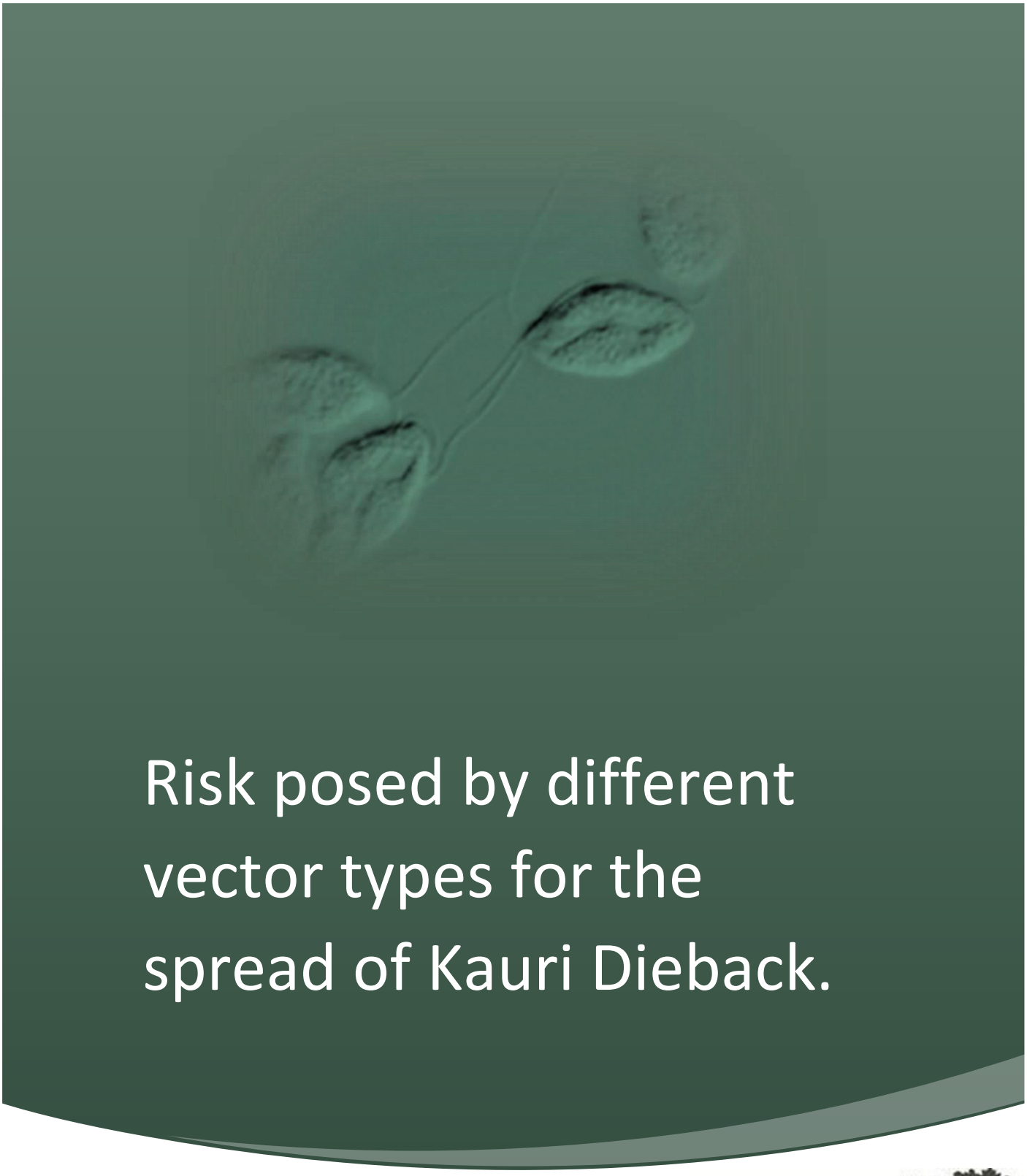

Risk posed by different vector types for the spread of Kauri Dieback.

KAURI DIEBACK PROGRAMME

KEEP KAURI STANDING
STOP KAURI DIEBACK DISEASE SPREADING
WWW.KAURIDIEBACK.CO.NZ

A risk analysis on interactions that are suspected to threaten kauri.

Hannah M. Smith

Contents

2. Introduction:

Phytophthora agathidicida is a fungus like pathogen within the class of Oomycete. Oomycetes or water moulds are commonly present as a plant pathogen(Scott & Williams, 2014). kauri dieback is a species specific plant pathogen that targets *Agathis australis* (kauri) at all ages and sizes, by parasitizing on the feeding roots of the trees (Waipara, Hill, Hill, Hough, & Horner, 2013). The pathogen starves the tree of essential nutrients and oxygen; this starvation is what eventually will kill the host tree making it a real threat to the survival of this species (Jamieson et al., 2014). This pathogen is a difficult biosecurity threat to manage, as the pathogen is highly resilient especially while in the oospore stage; the oomycete is able to remain dormant for at least 6 years which allows for the pathogen to be dispersed to new locations or to wait for optimum conditions(Waipara et al., 2013). Zoospores are the motile life stage when at this stage the oomycete is equipped with a tail. This allows the spore to swim through the water film present in the soil and actively seek out kauri roots to parasitize(McKenzie, Buchanan, & Johnston, 2002)(Waipara et al., 2013). Another difficulty with this pathogen is there can be a lag phase between infection and visibility of infection; this means that trees can appear healthy which limits the response for management.

The purpose of this report is to analyse how different activity and industry types use areas with kauri, and to understand how they interact with the soil, with particular regard to the extent to which they might distribute soil to new areas.

3. Aims and Objectives:

This study aims to identify high risk human vectors of *Phytophthora agathidicida* and address which areas require future management and partnerships to ensure the containment of kauri dieback is successful. A secondary benefit of the survey was to establish contacts with the representatives of the various activity groups.

