

The Impact of Vehicles on Northern Pegasus Bay Beaches

GEOG309, November 2020

| Ben Kirk, Callum Snell, Grace Middleton, Mary Millett, Sarah Wilson|
| 92307706 | 34432830 | 21770447 | 49875070 | 43785470 |

Executive Summary	3
1. Introduction	4
1.1 Background	4
1.2 Objective	4
1.3 Location	4
2. Literature Review	5
2.1 Physical	5
2.2 Social	5
3. Methods	6
3.1 Physical	6
3.1.1 Traffic counters	6
3.1.2 Drone Imagery	6
3.1.3 Aerial Photography	6
3.2 Social	6
3.2.1 Survey	6
3.2.2 Observations	7
3.2.3 Public Submissions	7
3.2.4 Mana Whenua Engagement	7
4. Results	8
4.1 Physical	8
4.1.1 Traffic Counter Data	8
4.1.2 Drone Imagery	8
4.1.3 Aerial Photography	9
4.2 Social	10
4.2.1 Survey Demographics	11
4.2.2 Preference for Restriction	11
4.2.3 Awareness of Current Bylaw	11
4.2.4 Observational Data	14
4.2.5 Public Submissions	14
4.2.6 Spatial Distribution of Respondents	15
5. Discussion	16
5.1 Impact of Management Strategies	16
5.2 Recommendations	16
5.2.1 Restrict Vehicle use North of Pines Beach	16
5.2.2 Dune Protection	16
5.2.3 Introduction of Gate and Permit System at Kairaki	16
5.2.4 Enforcement	17
5.2.5 Limitations	17
6. Conclusion	18
7. Acknowledgements	19
8. References	20

EXECUTIVE SUMMARY

The purpose of this study is to explore what impacts vehicle use has on the social and physical values of Northern Pegasus Bay beaches. The research area is located north of Christchurch, from the Waimakariri River to the Ashley-Rakahuri Estuary. In 2010, the Waimakariri District Council (WDC) created the Northern Pegasus Bay Bylaw. The Bylaw was reviewed in 2016, where recreational driving was prohibited, and restrictions were tightened. This was done in the interest of public safety and environmental protection. At Kairaki and Pines Beach, vehicles were allowed on the beach if they had reasoning such as fishing or surfing. On the contrary, vehicle access to the Ashley-Rakahuri Estuary is gated and requires a permit. The 2016 Bylaw is being reviewed in 2021, and the results of this study will assist the council decide whether any changes are required.

Through the first three weeks of September, a survey was distributed to beach users. It analysed opinions on vehicle use at the beaches and questioned respondents on how well they knew the rules of the Bylaw. Altogether, 90 responses were recorded. While gathering survey responses from beach users, observations of vehicles were also made. These observations recorded a count of driving vehicles, and whether they were abiding by the Bylaw.

Traffic counters were installed at the beach access point of Kairaki Beach and the Ashley-Rakahuri Estuary, and at the Kairaki Beach carpark. These recorded vehicles entering and leaving the carpark and beach at these locations for two weeks.

Aerial imagery was captured by a drone at Kairaki Beach and the Ashley-Rakahuri Estuary. This was to analyse the current state of the environment at the two points of vehicle access onto the Northern Pegasus Bay beaches (NPBB).

The results of the survey indicated 81% of beach users believed vehicle use should be controlled rather than prohibited or unrestricted. Most respondents were either unsure or incorrect about the rules of the Bylaw, indicating a lack of awareness. However, fishermen and whitebaiters were the most aware of the Bylaw rules. This suggested that vehicle users were the most aware group of respondents.

The observational data showed that a large proportion of vehicle users did not adhere to the Bylaw despite their awareness. Many either did not slow down around pedestrians or did not drive on the intertidal zone.

This research has been limited by a short timeline for data collection, which was heavily influenced by weather and seasonal trends of activities.

The recommendations of this project are to restrict vehicle access to south of Pines Beach to manage the interaction between vehicles and pedestrian beach users. The dunes south of Pines Beach should be fenced off to promote dune health. A gate and permit system could be incorporated at Kairaki Beach, similar to the Ashley-Rakahuri Estuary. Further enforcement could also be integrated to help uphold the Bylaw.

1. INTRODUCTION

1.1 Background

The Northern Pegasus Bay beaches (NPBB) are used for recreational activities such as fishing, whitebaiting, watersports, and other leisure activities. Growing popularity of the beaches has led the Waimakariri District Council (WDC) to create a Bylaw, regulating vehicle use at the NPBB. The Bylaw imposed restrictions on vehicle use of NPBB to improve environmental health and promote safety at the beach.

The Bylaw (Northern Pegasus Bay Bylaw, 2016) was introduced in 2010 and reviewed in 2016. The key rules are as follows:

- Recreational driving is prohibited
- Driving above the high tide mark is prohibited
- Speed limit 30 km/hour, reduced to 10 km/hour within 50m of pedestrians

1.2 Objective

The aim of this project is to analyse and address the social and physical impacts of vehicle use on the NPBB. The results of this study are significant as they will assist the WDC with recommendations for the upcoming 2021 Bylaw review.

There is consensus in the literature of the physical and social impacts of vehicle use on beaches. This study builds on local research surrounding vehicle use on New Zealand beaches. The results of this report provide insight into the values of beach users of Pegasus Bay, which, alongside an understanding of environmental impacts, will assist in the effective management of vehicle use on NPBB.

