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Safe Guarding Tomorrow's Natural World

THE CHALLENGES OF CONTAMINATION IN ENDANGERED SEED COLLECTION FOR CONSERVATION SEEDBANKS

DNB311 ID STUDIO 7: CAPSTONE

A1 Part 1: Research Report

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Executive Summary

This reports aim was to explore how contamination of endangered seeds within conservation banks affects how the seedbank collects, sorts, cleans, and banks the seeds.

The research then conducted within this aim identified the constraints and opportunities to influence the design solution. The initial research defined the seed banking process and types of contamination. The research concluded that the most significant contamination towards the seedbanks was biological and physical and that the cleaning and sorting stages managed the highest amount of this contamination. The benchmarking identified a middle ground gap between the specialised, complex, and expensive products and the off-the-shelf low-cost products. It produced an insight into the lack of existing products having a flexible use-case.

The primary research was made up of a structured survey and semi-structed interviews with workers involved in the endangered seedbank industry across Australia. The findings presented challenges linked to contamination such as time-constraints, compromises on quality, and limited resources.

The research within the report was combined and presented opportunities for a design, focusing more on modularity, specialisation for endangered seeds, affordability, and accuracy.

Acknowledgments

ACADEMIC STATEMENT OF AUTHENTICITY

I declare that this report is solely written by me apart from the direct quotes from participants and is my own work and intellectual property and is be specifically for this capstone unit.

STATEMENT OF AI USE

AI was used to sort through coded data represented as nothing more than numbers for my survey responses and find matches for bivariate analysis. AI was used for nothing else within this report.

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Introduction

The conservation seed banks within Australia are tasked with providing a safety net against extinction for endangered seeds. The seed banks are responsible for collecting, cleaning, sorting, banking, and replanting the seeds in order to restore the natural environment. While the seedbanks have meticulous and structured processes, the contamination of the seeds is a constant threat that cannot be avoided.

The contamination of seeds comes in different forms such as plant material, rock and soil debris, fungus, insects, and non-target seeds. While these contaminants are common in the commercial seed banking industry and is managed often, it can be fatal for a seed species that can only be found in the hundreds; every seed is a precious commodity.

There are also challenges surrounding contamination that either cause the contamination or negatively impact it further. These challenges are related to time constraints, automation difficulties, high variation in seeds, limited funding, and dealing with a smaller scale compared to commercial. Also, existing products within the conservation seedbanks are often not specialised for endangered seeds so the results become less accurate.

In this report, the effects of contamination within conservation seedbanks and processing roles will be explored. This will be through benchmarking existing products and analysing surveys and interviews of seedbank workers experiences. All with the purpose of gathering insights to create design opportunities to reduce endangered seed contamination.

Background

SEEDBANKS

Endangered seed collecting is one of the main strategies for environmental conservation because seeds banks provide a safety net against extinction and preserve the genetic diversity of endangered plants (Australian Seed Bank Partnership, 2026). There are approximately eleven major conservation focused seedbanks in Australia that are funded by third parties to supply germinated seeds for restoration projects (Australian Seed Bank Partnership, 2022).

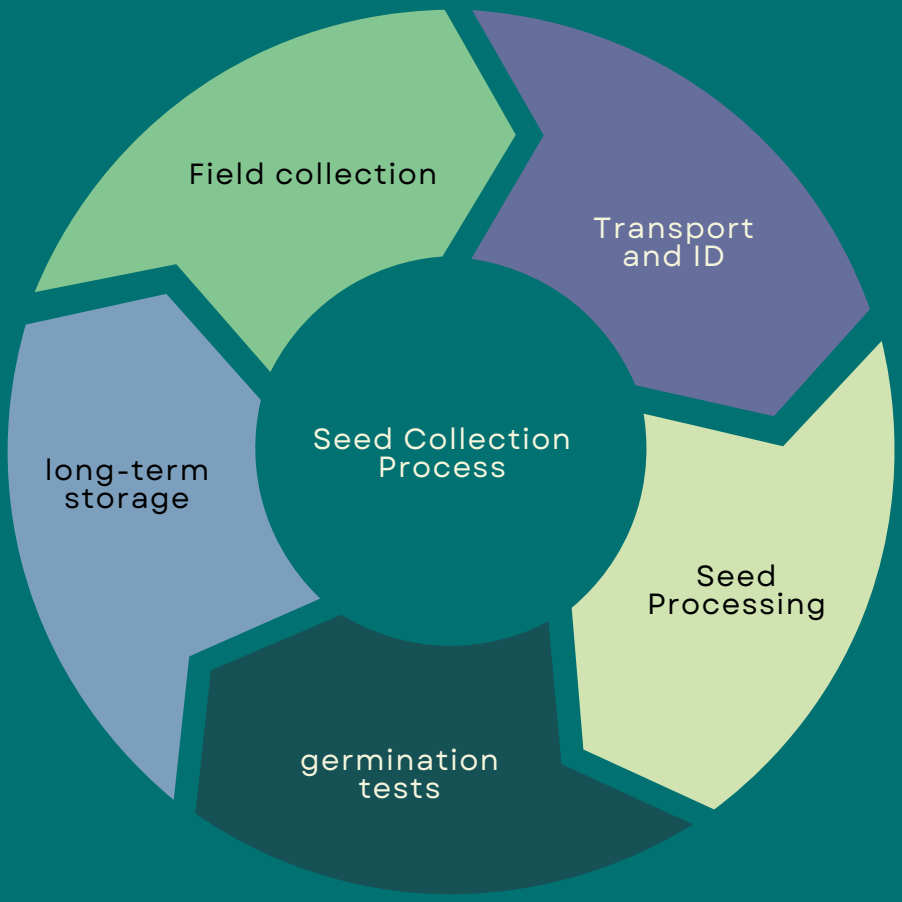


(Australian Seed Bank Partnership, 2026)

There are also smaller community run seed banks that may collect seeds that are under threat, using the same resources, but on a seed quantity scale between the 100s instead of 1000s (Hay, Baum , Oyatomi, & Wolkis, 2025). There are over 1300 different types of Australian plants that are categorised as endangered (Threatened Species Recovery Hub, 2020) and have been collected and safeguarded by these seedbanks for over 60 years (WA Seed Centre, 2026).

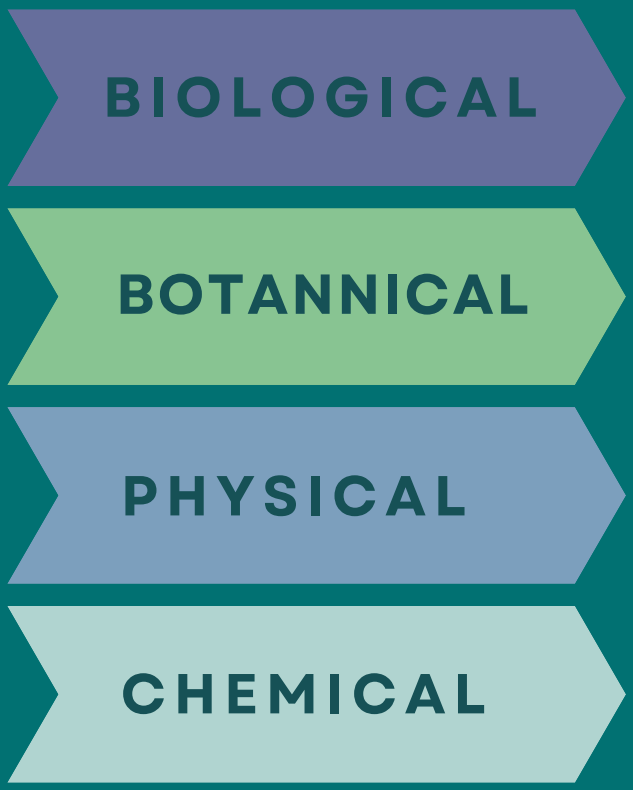
SEED COLLECTION PROCESS

The stages of endangered seed collection for the purpose of banking starts with the surveying and locating of the target species and calculating when the seeds will be ripe enough to harvest (Crawford, et al., 2021). The field collection then takes place, taking a substantial number of seeds but not enough to disrupt the natural seed dispersal (Mortlock, 1999). The seeds are then transported in paper bags (Aboriginal Landcare Education Program - collect, treat, and store, 2018) to a herbarium laboratory or processing centre within the seed bank to ID (Queensland Government, 2026). They are then dried, sorted, cleaned and tested for viability (Commander, et al., 2021). Viability refers to how likely a seed is able to germinate under favourable conditions (Sudhakar, Karthikeyan, RajhaViknesh, Selvam Saranya, & Shurya , 2021). The seeds are then placed into storage and can stay there for decades before they are broken out of dormancy and replanted when a project requires them (Dalziell & Merritt, 2026).



