fact, the examples are limited because of New Zealand's high dependence on food products that are not indigenous to New Zealand. However, products such as kiwifruit and tamarillos, which have been grown extensively in New Zealand, but were or are relatively uncommon in world markets are examples of products in this category. Other potential examples include possum fibre for use in textile manufacture and sphagnum moss. The major influence on the lifecycle in this case is the lack of an existing market. The technological difficulties associated with production

are probably less significant than those associated with achieving consumer acceptance and with developing markets. While there are substantial risks involved, the opportunities created by the lack of an existing market have the potential to make such industries extremely successful as the kiwifruit industry has demonstrated.

Industries driven by specific demands and niche opportunities. These tend to be initiated by individual firms either in New Zealand or overseas and are generally, because of their nature, smaller than those arising in response to the types of opportunity described above. They are not generally appropriate for the relatively rapid development of an industry envisaged here. They are however very important and can be developed alongside or used to position products into the future. The difficulties of such industries are that they are often developed from a technical or new innovation which requires time to develop a supply chain market structure to justify scale. Another way these develop is through the identification of a specific niche market opportunity or contractual arrangements are identified at an early stage. Consequently, the existence of market premia and market certainty can be used to justify investment in infrastructure, research and technology development at the outset. In such situations the clearly identified demand and focus on meeting consumer needs, often speeds the industry development, but the niche opportunities can also create an environment in which access to technologies, genetic material and market knowledge can be controlled, which may create barriers to entry for outside participants (Greer et al., 2000).

4.2 Sources of comparative and competitive advantage and innovation

The selection of industry to develop must be based upon comparative and competitive advantage. It is vital this is underpinned by innovation across the whole supply chain. This frequently requires good cooperation and information flows across all the sources and users of innovation be it scientists; market operators; producers or others. Industries differ with respect to the sources of innovation and information that drive industry development. Many industries develop as a result of the innovation and inspiration that emanates from relatively few individuals or specific firms. For example, production technologies that drive industry development could arise from such diverse sources as the activities of hobbyists, the research interests of scientists or the diversification efforts of members of other agricultural or horticultural industries. They could also arise from the careful market and technology analyses of firms seeking commercial opportunities. In the very early stages of industry development the specific nature of these sources of innovation may have a significant influence on the perception of the industryôs potential, and the speed with which issues, such as technology and market access, are investigated. Therefore it is important to identify where these innovations are and how they can be accessed to avoid complications arising from the ownership of intellectual property and other scarce resources that will affect the way in which an industry grows and develops. Where an industry considers that intellectual property developed, at least in part, with industry funds may be sold back to industry participants, or even to others, by the research agencies the incentive to invest in research and development is reduced and industry development may be delayed.

4.3 Market development, promotion and brand promotion

The opportunities for sophisticated product and brand development within any industry are likely to be limited by the nature of the product itself and quality aspects and variability associated with the production process. Opportunities for the development of local or internationally recognised branding depend on:

- Whether the product is unique at the individual firm or industry level so that there are points of difference that can be identified by consumers.

- Whether the unique product characteristics can be produced in a consistent manner and reproduced over time. This is often extremely difficult with agricultural and horticultural products where there is a high level of inherent variability within an individual growerôs crop, as well as across the industry.

Both these factors affect the extent to which any industry can create unique products and sophisticated marketing programmes. The most common form of marketing activity is generic promotion of the product at an industry level combined with general market development activities associated with introducing the product into new sectors of the market. This latter form of marketing is often undertaken at a trade rather than consumer level, but can be effective in identifying the opportunities to substitute the products of the industry for others that may be imported or shipped from other countries. The level of this type of activity is largely driven by the growth in total production industry and is likely to increase as the industry matures. At this point industries frequently recognise the importance of sustaining growth and market opportunities, but the impacts of generic promotion are notoriously difficult to measure and in the declining stage of an industry producers may increasingly question the effectiveness of expenditures in this area.

4.4 Leadership

It is often argued that the nature of industry leadership is an important determinant of industry growth and development. This too is likely to be a more important factor during the very early stages of the industry development when there are relatively few individuals or firms involved. As industries grow, the role of leadership becomes contestable and new leaders (both individual and in some cases institutional) will replace those perceived to be performing poorly. It is often possible to confuse the strength of leadership with the impact of factors such the rate of industry growth and the incentive structures within industry. It is common for industries with strong growth and clear profit incentives to be viewed as having strong leadership while in industries experiencing falling prices and reduced incentives there is often criticism of institutional structures and leadership (Greer et al., 2000).

In the very early stages, leadership and singularity of purpose amongst a core group of players in industry can assist industry development by creating appropriate institutions to cope with the challenges that are to be faced in the future. If industry development is driven by individuals whose motivation comes from having identified specific market demand, the development is more likely to be based on the longer term prospects of the industry than where development is driven by hobbyist groups or individuals whose focus is on production.

4.5 The policy environment

Because the incentive for potential entrants to invest in profitable industries is the driving force behind industry development, it is not surprising that the policy environment and incentive structures created by government and agencies can influence the rate and nature of the development. While this may benefit industry by increasing the rate of growth in production, it can create problems where there are not appropriate market structures in place.

4.6 The size of the industry

The concept of an agricultural industry lifecycle is based on the assumption that the phases of growth and development within any individual industry are to some extent predictable. The chain of events described by the lifecycle is initiated by the perception of a profitable industry followed by the entry of new firms to the industry and increased production. The basic economics behind these events imply that an awareness of the supply and demand conditions in markets for the products of the new industry would provide an indication of the potential for growth and ultimate size of the industry (Greer et al., 2000).

On the demand side it appears reasonable that industries that are focused on purely domestic markets and that face downward sloping demand curves will ultimately face falling prices as production increases. On the other hand, products produced for highly inelastic world markets in which there are a considerable number of substitutes from alternative sources will face an elastic demand and externally determined world prices. These prices would almost certainly be unstable and largely beyond the control of the individual industry. The ultimate limits to growth in such an industry would be determined by the costs of production or the ability to create niche markets within the larger global markets (Greer et al., 2000).

On the supply side it is generally acknowledged that the supply costs in most industries tend to drop over time as the scale of production and the increasing experience of producers results in lower costs of production. Another important element on the supply side is the entry to the market of competitors from other countries. It is often difficult to predict where such competition will arise but it is inevitable for any industry or new product that is seen to be successful and can be produced elsewhere. Knowledge of the supply and demand conditions and potential for growth and development in international markets can clearly provide valuable information about the potential for the growth and development of any emerging industry and may prove to be a useful tool in understanding the industryôs development path (Greer et al., 2000).