4. Method:

This risk analysis was undertaken in 3 steps. The first was the vector approach, in which background research into identified vector groups was performed and a list of contacts was compiled. The second step was the survey, which was designed to identify how high of a risk each vector type was to the spread of kauri dieback. The third was the risk analysis, in which all the data collected was analysed to show which of the vector groups are a high risk. A statistical analysis was then performed to measure the significance of the various findings.

4.1 Vector Approach:

The targeted vector groups were identified by either previous work (Harrison, 2015) or were compiled in a Kauri Dieback Programme workshop.

Background research was conducted to better understand how these potential vectors operated. Online research was used to learn about the different vector groups as well as to identify who the appropriate person to contact was to help tailor the approach before contact was made with each vector group. To help ensure the correct person was participating in the survey, contact was made with the organisation's human resources staff or their group coordinators. From there the survey would either be conducted, or a referral would made, typically an environmental coordinator. To

prompt any conversation an email was then sent to selected representatives of each activity group, introducing the researcher (myself) and the project. This involved explaining what would be expected of them as well as explaining that their answers would not lead to prosecution (so as to eliminate any bias and encourage people to be more forthcoming).

4.2 The Survey:

Each question in the questionnaire had multiple answers to select from. These answers were allocated a numeric value which represented the level of risk each activity posed. These values were then used to formulate a risk score which represented how likely each vector group was to spread soil containing *Phytophthora agathidicida.*

Interviews were conducted in a conversational style. This method was chosen as it allowed for richer conversation which rendered a better understanding of the risk each group posed (a formal interview could restrict the type of information volunteered, and limit the accuracy of the final risk score).

The questionnaire had two components; the first was a movement risk score which focused on the risk each activity posed in terms of spreading kauri dieback. The second was the perception risk score which evaluated how vector group members 'typically' perceive themselves as a potential vector, and how they prioritise helping stop the spread of dieback.

The categories used in the questionnaire were based on how the vector groups move soil, how much is moved, why this activity occurs, how often the activity typically occurs, and where the soil is moved to (urban areas or areas more likely to have significant numbers of native trees). Using these questions each activity then had an assumed risk value attached, which assisted in prioritising the order in which vector groups were interviewed.

4.3 Risk Analysis:

As this report is interpreting representative data collected from sample populations, statistical analysis was used to test how accurately the results represented the full population of the vector groups. Statistical testing was also used to test for any significant correlation between both the perceived risk score and the movement risk score.

To test if there was any significant relationship between the Perceived risk score and the Movement risk score an Analysis of Variance (ANOVA) test was performed. ANOVA was also used to test for any significance between vector types and Risk score.

$(\Sigma m + \Sigma p \ + \sum T = \frac{x}{3} =$ Average risk score)

(Average movement risk score + average perception risk score + average total risk score) / 3 = average risk score

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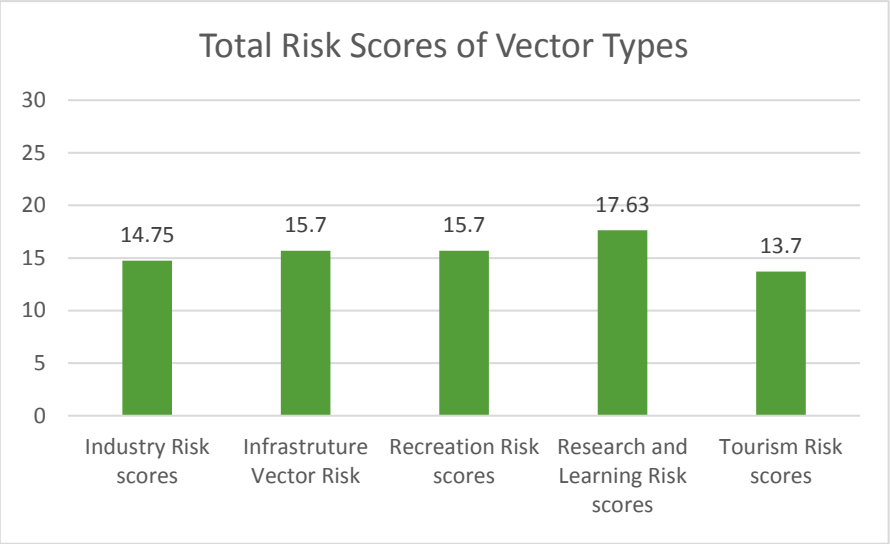
5. Results:

5.1 The Survey:

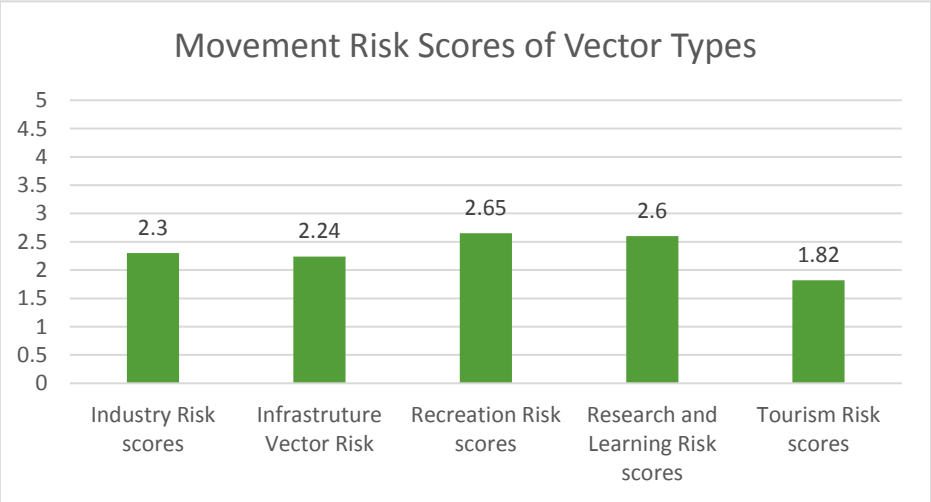
The Survey was conducted over 3 months (December through to February) however due to the time of year many businesses and organisations were not active over the holidays so the majority of sampling was conducted during late January and early February.

