OUR LAND & SOIL

TŌ TĀTAU WHENUA, ONE HOKI

HIGHLIGHTS

Tairāwhiti has varied land types with 71% of the region classified as steep hill country. Our gentle rolling land is very fertile - the Poverty Bay Flats is the single largest area of high-quality fertile soils in New Zealand.

Maize and sweetcorn are the most abundant crop types, making up 42% of crops recorded in the region.

On the Poverty Bay Flats there has been a 110% increase in irrigated high-value crops such as apples, kiwifruit and persimmons over the last ten years.

There has been an increase in commercial vegetables grown in winter. In 2019, there were 320ha of these vegetables (mainly lettuce, cabbage, cauliflower and broccoli).

Our region is susceptible to erosion due to our geology, heavy rainfall and previous removal of forest cover. Council is working with landowners to protect our most vulnerable land. 42,946ha (86%) of our land requiring treatment for erosion (Land Overlay 3A) now has effective tree cover, with a further 7,223ha (14%) still requiring action – 3,207ha of this is in the Waiapu catchment.

Forestry is important economically to Tairāwhiti. In 2018 the total harvest was 10,707ha. This included 9,451ha consented for harvest and 1,177ha as a permitted activity. 2018 was the first year that harvest was allocated as a permitted activity under the National Environmental Standard for Forestry.

A huge landslide in February 2018 formed a new lake – the largest in our district – on the Mangapoike River.

A new mud volcano erupted in the Waimata Valley in December 2018 covering an area of 2.1ha.

OUR LAND

Gisborne is a region with a young geology, located on an actively rising fold of the earth's crust, the crest of which is the bush-covered Raukumara Range. The high rate of uplift (4mm a year), tectonic crushing, soft rocks, frequency of heavy rainfall and removal of much of the original forest cover means Gisborne has significant erosion problems. Twenty-five per cent of the North Island's most severely eroding land is found in Gisborne. This presents a big challenge for sustainable land use.

A positive result of the erosion is that our flat and gently rolling land – 71,000ha – is incredibly fertile. In fact, the Poverty Bay Flats are the single largest area of high-quality fertile soils in New Zealand. Other fertile flats can be found at Tolaga Bay, Takamore and Tikitiki. The combination of fertile soil and climate means horticulture and cropping are more economically attractive land uses than dairy farming.

Steep hill country makes up 596,000ha (71%) of the district, the heartland of mixed sheep and beef farming and 20% of the district's forestry.

Two sides of erosion

25% of the North Island's most severely eroding land is found here, yet the Poverty Bay Flats is the single largest area of high-quality fertile soils in New Zealand.

CROPPING

Horticulture trends on the Poverty Bay Flats

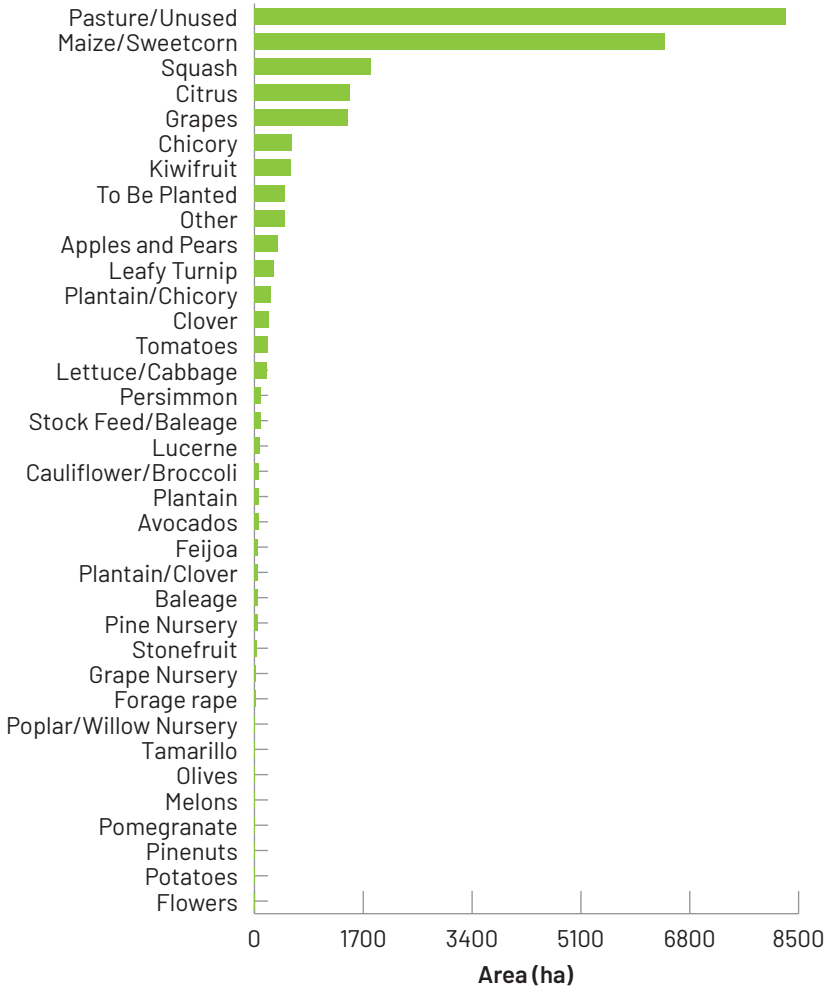
As the single largest area of horticultural land in our region, with approximately 10,200ha out of a possible 18,000ha cropped, Council has been monitoring the highly diverse crop trends on the Poverty Bay Flats since summer 2007-08. Over this period there have been significant changes to crop types. There has been a steady increase in the number of crops requiring irrigation such as modern apples, kiwifruit and persimmons. These "high-value" crops are displacing lower value crops which do not require irrigation, such as grapes and older apple varieties. Overall there has been a 110% increase in high-value permanent crops over the last ten years.

Maize and sweetcorn

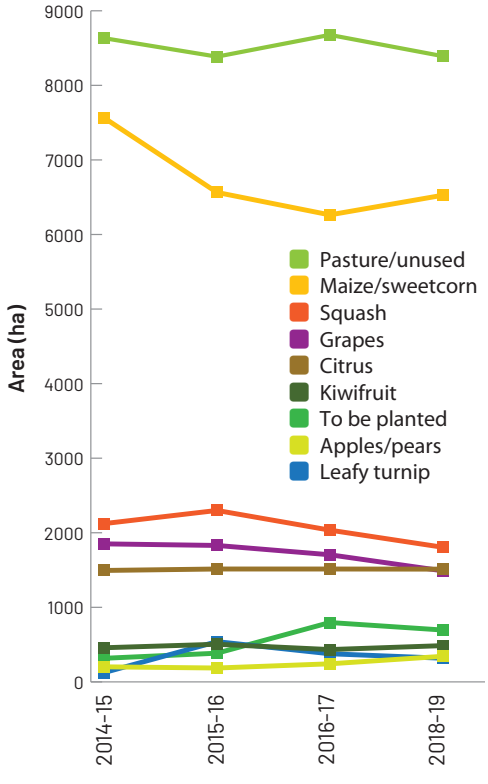
Maize and sweetcorn were the most abundant crop types in the Gisborne region. Maize and sweetcorn account for 42% of all crops recorded in the Gisborne region (excluding pasture and tilled land), covering 6,408ha. Maize and sweetcorn were grouped together for analysis as they were difficult to identify separately in some instances and have similar impacts on the environment and water use.