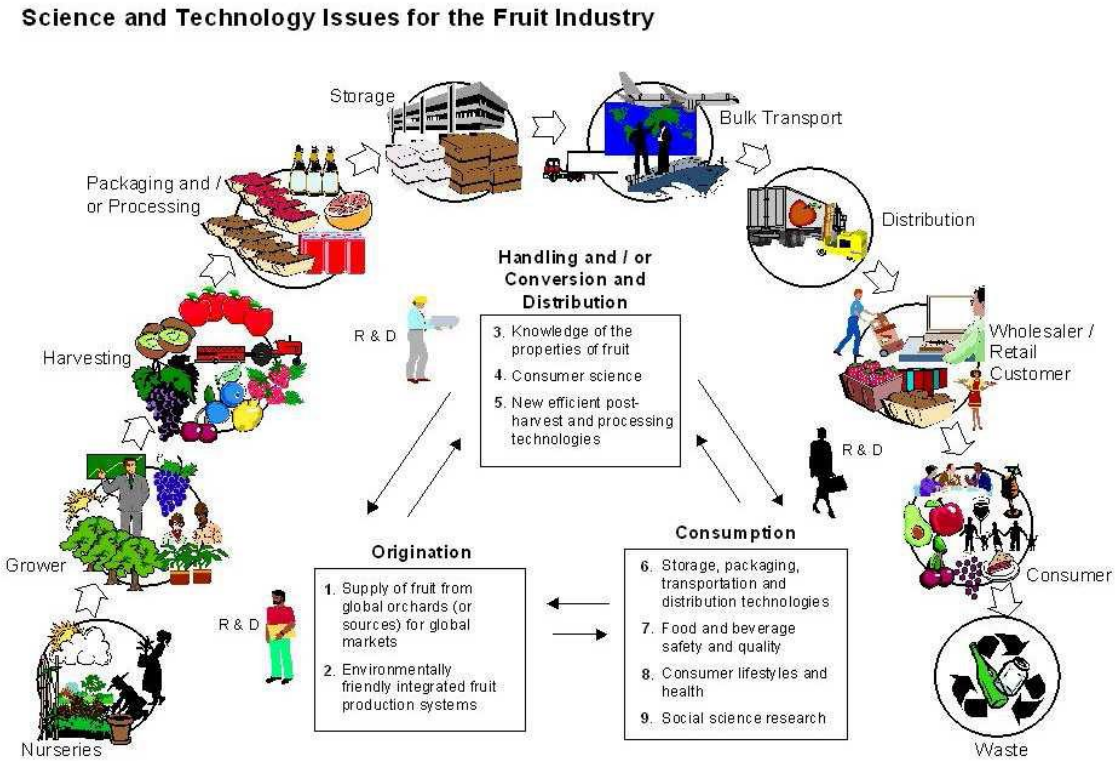
Chapter 5
Infrastructure

5.1 Horticultural supply chains and support infrastructure

The supply chain is the connected series of activities, which are concerned with planning, co-ordinating, and controlling material, parts, and finished goods from suppliers to customers. It is concerned with two distinct flows through the organisation: materials and information. The scope of the supply chain begins with the source of commodity being supplied and ends at the point of consumption. It extends much further than simply a concern with the physical movement of material and is just as much concerned with supplier management, purchasing, materials management, manufacturing management, facilities planning, customer service and information flow as with transport and physical distribution (Steven, 1989). The supply chain encompasses all activities associated with the flow and transformation of goods from raw materials stage, through to the end user form, as well as the associated information flows (Handfield/Nichols, 1999).

The supply chain of horticulture products can be defined as a set of production, distribution and marketing processes of horticultural products. This support infrastructure provides the perspective for horticulture growers to be able to participate in the commercial network or relations with processors and marketing agents. Horticulture supply chains comprise of many actors including input suppliers, growers, pickers, packers, processors, storage and transport facilitators, marketers, exporters, importers, distributors, wholesalers, and retailers. Each actor will add more value for the products when doing his task. Supply chain development can thus benefit a broad spectrum of society, both rural and urban (Sonko, Njue, Ssebuliba, & de Jager, 2005).

Figure 3: Science and technology issues for the fruit industry



Source: (Aitken et al., 2005)

Rural infrastructure, comprising rural roads, markets, irrigation systems, water supply, health and educational facilities, are basic to quality of life in rural areas, and are important engines in economic development *(*Ahmed & Donovan, 1992).

New agricultural industries often fail to establish an effective processing and/or value adding infrastructure. Virtually all but basic commodity items need to be value-added or processed in some form or another (McKinna, 1999).

Processing/value adding with new agricultural industries requires:

- Establishing appropriate technology and production systems, usually by adapting technologies from other industries. Unfortunately, this can involve compromises in productivity and quality, when compared with purpose-built technology.
- Skilling the labour force.
- Achieving economic through-put levels, since new agricultural enterprises do not have the through-put in the early stages to justify or finance an efficient processing/value adding plant. This problem can be exacerbated by the geographical spread of the participants. (McKinna, 1999)

5.2 Expertise

The environmental impacts of high moisture, humidity and temperature averages on the West Coast create a horticultural need for a higher level of agronomy than elsewhere in New Zealand. The level of professional advice available however is likely to be considerably less due to a national lack of experience in the management of horticultural cropping in such a moist climate (Crowder et al., 1978). This raises the possible requirement for West Coast specific horticultural training to optimise knowledge and production in their specific

To ensure the optimum and efficient development of an industry base a specialist, highly experienced project manager or supervisor will be required. To establish this horticultural foundation expertise in development of many different crops, specific environmental conditions and their infrastructure requirements will be essential. This role would involve overseeing all necessary developments within the entire supply chain from the land development to employing appropriate local contractors.

Coordination of educational training and skills development with the needs of the industry is important for the growth and success of any sector. This applies anywhere but in this case the training should contain curriculum specific to West Coast, not just Horticulture in general or in New Zealand. Monitoring and review of this education strategy could also be overseen by the project supervisor, if the right person is selected.

More so than many industries horticulture has a tight time frame. Days, even hours can mean reduced product quality or perhaps even loss so management must be planned and organised at every stage. This is due to the life span of many products once harvested but also the growth requirements of certain crops are very specific requiring particular knowledge.

5.3 Infrastructure brainstorm

General - required to varying degrees at all levels

Labour Market

Skills development

Nursery

Variety sourcing ï Which most suited to West Coast conditions

Propagation units

Grower

Seedling propagation and supply - outsourced nursery production or onsite seed raising and propagation units?

Weather Protection - shade, tunnel or glass houses, shelter belts, frost/hail protection

Soil preparation equipment

Disease protection ï spraying equipment

Irrigation ï little need on Coast, may need backup irrigation storage infrastructure

Harvesting

Specialist harvesting Equipment

Contractors

Onsite storage and refrigeration

Packaging and/or processing

Onsite/offsite equipment

Sorting, quality control equipment

Juicing, snap freezing, drying and canning

Storage

Cool stores, warehouses, dry storage

Transport - required at different stages along the supply chain depending on product

Land, sea, air

Distribution

Central West coast distribution centre, does one already exist?

Link in with existing distribution companies if possible either on the West Coast or in Canterbury, Nelson or Otago

Research and development

May be added funding for this when industry more established

For Consideration

Planned production volumes - basic idea required in planning infrastructure development

Infrastructure along supply chain

Table 7: Infrastructure requirements for an industry over time

Date/ time	Physical	Land Development	Labour, Education	Markets	Technical Help	Other
Now	Investigate existing	Explore, purchase?	Upskilling workforce in propagation, management, Educational Institutions	Investigation of potential, existing supply chains	Market/ economic research, Soil testing, Growth Trials/Trial plots	$$, investors?
2012?	Nursery stock? Perennials? Annuals?	Conditioning, increasing organic content	Recruit managers, cultivators/ growers		Soil testing, Explore best practice	
2013/4?	Planting Machinery		Planting	Relationship development, Supply chain development	Supply chain Research	
	Harvest Machinery		Early, minor harvest	Test or market uptake		
2015-20?	Processing, Distribution	Develop more if market uptake good	Harvesting	Distribute		
	Expansion?	More?		Expansion?	Efficiency management	

Chapter 6
Possible Crops

This section of the report scoped the possible crops for the West Coast. The scoping was initially as broad as possible to ensure that as many potential crops were considered, a list of these is given in Appendix 3. The criteria for considering crops were firstly the suitability to the climatic and soils conditions of the West Coast. Other factors considered were the potential marketing in particular that an existing potential marketing channel was available for the development of a relatively large scale industry. This later factor was a major determinant of which crops were considered as whilst there were many potentially minor crops for which a niche market would be possible it was felt at this stage not to be the subject of this report.

The crops considered were then rated not suitable (X); possible (B): and most likely to meet the criteria (A). The crops that were considered not suitable (X) are listed in table, Appendix 3, the A and B rated crops are listed in Table 8 below. The A crops were then considered further to select 4 or 5 crops for which there was possibilities of developing a horticultural industry on the West Coast and an investment plan could be developed.