5.2 Risk analysis:

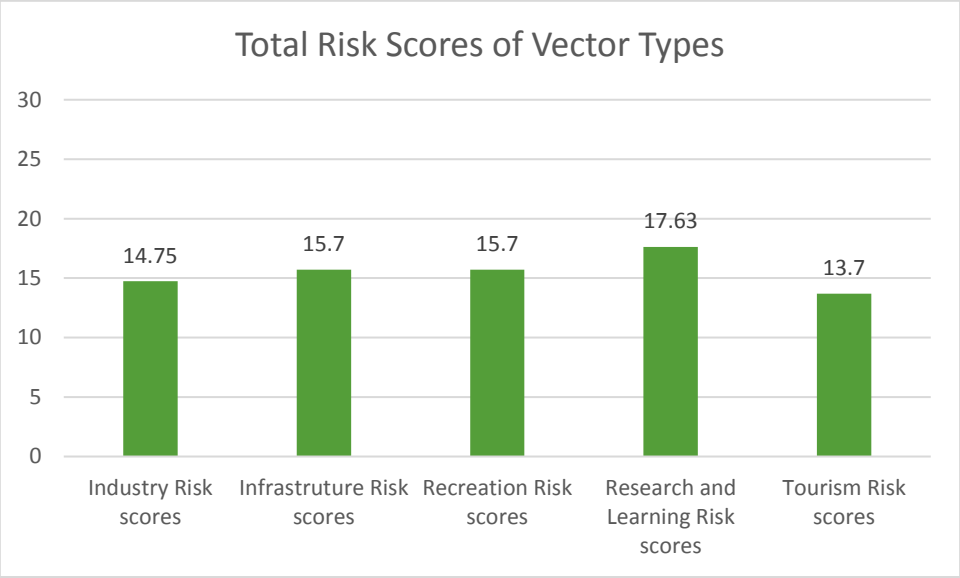
The risk analysis showed that there isn't a clear need to focus on any one vector group as they all present a moderate risk score. However the figures below do show that although each vector group did not have any significant variation on the different risks posed by the individuals within these groups, their awareness of kauri dieback and opinions on education and available information did vary.



This figure shows that research and learning has the highest total risk; this result is considered to be statistically significant as proven against a p value of 0.5. All represented vector types are seen to have a moderate total risk score.

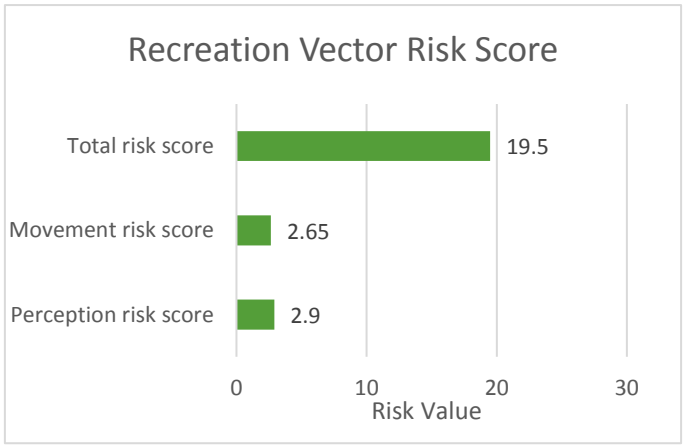


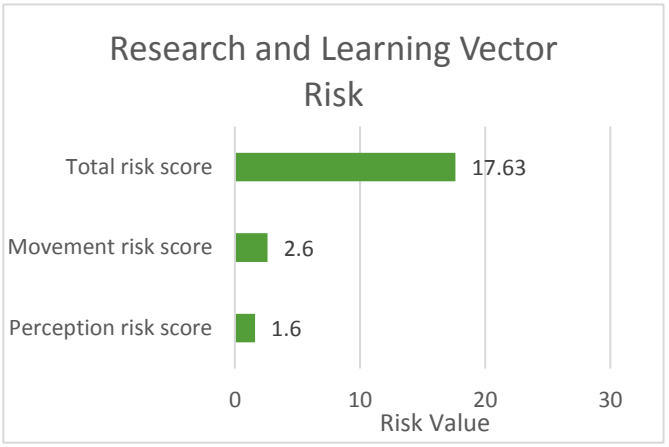
The Movement risk scores were tested against a p value of 0.5 and were found to be non-significant; this means that statistically the movement scores do not show enough variation between the scores for them to be considered different; this means these scores can't be compared amongst each other. The majority of represented vector types are seen to have a moderate movement risk score, with the exception of Tourism.

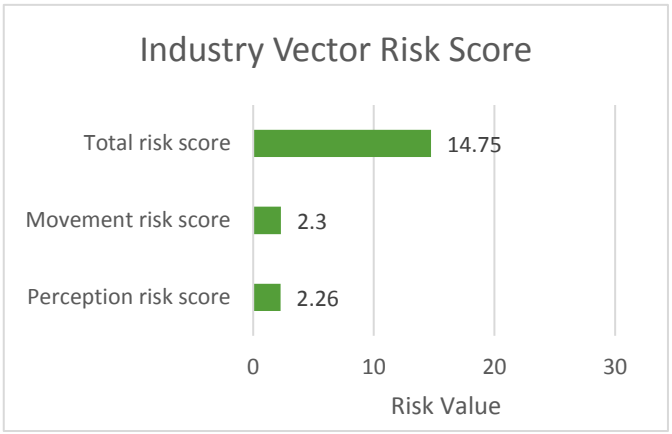


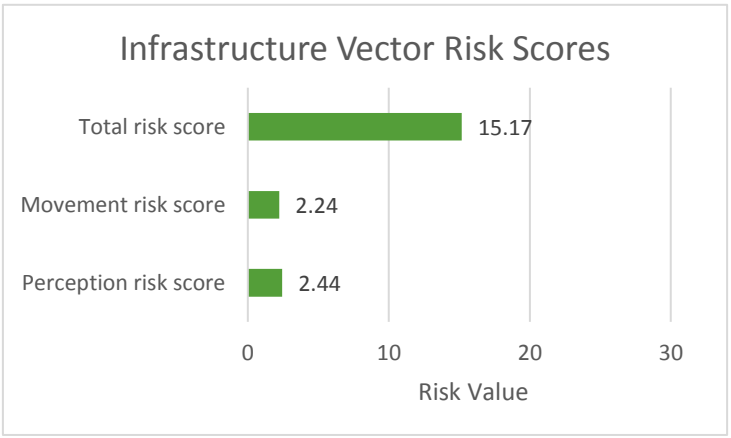
This figure shows that recreational users have a higher perception risk score, this means that generally this group is not as good as others when it comes to viewing kauri dieback as a cause for concern. Tourism had the lowest score indicating that they were aware of Kauri dieback and considered it to be threat. These scores were statically tested in ANOVA against a p value of 0.5 and were found to be significant; meaning the variance between the scores is able to be compared.