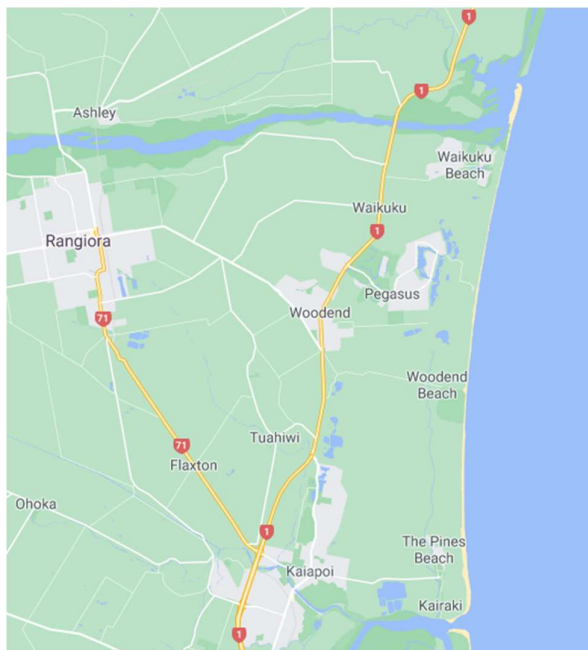


Figure 1: Location of the Northern Pegasus Bay beaches (Google Maps, 2020)

1.3 Location

The NPBB are located north of Christchurch, from the Waimakariri River to the Ashley-Rakahuri Estuary (Waimakariri District Council, 2020). This area includes Kairaki Beach, Pines Beach, Woodend Beach, and the Ashley-Rakahuri Estuary, the confluence of the Ashley River and Pegasus Bay (*Figure 1*). The main vehicle access point is at Kairaki Beach, where the Bylaws permits driving north, to a point between Pines and Woodend Beach. The Ashley-Rakahuri Estuary entrance is gated and requires a permit to gain beach access. All other beaches along the coastline are pedestrian access only. There are also varying degrees of dune protection along the study area, with the dunes north of Pines Beach, and at the Ashley-Rakahuri Estuary protected with cable fencing.

2. LITERATURE REVIEW

There has been extensive research that shows vehicle use on beaches has adverse physical and social effects. Within this project, there are several key themes. These include, but are not limited to, the impact of vehicles on sand dunes, vegetation, ecology, and community enjoyment.

2.1 Physical

Sand dunes are natural features that protect the land, people and houses from flooding and erosion. The taller the dune, the more protection they provide against coastal hazards. They also provide a habitat to many insects, birds, and lizards (Hoiser & Eaton, 1980). The two most important features of sand dunes are the height, which provides protection from flooding and storm events, and the sand-binding vegetation that helps prevent erosion (Stephenson, 1999). These features are jeopardised when driven over by vehicles, as the weight and tires destroy the vegetation and compact the dunes. This promotes erosion, which decreases their height and alters their form (Spence, 2014).

The overall stability of a dune system can be compromised from the degradation of vegetation (Schlacher, 2008) The damage to vegetation results in an unstable dune system, thus promoting erosion and providing a higher vulnerability to coastal hazards. After an initial disruption of the dunes, winds drive erosion processes. This generates more gaps in vegetation and therefore less coastal protection. Increased storminess will impact the overall protection of vegetation and dunes. Anthropogenic disturbances on the vegetation will further degrade their ability to support coastal environments.

Tuatua, among other invertebrate species, are filter feeders that live below the sand of the intertidal zone. They play a key role in the food chain as they support higher consumers like birds and fish and contribute to nutrient recycling on beaches (McLean et al., 2018). According to the Northern Pegasus Bay Bylaw, vehicles are only allowed to drive on the intertidal zone. This impacts the tuatua population as they are crushed when driven over by vehicles (Taylor, 2013). Tuatua are culturally significant to Māori as they are a traditional source of kai moana.

2.2 Social

Previous studies have found that vehicle use can be detrimental to both the enjoyment and safety of all beach users. Petch et al. (2018) found that for people who treated the beach as a place to explicitly four-wheel drive for enjoyment drove much faster than other people who drove on beaches. This disrupted over 70% of the area the vehicles drove on. A study conducted at south-eastern Australian beaches found 67% of people preferred vehicles to be banned from the beach. This was due to the safety of other beach users and environmental concerns (Maguire et al., 2011). In Port Elizabeth, South Africa, De Ruyck et al. (1995) found that 81% of survey respondents wanted vehicles banned from the three beaches studied, with the primary reasons again being the safety of other users.

3. METHODS

The issues surrounding vehicle use at the beach have both environmental and social impacts, therefore the methods section of this research has been separated into two parts. The social proportion focusses on beach users' perceptions, and the physical portion focusses on environmental impacts.

3.1 Physical

To measure the physical impacts, three methods were used to collect data. This included the use of traffic counters, drone imagery, and historical aerial photography.

3.1.1 Traffic Counters

Traffic counters were installed on 4th September at three points along the NPBB. Two were installed at Kairaki Beach - one at the entrance to the carpark and the other at the beach access point. The final counter was installed at the beach access point at the Ashley-Rakahuri Estuary. The data collection process continued until 22nd September. Traffic counters were used to assess the volumes of vehicle use at the two beach access points. This data can be used to gauge where people are accessing the beach, and compare the traffic volumes and relative impacts on the beach environment between the sites.

3.1.2 Drone Imagery

Drone imagery of Kairaki Beach and the Ashley-Rakahuri Estuary was captured by a Phantom 4 Pro Drone on 21st September 2020. This data was then used to produce a Digital Elevation Model (DEM) and a 3D Point Cloud using ArcGIS. The Ashley-Rakahuri Estuary is entry by permit only, whereas Kairaki Beach is accessible without a permit. The purpose of the drone imagery is to analyse the current health of the dune environment.

3.1.3 Aerial Photography

The final method was the use of historical aerial photography from Canterbury Maps (2020). The imagery was used to compare Kairaki Beach and the Ashley-Rakahuri Estuary in 2010 (before the Bylaw was implemented), 2014 (after the Bylaw was created) and in 2020 (after the Bylaw review). The purpose of this was to examine dune and vegetation health and analyse regeneration over time.

3.2 Social

To measure the social impacts that vehicles have on the community, four methods were used to collect data. These included the production of a survey, recording of observations, reviews of public submissions and engaging with mana whenua.

3.2.1 Survey

Previous studies have shown that surveys prove useful for gathering knowledge from a community (Sheskin, 1985). Therefore, a survey was produced and then distributed, both online and physically to beach users at Kairaki and Pines Beach, and the Pines Beach campground.