CONTAMINATION

Seed contamination is categorised into four types; Biological, botanical, physical, and chemical. Biological contamination is defined as pathogens either on the seed surface or internally (Riggio, Wang , Kniel, & Gibson , 2019). This pathogen can be catalysed by moisture, physical debris, insects, or the infected mother plant (Abbas & Aqleem, 2015). Botanical contamination is defined as non-target seeds or weed seeds going undetected in the collection stage (Australian Government, 2026).



This can be due to being unable to separate the seeds because they are too similar in size and weight (Potts, 1975). Physical contamination is categorised by either plant material of earth particles such as stems, pods, rocks, soil, or clay that the seeds are either transported with or get stuck in (FDA, 2024). Chemical contamination is categorised as any artificial or man-made pollutant such as microplastics or insecticide (Nuruzzaman, Bahar, & Naidu, 2025) (Briassoulis, 2023). Although this type of contaminant is not as big of a problem in endangered plants, since many harvesting sites are in conservation areas or national reserves that don't usually come into contact with unnatural factors (Australian Government, 2026). The most at-risk stage of contamination is at field collection which is why the cleaning and drying of the seeds directly after is considered sacrosanct to prevent loss of viability (Errington, Quarmby, Commander, & Philpott, 2021).

OTHER CHALLENGES

Endangered seed collecting for seed banks has certain challenges relating to funding, time-efficient means of processing the seeds, and the skill/technicality needed in order to conserve as many viable seeds as possible. Because most seed banks are funded based on specific projects and donations (White, et al., 2023), the majority of staff are volunteers with limited resources at their disposal and limited expertise (Finch, Jasny, Kucera, & Kiefer, 2022). High-end products used for the agriculture industry can process seeds at a faster rate than by hand, but they are expensive, bulky, and need professional calibration (De Falcis, et al., 2022). Analogue and DIY products are the main tools used in seed banks to allow customisation for the amount of variation in Australian seeds (Errington, Quarmby, Commander, & Philpott, 2021), but they are not as durable and accurate as what's on the market.



(Botanic Gardens and Parks Authority, 2026)



(Brown, 2023)

Benchmarking

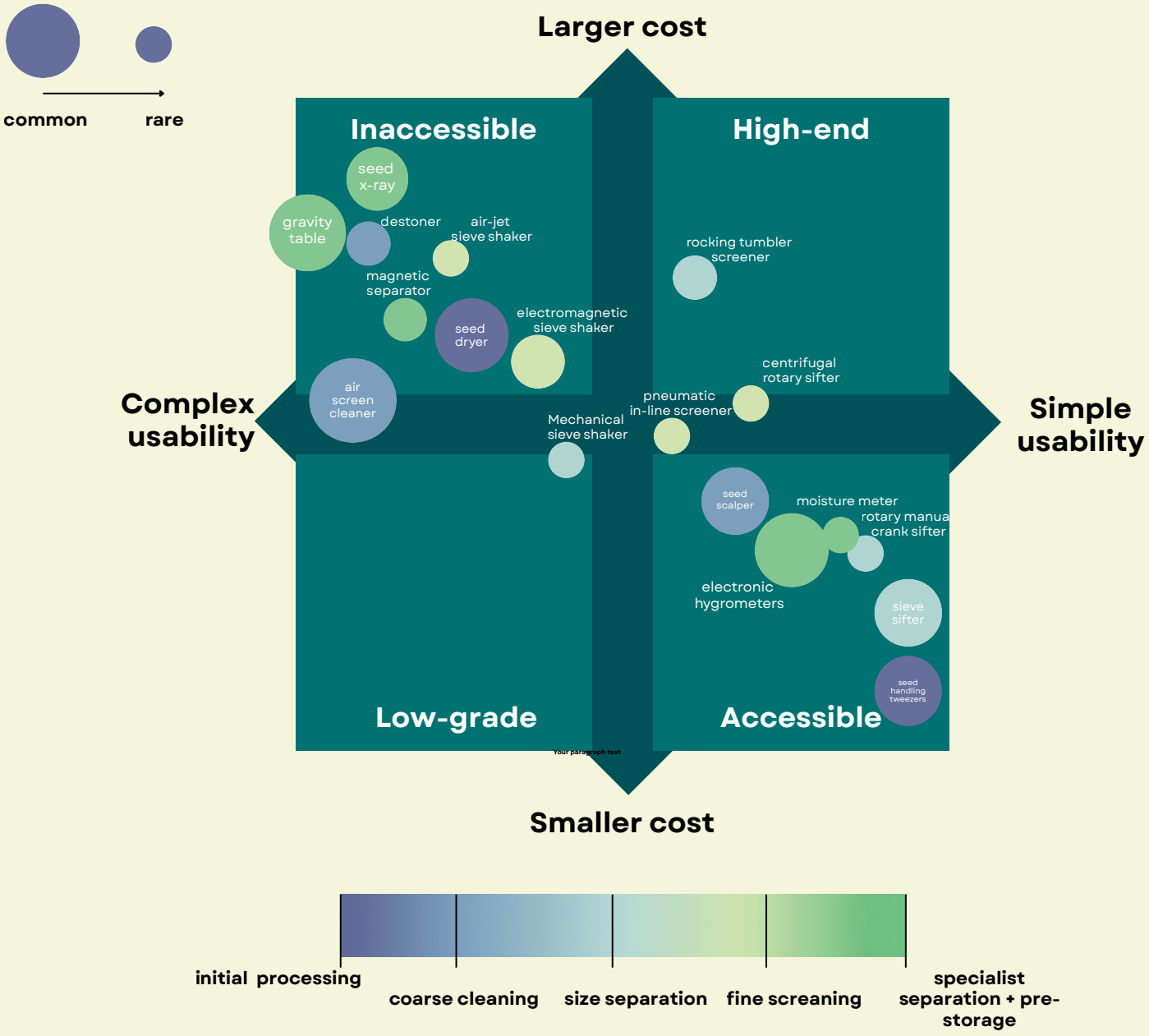
The existing products used in the seed collection and banking field are shown here to be combined with the more high-end products in the agricultural industry. This is to compare a broader selection of what can be utilised on seeds whether, realistically, a budget or similar constraints may be applied to some seed banks. Essential products that may have only high prices and complex functionality can inform a market gap.

The products are separated into stages of the seed collecting process; initial processing, coarse cleaning, size separation, fine screening, and specialist separation/pre storage. The cleaning and sorting stages are placed under a lens as the main points of focus since this is when most of the contamination is addressed and removed from the seeds.