The crops that potentially could be chosen were cranberries (although serious doubts about their financial viability). Of more potential were the berry crops such as blueberries and blackcurrants although blackcurrants maybe susceptible to heavy rainfall whereas blueberries were felt to be more resilient to the climate. Access to the Nelson market for juice and other processing was felt to be a reasonable channel for the marketing of these fruit.

Other fruits seriously considered were kiwifruit (which has a well established marketing chain through Zespri and does export from Nelson ports). However, concern was raised re the susceptibility of kiwifruit to the damaging rainfall especially at budding.

Feijoas were considered a potential crop again tolerant of the West Coast climate. Existing marketing channels are available, as for the berries, through the Nelson Juicing market.

There were potential for a number of niche products such as elderberries, Tea Tree, Hops, Brassicas, wasabi, lettuce etc. But these would not be at the scale originally intended for this report.

In selecting crops for a new industry the questions relating to comparative and competitive advantage have to be considered. A new industry generally will not succeed unless there is some comparative or competitive advantage. Whilst the West Coast does have some factors which lend itself to comparative and competitive advantage (such as a mild climate and generous rainfall) these are not really sufficient enough points of difference from elsewhere in New Zealand (or the world) to establish a sustainable industry. There certainly are areas where the West Coast could (with aid also of promotion) establish niches with those characteristics it is difficult to see how this could occur at industry or reasonable scale level in the short term.

Table 8: Potential crops from which a horticultural industry could be developed on the West Coast

	Possible Crop	Climatic and physical feasibility	Market availability/competition	Infrastructure available	Sales value ($m) Domestic	Sales value ($m) Export
	Main export crops					
A	**Blueberry (including processed)**	Require moderate to high winter chilling; moist, free draining, acid soils. Susceptible to dieback and crown rot (approximately 18% of NZ crop)	Japan, USA, Asia, Australia, Europe. Steadily increasing, in 2006 were NZôs most valuable export berry crop, worth $12.5m in fresh, $1.4m as frozen fruit.	Waikato and the Hawkeôs Bay are the main growing regions	25.6	14.4
A	**Blackcurrants (including processed)**	Cool moist climates; Humus enriched, heavier soils that retain moisture without becoming waterlogged are best however more tolerant of water logging than other currents	Probably. NZ supplies 3% of global production (largest outside Europe). Mainly for juice	Mainly grown in Canterburyï North Otago (1,000 hectares) and Nelson (400 hectares).	3.6	18.2 (Reduced figure -poor harvest year)
A	**Elderberry/ flower**	Cold tolerant; tolerate poor or very wet soil, drought intolerant.	Sounds like it www.sit.ac.nz/insitu/?p=722 Organic potential- few pests. Phoenix Beverages?	Elderflower processing in Canterbury, Berries/wine etc - unsure		
A	**Northern Cranberry**	-12°C min temperature; most soil types however they prefer acidic soil. Tolerate wet or flooded soils but good drainage is required during the active growing season for proper root growth and function. Keep weed free. They do not tolerate dry soils, and need careful watering in the heat	Possible Nelson and Ocean spray?	Nelson.		
A	**Honey - Native and/or Exotic**	Sourced from native plants ï naturally occurring or cultivated. Rata, Kamahi, Manuka, Beech.	Exports were worth $81 million in 2009. 39 markets, main markets UK, Australia, Singapore and Japan	Apiaries throughout the South Island that could be worked with.		81
A/B	**Feijoa**	Hot, dry weather is ideal for the production of a high quality crop, however water during flowering and fruiting beneficial; grow in wide variety of soils, best harvests in well-drained, slightly acidic soil; salinity slows growth and reduces yields. Harvest period March to May.	Insignificant, domestic worth $1.7 million in 2004, and exports earned $100,000 in 2006. Little increase seen in 2009 figures (right)	500+ commercial growers, range mainly from Nelson & Marlborough to Northland http://www.sp.co.nz/rural_news/articles/feijoa.html	1.7	0.2

B	**Boysenberry (including processed)**	Warm or cool climates. Frost tolerant, intolerant of salty marine air. Prefers lightly acidic and free draining soil	Domestic and Export but no evidence of growth found	Nelson is largest NZ growing region, Canterbury minor production.	4.8	4.1
B	**Tamarillos**	Frost tender. requires sheltered sunny position; prefer light, slightly acidic, well-drained soil with good moisture content. Not salt tolerant.	Declining export market, slowly increasing domestic. Canterbury main market for existing growers	Tamarillos are mainly grown in the Bay of Plenty, Northland and Auckland.	1.8	0.4
B	**New Zealand Cranberry or Chilean Guava**	Produces well in partial shade or full sun in fertile, well drained and loamy soil. Tolerate salty maritime air, moderate wind, cold temps, frost, sandy soils and clay but not drought.	No obvious market at present, www.hortnet.co.nz/news/2001/n4212.htm	Unlikely		
B	**Potatoes (including Processed)**	Best in sunny locations on rich well-drained soil with plenty of organic material. Silt loam is ideal soil. Heavy clay soils tend to restrict the development of tubers. Susceptible to fungal attack during wet and humid weather	Domestic and Export	Production mainly in Pukekohe, ManawatÎ, South Canterbury and Southland.	516.0	99.0
B	**Silverbeet/ spinach**	Silver beet prefers cool, dry, frost-free growing conditions; most soil types, provided the soil has good drainage, prefers deep, friable, fertile, well-drained soils such as alluvial soils and sandy loams. Vegetative crop - Adv	Mainly domestic, see figures. Possible winter market.	Main regions of production are Auckland, ManawatÎ and Canterbury	13.4	
B	**Australian tea tree** *(Melaleuca alternifolia)*	Grow best in high-rainfall areas with mild climate. Vegetative crop - Adv	Competition with well developed Australian industry, large market which has not enjoyed recent stability as production volumes have increased	Grown organically on West Coast, more information on NZ growers unavailable.		
B	**Gevuina** (spelt in some old sources *Guevina*) **(Macadamia equivalent)**	Frost protection of seedlings required; most soil types	No established market, European market for NZ grown Australian Macadamia so perhaps.	Apparently Grower in Akaroa		
B	**Gooseberry**	Excel in cool climates; tolerant of most soils but not water logging	Not Significant, Local best	Limited to Wellington region		

B	**Red and White Currant**	Prefer warmer climates; moist, well-drained, heavy soil	Not Significant	Thought to be limited and small scale		
B	**Brassicas:** **-Broccoli** **-Cabbage** **-Cauliflower**	Light soil, rich in organic matter and moist but not wet	Competitive market, especially for broccoli	Major regions of production are Auckland, ManawatÎ and Canterbury	80.3	1.5
B	**Lettuce (outdoor)**	Grow in well-drained soil, sandy to loamy soils work well for lettuce	Majority of leafy crops are consumed domestically, with a small volume exported to Hong Kong	Main regions of production are Auckland, ManawatÎ and Canterbury	41.8	1.1
B	**Persimmons**	Frost tender. Full sun, with wind protection. Best in well drained loam soil but ok in clay with drainage. Drought intolerant	Exports mainly to Asia, smaller markets in Australia and Europe.	Grown primarily in Gisborne and Auckland regions		7.6
B	**Hazelnuts**	Frost protection of seedlings required;, prefer sandy soils, but tolerant of clay	Small local market. Export market exists for Australia and parts of Europe.	Grown in Canterbury and Nelson		
B	**Chestnuts**	Frost protection of seedlings required; grow best in well drained soils (root rot potential). Japanese chestnut is well adapted to wet and humid weather with hot summers	Out of season commodity market in the Northern Hemisphere. Assumed small.	Most grown around Auckland, some in the Waikato, Nelson and Canterbury.		
B	**Lemons**	Meyer Lemon is relatively Cold hardy. Well drained fertile soil. In less than ideal situations Lemons cope better than other citrus.	Majority exported to Japan	New Zealandôs citrus industry is small covering 2,000 hectares, with 400 orchards in Northland, Gisborne and the Bay of Plenty	10.0	1.8
B	**Mandarins**	Satsuma mandarin is relatively Cold hardy. Need well drained fertile soil	Main export market is Japan	Mainly grown in Northland, Gisborne and the Bay of Plenty	21.0	2.8