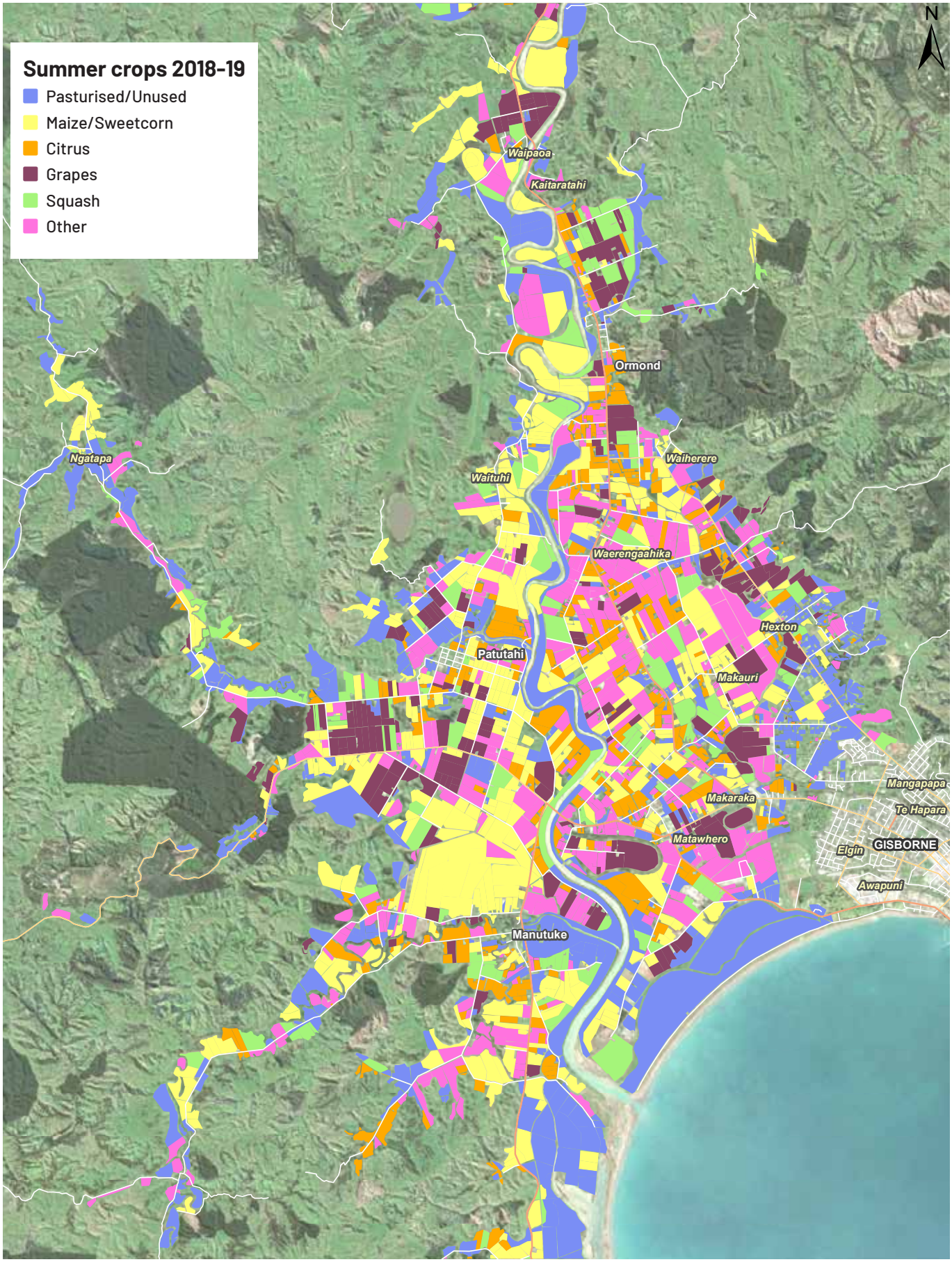
Overall, maize and sweetcorn is decreasing, with a major drop from 2015 to 2016. The trend appears to be plateauing at around approximately 6,400ha. This could be attributed to a large proportion of crop land transitioning to citrus and kiwifruit orchards and also leafy greens such as lettuce, cabbage, cauliflower and broccoli, particularly around the Poverty Bay Flats.

Total area (ha) of crop types identified in the 2018/19 Summer Crop Survey



Five year trend of the major crops in the Gisborne region (2014/15 – 2018/19)




Summer crops 2018-19
Pasturised/Unused
Maize/Sweetcorn
Citrus
Grapes
Squash
Other
N
Waipaoa
Kaitaratahi
Ormond
Ngatapa
Waituhi
Waiherere
Waerengaahika
Hexton
Patutahi
Makauri
Mangapapa
Makaraka
Te Hapara
Matawhero
Elgin
GISBORNE
Awapuni
Manutuke

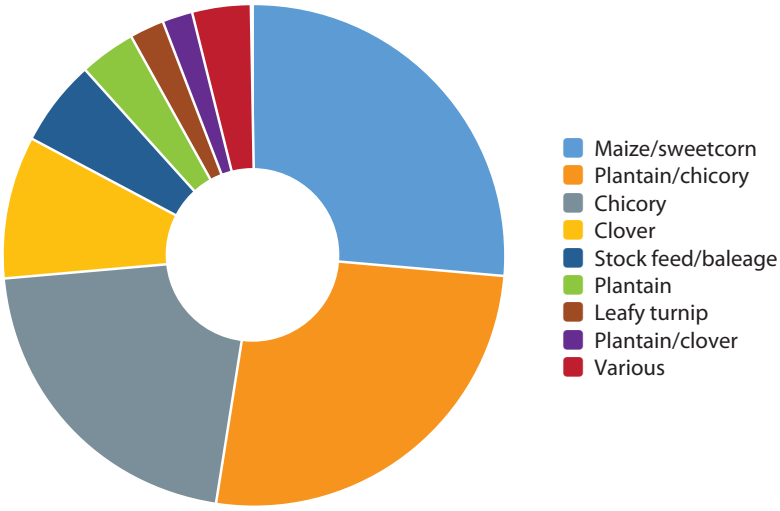
Summer crops

Over the last four years there has been a decline in the area planted – with crops in Tolaga Bay, Tokomaru Bay, Ruatoria and East Cape. Generally there has been an increase in crops for animal feed, partly offsetting a decrease in maize plantings which may have been trucked out of the district.

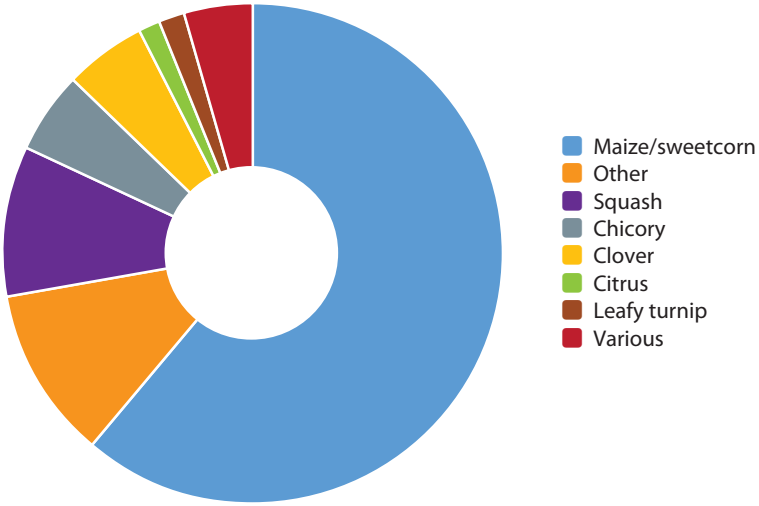
The most abundant crop in the East Cape and Ruatoria areas is maize and sweetcorn with 228ha, closely followed by plaintain/ chicory mix with 222ha. Chicory is the third most abundant crop with 182ha. The remaining crops — including baleage, citrus, clover, fodder beet, leafy turnip, lucerne, olives, plantain, plantain/cover, poplar/willow nurseries, other, and stock feed/baleage — were found in much lower quantities.