The survey gathered information on the respondents' demographics. It asked questions surrounding the Bylaw rules to gauge beach user awareness. The respondents were also asked to express their preference for restriction on vehicle use. After, they were asked to elaborate on their reasoning. This allowed an understanding of where awareness was lacking surrounding the Bylaw. The survey also provided information on what activities respondents

used the beach for. The intercept survey had 11 questions and was distributed to beach users, twice a week for three weeks. Time spent at the beach was equivalent to approximately two hours per session, with about 10 respondents per hour. The final number of respondents was 90, with 50 paper copies completed and 40 completed online. The online version was distributed through Survey Monkey, which only allowed 10 questions. This was linked through a quick response (QR) code on the paper copy of the survey, and posted in targeted community groups on social media. The link allowed people to fill in the survey, then share it to their friends and family. This snowball method was adopted from Biernacki and Waldorf (1981), and with the use of this method 40 online respondents took part. The survey has been designed specifically to target active beach users and is therefore not required to be representative.

3.2.2 Observations

Observations were recorded during each session at the beach, which allowed data collection on whether people were abiding by the rules. The two observations that were recorded were if a vehicle slowed down when they neared a pedestrian, and if the driver was driving on the intertidal zone. Though there was no way to measure speed, it was straightforward to determine whether a vehicle slowed when it came close to pedestrians.

3.2.3 Public Submissions

After a review of the 2010 Northern Pegasus Bay Bylaw, the WDC received submissions in 2015 from the public. These highlighted their concerns and allowed for comments on the proposed changes. The submissions were separated into categories representing key areas of concern, which included the environment, ecology, safety, accessibility, permits, motorbikes, and education.

3.2.4 Mana Whenua Engagement

The final method used to analyse the social component of this research was to engage with mana whenua. The connection that the WDC had with local iwi was used to notify them about this project. Before the survey was dispatched, it was passed onto the chair of Te Ngai Tuahuriri Runanga, allowing the opportunity for any comments. This was to ensure māori values were represented in the research.

4. RESULTS

4.1 Physical

4.1.1 Traffic Counter Data

During the observation period, 1,960 vehicles entered Kairaki Beach via the carpark. This was approximately 40% of the traffic volume of the carpark. Through the same period, less traffic was recorded entering the beach from the gated access of the Ashley-Rakahuri Estuary. The Ashley-Rakahuri Estuary is subject to approximately two-thirds of the traffic flow at Kairaki Beach (*Table 1*).

Table 1: Traffic data showing the number of vehicles entering the Kairaki carpark, Kairaki Beach and the Ashley-Rakahuri Estuary.

	Kairaki Carpark	Kairaki Beach	Ashley-Rakahuri Estuary
5/09/20 - 12/09/20	2406	987	564
12/09/20 – 19/09/20	2461	973	674
Total	4867	1960	1238

4.1.2 Drone Imagery

Figures 2 and 3 show the current health of the sand dunes at Kairaki Beach and the Ashley-Rakahuri Estuary. There are small vegetated foredunes at both locations, however they are thicker at the Ashley-Rakahuri Estuary. There are prominent vehicle tracks, shown in Figure 2, that are not present in Figure 3.



Figure 2: Aerial imagery of Kairaki Beach captured using the Phantom 4 Pro drone and merged using ArcGIS (2020).



Figure 3: Aerial imagery of the Ashley-Rakahuri Estuary captured using the Phantom 4 Pro drone and merged using ArcGIS (2020).

4.1.3 Historical Aerial Imagery

Figure 4 shows the temporal variations of the dunes through different regulatory periods at Kairaki Beach. Figure 4a shows sparse and heavily eroded dunes by the river mouth, with sporadic vegetation. This was before the Bylaw was implemented. Further up the coast the dunes are in similar condition, with little vegetation and vehicle tracks throughout. Figure 4b shows some regeneration of dunes both at the river mouth and along the coast. Developed vehicle tracks separate the dunes and only a small area of foredune is visible. This was after the introduction of the Bylaw. Figure 4c shows further dune regeneration, and pioneer plants have allowed the development of intermediate species such as Pohuehue. This was four years after the Bylaw was reviewed and recreational driving excluded.



Figure 4: Aerial photography of Kairaki Beach in 2010 (a), 2014 (b) and 2020 (c). Retrieved from Canterbury Maps (2020).

Figure 5 shows the temporal variations of the dunes through different regulatory periods at the Ashley-Rakahuri Estuary. Figure 5a shows heavy erosion, with vehicle tracks through the back dunes, and little vegetation on the retreating foredunes. Figure 5b shows significant development and revegetation of the foredunes. Embryo dunes have also developed, although erosion is still evident and there are patches where vegetation is sporadic. As shown by Figure 5c, the dunes have improved steadily since the Bylaw was set to allow vehicles only with a permit to access this area.



Figure 5 Aerial images of the Ashley-Rakahuri Estuary in 2010 (a), 2014 (b) and 2020 (c). Retrieved from Canterbury Maps (2020).

4.2 SOCIAL

4.2.1 Demographics

The demographics of the respondents are outlined in Tables 2, 3 and 4. There was a diverse age range, and a slight gender skew to the data. The majority of respondents were local to the Waimakariri region, with approximately one-fifth visiting from Christchurch.

Table 2: Age of respondents.

Age Range	18-29	30-39	40-49	50-59	60-69	70+	Total
Count	24	13	21	19	7	6	90

Table 3: Gender of respondents.

Male	Female	Total
56	34	90

Table 4: Where respondents were visiting from.

Waimakariri District	Christchurch	Total
79	21	90

4.2.2 Preface for Restriction

Respondents were asked their preferred level of restriction between restricted, controlled and prohibited. Out of the 90 beach users surveyed, the majority of respondents selected 'controlled' (Figure 6). An approximately equal number of respondents preferred unrestricted and prohibited vehicle use.