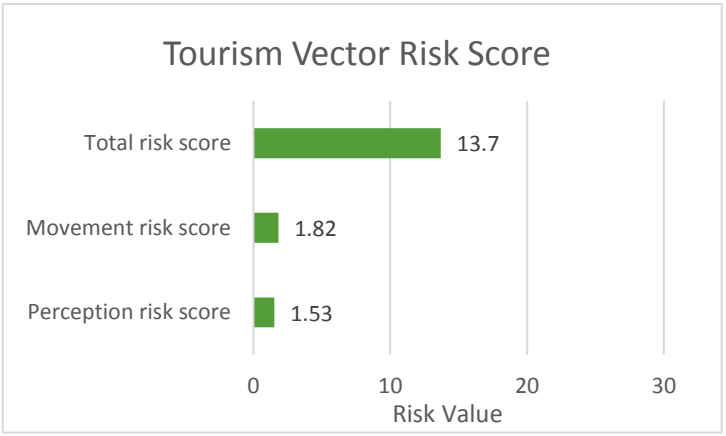
Risk score results:







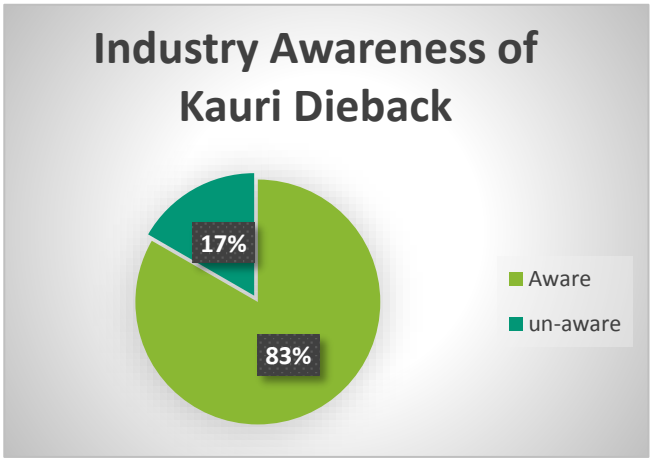


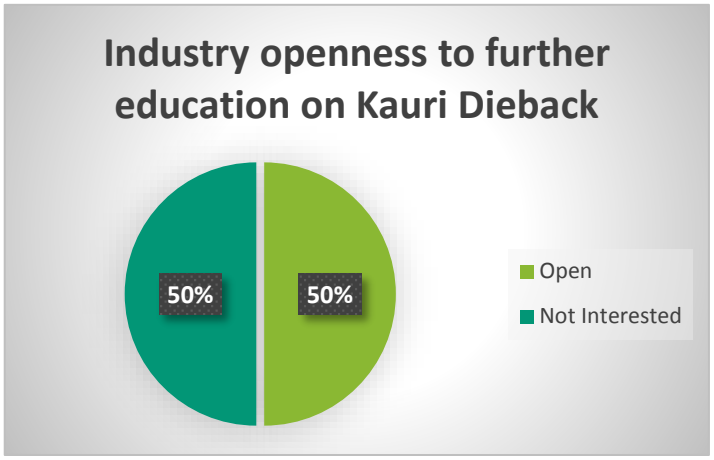


Because international tourism was underrepresented during the survey the results shown for the tourism vector risk score do not show the perspective of the international tourist.

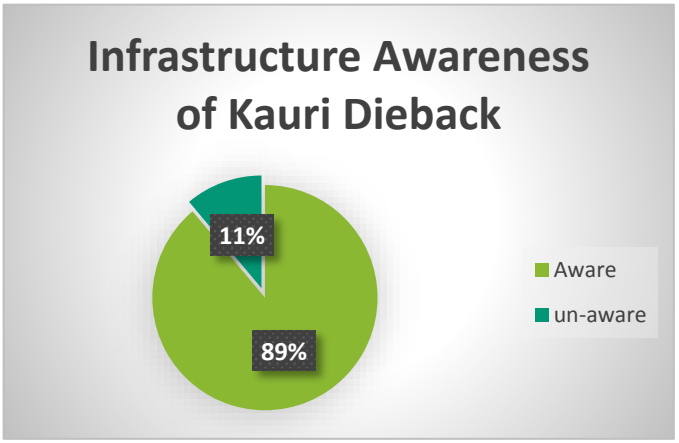
5.3 Response to Kauri Dieback:

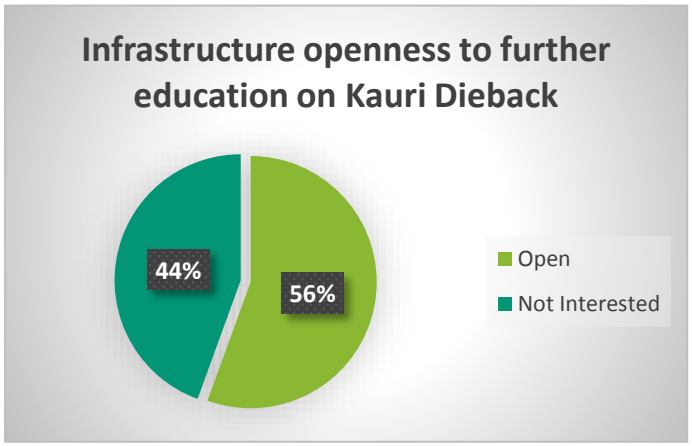
From those surveyed within industries that have contact with kauri dieback or soil, most had a strong grasp on what kauri dieback was, however half of those surveyed still felt that more information specific to their industry should be made available.