B	**Kiwifruit**	Intolerant of frequent rain during pollination, can also increase risk of disease spread but also need regular moisture especially through the fruiting season; grows best in deep, fertile, friable loam, need good drainage. Salt intolerant	Significant and increasing exports to 21 countries	Nelson the main S.I. growing region, supporting infrastructure assumed.		1071.7
B	**Goji Berry**	-26°C min; moist, well drained soil, high sun	Not Significant	Unlikely		
B	**Saskatoon Berry**	Cold tolerant; need well-drained soil, does not like wet roots	Only local at present	Unlikely		
B	**Sea Buckthorn**	Cold tolerant; arid to very wet conditions; prefers sandy, neutral soil	Product not really known in NZ. Future potential	Unlikely		
B	**Hemp**	Tolerate light frosts; most soil types, intolerant of drought, flooding, saturated or saline soils. best suited to areas with moderate rainfall and good soil fertility. Vegetative crop - Adv	No real local market established	No existing infrastructure known		
B	**Sphagnum moss**	Small areas cultivated	Existing market	Believed to be small scale.		5.5*
B	**Gentians (flowers)**	Donât like to be disturbed (donât touch their roots), need lots of light and never let their soil dry out: need well-drained soil	Japanese Market	Some exporting from New Zealand		
B	**Wasabi**	Most growth in the cooler winter months, does not like hot temperatures (+25° C) or direct sunlight. Clean flowing water or moist, fertile soil required. Water grown plants produce a higher quality product http://www.wasabi.co.nz/Meet.html Vegetative crop - Adv	For export, the fresh stems are highly sought after on the Japanese market. BHU state markets are uncertain however (see emails)	Information on NZ growers unavailable.		

B	**Tea (green/black)**	Needs a hot, moist climate. It grows in temperatures ranging from 10 -30° C, in areas with an average yearly rainfall of 2,000 mm and at a ground level of between 600-2000 meters above sea level.	Competing with established industries with low labour costs.	53 hectares grown with 1m plants in the Waikato. Processing infrastructure assumed		
B	**Ginseng**	Grows best in shaded areas with moist well drained soil. Drainage is essential and swampy or clay soil must be avoided.	BHU state markets are strong (see emails)	Apparently already grown on the West Coast		
B	**Nursery Crops**	Utilise growth advantage in East Coast nursery crops	Has been done in the past, potential to have winter growth scheme for much of South Island market.	Some nurseries exist on the Coast.		
					Plant and Food (2009)	

Sources: www.southlandnz.com, www.flaxcouncil.ca, www.wikipedia.org, www.olivesnz.org.nz, www.teara.govt.nz, www.enza.co.nz, www.canr.msu.edu, www.gojijuices.net, www.fruitexpert.co.uk, www.urbanorganicgardening.org, www.plantandfood.co.nz, www.edible.co.nz, www.gardeningknowhow.com, www.gardenguides.com, www.kings.co.nz, www.mitre10.co.nz, www.ehow.com, www.aggie-horticulture.tamu.edu, www.feijoa.org.nz, www.crfg.org, www.tropicalpermaculture.com, www.nzcc.org.nz, www.howstuffworks.com, www.plantcultures.org, www.wtea.com, www.purenewzealandhoney.com, www.tradewindsfruitstore.com,

*Estimate only. Blank sales entries indicate either that the information was not available or items are valued at less than $100,000. Processing includes juicing, freezing, canning and artificial drying. Prices in NZ$ unless stated

A- Indicates potential future commercial crop according to available growth requirements, markets and infrastructure.

B- indicates possible future commercial crop with market development and establishment of infrastructure or significant adaption and monitoring of environmental conditions.

X- indicates crops believed to have little or no commercial potential on the West Coast

Chapter 7
Industry Development

7.1 Selecting crops for further analysis

7.1.1 Business planning

- Appropriate climate, soil and other conditions to grow the crop
- Evaluate whether knowledge, skill and desire of local farmers in suitable climatic regions exist to develop the crop.
- Assess the scale necessary for a viable enterprise.
- Develop business plan

7.1.2 Determine market potential

- What is the overall production and consumption of crops (here and overseas) and the trends in this
- Who are the main suppliers and consumers and where are they based
- What is the marketing strategy of existing players in the industry
- Where is potential market for the crop from the West Coast
- How does the crop fit into the typical and potential supply chains for the product
- Finding market
    - Local market: Private, Auctions, Wholesalers
    - Processing or fresh
    - Export:

- How easy is it to access the market ï Eg: alongside existing supply chains
- What are the typical market requirements
    - Quality
    - Picking, Packing, Consistency, Grading, Market loyalty, Post harvest treatments, Cool storage, Presentation
- What is your comparative and competitive advantage and how is that derived

7.1.3 Plantings

- Scale at which to start industry
- Develop time path regarding the development of industry and the supply
    - What infrastructure needs are required to develop the industry and what are the current capabilities and gaps which would need to be addressed.

7.1.4 Monitoring and record keeping

- Record on paper all inputs: Initial plant costs, Ground preparation, Ground preparation, Sprays, Fertilisers, Harvesting, Packing, Transport, All labour hours

7.1.5 Benchmarking

- Establish criteria on which you will judge the success or failure of the crop
    - Based on Production or Economic figure
    - Financial gain required to continue growing the crop