MATRIX 1: COST VS USABILITY



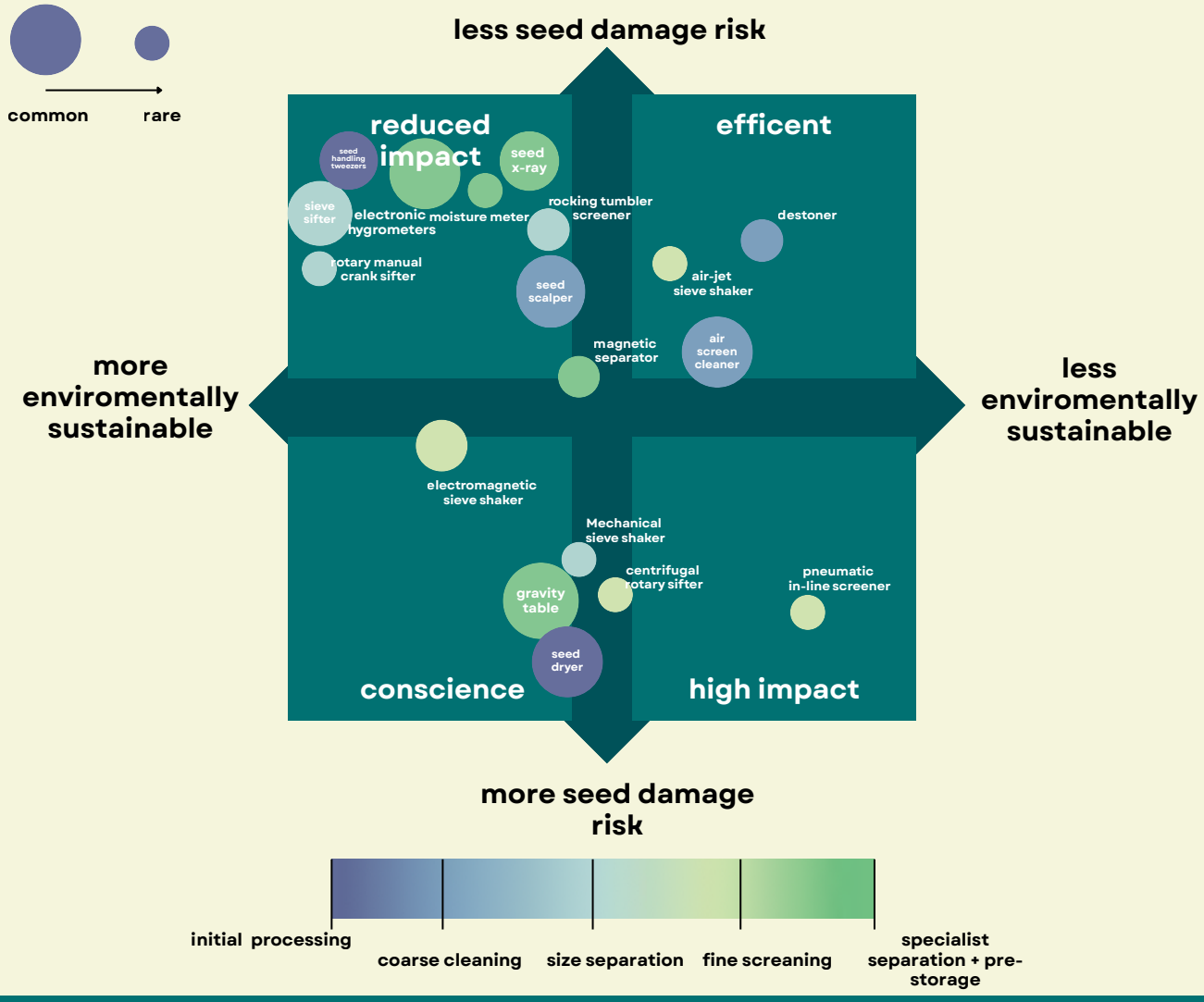
(See Appendix 1 for products)

Matrix 1 shows the difficulty level of using a product without any pretraining compared with the cost. This depicts a clear trend of products following a scale from inaccessible to accessible. Having these products grouped together shows a wide variation in seed processing technique but little variation in manufacturing. All the simple and small cost products are off-the-shelf and general-purpose that can be easily be DIYed from its basic materials to make customisable and at a smaller cost. The expensive and complex products cannot be adjusted or customised at all due to the heavy machinery involved and their ridged use-case.

Most of the top left products cannot be used in conservation seedbanks as there are no extensive settings for seed size (at most three to five sizes) and adjustability for smaller seed quantity.

The gaps in the market fall into the high-end and low-grade categories. The market does not have a product that is a bit more expensive and in relation, higher quality as well as simpler to use. This would represent investment tools that are can be durable, modular and have room for customisation if only to do a basic function. The market also does not have a cheaper version of any of the technologically heavy top left products, while it might sacrifice on quality it could suite the needs of a smaller, low seed quantity receiving community banks.

MATRIX 2: DAMAGE RISK VS SUSTAINABILITY



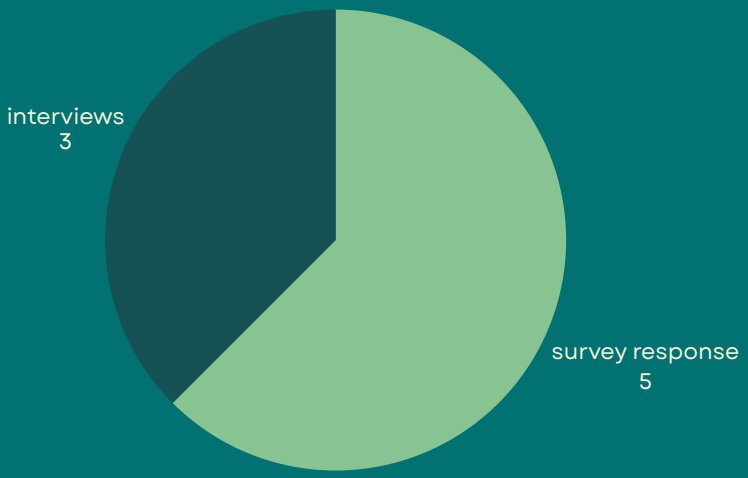
(See Appendix 1 for products)

Matrix 2 compares the environmental sustainability of the products (energy consumed, materials used) to the risk of damaging the seeds when using the products. The products, as a majority, are situated in the left half of the matrix, making them overall not drastically damaging to the environment. While the end goal of environmental conservation would factor into how eco-friendly the user would want their processing machines, efficiency would be a key player in product evaluation also. Less seed damage and more environmentally sustainable is the best-case scenario and represents its popularity as the majority of large representations fills this quadrant. Although, that section lacks any fine screening products and hardly any coarse cleaning, leaving a market gap in that part of the process. A lot of popular products are shown outside this 'golden zone' but are too much of a staple and necessity within the industry to completely shift to an alternative. More seed damage risks are a part of the function for some products so the gap to fill would be to focus on shifting them left for more sustainable materials and energy use.

Some developing technologies that could replace the more abrasive sorting machines would be AI-powered detection software that uses visuals instead of vibrating or shaking seeds into sieves or layers. While this would be a gentler approach to the seed sorting and cleaning process, its debated that the environmental effects would be worth the undertaking (Moffett, 2026).

Methodology

The primary research undertaken creates an insight into the seed collection workers and volunteer's experiences. The qualitative nature of this research could provide understanding into the emotion behind the expertise in tandem with the practical logistics.



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The methods deemed most realistic and effective were a structured ten-minute survey and a semi-structured thirty-minute interview. The seedbank community is a smaller circle than most industries with remote locations and minor numbers. This is why observations were not an option as the seedbanks were not close enough to be accessible.

After the data was collected, five survey responses and three interviews were all individually looked over and analysed. While this number is small, with a specialised industry such as conservation seed banking posed a challenge for getting a reasonable amount of response. Although, by reviewing the results, it was deemed that the current number was effective enough to contain variables and therefore potential for relational analysis. It was also found out that the workers across Australia were scheduled to be out in the field for most of august and September which added a layer of difficulty when trying to assess availability.

SURVEY

1. Researching through the internet for major seedbanks in Australia

2. Creating suitable interview and survey questions

3. Contacting these seedbanks through email for both requests for survey and interviews. Providing consent forms and information sheets

The survey was chosen to reach out to as many volunteers and workers as possible throughout the country on topics such as roles, tools used, experiences with tools, contamination managed, and seed contact frequency. The main variables were the short form answers, mainly the different roles in the seedbank, which gave context to the long responses and let each experience be more comparable to each other.

The anonymity of the surveys may have granted the volunteers and workers a freedom to express honest opinions on certain products and lift the burden of representing their seedbanks in a positive light.