The major crop type found in the Tolaga and Tokomaru areas was maize and sweetcorn with a total area of 1,224ha.

Crop types in the East Cape/ Ruatoria area (ha)



Crop types recorded in the East/Tolaga/Tokomaru area (ha)



Winter crops

The 2019 Winter Crop Survey is the fifth consecutive survey to be conducted in the Gisborne region. The crop survey identifies the type, location and total area of different winter crops. In previous years the survey was conducted over the Gisborne region, and in 2019 there was a specific focus on the Taruheru catchment in response to the growing land use intensification in this area.

The 2019 Winter Crop Survey outlines how the land use trends within the Poverty Bay Flats may influence water quality in the Taruheru River. A total of 1,202ha within the Taruheru catchment was surveyed, with the total winter crops recorded covering 447ha (excluding maize stubble, tilled land and pasture). The main crop types included lettuce/cabbage, cauliflower/broccoli, unidentified, clover, kale and other.

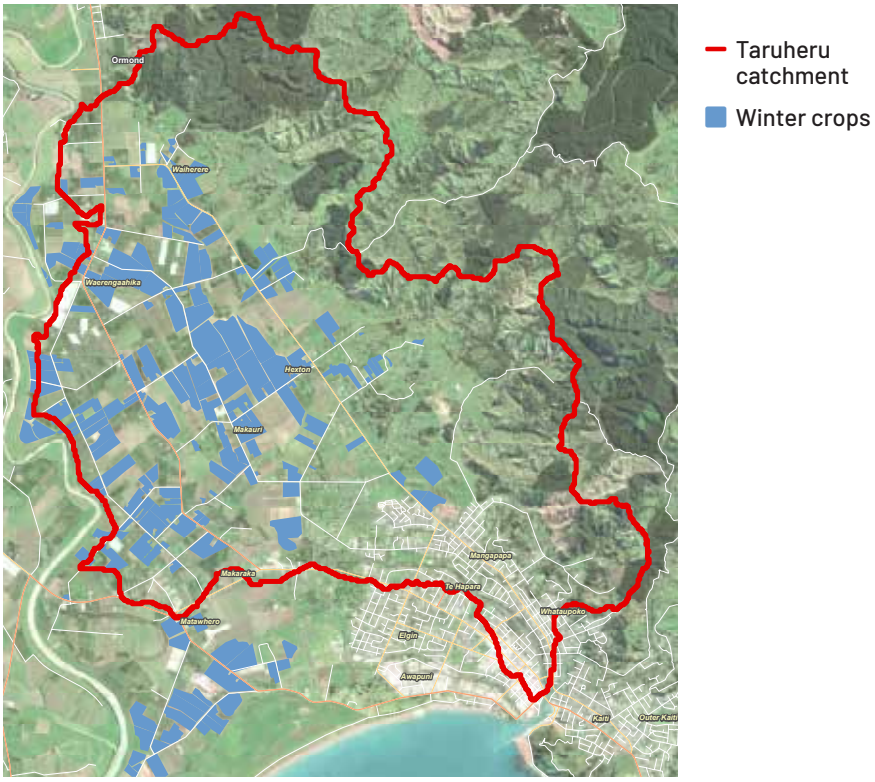
The Taruheru catchment area surveyed in 2019 (1,201.9ha) was smaller than 2018 (1,286.5ha) but more than 2017 (751.2ha) and 2016 (733.8ha). The decrease from 2018 is due to more areas being converted to high-value permanent horticulture, for example kiwifruit, which are excluded from the Winter Crop Survey. The increase from 2017 reflects the horticultural intensification of the wider Poverty Bay Flats area.

The area of winter crops excluding pasture, tilled land and maize stalk was 304ha. The total area surveyed and recorded was 1,201ha. The areas of pasture (328ha), tilled land (469ha) and maize stalk (99ha) were excluded to calculate the total area of winter crops. Pasture is not cropped for winter fodder and was therefore excluded from the total number of winter crops surveyed.

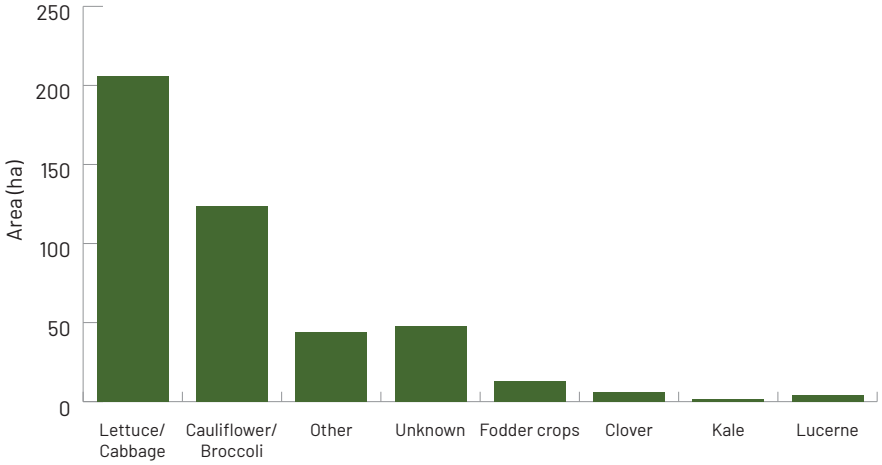
On the Poverty Bay Flats there is an increasing trend in the production of commercial winter vegetables with 311.9ha planted in winter 2018. The winter vegetables are lettuce, cabbage, cauliflower and broccoli.

Winter cropping is also undertaken as feed to support sheep and beef farms. Because of the amount of land disturbance and potential impacts on the environment, there are rules in our Tairāwhiti Resource Management Plan

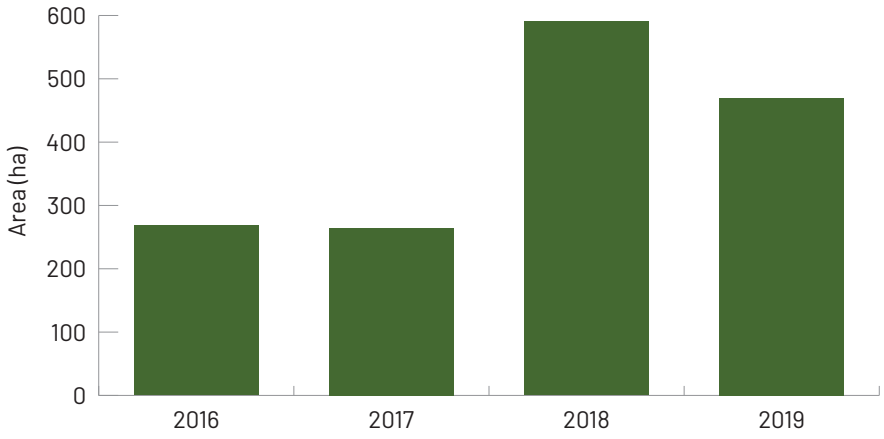
Winter crops within the Poverty Bay Flats (Taruheru catchment)



2019 winter crops (excluding pasture, tilled and maize stubble)



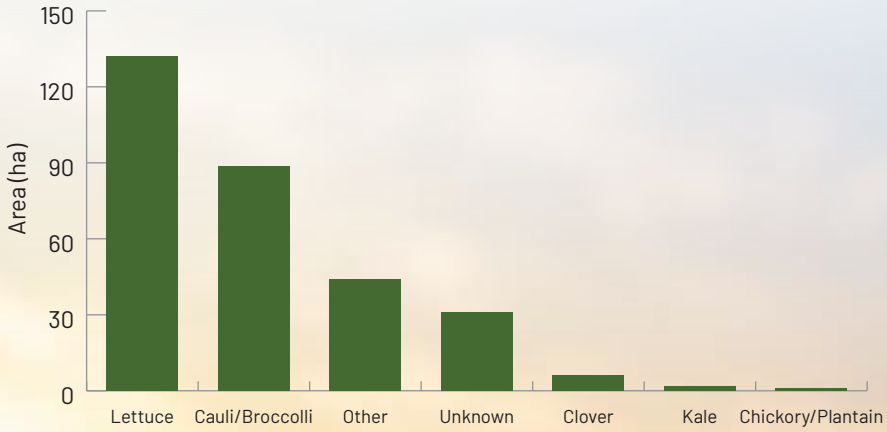
Winter tilled land trends in the Taruheru catchment (2016-19)



about how close to streams cropping can be undertaken.