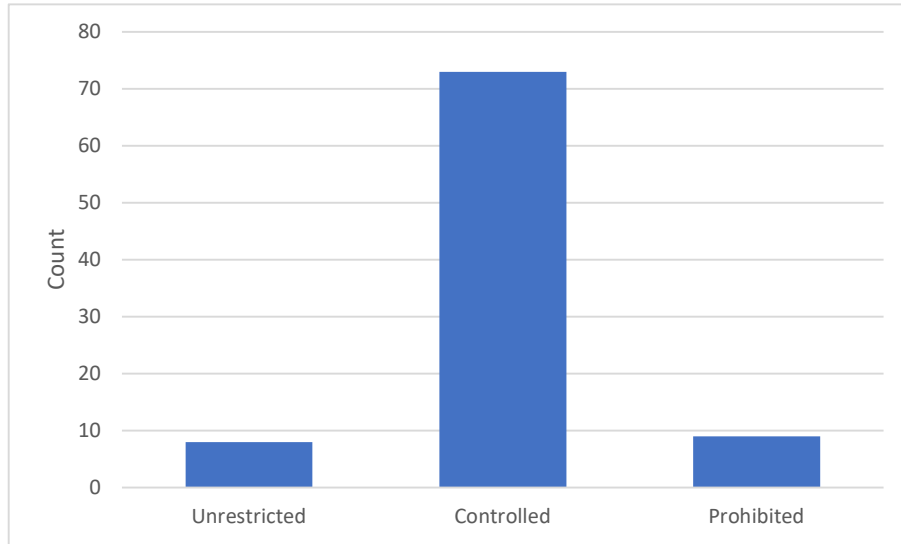


Figure 6. Respondents preferred level of vehicle restriction

After being asked their preferred level of restriction, respondents were asked to comment on their decision. Figure 7 outlines the categories of concern of the survey respondents. Pedestrian safety and maintaining accessibility for those with legitimate reasons to drive on the beach were the most reoccurring comments. Environmental and ecological concerns were also frequently mentioned. There were an approximately even number of people calling for further and fewer controls. Beach users also suggested that a permit system be introduced, and the Bylaw be sufficiently enforced.

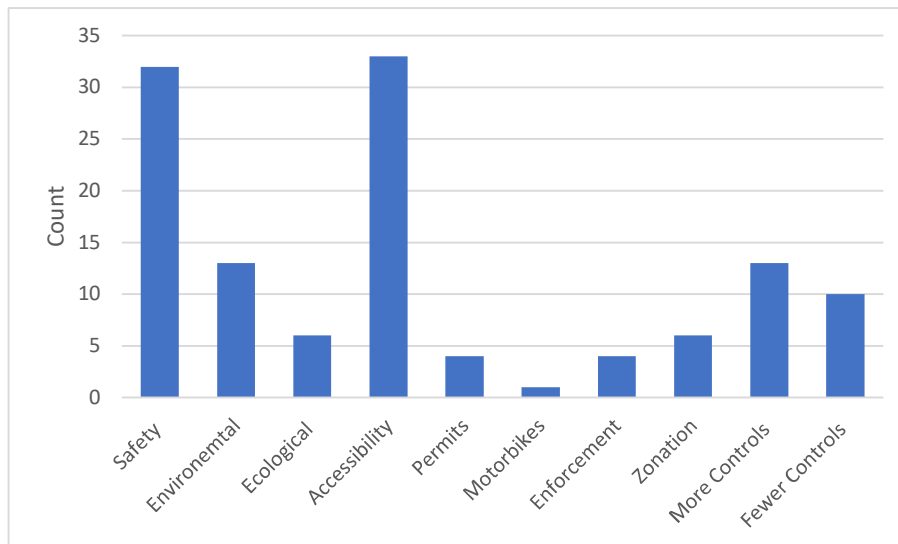


Figure 7: Categories of concern to survey respondents.

4.2.3 Awareness of the current bylaw

Table 6 displays how aware respondents claimed to be. Approximately half of the beach users claim to have had some level of awareness around the Bylaw, or understood there were controls around certain activities. Many respondents had no awareness of the Bylaw or rules.

Table 5: Respondent awareness of the 2016 Bylaw.

Aware	Aware of Bylaw, but unsure of rules	Unaware, but understand some activities are controlled	Unaware
30	12	11	37

Respondents were then asked about their understanding of vehicle related controls on the beach (Figure 8). This covered the main points surrounding the Bylaw. These were: what sections of the beach were permitted to drive on, whether four-wheel driving is permitted, the speeding regulations, and whether driving on stretches of the beach was prohibited.

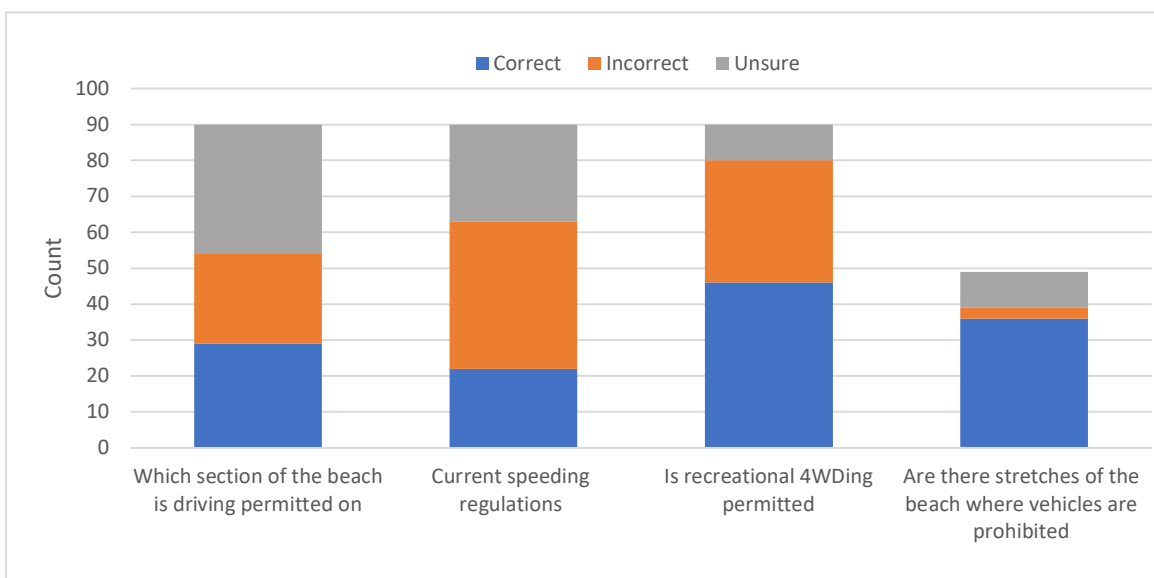


Figure 8. Respondents understanding of vehicle related controls.