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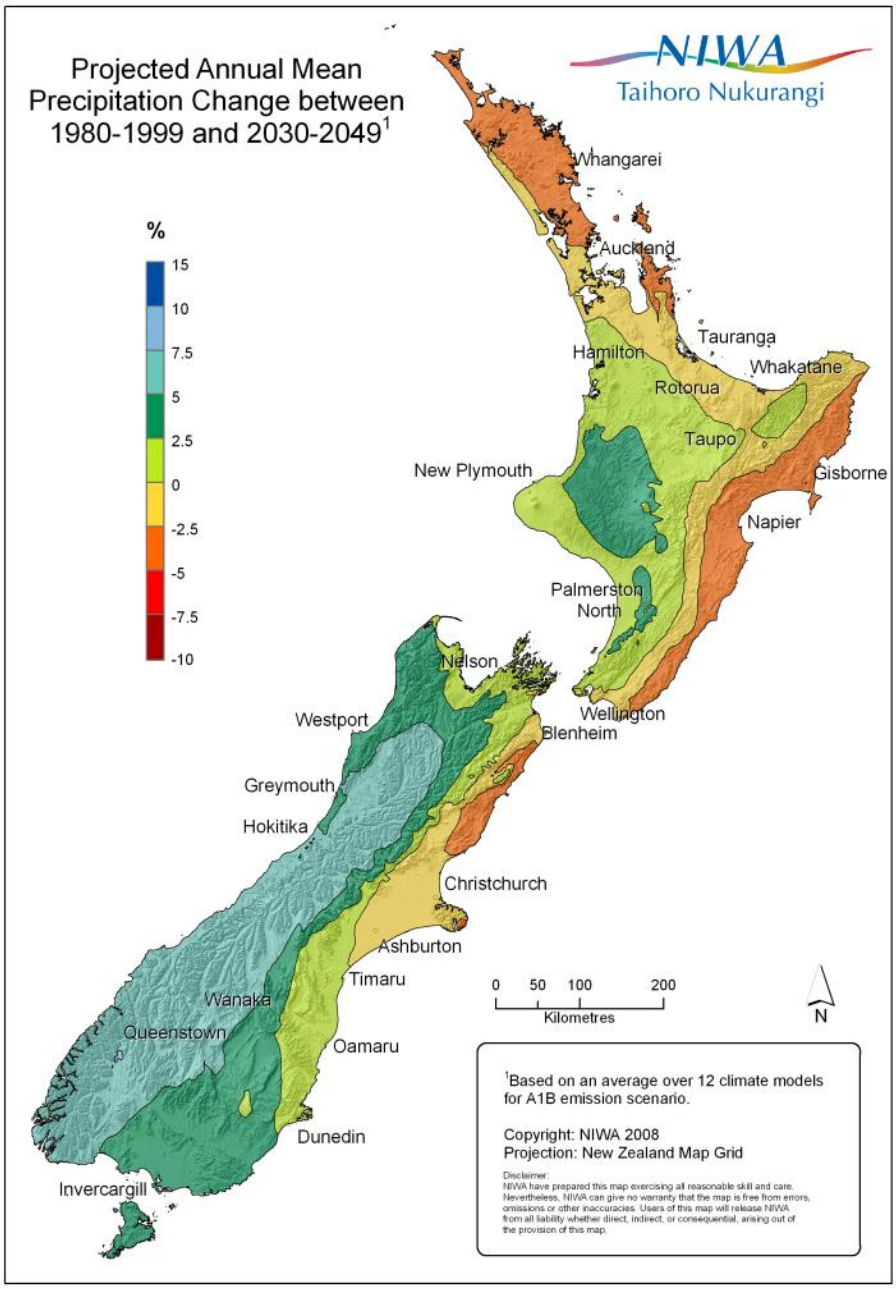
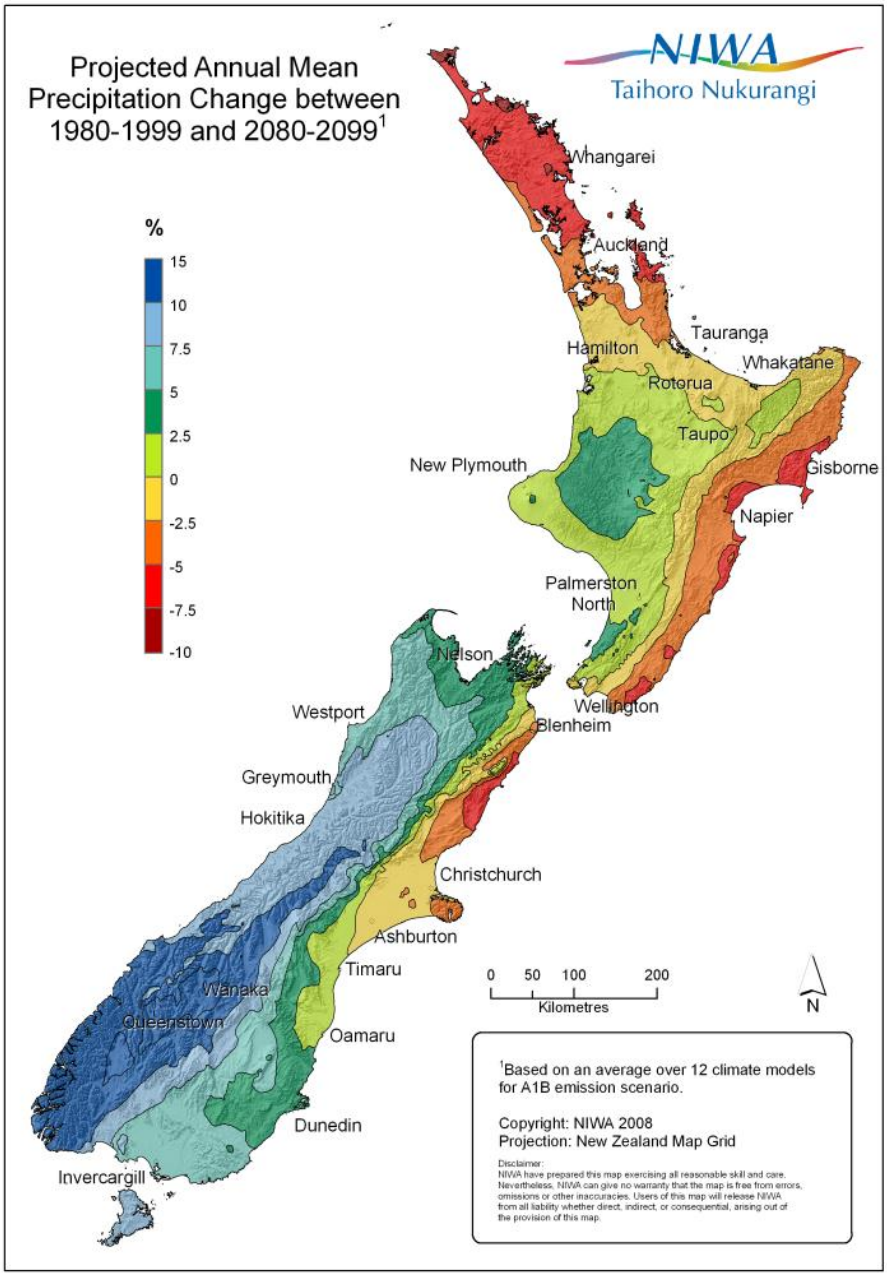
Appendix 1
Climate Change Predictions

Precipitation

The annual-average rainfall change has a pattern of increases in the west (up to 7.5 per cent by 2040 and 10-15 per cent by 2090) (NIWA).