Trends in winter cropping for fodder crops show, after a peak of 2,120ha in winter 2015, there has been a reducing area of winter crops to 1,678ha in winter 2018. However, this reflects only part of the story as hill country areas have not been included in past surveys and fodder crops are known to be increasing in the hill country.

Winter crops within the Taruheru catchment (excluding pasture, tilled and maize stubble)



"Other" covers a wide range of different crops including spinach, beetroot, pumpkin/squash and also market gardens

LIVESTOCK

Livestock trends show that stock numbers have fluctuated over the last five years. These trends generally reflect the quality of growing season and market conditions. However, there is a longer term trend of reduction in sheep numbers due to retirement of land from pastoral farming. The number of dairy cattle has decreased since 2012. A percentage of Gisborne's dairy cattle are being grazed not milked, as cattle from the Bay of Plenty and Hawke's Bay are wintered in Gisborne.

Livestock numbers at June each year	2014	2015	2016	2017	2018
Total sheep	1,602,000	1,472,000	1,515,000	1,412,000	1,457,000
Total beef	277,000	245,000	247,000	261,000	277,000
Total deer	18,000	13,000	8,000	12,000	-
Total dairy cows	15,000	10,000	12,000	9,000	-

New Zealand Agricultural Production Statistics

Sheep muster east of Matawai

EROSION

The Gisborne district is well known for its soft rock soil erosion – on a scale and severity greater than any other part of New Zealand. Our natural erosion susceptibility has been aggravated by deforestation as native forests were cleared for pastoral farming over the 19th and early 20th centuries.

Efforts to re-establish vulnerable hill country areas in trees began in the 1950s and came together as the East Coast Project in 1970. That project set about planting exotic forests in the back country, small woodlots and strategically placed trees in the pastoral forelands. Later this was changed to better match land use to land use capability.

These schemes have seen erosion protection plantings such as poplars and willows, the planting of forestry, native reversion and most recently manuka plantations for honey production.

Cyclone Bola in 1988 was a key event and a "step change" in the erosion problems in our district. The worst eroding or erosion-prone land (Land Overlay 3A) must be treated with effective tree cover or fenced for reversion by 2021, according to the Gisborne District Council Tairāwhiti Resource Management Plan. Funding from the Ministry for Primary Industries through the Erosion Control Funding Project (ECFP Land Treatments) has been available to assist landowners in the implementation of works plans which detail planting and are prepared in conjunction with Council.

Severe erosion at Waerenga-o-Kuri reserve

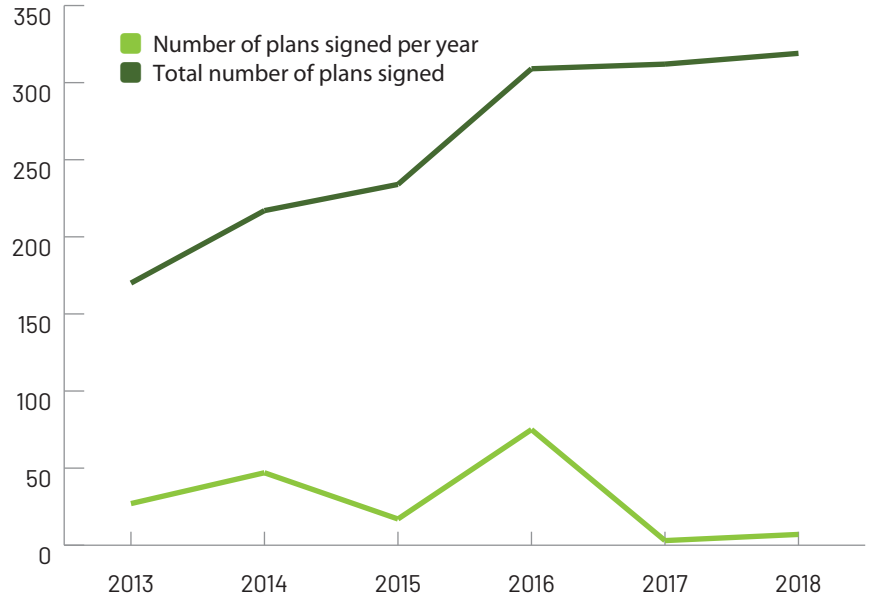
The Sustainable Hill Country Project

Works plans were required to have been submitted by 2011 and treatment works are to be completed by 2021. While the deadline for completion of works plans has now passed, with a number of properties still yet to complete their plans, substantial progress has been made particularly in securing funds while they were available and progressing planting and reversion works.

Progress of Overlay 3A works plans development 2013-18

Year ending 31 Dec	No. plans signed/year	03A area (ha) signed off/year	Total no. of plans signed	Total 03A area (ha) covered by plans
2013	27	1,214	170	17,339
2014	47	6,388	217	23,727
2015	17	4,161	234	27,888
2016	75	6,548	309	34,436
2017	3	581	312	35,017
2018	7	761	319	35,778

Progress in Overlay 3A works plans



Area (ha) with Overlay 3A works plans

What exactly is Land Overlay 3A?

Land Overlay 3A is a subset of Land Overlay 3 and is the worst eroding land in our district. It consists of land identified on the Tairāwhiti Plan Maps as "LO3A" and was mapped at a farm scale (1:10,000 and 1:15,840). Land Overlay 3A includes Land Use Capability units which feature severe to extreme soil erosion.

Establishing effective tree cover

Establishing effective tree cover on Land Overlay 3A is the key measure of success in reducing erosion throughout our region. In April 2019 it was estimated there was 7,223ha (14.4%) of untreated Overlay 3A remaining. This does not include land that holds an Erosion Control Funding Programme (ECFP) grant where treatments have yet to be implemented.

Within the Waiapu catchment there is 22,995ha (45.8%) of Overlay 3A, of this 19,788ha (86%) has effective tree cover or holds an ECFP grant to apply treatments, and 3,207ha (14%) remains to be treated.

Total area of Overlay 3A in Gisborne region: 50,169ha

Year	Area of Overlay 3A with effective tree cover	Area of Overlay 3A remaining to be treated
2016	41,466ha	8,703ha
2019	42,946ha	7,223ha

Waiapu catchment – Overlay 3A land treated

Overlay 3A in the Waiapu catchment	Area of Overlay 3A with effective tree cover	Area of Overlay 3A remaining to be treated
22,995ha	19,788ha	3,207ha

Funding for erosion control

The Erosion Control Funding Programme (ECFP) has been running for a number of years and has contributed significantly to the establishment of effective tree cover on both Overlay 3A and other eroding land within the Gisborne district.

As of 2019, the landowner grant component of the ECFP Land Treatments is fully allocated. Funding can now be obtained through the ECFP community grants and the One Billion Trees Programme to allow landowners with eroding land to achieve effective tree cover. The One Billion Trees Programme includes land treatment options of mixed native planting, manuka/kanuka, native regeneration and exotic forestry.