Figure 8 indicates that in almost all cases, beach users were either unaware or mistaken in their understanding of the current Bylaw. The only exception to this is the final question, where most beach users were able to identify that there were sections of the NPBB where vehicles were prohibited. Just 22% of beach users were able to identify the correct speeding regulations, and less than one third could determine which section of the beach driving is permitted on.

Figure 9 shows how aware respondents were of the Bylaw, grouped by how they used the beach. Both proportionately and outright, the most aware group was fishermen, with approximately two-thirds saying they were aware. The next most aware groups were the walkers and dog walkers, with approximately one in five being aware.

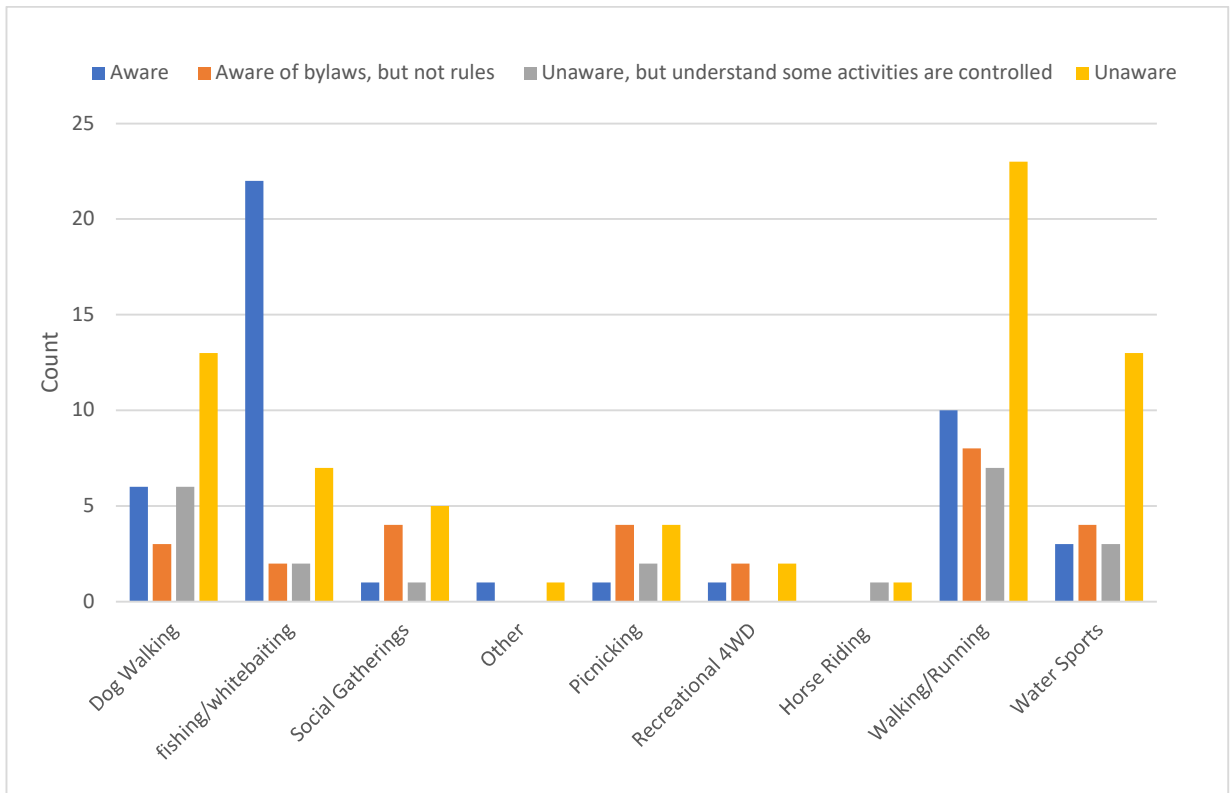


Figure 9: Respondents' awareness grouped by activity.

To ensure the data has not been skewed by participants selecting they were aware when they were not, Figure 10 shows a breakdown of how well the 'aware' group understood the Bylaw. Of the 30 respondents who selected aware, 20 have a maximum of one incorrect answer. This indicates 33% of respondents were either untruthful, or had mainly false understanding of the Bylaw.