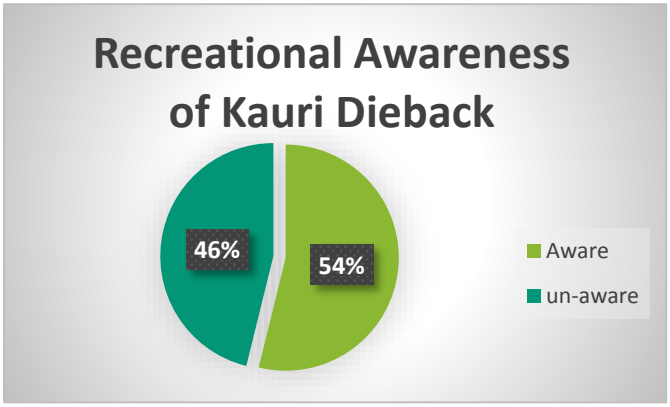


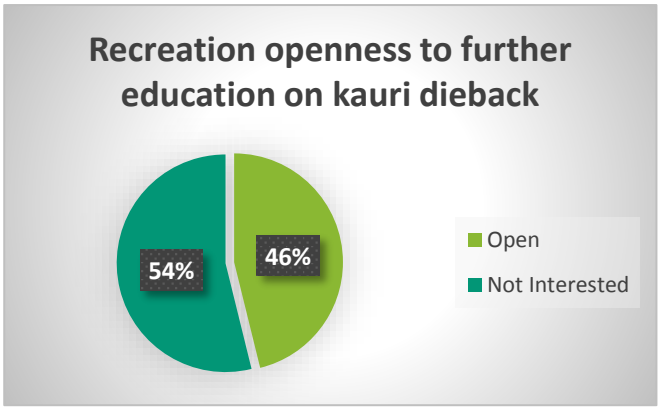
Organisations surveyed within the infrastructural operations found that the majority (89%) were aware of what kauri dieback was and were often affiliated or had worked for/with a governmental organisation such as local councils or DOC. Those that had a poor understanding felt that they had no role in the dispersal of kauri dieback. Most were unaware of how it spread, many incorrectly suggested it was airborne or waterborne. Of the surveyed Infrastructural operations just over half of were open to having more information and training being made available to them.



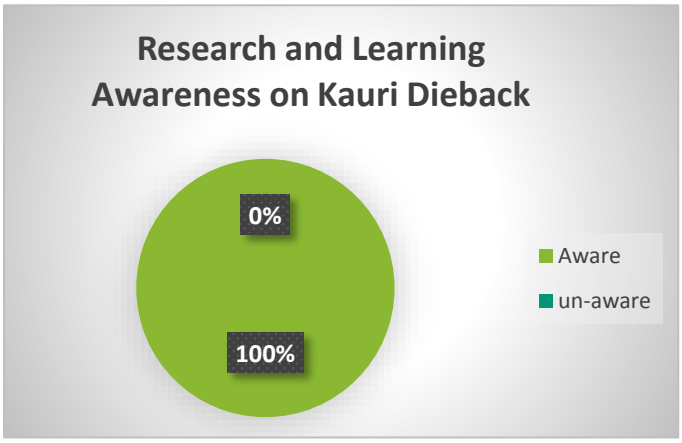


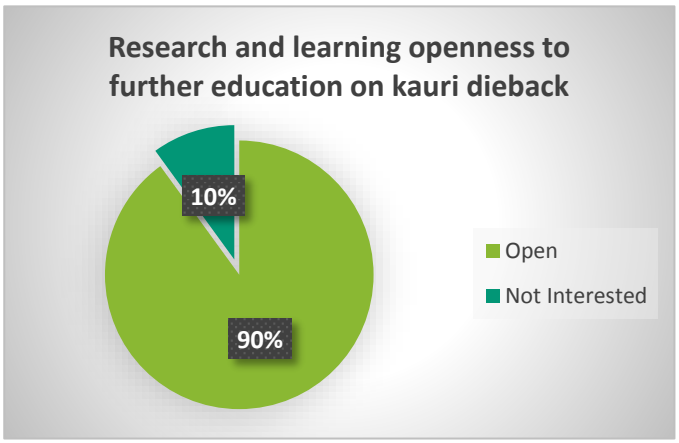
Recreational users were seen to be near evenly split on their awareness of kauri dieback with 54% being aware of the threat, out of the sampled group just over half were not interested in any further education or information being made available to them.



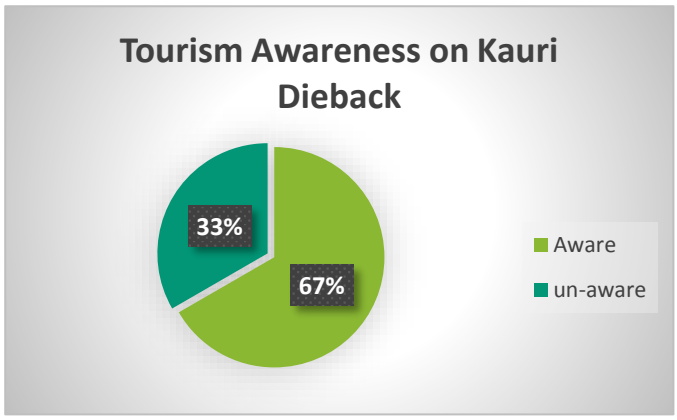


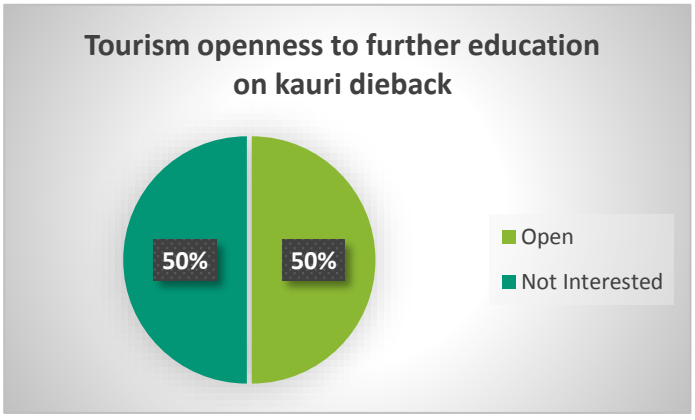
People surveyed within the research and learning vector type were all aware of kauri dieback and the large majority were open and encouraged further education to help prevent the spread of Kauri dieback.