Forestry was once the major component of ECFP grant approvals. However, in recent years there has been a trend towards increased use of indigenous reversion and manuka plantings. This has been particularly notable in areas more remote from Gisborne Port, and on land less suited to plantation forestry, and follows changes to the funding scheme to better reflect iwi and community aspirations for long-term land uses.

ECFP grants approval data shows a very successful picture of engagement from 2016-18, with a further 11,105ha now being included in the ECFP scheme. Of this, 5,544ha is apportioned to forestry, 507ha to manuka, 3,952ha to reversion and 1,102ha to pole planting - in the previous three years there was only 1,625ha committed to the scheme.

The increase in ECFP engagement can be attributed to a better understanding of landowner needs to treat erosion, and adjustments made to treatment options. Implementation of ECFP grant agreements will be an important focus for Council to ensure the funding results in effective tree cover.

ECFP — established tree cover

Year	Treatment	Total area (ha)	O3A area (ha)	Regional target land (ha)
2013	Forestry	671	77	419
	Native reversion	186	23	86
	Conservation pole planting	32	8	8
2014	Forestry	347	93	158
	Native reversion	10	3	5
	Conservation pole planting	29	15	6
2015	Forestry	77	14	21
	Native reversion	43	18	25
2016	Forestry	6	0.02	5
	Native reversion	47	21	32
	Conservation pole planting	110	70	49
2017	Forestry	16	3	0
	Native reversion	207	155	179
	Conservation pole planting	29	19	19
2018	Forestry	385	0.45	7
	Native reversion	16	13	15
	Conservation pole planting	No data	No data	No data

**Successfully established and paid out (ECFP GIS Geodatabase)*

Land treatment area granted

Year	Treatment	Total area (ha)
2013	Forestry (all exotic incl P.radiata)	107
	Manuka	40
	Indigenous reversion	24
	Pole planting	340
	TOTAL	**511**
2014	Forestry (all exotic incl P.radiata)	78
	Manuka	186
	Indigenous reversion	22
	Pole planting	92
	TOTAL	**378**
2015	Forestry (all exotic incl P.radiata)	6
	Manuka	0
	Indigenous reversion	475
	Pole planting	255
	TOTAL	**736**
2016	Forestry (all exotic incl P.radiata)	16
	Manuka	102
	Indigenous reversion	1,053
	Pole planting	267
	TOTAL	**1,438**
2017	Forestry (all exotic incl P.radiata)	3,808
	Manuka	0
	Indigenous reversion	807
	Pole planting	283
	TOTAL	**4,898**
2018	Forestry (all exotic incl P.radiata)	1,720
	Manuka	405
	Indigenous reversion	2,092
	Pole planting	552
	TOTAL	**4,769**

** Indicates year of grant approval, not year of establishment*

Forestry was once the major component of ECFP grant approvals. In recent years there has been an increase in use of indigenous reversion and manuka plantings following changes to the scheme to better reflect iwi and community aspirations for long-term land uses

#01 CASE STUDY | HE TAUIRA

MANAGING EROSION AT TAUWHAREPARAE

In 1945 the land had been completely cleared and the erosion was severe

In 1988 , soon after Cyclone Bola there was a significant increase in the extent and severity of the erosion

By 1998, the lower half of the paddock had been established in pine. This was an important first step towards long-term erosion control

In the 2012 photo there is a further reduction in bare ground. While the erosion is still severe in the main gully, it is not increasing

The 2018 photo shows part of the pine forest has been harvested

Aerial photos taken in 1945, 1988, 1998, 2012 and 2018 provide a visual timeline of the progress in addressing severe gully and slope erosion in the Lakes paddock at Tauwhareparae farm.

In 1945 the land had been completely cleared and the erosion was severe.

In 1988 – soon after Cyclone Bola – there was a significant increase in the extent and severity of the erosion.

By 1998, the lower half of the paddock had been established in pine. This was an important first step towards long-term erosion control.

In the 2012 photo there is a further reduction in bare ground. While the erosion is still severe in the main gully, it is not increasing.

The 2018 photo shows part of the pine forest has been harvested. Replanting is a critical requirement for the block. Consent conditions require willows and coppicing species to be planted in the gully, and on bare land where pines have not succeeded.

The aerial images of Tauwhareparae farm show how planting has been used to address erosion over more than 70 years.

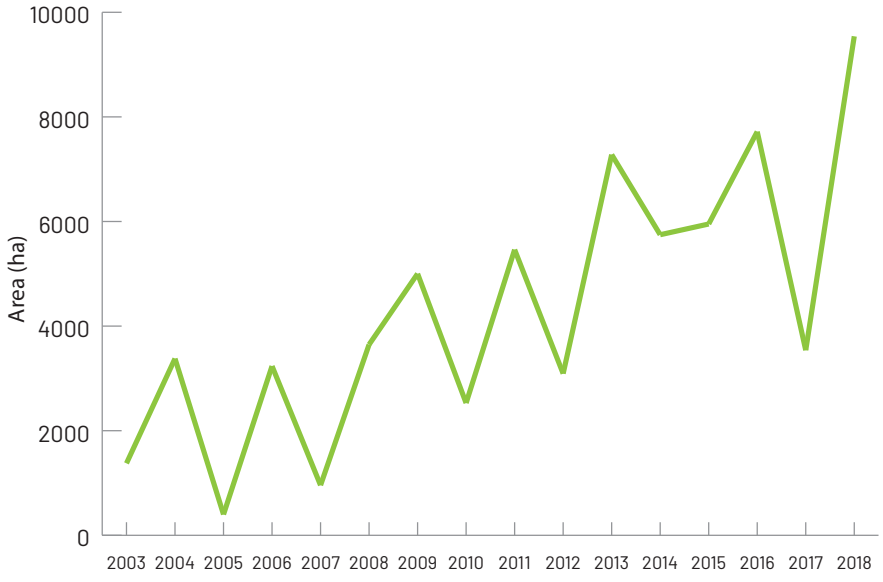
FORESTRY

Much of the forestry was planted as a result of erosion protection schemes, with the rate and amount of plantings accelerating after Cyclone Bola. Many of these forests are now being harvested. Until 2018, all forestry in Gisborne required a resource consent. However, from May 2018 only forestry on the most severely eroding land (Erosion Susceptibility Classification Very High/ Red) requires consent for harvest. All forestry harvest does, however, require lodging of Permitted Activity notices with Council. These notices must be lodged within 20 and 60 working days of harvest commencing.

Forestry harvest planning tends to be on a two-year cycle which is then reflected in consenting activity – with a busy year followed by a less busy year. This trend can be generally observed since 2003, with a step change increase in harvest areas from 2009. However, the strongest trend is the large increase in area of harvest, with a peak of 9,541ha in 2018. When permitted forestry harvest under the National Environmental Standards for plantation forestry is also considered, 2018 saw 10,707ha of forestry harvest commencing under these rules, more than three times the amount of harvest underway in the previous year.

Year	Area of consented forestry harvest (ha)	Area of permitted forestry harvest (ha)	Total harvest area approved (ha)
2003	1,376	N/A All harvest required resource consent	1,376
2004	3,379		3,379
2005	398		398
2006	3,236		3,236
2007	957		957
2008	3,647		3,647
2009	5,002		5,002
2010	2,528		2,528
2011	5,462		5,462
2012	3,091		3,091
2013	7,279		7,279
2014	5,747		5,747
2015	5,952		5,952
2016	7,718		7,718
2017	3,538		3,538
2018	9,541	1,177	10,718

Area of consented forestry harvest (ha)



Forestry & erosion risk

The first major forestry plantings in the Gisborne district were undertaken in the Mangatu forest in the 1960s. Since then, there has been significant forestry planting in a range of areas across the district. By 2016 the total area in exotic forestry comprised 141,581ha, down from a peak of 156,400ha in 2011. It is estimated that around 24,000ha of mature exotic forest was available for harvest in 2016 with a further 10,000ha available for harvest by 2021.