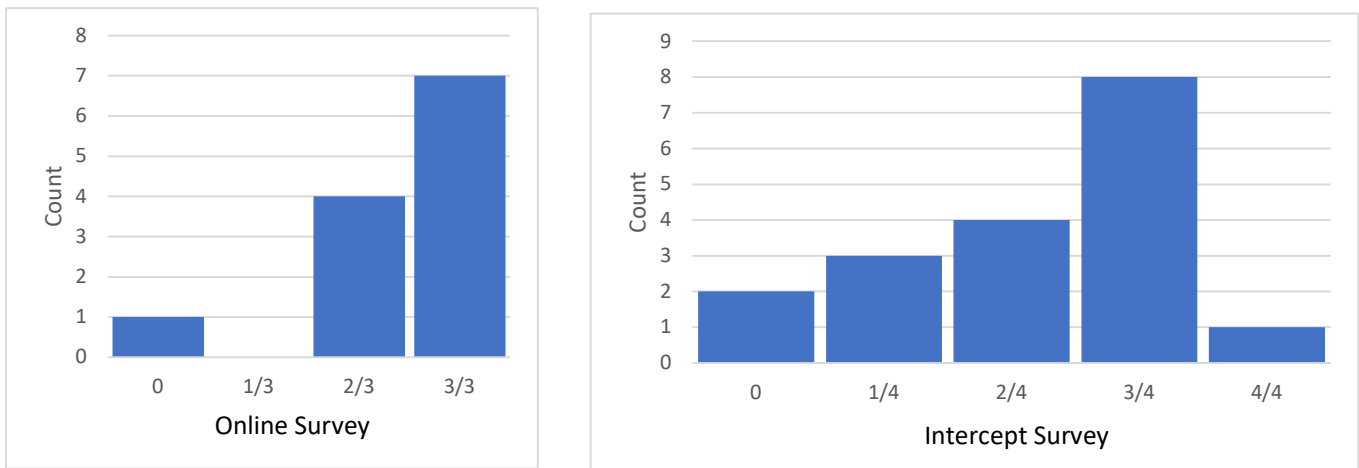


Figure 10. Understanding of vehicle related controls of the 'aware' respondents

4.2.4 Observations

Thirty-five observations revealed that vehicles slowed down near pedestrians approximately two-thirds of the time (Figure 11). However, only half of the recorded vehicles were driving on the intertidal zone. These results demonstrate that of active vehicle users of the beach, there are a large proportion that are either unaware, or unwilling, to abide by the current regulations.

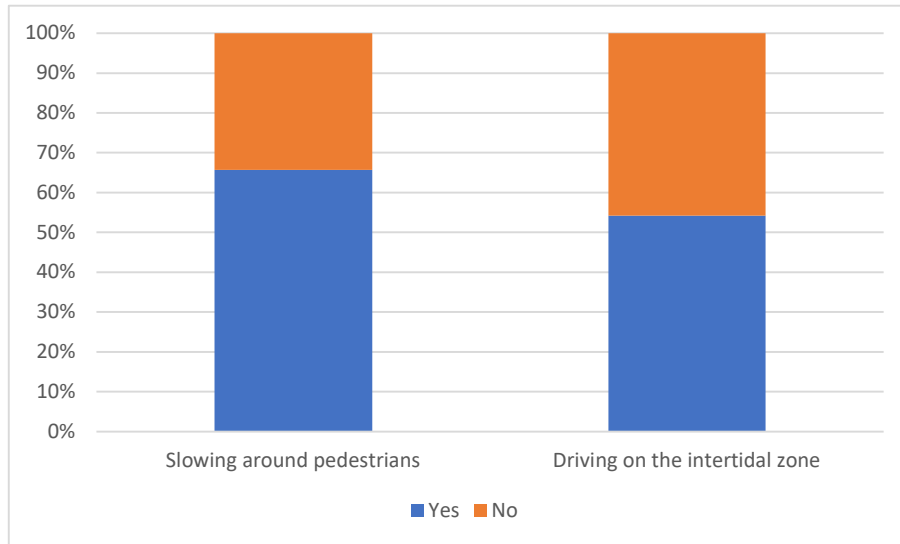


Figure 11. Observational data on whether people were abiding by the Bylaw rules.

4.2.5 Public submissions

Figure 12 shows the categories of concern from the 2015 vehicle related submissions. Although collected under different circumstances, the comments in these submissions broadly align with the results outlined in section 4.2.2. Public safety was again the most reoccurring issue, and environmental and ecological concerns were much more prominent. The concept of a gate and permit system for Kairaki Beach was again raised.

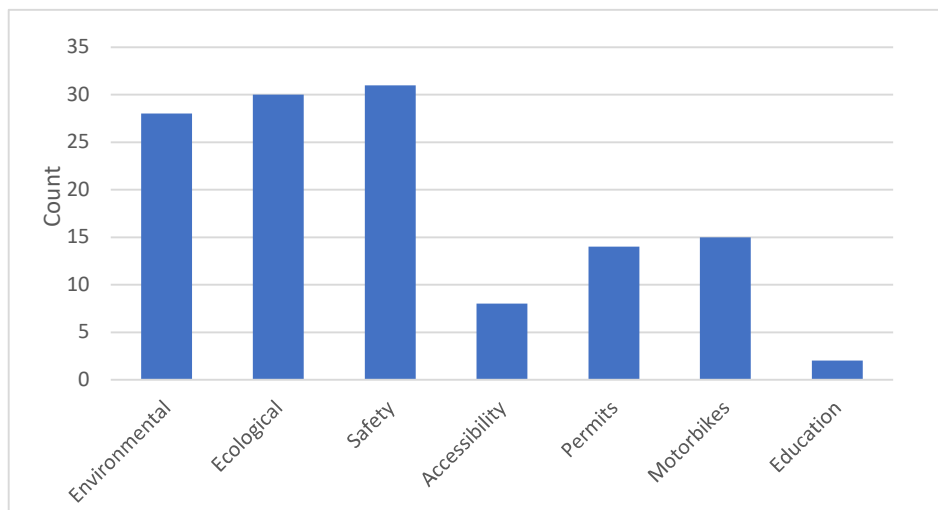


Figure 12: Vehicle restriction based on area of residency.

4.2.6 Spatial Distribution of Respondents

The research has revealed a spatial relationship between where respondents were from and their preference for restriction. Figure 2 shows an approximately even number of people preferring 'uncontrolled' and 'prohibited' with regards to vehicle restrictions (section 4.2.2). However, analysing the spatial structure of these preferences revealed that most respondents preferring unrestricted vehicle use are from Christchurch, and almost all the respondents preferring control were local to the region (*Figure 13*).