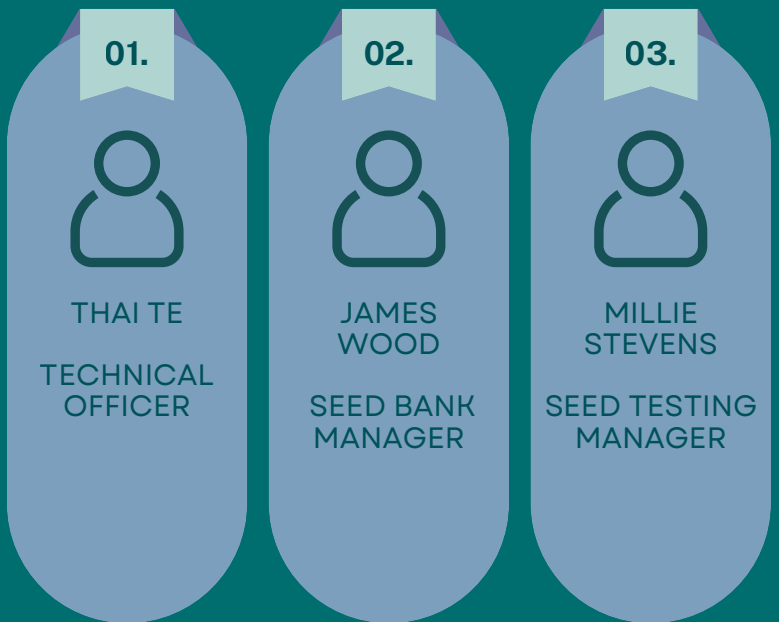
INTERVIEWS

For the interviews, the participants wished to be attributed by name on their consent forms:

4. Organising interview times and gathering consent forms

5. Initiating interviews over phone call and Microsoft teams while recording for a transcript

6. Doing an overview of the data and starting to analyse patterns and contexts



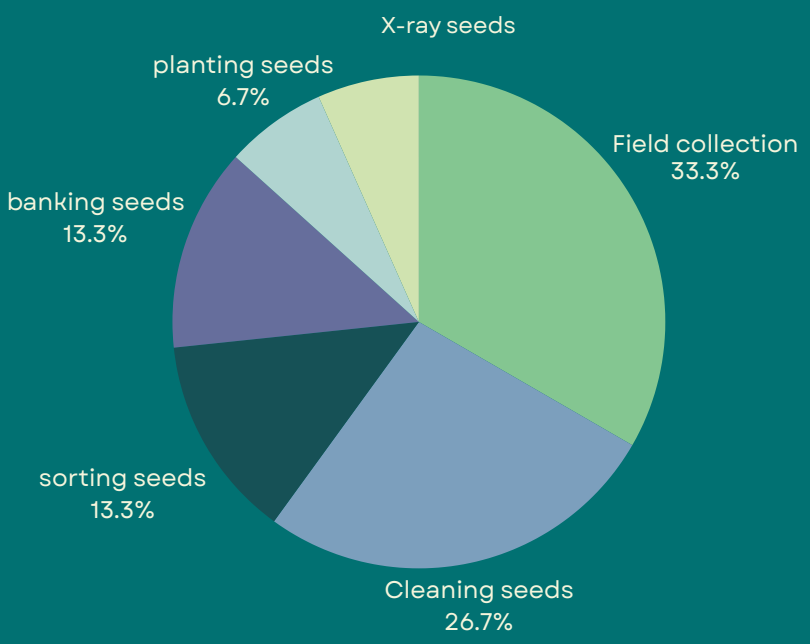
The participants came from a wide variety of roles within the seedbanks, such as, seed bank manager, germination specialist, seed collector, seed processor and cleaner, and technical officer. This helped in getting a more detailed understanding of all processes and their associated issues. They were also from vastly different areas in the country, which gave insight into the different weather conditions and different types of seed species that could be experienced. The seedbanks also had clear differences in budget and resources available, which created comparisons in timelines, processes, and products available.

The interviews were either conducted on the phone or Microsoft teams and recorded on a phone to create a transcript. Since the interviews could only be done remotely the audio quality is not clear in some parts, which unfortunatly made the transcripts contain errors. Though, extensive notes were taken to be able to fill in the gaps.



Survey Analysis

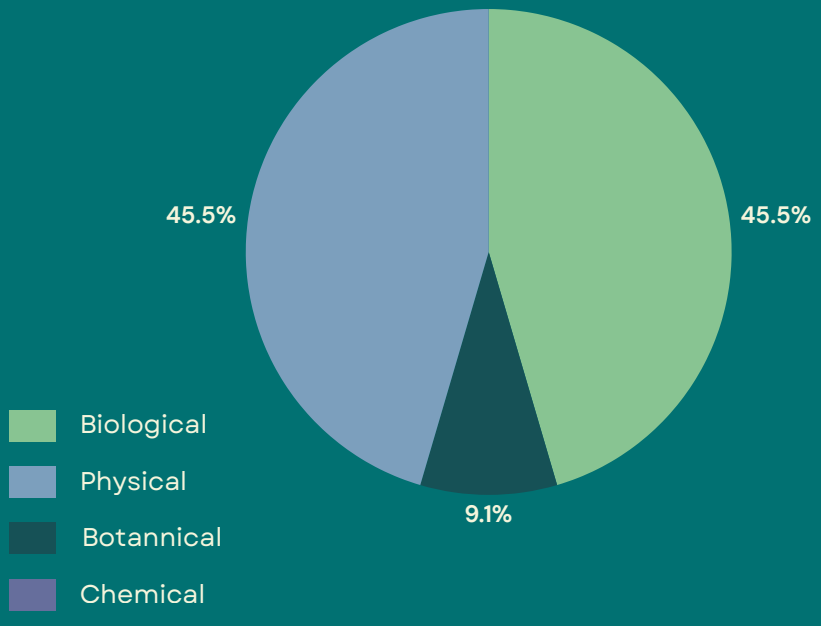
STATISTICAL INSIGHTS



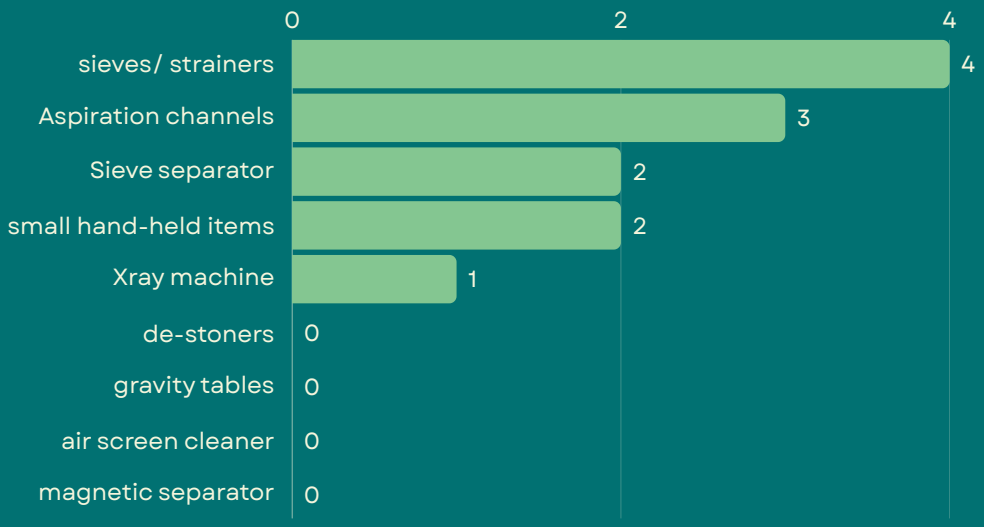
ROLES IN SEEDBANKING

The responses show that all five participants are involved in field collection and most are cleaning the seeds. An option was added by one participant for x-raying seeds. An option that was also overlooked was the germination testing- that was later further explored in an interview. There were no responses for seed transportation due to the small range of people.

The participants confirmed that biological and physical contamination were as equally common as each other within the process. Notably, the chemical contamination was not seen in seeds by this group of participants; confirming the prior research that it is not a key problem within conservation seedbanks.