Initial harvesting was on highly erosion prone, but generally less steep, areas. As the first rotation harvests on steep lands with thin soils have proceeded, the issue of sediment and woody debris deposition into waterways, onto floodplains, beaches and ultimately the coastal environment have become an increasing concern.

Harvesting of steep land followed by heavy rainfall events during the length of the risk period (five to seven years post-replant) can result in landslips and mobilisation of soil and sediment, which is then deposited in waterways. With the relatively high level of harvest residues occurring in Tairāwhiti relative to other regions, this results in forestry harvest residues – including logs, slash and other woody debris – migrating to the waterways. In some instances, the weight of material is so significant it will crash through remaining pine or native riparian areas or buffers, which get incorporated into the mobilised woody residues. The key risk periods are harvesting to canopy closure (around a seven-year period, which is approximately 25% of the year rotation cycle).

Since 2010, this situation has become increasingly prevalent as steeper land such as the Wharerata Ranges, upper Waimata and inland Tolaga Bay have been harvested (table below). As other very steep lands are harvested, these concerns are expected to continue.

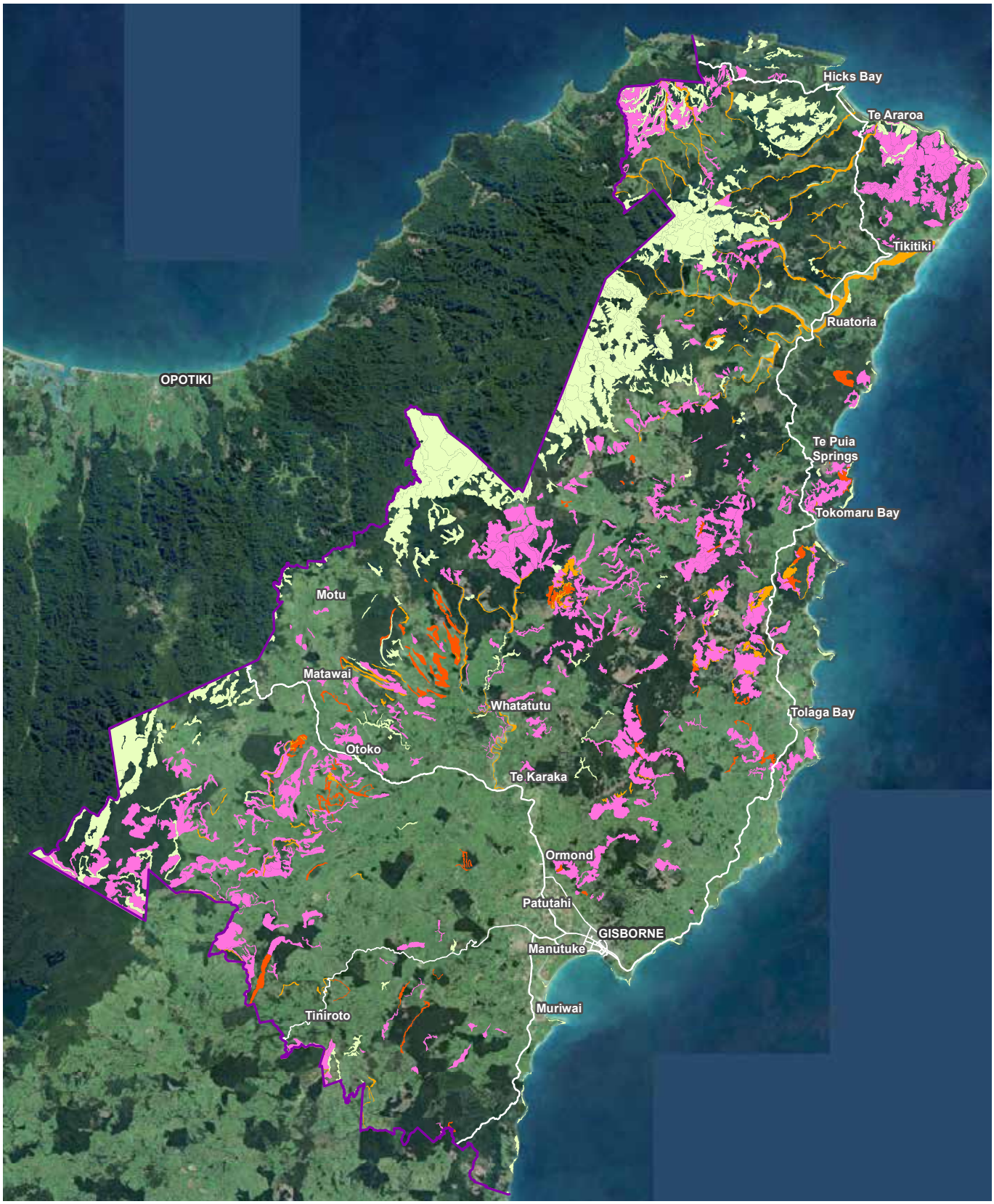
Council commissioned The School of Forestry at the University of Canterbury to undertake a study on the forest management production cycle. The findings show that pine plantations are typically harvested at between 25-30 years. The national average volume for a pine stand at harvest is estimated to be 500m^3/ha but are typically 650m^3/ha or higher on professionally managed stands with good soils. The merchantable volume (volume converted to logs for sale) depends on the quality and characteristics of the trees in a stand, but also on the desired product mix. Based on estimates from the Ministry for Primary Industry, an average of 85% of the total standing volume will be merchantable. This ranges from 90% for well-tended stands in good condition, down to 80% for untended stands on moderately steep terrain.

Conversely, this means between 10 and 20% of the total standing volume is left on site post-harvest. As a national average, this would be approximately 75m^3/ha. For the Gisborne region, however, on most stands there is a higher volume left on site at harvest (estimated to be 650m^3/ha), and given the difficulty of the terrain and poorer markets, it would be reasonable to estimate 100-125m^3/ha of residue left at harvest. As a result, the volumes of material available to be mobilised during storms may be greater than in other regions.

Weather events recorded as causing harvest residue mobilisation in Tairāwhiti

Year	Location	Key impacts
2018	Mangapoike, Waimata, Tolaga, Waiau, Waiapu	Extensive landslides and slips with significant mobilisation of forest harvest residues, particularly in the inland Tolaga Bay (Uawa) area, Waiapu, Waimata, Kanakanaia, and Mangapoike
2017	Waimata, Tolaga, Mata	Extensive landslides and slips with significant mobilisation of forest harvest residues, particularly in the inland Tolaga Bay (Uawa) area
2015	Wharerata Forest	Major slash mobilisation, debris on beaches, sedimentation of waterways and coastal environment, destruction of farm infrastructure
2014	Inland Tologa, Wharerata Ranges	Slash mobilisation, debris on beaches
2013	Tokomaru Bay	Slash mobilisation, debris on beaches
2012	Wharerata Forest	Major slash mobilisation, debris on beaches, sedimentation, loss of railway line, loss of culvert on SH2 (closing the road)
2002	Muriwai-Manutuke	Widespread flooding caused by forestry slash blocking culverts on public and private land
1994	Wharerata Forest	First major post-forestry harvest event – substantial erosion and landsliding, sedimentation and slash mobilisation
Annual	Region-wide	Localised storms causing sedimentation of downstream waterways, blocking of private & public road culverts, forestry debris on local beaches

Land vulnerable to land sliding



- District – 839,197ha
- 7e – vulnerable classes 78,922ha (9.4%)
- 7s – 6,866ha (0.8%)
- 8e – 60,331ha (7.2%)
- 8s – 11,549ha (1.4%)

#02 CASE STUDY | HE TAUIRA

A new lake forms at Mangapoike

Landslide dams can be very dangerous, with inundation occurring via rising waters upstream, and flooding downstream via dam breaching. On 25 February 2018, local landowners heard a noise and saw a dust cloud downstream from the Mangapoike and Paparatu Stations and on 26 February, a topdressing pilot reported to the landowner the presence of a large rockslide that had dammed the Mangapoike River. They in turn contacted both Gisborne District Council and Hawke's Bay Regional Council. An initial inspection was undertaken followed by a more detailed investigation in early March. While it was envisaged that the lake forming behind the landslide would take several months to fill, over 140mm of heavy rain fell over the 9-10 March resulting in the lake filling faster than anticipated.