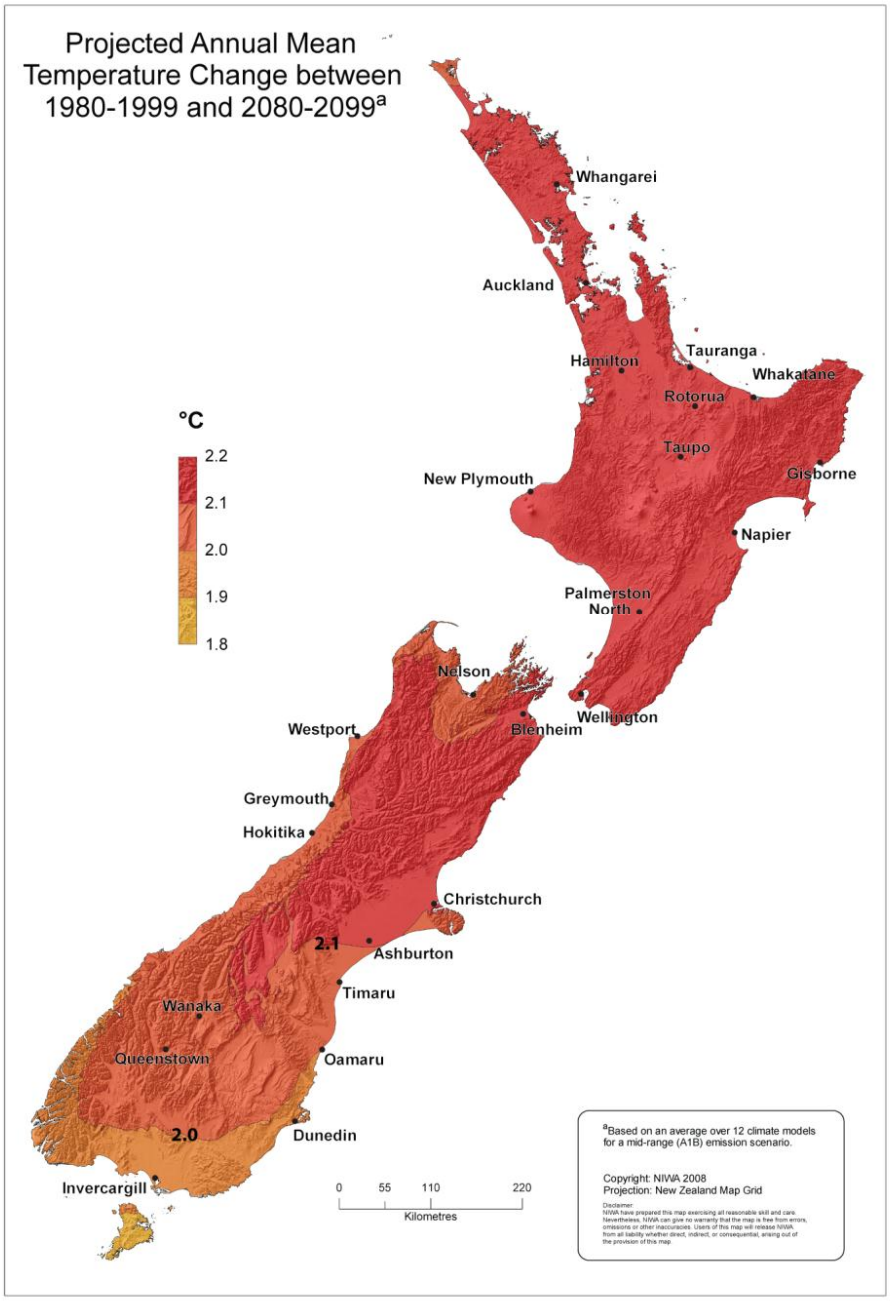




Source: (Wratt & Mullan, 2008)

Temperature

Regional Council Region	B1 Scenario	A1T/B2 Scenario	A1B Scenario	A2 Scenario	A1FI Scenario
West Coast (2040)	0.6 [0.2, 0.8]	0.8 [0.2, 1.1]	0.9 [0.3, 1.3]	1.1 [0.3, 1.5]	1.3 [0.4, 1.8]
West Coast (2090)	1.3 [0.7, 2.2]	1.7 [0.8, 2.9]	2.0 [1.0, 3.4]	2.4 [1.2, 4.1]	2.9 [1.4, 4.9]



Source: (Wratt & Mullan, 2008)

What is a climate change scenario?

Predicting human-induced ("anthropogenic") changes in climate, over the next 100 years, for a particular part of New Zealand requires:

- A prediction of global greenhouse gas and aerosol emissions for the next century
- A global carbon cycle model to convert these emissions into changes in carbon dioxide concentrations (and similar models for calculating concentrations of other greenhouse gases and aerosols)
- A coupled atmosphere-ocean global circulation model (AOGCM) which uses the greenhouse gas and aerosol concentration information to predict climate variations forward in time.
- Downscaling of the AOGCM results through a procedure which takes account of the influence of New Zealandôs topography on local climate. This can be done either statistically or with a high resolution regional climate model.

Given our current knowledge and modelling technology, there are uncertainties in each of these steps. For example, emission predictions depend on the difficult task of predicting human behaviour, such as changes in population, economic growth, technology, energy availability and national and international policies, including predicting the results of international negotiations on constraining greenhouse gas emissions. Our understanding of the carbon cycle and of sources and sinks of non-carbon dioxide greenhouse gases is still incomplete. As discussed in NIWAôs climate modelling web page, there are significant uncertainties in current global climate model predictions ï particularly at the regional level (Wratt & Mullan, 2008).

The climate change scenario approach recognises these uncertainties. A scenario is a scientifically ï based projection of one plausible future climate for a region. For guidance on regional impacts of climate change, a range of scenarios is desirable. These can span credible estimates of future greenhouse gas emissions, and the uncertainty range in climate model predictions.

The Intergovernmental Panel on Climate Change developed 40 different emissions pathways or ôscenariosô in its Special Report on Emission Scenarios (Nakicenovic & Swart, 2000). These SRES scenarios cover a range of demographic, societal, economic, and technical-change "storylines" and formed the basis for much of the climate projection work done for the IPCCôs Third and Fourth Assessments. The SRES scenarios cover the key greenhouse gases (carbon dioxide, methane, nitrous oxide and CFCs) and the sulphate aerosols. They do not include specific initiatives to control greenhouse gas emissions, such as the Kyoto Protocol, but some of them (e.g. the B1 scenario) assume a reduction in world population after a mid-century peak, and the rapid and widespread introduction of clean and resource-efficient technologies. The SRES scenarios also do not account for any unexpected climate ôsurprisesô, such as increased methane emissions from permafrost melting or undersea methane clathrates. Full AOGCMS were run for only some of these scenarios. A simpler globally-averaged model was then "tuned" to these AOGCM runs and applied to all 40 SRES scenarios (Wratt & Mullan, 2008).

Appendix 2
Possible Crops List

Fruit, nut and tree crops

Apples
Avocados
Bananas
Berryfruit
- Blackcurrants
- Boysenberries
- Raspberries
- Blueberries
- Strawberries
- Cranberryies
- Goji Berry
- Saskatoon Berries
- Gooseberries
- New Zealand Cranberries or Chilean Guava
- Sea Buckthorn
- Elderberries

Citrus
- Grapefruit
- Lemons
- Limes
- Mandarins
- Oranges
- Tangelos

Elderberry
Feijoa
Grapes table
Hops
Kiwifruit
Melons
Nashi
Nuts
- Chestnuts
- Gevuina
- Hazelnuts
- Macadamias
- Walnuts

Olives
Passionfruit
Pears
Persimmons
Summerfruit/stonefruit
- Apricots
- Cherries
- Nectarines
- Peaches
- Plums

Tamarillos
Wine Grapes

Vegetables and culinary herbs

Asparagus
Azuki Bean
Basil
Beans
Brassicas
Burdock
Capsicums
Carrots (incl Processed)
Coriander
Daikon Radish
Garlic
Globe Artichoke
Horseradish
Kumara
Lettuce (outdoor)
Mushrooms
Onions
Oregano
Peas (incl Processed)
Potatoes (incl Processed)
Pumpkin
Saffron
Silverbeet/ spinach
Soramame Bean
Squash
Sweetcorn (incl Processed)
Tomatoes
Wasabi

Arable, bio-oil, fibre crops and by-products

Flax Oilseed (common flax or linseed)
Grain Amaranth
Hemp
Honey
Meadowfoam
Rice

Flowers and foliage

Gentian
Orchids

Allium
Astilbe
Ballota
Bells of Ireland
Brachyglottis
Campanula
Carex
Chatham Island Forget-me-not
Daffodils
Delphiniums
Forsythia
Freesias
Galtonia Moonbeam
Gentians
Hosta
Irises
Lady's Mantle
Larkspur
Lilac
Lilies
Nerines
Olearia
Paeonies
Rainbow grass
Restio
Sandersonia
Southland Pod Bush
Sunflower
Sweet Pea
Tamarisk
Tulips
Viburnum
Winter Rose

Appendix 3
Possible Crops, Markets and Infrastructure Table

	Possible Crop	Climatic and physical feasibility	Market availability/ competition	Infrastructure available	Sales Value ($m) Domestic	Sales Value ($m) Export
	Main export crops					
X	**Apples**	Dry, warm summer with intense sunshine, sensitive to spring frosts; need well-drained soils with good moisture retention	Key markets are the UK, continental Europe, the USA and South-East Asia. 26 countries in total	Nelson and Otago are the main South Island growing regions, assumed to have supporting infrastructure.		395.7
	Apple (processed)	See above			45.9	36.9
B	**Kiwifruit**	Intolerant of frequent rain during pollination, can also increase risk of disease spread but also need regular moisture especially through the fruiting season; grows best in deep, fertile, friable loam, need good drainage. Salt intolerant	Significant and increasing exports to 21 countries	Nelson the main S.I. growing region, supporting infrastructure assumed.		1071.7
X	**Wine Grapes**	good drainage, access to full sunlight and dry, nutrient-poor soil	Increasing annual exports to 95 countries	Marlborough is main NZ production region, Nelson and Canterbury also produce wine		984.5
	Common fruit and nut crops					
X	**Avocado (incl oil)**	Prefer warm, sheltered sunny conditions. Any free draining soil is suitable; very intolerant of drought and water logging, especially young. Frost tender. Salt tolerant	Potential local and international.	Northland and the Bay of Plenty are the main growing regions	18.1	40.4
	Berryfruit			Mainly Nelson and Canterbury		