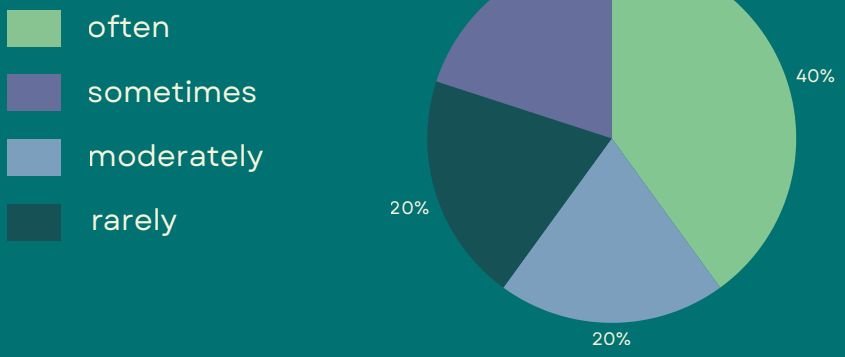
KIND OF SEED CONTAMINATION ENCOUNTERED



USE OF EXISTING PRODUCTS

The participants surveyed used a smaller range of products than initially estimated within the benchmarking. Many who used the sieves, used the aspirators in tandem, showing that these two were the most common and therefore most effective compared to the rest.

The frequency at which the participants were working with seeds was varied. Most likely due to many being volunteers and only getting the chance to harvest and process seeds in the spring of each year.



FREQUENCY OF CONTACT WITH ENDANGERED SEEDS IN A YEAR

LONG RESPONSE INSIGHTS

Some participants had no preference for particular products while others found that manual hand collection worked well consistently.

"Much of our seed processing is done manually without the need for tools or systems"

"Hand collection is good and is often used, though passive seed collection is less destructive to the seed coatings"

A downfall was mentioned in this section as the "longer collection timeframes" may result in higher concentration of biological contamination. E.g. the bugs caught in the seed bags would have only the seeds as a food source. The hand collecting method is also mentioned to pick up more physical debris along with the seeds.

Only a couple of participants had products they seemed to avoid within the seed banks while most did not. One participant expressed their discontent around tweezers and ruber bungs

"...Certain tweezers I will not use on various types of seed...as they can scratch and damage the seed coating."

"I disliked using the rubber bungs as they could easily damage the seed coats if too much downward pressure is applied."

To prevent contamination, participants mentioned wearing disposable gloves, sorting the seeds, and taking the seeds directly form the plant or individually from the ground. To manage contamination, participants said they remove insects and send seeds back into the cleaning stage.

VARIABLE RELATIONS

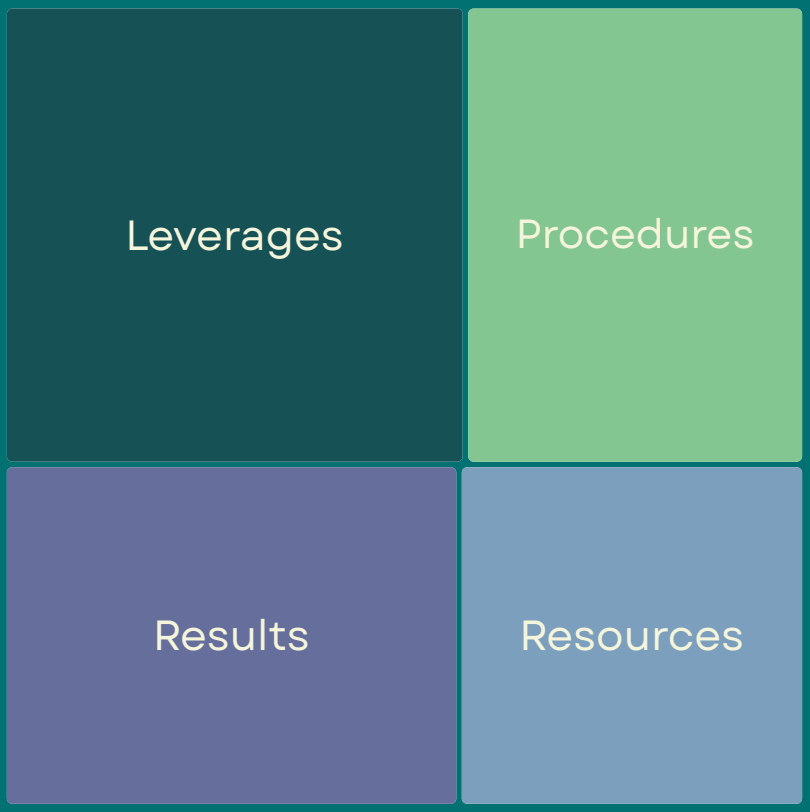
- Participants who had a role in sorting were also in contact with seeds often
- Participants who rejected less than ten seeds a year recorded they were all rejected because of non-viability
- Participants who had roles in cleaning all used sieves
- All participants had roles in field collection, and all collected by hand

These consistent matching responses from participants can strengthen the knowledge about causality within the seed collection process. This shows that the role of sorting seeds is most likely under the most time constraints as they would have to process all seeds that come in constantly - leading to the inclusion of more debris in storage. The participants who reject seeds do not reject any with present contamination, only ones that cannot germinate, meaning that the seeds may often be sent back to cleaning regularly, which increases an already long processing time. The sieves are confirmed to be necessary to clean seeds, and hand sorting is necessary to pick seeds.

Interview Analysis

QUANTATIVE INSIGHTS

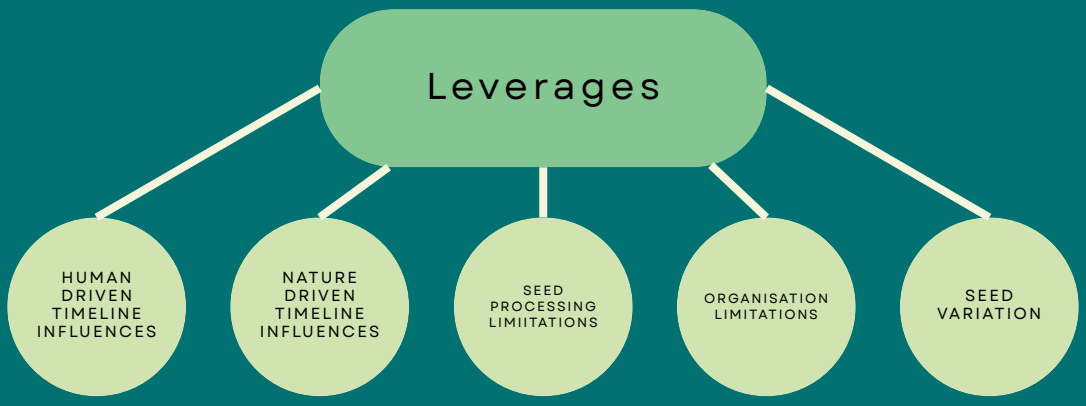
The three interviews that were conducted presented four categories that were made up of key words mentioned within the transcripts (see appendix 4). The categories found were procedures (actions within the seed banking process), results (the consequences/ outcomes that are caused by or related to the seedbanks),



resources (products used within the seed banking process), and leverages (the influences toward the seedbanks of either exterior or interior forces). The leverages had the largest frequency of keywords, making up 33.05% of all interviews (for all key words see appendix 2). This suggests a strong priority from the participants about the challenges they face that are out of their control as well as how they choose to influence what they can control.

Procedures and Results both were mentioned fifty-eight times each within the interviews, taking up 24.27% per category. This implies that the actions taken and outcomes of those actions are both as equally important as each other. This could infer that the outcome would suffer (even if positive) if the actions to get there were not taken with consideration. Every step of the process from field collection to freezing the seeds could have a possible risk of the seeds becoming non-viable and being contaminated. In a way, the final result is never actually the ultimate conclusion as the replanted seed could survive all the way to a tree and still get damaged and all the efforts to conserve it will be lost.

The resources category was mentioned the least, concluding that the problem of contamination was a more focused on talking point than its possible solutions through products. This could mean that the existing solutions are accepted by the seedbank community and are dealt with despite their faults because funding or the off-the-shelf nature of all existing products isn't worth seeking out alternatives.



Within the leverages category, limitations are presented that negatively influence the seed collection process and are either caused by contamination or make it harder to treat the contamination. The most mentioned pain points within this category are time constraints, losing viability, and automation complications (see appendix 3).

CONCEPTUAL INSIGHTS

Resources | Procedures | Leverages | Results

Certain themes arose from the coding of interviews that summarises the five major problems within managing contamination in the seedbank process. The pain points within the leverages are backed up by these themes as tangible problems that combine all four categories.