While Mangapoike Lake occupied an area of around 9ha on 8 March, by 15 March it had grown to around 30ha and was beginning to threaten access to Mangapoike Station by 20 March. As a result, Council along with Hawke's Bay Regional Council engaged specialist engineering consultants along with scientists from Auckland University to assess the risk of possible landslide dam collapse as well as the impact on Mangapoike Station several kilometres upstream.

By this stage the lake had grown to 33ha and the bridge to Mangapoike Station and two dwellings were close to being inundated. With Easter approaching and more bad weather expected, the decision was made to blast a channel to direct water to a depression that had formed between the headscarp and the main dam. This channel was blasted on 28 March and by 3 April water broke through and began filling the depression forming an additional smaller lake (Tukemokihi Lake). A second larger set of blasting was then undertaken on 9 April to allow water to flow from the Tukemokihi Lake back into the Mangapoike River. This resulted in the new Mangapoike Lake stabilising at a size of around 30ha, which makes it the largest lake in Tairāwhiti.

View of the Mangapoike Lake on 15 March after heavy rain caused it to rapidly increase in size, fully drowning the trees previously occupying the valley floor. By this time the lake was around 50m deep at its deepest point and extended upstream more than 2km

The lakes have since been actively monitored by Council as well as being the subject of detailed study by both Council and Auckland University so that a better understanding of what caused such a massive landslide and the long-term risks of further such landslides occurring in the region.

The rockslide formed along an escarpment in northwest-dipping sandstones, and is characterised by a linear lateral scarp, a headscarp, and a bedding-plane rupture surface. It is the intersection of these features that controlled the rockslide block geometry. The slide surface is a smooth, northwest-dipping bedding plane that intersects with vertical fractures in the lateral scarp, forming a wedge. But this escarpment is only one of several in the area and so a detailed assessment of the other escarpments will be undertaken to assess the long-term risk of further rockslides in the landscape.

It is known that the principal failure mechanism was sliding involving a single large wedge-shaped block and that this rapid movement led to the partial disintegration of most of the block. Part of the detached slide block remained intact and has a mass of around 8.5m tonnes. The rest of the displaced mass forming the rockslide dam comprises disaggregated blocks in a sandy-silty matrix and the total mass of the rockslide dam. Luckily this disaggregated material helped form an excellent seal, stopping the leakage of water through the dam and reducing the risk of the dam being undermined.

With the lake now looking like it will be a permanent feature of the landscape, Council and the owners of Mangapoke and Paparatu Stations are looking to the lake's future. The new lake will provide a habitat for rare and endangered wildlife, and species such as dabchicks have already made their home there. The stakeholders plan to embark on indigenous planting programme to protect the rockslide dam from erosion and work to armour the outfall against scour from flood events. The lake is not accessible to the public and it is not available to boating since access is across private land with landowner permission required.

#03 CASE STUDY | HE TAUIRA

The mud volcanoes of Tairāwhiti

The new mud volcano in January 2019

The uplift and rupture of the land as the mud volcano was forming in 2016 after the Te Araroa earthquake – the uplift was a height of at least 1m

Our region is home to a significant number of mud volcanoes and their associated diapiric or dome-like structures. Others occur on the East Coast margin between Mahia and southern Hawke's Bay and there is also one in Northland. There has been very little detailed mapping and analysis of the features or understanding of relationship of the mud volcanoes' geological processes. It is known, however, that they form when pressures in the crust force mud and rocks to the surface along fault zones and that they typically include bentonitic muds, cold hyper-saline water and hydrocarbon gases.

More recently, Council has initiated a project to better understand the natural hazard implications, and the relationship between recent spectacular mud volcano activity that occurred in the Waimata Valley in December 2018 and earthquake shaking. Complementary geophysical projects by Council together with GNS Science have focused efforts on providing a rich source of new information on the mud volcanoes and the role they play in the plumbing of the margin.

While these mud volcanoes have been known for many years, it is very rare to see a new one form but that is what happened between November 2016 and December 2018. On 1 September 2016, a 7.1 magnitude earthquake occurred off East Cape north of Te Araroa, but caused little real damage . However, 175km away in the upper Waimata Valley the shaking caused one large well-known mud volcanic dome to push up which resulted in the ground on one side to be pushed sideways by 11.5m overnight. Close by, an area not known to have a mud volcano ruptured with many cracks forming and the area uplifting by at least a metre or more.

The area has been monitored regularly and on 15 December 2018 a new mud volcano erupted over a period of around five hours at the uplifted site. The eruption was not observed as the closest landowners were not home at the time but arrived to find the new mud volcano fully formed and occupying an area of 2.1ha (figure 3). Analysis of the rocks ejected from the mud volcano shows that they are dominated by sheared altered sandstone basement rocks but with six different types of younger rocks including highly gassy sandstones and siltstones.

#04 CASE STUDY | HE TAUIRA

Cyclone Cook Easter 2017

Ex-tropical Cyclone Cook struck Tairāwhiti late on 12 April 2017. The duration of peak rainfall intensities was a key driver during the event with rainfall of 80mm+ over a three-hour period causing woody debris within recently harvested forests to mobilise. The area of maximum rainfall was in the headwaters of the Uawa and Waiapu catchments. The impacts of the storm were exacerbated by the antecedent rainfall conditions with Cyclone Debbie occurring just over a week earlier.

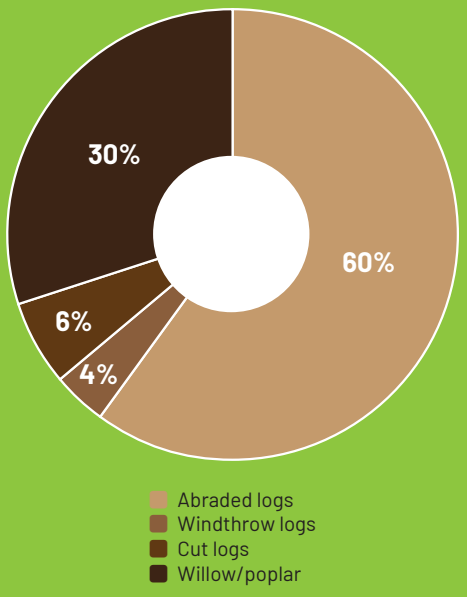
Only two major debris flows occurred, but smaller debris flows and landslides occurred in a number of locations across the Uawa catchment in particular. It was found that while not regionally extensive, those relatively small landslides that did occur were frequently associated with forestry areas that had been harvested in the previous five years.

The woody debris from the forests migrated down the Uawa catchment via the Mangaheia and Mangatokerau Rivers, eventually reaching the sea at Tolaga Bay. A considerable amount of debris was caught up against Wigan Bridge in the Mangaheia. The piles of woody debris at Wigan, along with log counts upstream of Wigan Bridge, and on Tolaga Bay Beach where students from Tolaga Bay Area School analysed the woody material established the dominant role of pine in the woody debris mobilised by the storm. This is not to say that willow did not contribute, since 30% of the debris was willow or poplar at Wigan and 32% on Tolaga Bay Beach.