Those sampled from the tourism vector type were mostly aware of kauri dieback, however the larger majority of those sampled were local tourist activity providers or guides; actual tourists sampled were unaware on the issue but were still compliant when confronted with cleaning stations. Almost all of those sampled felt that further education would be useful and that they would take part.





6. Discussion:

While conducting this research something that became apparent very early on was the inconsistency of people's understanding of kauri dieback. The level of understanding varied within the sampled groups, as well as there being an overall variation, with the exception of the research and learning group (amongst which there was 100% awareness). This variance indicates that there that all groups could benefit from type specific information and education.

Recreational users are the most unaware of kauri dieback; this could mean they do not see themselves as the issue (which has been observed by recreational forest users internationally (Audrey R. Taylor, 2003), or that they only have a limited understanding of what kauri dieback is. Poor understanding of human inflicted disturbance to wildlife areas is easily overlooked by the casual forest user (P. Sterl, C. Brandenburg, 2008). This became apparent while holding conversations with people within these recreational groups, as they often repeatedly claimed that their group was not a risk, despite having regular interactions with kauri and soil/mud. This indicates a lack of responsibility being taken by these recreational groups. For example the surveyed four wheel drivers felt that even though their vehicles could come into close proximity to kauri and do move large amounts of mud and soil to different areas, they still felt that they should not be a cause for concern when looking at vectors of kauri dieback. In situations like this, when groups do not

comprehend their role in the spread of kauri dieback, targeted educational approaches would be beneficial and have been successfully used in the United States where similar attitudes around recreational behaviours have been seen to harm the surrounding environment (Gwenn Prinbeck, Denise Lach, Samuel Chan, 2011).

Tourism was the second highest group to have a poor understanding of what kauri dieback actually was, however it is to be expected that international tourists would be less aware of the biosecurity threats within New Zealand. However awareness levels were poor amongst the local guiding companies surveyed.

Education was quite evenly split for most vector types. Those who did not see the point to more education and training were often unsure on why they would need to be involved or for some, such as search and rescue teams, compliance was described as being impractical.

Contacting the people required to conduct the survey proved to be the only challenge faced during this study; many were unavailable or did not want to partake. This meant the sample size was smaller than intended. However even with the smaller sample size this research has identified that there is a need to further educate and provide training for all vector groups rather than targeting a single vector group.

The survey of tourism representatives also suggests some form of certification – which shows that they adhere to all required biosecurity best practices – could be useful for the operators (being able to promoting themselves as an eco-friendly tourism attraction) and to the agencies managing the disease (through an increase in compliance).

Recreational users suggested using a webpage that was constantly updated with track closures and updated information on where kauri dieback is present. Some clubs also suggested blanket biosecurity training that would cover best practices for more than just kauri dieback. However after further questioning most were unaware of any current publications and resources already available to them, so it is questionable whether or not these resources would end up being used. The Science

and Learning group felt that there should be more track closures and more studies on *Phytophthora, in order* to try eradicate it.

During the interviewing process many people made suggestions about what would make kauri dieback management more understandable; for industry and infrastructure some form of training that was relevant to their field of work that ended in some sort of certification was suggested, others within these vector types also suggested a couple of pages that clearly stated best practices for them to keep on-site and in break rooms, for example.

7. Conclusion:

Due to the varying responses from the sampled vector groups a targeted method that addressed each vector's needs is recommended, as this will educate and support each group and effectively engage them with the Kauri Dieback Programme (Gwenn Prinbeck, Denise Lach, Samuel Chan, 2011). Certification for people and businesses who regularly have to encounter high risk areas should be made available, especially for Industrial and Infrastructural vectors. These are the people who have to interact with kauri, even though as vector groups they were aware of kauri dieback, and open to mitigating actions, they often felt that more support and training should be made available to them. Many of those sampled from Industrial and Infrastructure groups they had their own mitigating measures in place, and felt that some sort of certification would help them celebrate what they had already done to mitigate their vector risk. It would also be expected that by providing the training that will lead to a change in behaviour, the overall approach to combating kauri dieback would become more proactive(Colmar Brunton, 2016).

8. References:

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10.Appendix:

The Survey:

How frequently does the activity occur in or around native bush?		Do you or your gear come into contact with soil that surround native trees (Kauri)?	
Not applicable	Low 0	Not applicable	0
Annually (once or a couple of times a year)	1	no never	1
Monthly	2	Very unlikely	2
every few weeks	3	sometimes	3
weekly	4	yes	4
more than twice a week	High 5	yes it is un-avoidable	5
Do you visit multiple sites that have native trees?		Does your activity bring vehicles near native trees or bush?	
Not applicable	0	Not applicable	0
No never	1	no just roads and paved carparks	1
Just a couple	2	no just boundaries and carparks	2
a few local tracks	3	no but I sometimes bike	3
Multiple forested areas (track or no track)	4	yes sometimes.	4
yes very frequently	5	yes it is un-avoidable (multiple vehicles)	5
How often are you using Tracks?- how do you use tracks		Does your activity involve the use of animals?	
Not applicable/ My activity doesn't use a track	0	Not applicable	0
Not often (1-3) tracks a year	1	sometimes a restrained animal	1
a few (3-6) tracks a year	2	an on track restrained animal	2
6-12 tracks a year	3	a restrained on/off track animal	3
yes very frequently (4+ tracks a month)	4	one off track animal	4
all the time on and off track (6+ tracks a month)	5	multiple animals with large amounts of off-track time	5
How do people involved with your activity perceive the threat of K.D spreading (P)		Where does your activity distribute soil?	
Not applicable	0	Not applicable	0
It is something we are all concerned about and active on.	1	never off site	1
Majority are concerned and active on the issue	2	small amounts to urban areas	2
evenly split between concerned at not concerned	3	small amounts to different locations	3
Majority are complacent about the issue	4	large amounts occasionally to areas with native trees	4
It's not our concern	5	large amounts and often	5