01.



TRAPPED IN A SMALL CIRCLE

"It's not worth chasing some species…we don't have the resources to go across the state to try and chase them (seeds)." - participant 1

"Part of it (the problem) is funding because we're project funded" - participant 1

"I know these things exist (separating machines based on physical appearance) but they tend to be fairly bulky and pretty expensive. Our facility here is pretty small so we only have a little lab, and we don't have a particularly big budget" - participant 2

The participants were recorded to be limited in their freedom to collect substantial amounts of seeds and expand their operations due to having to rely on 3rd party funding and therefore being small scale with little employees. This would limit the ability to replace contaminated seeds if needed and complete more accurate removing of the contaminants with a wider range of machinery and space.

02.



ACCEPTANCE OF THE IMMOVABLE

"there's a species that we're after and it has 100% (insect) predation… so we would bring it (seeds) back and x-ray and we basically got no viable seeds… we just have to keep trying." - participant 1

"You cannot easily distinguish the seeds from the debris. You cannot extract that out… we'll run a cut test, quantify the levels of debris in the collection and then live with it" - participant 2

"You can't lavish a days' worth of attention on a single collection… at some point you have to get to a pragmatic endpoint." - participant 2

The workers process was reported to have a lot of making do with forces they couldn't control or prevent. Even if this came at the cost of contaminating the seeds. This was usually a means to an end; the seeds had to be contaminated in order to save the seeds at all. Factors such as time, availability of advanced tech and wavering viability could either prevent this theme or be the reason for happening.

03.



SAFEGUARDING TOMORROW WITH YESTERDAY'S TECHNOLOGY

"There's only so much automation that's really suitable so a lot of what we do is still done by hand" - participant 2

"So, automating that (seed banking) process with a piece of machinery, I would imagine, is immensely complicated (due to seed variation)" - participant 2

"I don't even know if it's possible to replace people in a lot of this (process) because it takes observation and some kind of level of discernment." - participant 3

A lot of the hand-sorting and basic tools were mentioned to be used because of budgeting but also because of the widening complexity of automating an organisation with a great level of variation. Participants stated that the process, physicality, and biology of seeds were almost impossible to create one or a realistically sized group of machines for.

"Part of the problems with what makes native seed banks so difficult is the shapes and sizes and nature of these collections is unbelievably variable" - participant 2

"We are working with native seeds that come in all shapes and sizes... so we have so many processes depending on the seeds type" - participant 3

"Sometimes it's (contamination) unavoidable, you get two things co-occurring, and you don't know about it until afterwards, after it happens." - participant 2

04.



ORGANISED CHAOS

Participants reported that the process of seed banking was both very methodical and rigidly structured as well as variable and every changing depending on the seed, weather, location, and type of contamination they might find. All the different contingency combinations trained the participants to have a prepared mindset for what might change in the process.

05.



FOREVER THE ELEVENTH HOUR

"We weren't able to get the packets dried down quickly enough and there was moisture retained in the seeds… the seeds would then get mouldy" - participant 3

"If you got time, you pick each individual seed but sometimes you snip the whole head because you're time restricted" - participant 1

"I would like to be able to work through the seed cleaning and processing phase faster because the sooner we can do that; the sooner we can test collections and get them banked. So, shortening that time would really benefit." - participant 3

The seed collection process was referred to a lot as racing against the clock to keep the viability of the seeds long enough to store. They were also lamenting the fact that they couldn't be more meticulous as well as wishing that the process would be even faster. Often it was mentioned that the avoiding of contamination was neglected in favour of saving time.

Discussion

The research undertaken through surveys, interviews, benchmarking, and initial research, brought to light insights with multiple backing factors and experiences. Throughout the report, the new information gained connected to previous research and created a more nuanced and detailed outline of the most impacting factors that come with managing contamination. By finding relationships in the data, the end criteria can be informed.

A big insight that was found from the surveys and interviews that did not present in the initial research was how big of an impact time has on how well the contamination is removed from the seeds. The research into articles were homed in on the necessity of the cleaning and sorting phase but the interviews added some nuance to this take where it was not always possible to clean with accuracy. The viability of the seeds was determined the most by time, and the preferred method of processing by hand was slower, meaning when time was minimised, so was the tenacity for removing contamination. Having to leave the contamination with the seeds was a comprise for having time to collect the seeds at all.

The research had a lot of references regarding contamination as an accepted force of nature that could not be fully eradicated. Nature was described as being too volatile to predict no matter how many processes are invented; no single product could keep up with the variations. This leaves a lot of rudimentary tactics to become solutions as they can be easily moulded and formed to fit all types of leverages (seen in the categories). This was seen most prominently in the benchmarking as a market gap, as modular and customisable products made for conservation seed banking were identified as a potential need.

The limited funding made seedbanks turn away from most of the complex specialised products in favour of hand-sorting or small off-the shelf tools with an assortment of guaranteed variations.

Another insight within all modes of research was the funding aspect and how it limited a lot of the organisations' purpose. Being restricted by a small-scale context, chained the seedbanks to limited people power, limited products, and limited capacity. While this may be indirectly linked to contamination as it piles onto the number of problems that make it harder to remove contamination, it also puts any new solutions into perspective. The seedbanks are trapped by specificity, meaning, the potential for expansion and change cannot be financially viable if the concept is viewed to be too narrow by these third-party funders.

LIMITATIONS

The research, while expansive, has some drawbacks that are important to mention. The research suffered from not having any observations, such as visual examples of issues present in the other forms of data, as there is no mention of ergonomics, or human-centred problems that could have been naturally observed. This would have added an extra dimension of emotional experience instead of just logistical.

The sample sizes of survey and interview participants is an obvious limitation as there was a smaller variation in different experiences as different roles, and limited knowledge or more than three seedbanks within Australia. Another drawback would be the benchmarking and how useful the insights into every graph has been, as the context of sustainability or the certain range of products is not as large of a factor within the rest of the report.

Design Implications

The insights presented within the research, create a solid basis for the design solution toward managing contamination in the conservation seedbank industry. the existing products on the market are either expensive and complicated, or generic and cheaply made. The opportunity here is to find a middle ground, with no limitations on letting the user customise the product to fit the broad array of experiences needed to process seeds in a seedbank. The product should offer the user a positive experience that they don't have to compromise on.

The emphasis on the large variation of seeds as well as processes to treat those seed, leads the design direction that is open-ended for different roles in the seedbanks but is specifically designed for endangered seeds (non-abrasive features, handles small quantities). The research finds that almost every worker is involved in multiple parts of the seed banking process, using the same generic tools in many areas. The freedom to change the design using quality, repairable parts available would ease pressure on the budget and encourage the user to not accept inaccurate results with non-specialised tools. Easily modified products are a solution to natures variability.

The time constraint aspect of seed banking will be approached with a precise and thorough function. The compromise on quality and therefore increased contamination stems from the little time given to complete tasks. The task cannot be repeated if contamination is still present and more time cannot be given. By focusing on the accuracy of a design and an effectiveness that will result in only using it once, the contamination will be reduced.

MUST

- Aid in the sorting or cleaning of endangered seeds, reducing biological and physical contamination
- Be modular, adjustable, or customisable to accommodate variations in seeds or process
- Be easy to use and must be accessible for all ages of adults (volunteers as well as workers)

MUST NOT

- Be overly large scale, technologically complicated or be too expensive
- Have a high energy use or low quality unsustainable materials
- Compromise on accuracy

SHOULD

- Reduce the time taken to clean and sort seeds compared to doing by hand
- Must not have to take multiple times to remove the contamination
- Have several functions that can advertise to a wider range of industries



Conclusion

The contamination of endangered seeds for conservation seedbanks is an ongoing challenge that effects the processing of the seeds. The research and experiences presented by seedbank workers offers insight into the impacting factors of contamination. Time-constraints have increased the amount of contamination and have affected the precision of worker's output. The smaller scales of conservation seedbanks harm the possibilities of gaining further resources to treat contamination. The automation of existing products makes them unusable for these seedbanks as they can't account for the excessive seed variation.