Of the nearly two-thirds of material that was pine, it was found that the largest proportion of all pine were weathered or abraded logs (67% of all pine). Assessment of this suite of logs indicates that these weathered logs were originally cut logs and a number were observed with waratah marks. Equally significant was the finding that a small but notable proportion of the pine logs observed at Wigan Bridge were freshly cut logs. These comprised 8% of all pine. Windthrow pine was less abundant at 6% of all pine.

Log jam of pines in the Mangaheia River after Cyclone Cook

Percentage of woody material caught up against Wigan Bridge



LiDAR mapping

LiDAR (Light Detection and Ranging), is a remote sensing tool that has many applications in environmental and land management and is used extensively in industries such as forestry. It works by generating light pulses that can hit the earth's surface many times per square metre and accurately measure the position and elevation of those points over very large areas with vertical accuracies of 0.15m or more. This allows for maps and computer models to be generated that give a far more accurate definition of the earth's surface than other methods.

In 2017 Council obtained funding from the Ministry of Primary Industries and Land Information New Zealand (LINZ) to acquire high-resolution LiDAR covering the entire 8,355km^2 of our region. NZ Aerial Surveys commenced mapping in 2019. Mapping was 85% completed by early 2020 and is scheduled to be completed by mid 2020.

The LiDAR survey generates a huge amount of data and when the project is completed around 6-10 terabytes of computer storage will be required to hold the data. The LiDAR information is being made freely available to anyone by Council directly or via LINZ and is already being used by a number of parties:

- forestry industry for environmental planning
- Auckland University for a landslide risk assessment for Gisborne city, and erosion issues in the Waiapu catchment
- GNS for active fault mapping in the area south of Tolaga Bay, and a project to assess sedimentation patterns in the Waipaoa River is planned
- Canterbury University study into the processes at the Mangapoike landslide dam
- Council for a new Wainui Beach erosion management strategy, mud volcano mapping, landslide mapping and Gisborne city/Poverty Bay/Tūranganui-a-Kiwa flood hazard mapping
- other uses include enhanced mapping of potential pa and urupa, land use planning, landslide mapping, road design among many other uses.

Use of LiDAR to better define the Wheatstone Road mud volcano. The Wheatstone Road mud volcano is a well known feature on the outskirts of Gisborne city. The eruptive features are close to houses and are clearly visible on the 2018 aerial imagery. But the full size of the mud volcano is not apparent in the conventional aerial imagery and its not until the area is analysed using LiDAR that the full scale of the mud volcano can be appreciated. This shows that the area occupied by the mud volcano is far larger than previously known extending down Wheatstone Road for some distance and including the footprint of several houses.

URBAN LAND USE

Population growth and development

Most of our region's 47,900 people live in the Gisborne urban area – an increase of 900 from 47,000 in 2013. By 2048, 5,140 more people will be living in our region, in 2,565 additional households (McIlrath, Erasmus, and Fairgray, 2019)*.

Despite this modest growth, Gisborne remains among the country's slower growing regions at 1.7% a year compared to a national increase of 2.1%.

Over the next 20+ years, we expect to see the number of people living in the urban areas around Gisborne city to increase, while small settlements like Ruatoria, Tolaga Bay and Te Karaka will see a decline in the number of residents, consistent with overall historic patterns of population decline, as well as the broader trend towards increasing urbanisation (Hurst, 2020)*.

Urban growth will invariably put pressure on existing Council services and infrastructure within Gisborne. Conversely, rural population decline may affect the viability of Council services in our townships.

Housing supply and affordability

We are currently observing a rental market shortage in the Gisborne district — a shortage of homes on the market to buy, and an increasing demand for public housing. House prices have steadily increased over the last five years. In February 2020, the median house price was $450,000, a 15.4% increase on February 2019. Around two-thirds of the demand is for housing at $440,000 and below, suggesting that affordability will be an issue for many prospective home owners.

While there is currently a shortage of properties available to rent and buy, there is sufficient commercially feasible residential development capacity available to meet the level of projected demand over the short and medium terms.

Land capacity for business development

There is a reasonable mix of opportunities for business development across Gisborne. In the urban area, most of the capacity (61%) is associated with redeveloping sites to a higher density. Most of the other urban zones reveal a similar pattern, ranging between 58% and 67%. In the suburban commercial zones, the situation is reversed with 72% of capacity associated with vacant sites (McIlrath, Erasmus, and Fairgray, 2019)*.

	Mix of capacity	
Planning Zone	**Vacant**	**Redevelopment**
Amenity commercial	0%	100%
Fringe commercial	40%	60%
Industrial	42%	58%
Inner commercial	38%	62%
Outer commercial	33%	67%
Suburban commercial	72%	28%
TOTAL	**39%**	**61%**
Rural industrial	83%	17%
Rural commercial	60%	40%
TOTAL	**80%**	**20%**

* Population projections and capacity for business development taken from consultant reports prepared for Council.

Urban development trends

Gisborne city has continued to show an increasing intensification of housing. The area around the Taruheru Block has continued to see residential development in line with that signalled by the Tairāwhiti Resource Management Plan. Many of the residential lifestyle developments in the Taruheru Block are outside the reticulated boundary for sewerage. The impact of on-site wastewater in this area is an emerging issue for investigation particularly in light of the degrading water quality in the Taruheru River catchment as the land is poorly drained.

Other residential subdivisions include the Sponge Bay subdivision, Scarly's Way subdivision and Gaddums Hill Heights subdivision. There have been a number of new subdivisions approved which have created residential sections of varying sizes from 400m^2 urban plots to lifestyle options of around one hectare. Re-zoning changes in 2013 (Private Plan change 7) have seen the development of the Aerodrome Road Industrial Park commencing, and the relocation of several industrial business to the Dunstan Road area. Over the next three years, it is expected that the aspect of these areas will change from a predominantly rural outlook to that of an industrial land use.

Noise

Land use changes are impacting on background noise. Council undertakes a background noise survey every five years with the most recent survey undertaken in 2016. The present level of background noise was generally similar to the background noise level in 2004 although there are noticeable increases at several sites located near or adjacent to state highways, arterial and primary collector roads.

From the time of the first survey in 1993 to to the most recent one in 2016, there has been a noticeable increase in vehicle movements. Data provided for Tairāwhiti Roads indicates that there are around 3,500 more vehicles on our roads since 1999. The volume of heavy vehicles, particularly logging trucks, is likely to be responsible for an increase on the arterial roads.

Our region's log harvest has grown substantially to 1.6 million tonnes a year in 2014. This is forecast to have increased to 3.5 million tonnes during 2020 (NZTE Regional Investment Profile). This will increase the number of logging trucks on the roads. Monitoring sites on Moana, Ormond, Lytton and Awapuni Roads are recording an average of 8,000 -12,000 vehicles a day.

Urban revitalisation

Over the past five years, Gisborne has made significant steps forward with the regeneration of the city centre and surrounding urban area through successful interventions such as the Urban Cycleways Programme, Tairāwhiti Navigations, Inner Harbour redevelopment and redevelopment of vital community infrastructure such as the HB Williams Memorial Library and War Memorial Theatre. Through its Spatial Plan – Tairāwhiti 2050 – Council will begin to explore ways to revitalise the CBD through a number of key moves. These include:

- investigating the potential for a more compact city centre
- incentivising infill residential development
- construction of a linear park along Grey Street
- investigating the development of 'town squares'
- continuation of cross-town cycle links, and
- place activation through art displays, temporary events and low-cost installations.