What sort of equipment does your activity use?	
Not applicable	0
none	1
Hand-held tools e.g. spades (washed with disinfectant)	2
light vehicles and long standing equipment (stands and ramp	3
Vehicles and tools (equipment that will disturb soil)	4
Heavy machinery	5

How do you/ your activity use tracks	
Not applicable	0
Normally just one track (start to end)	1
mostly on track (start to end) but will venture off sometimes	2
starts on track and ends on track but mostly off track.	3
not often at all (sometimes starts or ends on track).	4
Never	5

Is Kauri Dieback management practical for your activity? (P)	
Not applicable/don't know about KD management	0
Yes!	1
Yes, for the most part	2
I guess I could go either way with more information	3
not really	4
not at all it's a waste of time	5

How regularly does your activity encounter native trees/ bush?	
Not applicable	0
almost never	1
hardly ever	2
some of the time, but it is avoidable	3
Most of the time	4
It is unavoidable, we/I am in or around it all the time	5

Does your activity occur in all types of weather?	
Not applicable	0
Just when the ground/track is dry	1
Just when the ground is dry	2
Not during rain	3
All year round, on and off	4
All year round, muddy is ideal	5

How many people are involved in your activity	
Not applicable	0
small scale (1-10)	1
It's a group activity (10-100)	2
small scale operations (100- 1000)	3
moderate scale operations (2000-5000)	4
Large scale operations (5000+)	5

ow many people come into contact with native trees during an activity	
Not applicable	0
No one if possible otherwise only a few (1-5)	1
A few people (1-20)	2
it varies (20-200) can be large groups, but mostly smaller grou	3
normally larger groups (100-1000)	4
Large groups (1000 +)	5

How many water catchments would a typical user cross daily	
Not applicable	0
1 to 5 times	1
5 to 10 times	2
10 to 15 times	3
15 to 20 times	4
20 to 30 times	5

What sort of cleaning practises are realistic for your activity? (P)	
Not applicable	0
we adhere to all practices	1
We adhere to protocols most of the time/protocols are practical most but not all of the time	2
We adhere to protocols sometimes/protocols are only	3
We seldom adhere to protocols/protocols are seldom practica	4
We never adhere to protocols /protocols are never practical	5

Vector Description:

Vector	Movement Type	Mitigation measures	Views on who is responsible	Successfully sampled
Covenant land	vehicles, feet, animal close proximity to trees			
lifestyle land/small scale property owners	vehicles, feet, animal close proximity to trees	Typically had none	KD is government's responsibility	**Yes**
Mana/tangata whenua	Feet, animal and vehicle movement off track			
Quarries	Multiple Vehicles and people. Aggregates moved, not a lot of interactions with soil.	Often already had mitigation measures in place, however not specifically for KD.	It is a joint effort, requires management by all groups	**Yes**
On site diesel refuelling	Multiple Vehicles off track.	Some Hosed down before entering a site, but it depends on clients' wishes	Not too sure what the threat is, or how it relates to them, suggested hunters and tramper's were the issue	**Yes**
Forestry/forestry roading	Multiple Vehicles off track.	Yes, but for pest plants and pine pathogens.	It is a joint effort, requires management by all groups	**Yes**
Landscapers	Plants/soil/vehicle movement near and of Kauri	Depends on who has hired them. Often none	Varies on who you speak too	**Yes**
Nurseries	plant/ soil/equipment/ vehicle movement	Often will, however not always specifically for KD.	It is a joint effort, requires management by all groups however in their view government agencies could do more	**Yes**

Farming /ag industry	Multiple Vehicles and animals off track.			-
Partner agency contractors/staff.	Multiple Vehicles off track.	Yes, except for contracted hunters.	It is a joint effort, requires management by all groups however in their view government agencies could do more	**Yes**
Arborists.	Feet, vehicle movement on and off track	Yes, however not for Kauri dieback, they take mitigation measures against other pest plants	It is a joint effort, requires management by all groups however in their view government agencies could do more	**Yes**
Bee keepers	Feet, vehicle movement on and off track, almost never off track, and aren't interested in Kauri bush, more likely to be around Manuka Bush	yes, but not for KD	It is a joint effort, requires management by all groups however in their view government agencies could do more	**Yes**
Defence forces	Multiple Vehicles off track.			
Rural fire/search and rescue (training)	Multiple Vehicles off track.	None, it is not their concern.	Didn't have a view, KD is not their concern	**Yes**
Mining	Vehicles, feet and large soil movement	Yes, not often specifically for KD but for other biosecurity threats. All sites undergo an environmental evaluation	It is a joint effort, requires management by all groups however in their view government agencies could do more	**Yes**
Earthmoving contractors	Multiple Vehicles off track. Soil intentionally moved	Yes but not often for KD.	It is a joint effort, requires management by all groups however in their view government agencies	**Yes**