The research conducted identified several gaps in the market for design opportunities. Instead of relying on complex automated products and slow manual processing, the solution will be specialised for endangered seeds. It will support the users needs through designing with an understanding about the different roles required. It will be an affordable, adaptable solution that priorities a smaller scale and accuracy in reducing contamination.



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Appendices

APPENDIX 1: PRODUCT LINKS

x-ray
https://www.kubtec.com/products/the-xpert-20-core-specimen-radiography-system

https://oncomed-solutions.com/solutions/pre-clinical-imaging/x-ray-imaging/xseed/

https://www.phenokey.com/applications/benchtop-x-rayct

Tweezers

https://cannakan.com/products/3-pcs-huggers%E2%84%A2

https://estore.oxinst.com/asia/products/general-consumables/tweezers-&-tools/dumont-tweezers/zid51-1625-0166?srsltid=AfmBOop59P9kaaneaKoVtY6lXA5xHKKR4Lv7sm_F9wvkjfbTzH-CihqlPy8

https://www.gapgames.com.au/products/tamiya-hg-straight-tweezers-reverse-action?variant=42703833825450&country=AU&currency=AUD&utm_medium=product_sync&utm_source=google&utm_content=sag_organic&utm_campaign=sag_organic&srsltid=AfmBOopPTENBkhDNig5RM_6KlGDP_Llzu4SrMpjN5fh1FwyVokpuwnN1kzc

https://www.hobbytools.com.au/rubber-tipped-tweezer/?srsltid=AfmBOoqcGQCkoqvzRpFf29OEiGNyCrcAkMiFIM85052CDTzdFmZVEMiu

https://ore-metals.com/products/paddle-tip-tweezer?srsltid=AfmBOoqtnTKDtN9EOXDYKps0WyqU7Ck2n9Py7PCouZlb57586AU-WPRnJaw

Screen separator

https://sanyuantangcn.com/products/vibrating-screen-separator

sieves

https://www.amazon.com.au/Stainless-Interchangeable-Sifting-Filtration-Gardening/dp/B0GMX5X6N6/ref=asc_df_B0GMX5X6N6?mcid=fd4092c948433146b7f384ff9054adf0&tag=googleshopmob-22&linkCode=df0&hvadid=798335325988&hvpos=&hvnetw=g&hvrand=3006878655984635722&hvpone=&hvptwo=&hvqmt=&hvdev=m&hvdvcmdl=&hvlocint=&hvlocphy=9068937&hvtargid=pla-2477206839806&psc=1&hvocijid=3006878655984635722-B0GMX5X6N6-&hvexpln=0&gad_source=1

rotary sifter

https://m.indiamart.com/proddetail/turbo-centrifugal-sifter-rotary-sifter-9806234848.html

tumbler screening machine

https://m.made-in-china.com/product/Rocking-Sieve-Dolomite-Powder-Separator-Automatic-Tumbler-Screening-Machine-739979602.html

VIBRATORY SCREENERS

https://www.kason.com/assets/files/Kason_Vibroscreen_Brochure.pdf
Sieving Machine
https://www.ebay.com.au/itm/187033811757?chn=ps&_ul=AU&_trkparms=ispr%3D1&amdata=enc%3A1g6ZcC4IcQ3KfL7yAIjvIRA8&norover=1&mkevt=1&mkrid=705-173151-935305-0&mkcid=2&mkscid=101&itemid=187033811757&targetid=2367800370202&device=m&mktype=pla&googleloc=9068937&poi=&campaignid=21776442415&mkgroupid=173963205248&rlsatarget=pla-2367800370202&abcId=10047386&merchantid=640714464&gad_source=1&gad_campaignid=21776442415&gbraid=0AAAAAD97CxTPeUO4cMP2pMjsf7VdXmgUq&gclid=Cj0KCQjwkOvTBhDgARIsAKUNyRs5NnNQKF9cH8-dkjExJSZz0pT_JRs8CKO5XTlSadVzdmwlEmYjlPAaAiSQEALw_wcB