A	**-Blackcurrants (incl processed)**	Cool moist climates; Humus enriched, heavier soils that retain moisture without becoming waterlogged are best however more tolerant of water logging than other currents	Probably. NZ supplies 3% of global production (largest outside Europe). Mainly for juice	Mainly grown in Canterburyï North Otago (1,000 hectares) and Nelson (400 hectares).	3.6	18.2 (Reduced figure -poor harvest year)
B	**-Boysenberry (incl processed)**	Warm or cool climates. Frost tolerant, intolerant of salty marine air. Prefers lightly acidic and free draining soil			4.8	4.1
X	**-Raspberry (incl processed)**	Good drainage essential, fruit intolerant of heavy rain when ripening (disease)			3.2	
A	**-Blueberry (incl processed)**	Require moderate to high winter chilling; moist, free draining, acid soils	Japan, USA, Asia, Australia, Europe. Steadily increasing, in 2006 were NZôs most valuable export berry crop, worth $12.5m in fresh, $1.4m as frozen fruit.		25.6	14.4
X	**-Strawberry**	Require good drainage, fruit intolerant of heavy rain when ripening (disease risk)			21.3	5.0
	Citrus	Grow best in frost-free regions out of wind. Well drained fertile soil, cannot abide waterlogged sites				
X	**-Grapefruit**	Most need a sub/tropical climate, where there are very hot days and warm to hot nights.				
B	**-Lemons**	Meyer Lemon is relatively Cold hardy. Well drained fertile soil. In less than ideal situations Lemons cope better than other citrus.			10.0	1.8
X	**Limes**	Another important growing criteria for lime tree is proper drainage of the soil. Lime trees cannot tolerate prolonged waterlogged conditions and air pockets in the soil. Prone to root rot				
B	**- Mandarins**	Satsuma mandarin is relatively Cold hardy. Need well drained fertile soil			21.0	2.8
X	**-Oranges**	Achieve the best quality under subtropical conditions; deep, well-drained soils preferred, heavy clays and poorly-drained soils will result in poor growth			11.0	0.4

X	**-Tangelos**	Warm, sunny sheltered spot, which is protected from winter frosts; fertile and well drained soil				
A	**Elderberry/ flower**	Cold tolerant; tolerate poor or very wet soil, drought intolerant.	Sounds like it www.sit.ac.nz/insitu/?p=722 Organic potential- few pests. Phoenix?	Elderflower processing in Canterbury, Berries/wine etc unknown. Unsure of scale		
A/B	**Feijoa**	Hot, dry weather is ideal for the production of a high quality crop, however water during flowering and fruiting beneficial; grow in wide variety of soils, best harvests in well-drained, slightly acidic soil; salinity slows growth and reduces yields. Harvest period March to May.	Insignificant, domestic worth $1.7 million in 2004, and exports earned $100,000 in 2006. Little increase seen in 2009 figures (right)	500+ commercial growers, range mainly from Nelson & Marlborough to Northland http://www.sp.co.nz/rural_news/articles/feijoa.html	1.7	0.2
X	**Grapes table**	Good drainage, access to full sunlight and deep and well-drained light textured soils	Insignificant			0.5
X	**Hops (incl processed)**	Long sunshine hours, regular rainfall, and low wind. Grow best in loose, well drained soil.		Nelson the only centre of production in New Zealand.	0.8	12.3
X	**Kiwiberries**	Very cold hardy plant but fruits best in full sun conditions. Well-drained fertile soil	Insignificant		0.2	1.2
X	**Melons**	Hot and moist conditions. Rich and well drained soil.	Insignificant			1.3
X	**Nashi**	Dry, warm summer, sensitive to spring frosts; need well-drained soils with good moisture retention			1.2	0.1
	***Nuts* (only processed figure available)**					6.6
B	**-Chestnuts**	Frost protection of seedlings required; grow best in well drained soils (root rot potential). Japanese chestnut is well adapted to wet and humid weather with hot summers	Out of season commodity market in the Northern Hemisphere. Assumed small.	Most grown around Auckland, some in the Waikato, Nelson and Canterbury.		

X	**-Macadamias (note Gevuina – 'cold climate Macadamia' below)**	Warm, sub-tropical conditions, grow well in coastal regions in the upper North Island. Wide range of soil types from heavy to sandy but not wet (root rot). Winter harvest.		Most orchards in Northland and Auckland		
X	**-Walnuts**	Grow best in a dry climate, on well-drained soils		Grown in Canterbury and Nelson		
B	**-Hazelnuts**	Frost protection of seedlings required;, prefer sandy soils, but tolerant of clay	Small local market. Export market exists for Australia and parts of Europe.	Grown in Canterbury and Nelson		
X	**Olives (incl oil)**	-8°C min and long, dry summers; well-drained soil	Probably local market	Canterbury Olive Processors Ltd will press on contract	2.3	0. 6
X	**Passionfruit**	Prefer light sandy soils and good drainage. Do not grow well in clay soils.		Concentrated in Northland, Taranaki and the Bay of Plenty		0.6
X	**Pears (incl processed)**	Dry, warm summer, sensitive to spring frosts; need well-drained soils with good moisture retention				9.7
B	**Persimmons**	Frost tender. Full sun, with wind protection. Best in well drained loam soil but ok in clay with drainage. Drought intolerant	Exports mainly to Asia, smaller markets in Australia and Europe.	Grown primarily in Gisborne and Auckland regions		7.6
X	***Summerfruit/ Stonefruit***	Cold winters, short springs and long hot summers produce the best conditions. Stone fruit benefit from dry conditions during harvest. Rain at that time can damage the fruit, particularly cherries, and encourage disease.	Rapidly growing export market $21.3m (2008) to $30.1m (2009). Figures due in part to temporary demand spike.		41.0	30.1
X	**- Apricots**	Cold winters, short springs and long hot summers produce the best conditions. Stone fruit benefit from dry conditions during harvest. Rain at that time can damage the fruit, particularly cherries, and encourage disease.			7.0	7.5
X	**-Cherries**	Cold winters, short springs and long hot summers produce the best conditions.			10.0	21.9

		Stone fruit benefit from dry conditions during harvest. Rain at that time can damage the fruit, particularly cherries, and encourage disease.				
X	**-Nectarines**	Cold winters, short springs and long hot summers produce the best conditions. Stone fruit benefit from dry conditions during harvest. Rain at that time can damage the fruit, particularly cherries, and encourage disease.	Mainly local		9.0	0.2
X	**-Peaches**	Cold winters, short springs and long hot summers produce the best conditions. Stone fruit benefit from dry conditions during harvest. Rain at that time can damage the fruit, particularly cherries, and encourage disease.	Mainly local		8.0	0.1
X	**-Plums**	Cool winters, hot dry summers with plenty of sunshine hours and low humidity	Mainly local		7.0	0.4
B	**Tamarillos**	Frost tender. Requires sheltered sunny position; prefer light, slightly acidic, well-drained soil with good moisture content. Not salt tolerant.	Declining export market, slowly increasing domestic. Canterbury main market for existing growers	Tamarillos are mainly grown in the Bay of Plenty, Northland and Auckland.	1.8	0.4
	Main NZ vegetable crops					
X	**Asparagus**	Excessive rain leading to waterlogged soil can cause the plants problems; require free draining soil. Sandy loams are ideal	Japan is the major overseas market for fresh product	Waikato, the south-west North Island, and Hawke's Bay are main producing areas	10.0*	4.1
X	**Beans**	Grow in many soil types, but are happiest when its well drained and friable		Generally need processing infrastructure at hand	12.8	8.0
B	**Brassicas**	Light soil, rich in organic matter and moist but not wet	Competitive market	Major regions of production are Auckland, Manawatî and Canterbury	80.3	1.5
X	**Capsicums**	Hot summer climate. Soil should be free draining,			29.3	36.1