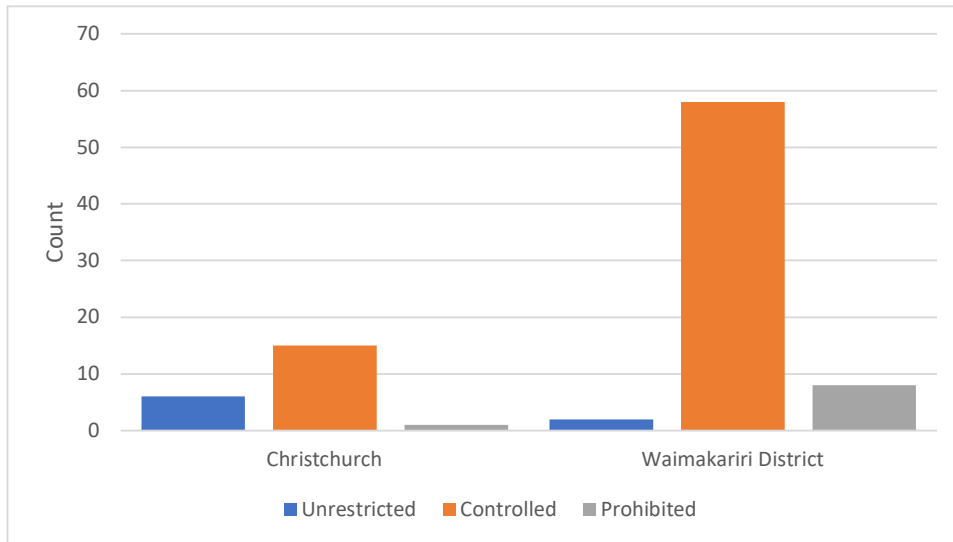


Figure 13. Spatial distribution of preference for restriction

This is a dynamic and complex pattern which this study was not designed to explore conclusively. However, it is possible that beach users who have a closer geographical connection to the area are more likely to have stronger stances on the issues identified in sections 4.4.2 and 4.2.5.

5. DISCUSSION

5.1 Impact of management strategies

Comparing the aerial photography of the two vehicle access points over time highlights the impacts of different management strategies on the regeneration of dunes and vegetation (section 4.2.3). The Ashley-Rakahuri Estuary entrance has a gate and permit system. Greater restriction of access has led to a faster regeneration of the dunes and vegetation compared to the ungated entrance at Kairaki Beach. This is partially due to the lower traffic volumes (*Table 1*), leading to a lower physical impact. However, dune health is disproportionately better at the Ashley-Rakahuri Estuary, which saw approximately two-thirds of the vehicle activity at Kairaki Beach through the observation period. The accelerated regeneration of the Ashley-Rakahuri Estuary may be due to the gate and permit system. This helps to ensure that vehicle users have a legitimate purpose for beach access. The drone imagery further exemplifies this, showing several vehicle tracks cutting through the vegetated dunes at Kairaki Beach, compared with almost no tracks at the Ashley-Rakahuri Estuary (section 4.1.2). This will be a factor in the accelerated regeneration of the dunes at the Ashley-Rakahuri Estuary.

5.2 Recommendations

The main concerns that the community raised were public safety, environmental impacts and ensuring accessibility to those who require it. Therefore, several recommendations have been produced to mitigate the impacts that vehicles have on the NPBB, surrounding these key issues.

5.2.1 Restrict Vehicle Use North of Pines Beach

As identified in sections 4.2.2 and 4.2.5, safety was the largest concern in the survey and the 2015 submissions. The majority of respondents indicated a preference for vehicle use to be controlled as opposed to prohibited (*Figure 1*). This demonstrates that beach users accept the multi-use nature of the beach, and so a balance is required to ensure that the interests of different groups are represented fairly with the level of regulation.

Therefore, this report proposes to restrict vehicle access to south of Pines Beach. Currently, the entrance to Pines Beach is pedestrian only. Due to this, the area is used for social gatherings, picnicking and leisure activities. Although there is no vehicle access from the Pines Beach carpark, vehicle users can drive north from Kairaki Beach and past pedestrians at Pines Beach. This jeopardises the safety of pedestrian beach users, as vehicles frequently drive past them. Restricting vehicle use to south of Pines Beach uses zonation to minimise interactions between vehicles and pedestrian beach users.

5.2.2 Dune Protection

Sections 4.2.2 and 4.2.5 of this report also demonstrates that the environment and ecology of the beach are also areas of concern for the public. This report recommends installing cable fencing around the dunes between Kairaki and Pines Beach, similar to the Ashley-Rakahuri Estuary. This will mitigate environmental degradation and dissuade vehicle users from

entering the dunes. Aerial photography and drone imagery have indicated that the health of the dune environment in this area is significantly better than that of Kairaki Beach (section 4.1.2, section 4.1.3). Due to the improvement of dunes and vegetation in the areas that are fenced, it is evident that the fencing has encouraged people to keep their vehicles off the sand dunes. Therefore, fencing of all sand dunes will benefit the environment of NPBB.

5.2.3 Introduction of Gate and Permit System

This research has indicated that a large proportion of average beach users, self-proclaimed 'aware' beach users, and observed vehicle users all showed either a lack of understanding, or an unwillingness to follow the Bylaw (section 4.2.2, section 4.2.3, section 4.2.4). This is a challenge for effective management of vehicles at NPBB. The Bylaw has been implemented in consideration of safety and environmental concerns; however, results are limited by how closely these restrictions are followed. A possible solution to this is to gate access at Kairaki Beach and to adopt a permit-based system, similar to the one in place at the Ashley-Rakahuri Estuary. This is echoed by the survey and submission data, in which a permit system was a reoccurring suggestion (*Figures 2 & 11*). This maintains a balance between environmental and public safety values, and ensures accessibility for vehicle users acting within the rules of the Bylaw; the three most reoccurring comments of the survey and public submission results.

Kairaki Beach is the main access point to all beaches north of this area. Gating the entrance would mean vehicles are required to apply for a permit through the WDC to gain access. This ensures vehicle users have a legitimate reason for access, as outlined in the current Bylaw. Permits must be inexpensive to ensure that there is no financial barrier to access the beach. This has the potential to further reduce recreational driving, which, as indicated throughout this report, is a significant issue for NPBB. Granting permits can be used as a tool to raise awareness of the Bylaw and environmental importance of the beach; issues identified in the survey that needed improvement (section 4.2.3). All vehicle users would then gain an understanding of the Bylaw and the environmental significance of the area.

5.2.4 Enforcement

Many of the submissions stated that because the Bylaw is not properly enforced, the rules are less likely to be followed. To maximise the efficiency of a permit system, a Bylaw breach submissions scheme could be introduced on the council website. The submissions scheme would have a drop box to upload a photo or video to report vehicles not adhering to the Bylaw. This introduces a platform for disciplinary action, which could be in the form of a financial penalty. If used in conjunction with the recommended permit system, this could result in the loss of access privileges.