			could do more. Often suggested Hunters and Dog walkers as vectors	
Roading	Multiple Vehicles off track. Soil intentionally moved	Yes. Will have cleaning stations and methods in place to prevent soil being moved.	It is a joint effort, requires management by all groups however in their view government agencies could do more	**Yes**
Developers/ Builders	Multiple Vehicles off track.	Not often, depends on employer	Government is responsible for these issues	**Yes**
Power /telecoms companies/NIWA	Multiple Vehicles off track.			
Mountain bikers	Bike on/off track	No, visit multiple areas with no cleaning.	Do view themselves as a vector, were unsure on who should be responsible for protecting kauri	**Yes**
Motor cross riders/ATVing clubs	Vehicle off track			**Yes**
Campgrounds	Animals, people and vehicles in close proximity to Kauri			
Dog Walkers	on foot and animals off track/ on track	Sometimes but not always.	It is a joint effort, requires management by all groups however most also felt that others should be blamed for the spread of KD	**Yes**
Hunters licensed and unlicensed	Vehicle off track, feet and animals off track	Sometimes, not often thorough	It is a joint effort, requires management by all groups however often feel targeted by conservation	**Yes**

			groups and government for potentially spreading KD.	
four wheeler clubs	Multiple Vehicles off track, have own tracks, muddy is ideal cleaning is not regulated	None, in the North Island. Do not believe that they are potential vectors of KD	They are not the issue, hunters, and trampers are. Did not think that spraying potentially infected mud near Kauri could be spreading KD.	**Yes**
Off track users/orienteering/geocachers	On foot. On/off track. Orienteering is all off track, often in bush of summer	Often have none.	Government is responsible for these issues	**Yes**
Tramper's	On foot. On/ off track. Tramping poles and bags.	Will use cleaning stations	Opinions varied, most felt that everyone plays a part	**Yes**
Photographers	On foot. On/ off track	Often have none.	Were very unaware, did not have much of an opinion on KD	**Yes**
Horse riders	Animal movement on and off tracks			
Outdoor education orgs /scouts	On foot. On/ off track			
QE II/major conservation groups	Vehicle and foot movement off track.	Yes, will often have their own.	Government is responsible for these issues	**Yes**
Botanists/lichen searchers	On foot. On/ off track	Yes	Government and public cooperation is needed to protect kauri	**Yes**
Research permit holders/university students	Feet, vehicle movement on and off track	Yes	Government and public cooperation is needed to protect kauri	**Yes**
Overseas tourists	On foot. On/ off track	Yes	Wereunsure	**Yes**

Domestic casual users	On foot. On/ off track. Dogs			
Horse ride activities	Animal movement on and off tracks	None	They were not the issue, probably hunters and trampers.	**Yes**

ANOVA testing:

Vector groups were tested against a *P* value of <.05

Result Details: Industry vector types.

Source	*SS*	*df*	*MS*	
Between-treatments	0.1216	1	0.1216	*F* = 0.17306
Within-treatments	19.6749	28	0.7027	
Total	19.7965	29		

This table shows the ANOVA results for testing whether or not there was a correlation between the Movement risk score and the perception risk score. The results give a P value is .68058 which means that the null hypothesis is accepted, there is no correlation between the Movement risk score and the Perception risk score for industry vector types.

Result Details : Infrastructure vector types

Source	*SS*	*df*	*MS*	
Between-treatments	1.9811	1	1.9811	*F* = 0.95821
Within-treatments	28.9442	14	2.0674	
Total	30.9253	15		

This table shows the ANOVA results for testing whether or not there was a correlation between the Movement risk score and the perception risk score. The results give a P value is .344251 which means that the null hypothesis is accepted, there is no correlation between the Movement risk score and the Perception risk score for infrastructure vector types.

Result Details: Recreational

Source	*SS*	*df*	*MS*	
Between-treatments	0.4239	1	0.4239	*F* = 0.61815
Within-treatments	16.4596	24	0.6858	
Total	16.8836	25		

This table shows the ANOVA results for testing whether or not there was a correlation between the Movement risk score and the perception risk score. The results give a P value is .43943 which means that the null hypothesis is accepted, there is no correlation between the Movement risk score and the Perception risk score for recreational vector types.

Result Details: Research and learning				
Source	***SS***	***df***	***MS***	
Between-treatments	5.3354	1	5.3354	*F* = 16.05383
Within-treatments	5.9823	18	0.3323	
Total	11.3177	19		

This table shows the ANOVA results for testing whether or not there was a correlation between the Movement risk score and the perception risk score. The results give a P value is .000827 which means that the alternative hypothesis is accepted, there is a correlation between the Movement risk score and the Perception risk score for the Research and learning vector types.

Result Details: Tourism				
Source	***SS***	***df***	***MS***	
Between-treatments	0.2494	1	0.2494	*F* = 1.99131
Within-treatments	1.2525	10	0.1252	
Total	1.5019	11		

This table shows the ANOVA results for testing whether or not there was a correlation between the Movement risk score and the perception risk score. The results give a P value is .18855 which means that the null hypothesis is accepted, there is no correlation between the Movement risk score and the Perception risk score for the Tourism vector types.

Result Details : Total risk scores of all vector groups

Source	*SS*	*df*	*MS*	
Between-treatments	242.6152	4	60.6538	*F* = 2.81256
Within-treatments	1099.8328	51	21.5653	
Total	1342.4479	55		

This table shows the ANOVA results for testing whether or not there was a correlation between the Movement risk score and the perception risk score. The results give a P value is .34777 which means that the alternative hypothesis is accepted, there is a significant difference between the different vector types risk scores

Result Details Movement risk scores of all vector types

Source	*SS*	*df*	*MS*	
Between-treatments	3.5956	4	0.8989	*F* = 2.29656
Within-treatments	19.9622	51	0.3914	
Total	23.5579	55		

This table shows the ANOVA results for testing whether or not there was a correlation between the Movement risk score and the perception risk score. The results give a P value is .071673 which means that the null hypothesis is accepted, there is no significant difference between the Movement risk scores of the vector types.

Result Details: Perception risk scores of all vector types

Source	*SS*	*df*	*MS*	
Between-treatments	14.1534	4	3.5384	$F = 2.90657$
Within-treatments	62.0855	51	1.2174	
Total	76.2389	55		

This table shows the ANOVA results for testing whether or not there was a correlation between the Movement risk score and the perception risk score. The results give a P value is .030493 which means that the alternate hypothesis is accepted, there a significant difference between the Perception risk score of all the vector types.