X	**Carrots (incl Processed)**	Light, stone free, well drained, fertile, rich sandy peaty soils are perfect. Excess water causes root crack			30.0*	10.6
X	**Garlic**	Best on fertile, well-drained, loamy soils, the lighter the soil the better.			6.5	0.6
X	**Kumara**	Silt loam is ideal soil. Heavy clay soils tend to restrict the development of tubers. Susceptible to fungal attack during wet and humid weather. Require warmer climate than potatoes		NZôs crop grown on the fertile plains of the Wairoa River near Dargaville, in Northland	33.8	
B	**Lettuce (outdoor)**	Grow in well-drained soil, sandy to loamy soils work well for lettuce		Main regions of production are Auckland, ManawatÎ and Canterbury	41.8	1.1
X	**Mushrooms**	Mainly indoors			41.1	1.6
X	**Onions**	Soil should be fertile and rich in organic matter. Bulbing onions need full sun, but green onions can be grown in partial shade	New Zealandôs highest-earning export vegetable. Since the 1990s most of the crop has gone to Europe	Mainly grown in Pukekohe and around Matamata	25	76.3
X	**Peas (incl Processed)**	Free draining soils in a dry and sunny summer climate	Frozen peas are New Zealandôs fifth most valuable vegetable export, and are exported to 35 countries.	Main commercial production in Canterbury, Marlborough, ManawatÎ and Hawkeôs Bay. Need processing infrastructure at hand	50.0	85.3
B	**Potatoes (incl Processed)**	Best in sunny locations on rich well-drained soil with plenty of organic material. Silt loam is ideal soil. Heavy clay soils tend to restrict the development of tubers. Susceptible to fungal attack during wet and humid weather	Domestic and Export	Production mainly in Pukekohe, ManawatÎ, South Canterbury and Southland.	516.0	99.0
X	**Pumpkin**	Fertile soils, hot summer days and cool nights are ideal for ripening firm-fleshed squash (pumpkin). Intolerant of water logging		Grown around Gisborne and Hawkeôs Bay		

X	**Rice**	Grows in hot climates. Needs flat land, suitable clay-based soils, and available water. Minimum temperature 10°C	Would compete with developed markets with far lower labour costs and established infrastructure. Heavily protected overseas market so vulnerable to changes in policy	Would need development		
B	**Silverbeet/ spinach**	Silver beet prefers cool, dry, frost-free growing conditions; most soil types, provided the soil has good drainage, prefers deep, friable, fertile, well-drained soils such as alluvial soils and sandy loams		Main regions of production are Auckland, Manawatî and Canterbury	13.4	
X	**Squash**	Warm climate with hot days and cool nights; most soil with good drainage. Intolerant of water logging			2.9	69.3
X	**Sweetcorn (incl Processed)**	Needs plenty of sun, grows in hot or milder climates, provided there are long sunshine hours			10.0*	45.6
X	**Tomatoes**	Need a warm, well drained planting site with full sun			113	9.9
	Lesser known crops					
A	**Northern Cranberry**	-12°C min temperature; most soil types however they prefer acidic soil. Tolerate wet or flooded soils but good drainage is required during the active growing season for proper root growth and function. Keep weed free. They do not tolerate dry soils, and need careful watering in the heat	Possibly Nelson and Ocean spray. Others?	Nelson		
B	**New Zealand Cranberry or Chilean Guava**	Produces well in partial shade or full sun in fertile, well drained and loamy soil. Tolerate salty maritime air, moderate wind, cold temps, frost, sandy soils and clay but not drought.	No obvious market at present, www.hortnet.co.nz/news/2001/n4212.htm	Unlikely		
B	**Goji Berry**	-26°C min; moist, well drained soil, high sun	Not Significant	Unlikely		
B	**Red and White Currant**	Prefer warmer climates; moist, well-drained, heavy soil	Not Significant	Unknown but likely to be small scale		

B	**Gooseberry**	Excel in cool climates; tolerant of most soils but not water logging	Not Significant, Local best	Unlikely or limited		
B	**Saskatoon Berry**	Cold tolerant; need well-drained soil, does not like wet roots	Only local at present	Unlikely		
B	**Sea Buckthorn**	Cold tolerant; arid to very wet conditions; prefers sandy, neutral soil	Product not really known in NZ. Future potential	Unlikely		
B	**Gevuina** (spelled in some old sources *Guevina*) **(Macadamia equivalent)**	Frost protection of seedlings required; most soil types	No established market, European market for NZ grown Australian Macadamia so perhaps.	Apparently Grower in Akaroa		
X	**Flax Oilseed (linseed)**	Soils with high water-holding capacity and good inherent fertility	Potential local market (paint oils, etc). Large scale global competition from Canada, China, India etc			
B	**Hemp**	Tolerate light frosts; most soil types, intolerant of drought, flooding, saturated or saline soils. best suited to areas with moderate rainfall and good soil fertility	No real local market established	No existing infrastructure known		
B	**Sphagnum moss**	Small areas cultivated	Existing market	Believed to be small scale.		5.5*
B	**Gentians (flowers)**	Donôt like to be disturbed (donôt touch their roots), need lots of light and never let their soil dry out: need well-drained soil	Japanese Market	Some exporting from New Zealand		
B	**Wasabi**	Most growth in the cooler winter months, does not like hot temperatures (+25° C) or direct sunlight. Clean flowing water or moist, fertile soil required. Water grown plants produce a higher quality product	For export, the fresh stems are highly sought after on the Japanese market. BHU state markets are uncertain however (see emails)			
B	**Tea (green/black)**	Needs a hot, moist climate. It grows in temperatures ranging from 10 -30° C, in areas with an average yearly rainfall of 2,000 mm and at a ground level of between 600-2000 meters above sea level.	Competing with established industries with low labour costs.	53 hectares grown with 1m plants in the Waikato. Processing infrastructure assumed		
A	**Honey**	Sourced from native plants ï naturally occurring or cultivated. Manuka, Rata, Beech	Exports were worth $81 million in 2009			$81.0
X	**Goldenseal**	Already grown on coast	Would need developing	Nothing known of.		

B	**Ginseng**	Grows best in shaded areas with moist well drained soil. Drainage is essential and swampy or clay soil must be avoided.	BHU state markets are strong	Apparently already grown on the West Coast		
B	**Australian tea tree** *(Melaleuca alternifolia)*	Grow best in high-rainfall areas with mild climate.	Competition with well developed Australian industry, large market which has not enjoyed recent stability as production volumes have increased			
					Plant and Food (2009)	

Sources: www.southlandnz.com, www.flaxcouncil.ca, www.wikipedia.org, www.olivesnz.org.nz, www.teara.govt.nz, www.enza.co.nz, www.canr.msu.edu, www.gojijuices.net, www.fruitexpert.co.uk, www.urbanorganicgardening.org, www.plantandfood.co.nz, www.edible.co.nz, www.gardeningknowhow.com, www.gardenguides.com, www.kings.co.nz, www.mitre10.co.nz, www.ehow.com, www.aggie-horticulture.tamu.edu, www.feijoa.org.nz, www.crfg.org, www.tropicalpermaculture.com, www.nzcc.org.nz, www.howstuffworks.com, www.plantcultures.org, www.wtea.com, www.purenewzealandhoney.com, www.tradewindsfruitstore.com,

*Estimate only. Blank sales entries indicate either that the information was not available or items are valued at less than $100,000. Processing includes juicing, freezing, canning and artificial drying. Prices in NZ$ unless stated

A- Indicates potential future commercial crop according to available growth requirements, markets and infrastructure.

B- Indicates possible future commercial crop with market development and establishment of infrastructure or significant adaption and monitoring of environmental conditions.

X- Indicates crops believed to have little or no commercial potential on the West Coast.