5.3 Limitations

The short observation period has limited the robustness of the data collected. The three weeks of survey and observational data, and two weeks of traffic data have given a snapshot of the physical and social environment. However, these time scales are too short to extrapolate out to seasonal and annual trends. The observation period of this research also falls within the whitebaiting season, which has potentially skewed the traffic data and shifted the demographic of beach users.

This was further exacerbated by poor weather limiting the opportunities for field work, resulting in fewer potential respondents at the beach. The online survey combated this, however as it is an anonymous survey, it was not possible to verify they were active beach users. The survey software was restricted to 40 respondents and a maximum of 10 questions, which further limited the effectiveness of the online survey.

This research has implications for access to mahinga kai sites, therefore is of significance to mana whenua. Local iwi were contacted at the onset of the research and asked for comments, to ensure mana whenua values were appropriately represented. Again, due to the short timeline, the research communication was limited. However, mana whenua values were still represented through the review of public submissions.

6. CONCLUSION

This research addresses and analyses the social and physical impacts of vehicles on the NPBB. The study is of importance to the wider community as it builds on local knowledge of the impacts that vehicle use poses on New Zealand beaches. The physical and social components of this research show that vehicles have a significant impact on beach users and the environment of the NPBB. This research has illustrated that dune health had increased drastically when permits were put in place. There has also been a strong indication that the beach users accept the mixed-use nature of NPBB, therefore effective management is required to balance the interests of different groups. The proposed recommendations will mitigate these impacts and will increase public awareness on the Bylaw and the environmental significance of the area. If instated, these recommendations will generate a safer environment and minimise the social and physical impacts of vehicle use on the NPBB.

7. ACKNOWLEDGEMENTS

A special thanks to Mike Kwant from the Waimakariri District Council, our community partner. Further acknowledgments to our supervisor Lindsey Conrow for guiding us through the course, and Matt Cockcroft for piloting the drones for our data analysis. Lastly, thank you to the GEOG309 course coordinators Simon Kingham and Jillian Frater.

8. REFERENCES

- Biernacki and Waldorf. (1981). Snowball Sampling. *Problems and Techniques of Chain Referral Sampling*, 141-63. Retrieved from <https://journals.sagepub.com/doi/pdf/10.1177/004912418101000205>
- Canterbury Maps. (2020). Retrieved from <http://mapviewer.canterburymaps.govt.nz/>
- Google Maps (2020). Retrieved from <https://www.google.com/maps/search/beach+near+Pegasus+Bay,+Canterbury/@-43.3451736,172.6515963,12z>
- De Ruyck, A. M. C., Soares, A. G., & McLachlan, A. (1995). Factors influencing human beach choice on three South African beaches: A multivariate analysis. *GeoJournal*, 36(4), 345-352. Retrieved August 13, 2020, from www.jstor.org/stable/41146541
- Hilton, M. J. (2006). The loss of New Zealand's active dunes and the spread of marram grass (*Ammophila arenaria*). *New Zealand Geographer*, 105-120.
- Hosier, P., & Eaton, T. (1980). The Impact of Vehicles on Dune and Grassland Vegetation on a South-Eastern North Carolina Barrier Beach. *Journal of Applied Ecology*, 17(1), 173-182. doi:10.2307/2402972
- Luke MC. Thompson, T. A. (2008). Physical damage to coastal dunes and ecological impacts caused by vehicle tracks associated with beach camping on sandy shores: a case study from Fraser Island, Australia. *Journal of Coastal Conservation*, 67-82.
- Maguire, G. S., Miller, K. K., Weston, M. A., & Young, K. (2011). Being beside the seaside: Beach use and preferences among coastal residents of south-eastern Australia. *Ocean & Coastal Management*, 51(10), 781-788. <https://doi.org/10.1016/j.ocecoaman.2011.07.012>
- McLean, I., Richardson, D., Schlacher, T. (2018, February 12). Impacts of Off-Road Vehicles (ORVs) on Macro-benthic Assemblages on Sandy Beaches. Retrieved from <https://link-springer-com.ezproxy.canterbury.ac.nz/article/10.1007/s00267-008-9071-0>
- Petch, N., Maguire, G. S., Schlacher, T. A., & Weston, M. A. (2018). Motivations and behaviour of off-road drivers on sandy beaches. *Ocean & Coastal Management*, 163, 82-91. <https://doi.org/10.1016/j.ocecoaman.2018.05.021>
- Sheskin, I.M. (1985, January). Survey Research for Geographers. Retrieved from https://www.researchgate.net/publication/304249085_Survey_Research_for_Geographers
- Spence, H. (2014). Effects of vehicles on sand dunes. Dune Restoration Trust. 10(2), 1-12. Retrieved from https://www.coastalrestorationtrust.org.nz/site/assets/files/1185/10.2_effects_of_vehicles.pdf
- Stephenson, G. (1999). Vehicle impacts on the biota of sandy beaches and coastal dunes. Science for Conservation (Report No. 121). Department of Conservation. Retrieved from <https://www.doc.govt.nz/Documents/science-and-technical/sfc121.pdf>
- Taylor, G. (2013). Management of Sand Beaches for the Protection of Shellfish Resources. 1-258. Retrieved from https://ir.canterbury.ac.nz/bitstream/handle/10092/8207/thesis_fulltext.pdf?sequence=1&isAllowed=y
- Thomas A. Schlacher, L. M (2008). Physical Impacts Caused by Off-Road Vehicles to Sandy beaches: Spatial Quantification of Car Tracks on an Australian Barrier Island. *Journal of Coastal Research*, 234-242
- Waimakariri District Council. (2016, June 20). Waimakariri District Council Northern Pegasus Bay Bylaw 2016 Retrieved from

https://www.waimakariri.govt.nz/__data/assets/pdf_file/0018/24138/Northern-Pegasus-Bay-Bylaw-2016.pdf

Waimakariri District Council. (2020). Beach and Estuary. Retrieved from Waimakariri District Council: <https://www.waimakariri.govt.nz/leisure-and-recreation/activities/outdoor-activities/beach-access>