aspiration channel

https://www.tradeindia.com/products/aspiration-channel-c11482752.html

zig-zag aspirator

https://www.shaivision.com/product/zig-zag-aspirator/

destoner

https://vinanhatrang.com/products/destoner/

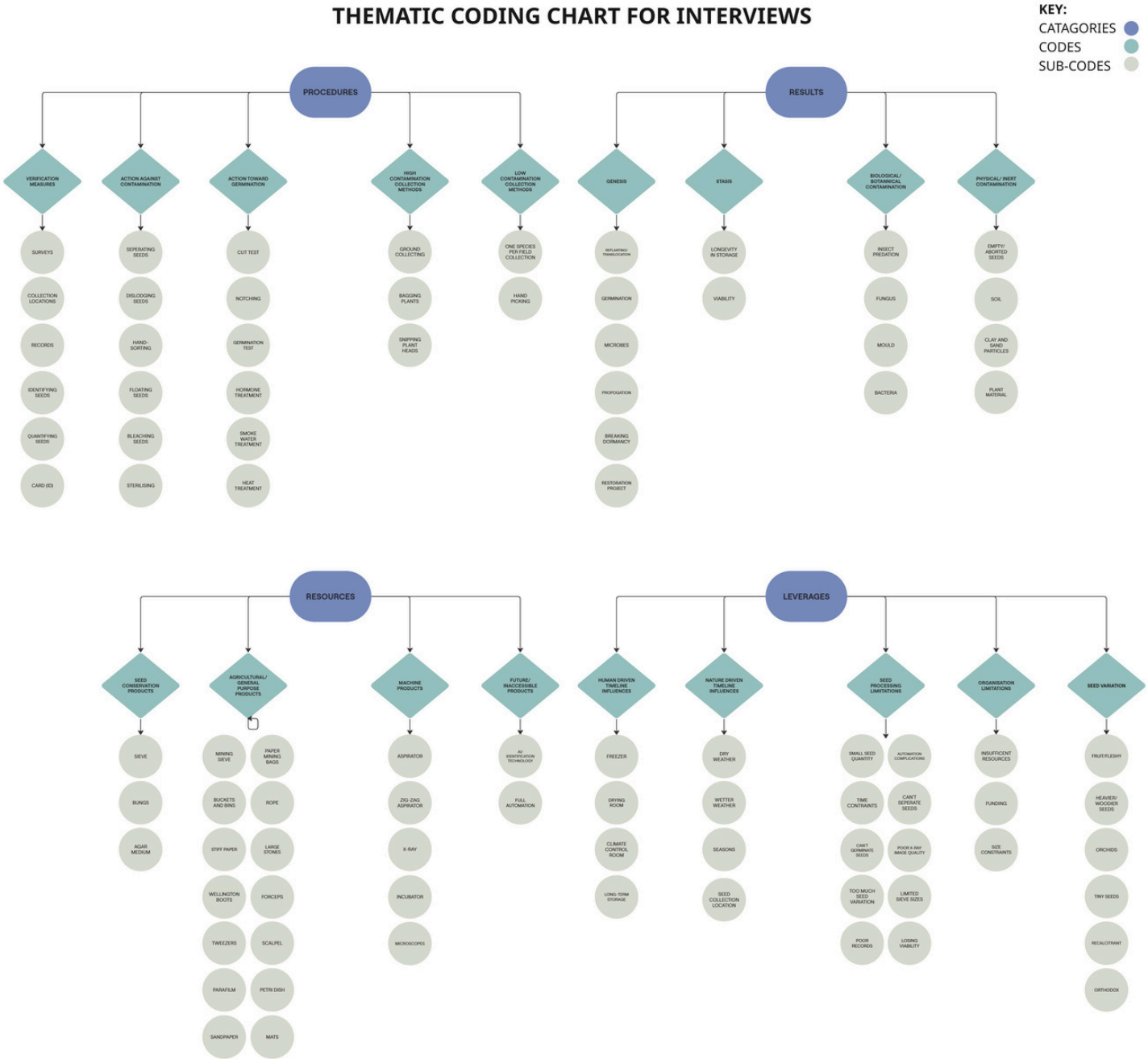
coffee destoner

https://www.wintopmachinery.com/Coffee-Destoner-2.html

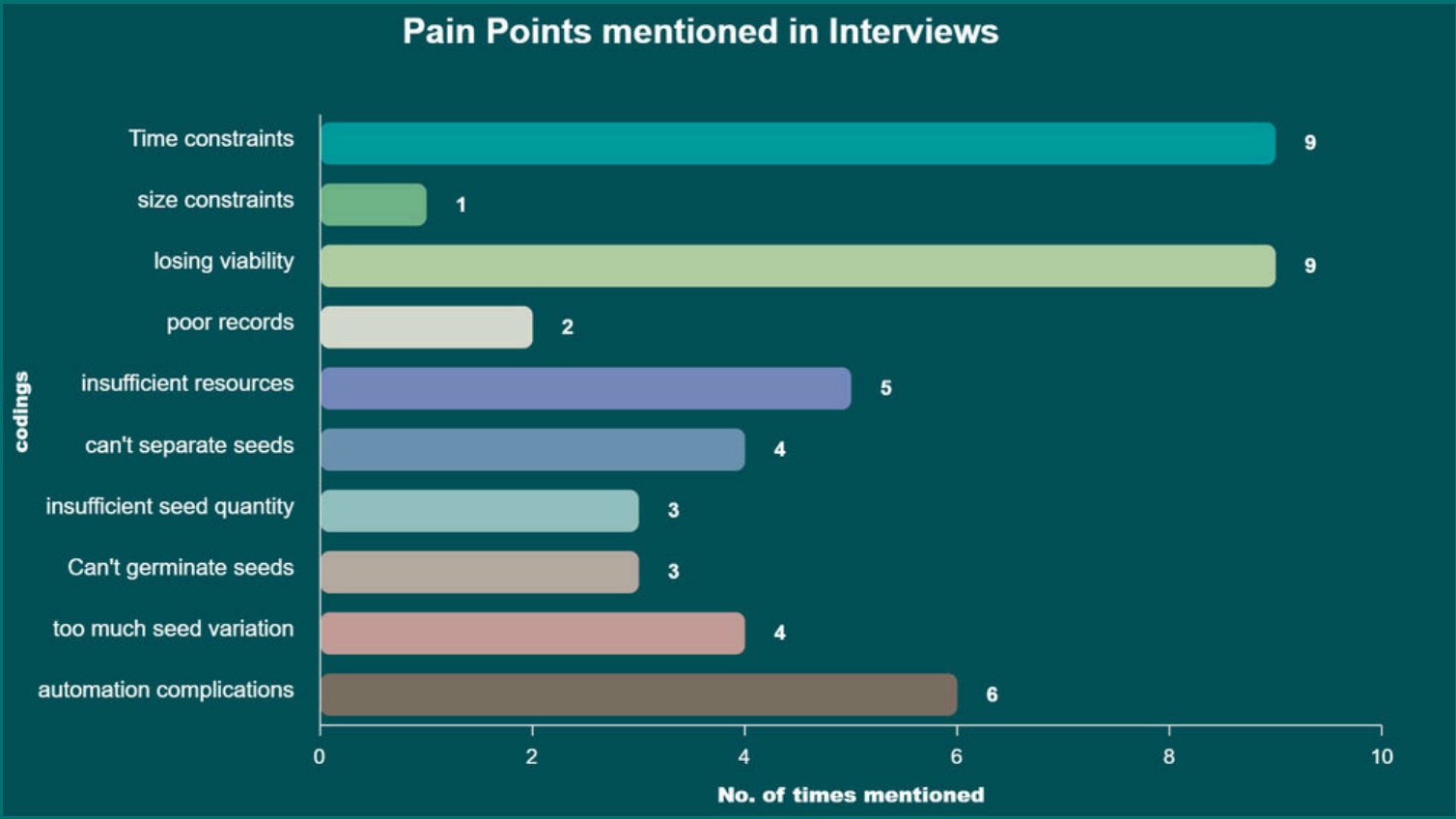
gravity table

https://jk-machinery.com/machines/jgt-gravity-tables/

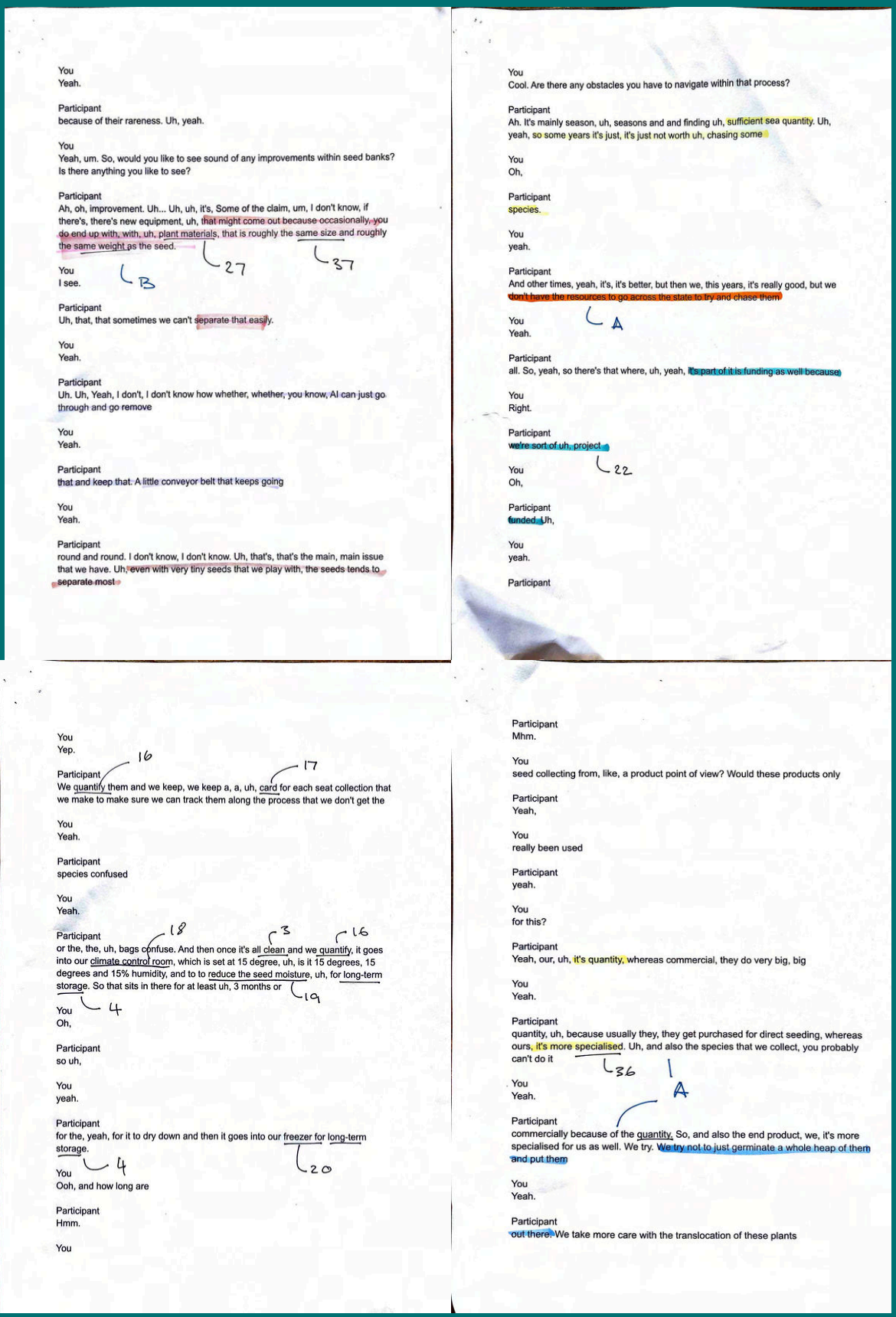
APPENDIX 2: THEMATIC CODING CHART



APPENDIX 3: PAINT POINT GRAPH



APPENDIX 4: TRANSCRIPTS



You
Yeah.

Participant
because of their rareness. Uh, yeah.

You
Yeah, um. So, would you like to see sound of any improvements within seed banks? Is there anything you like to see?

Participant
Ah, oh, improvement. Uh... Uh, uh, it's, Some of the claim, um, I don't know, if there's, there's new equipment, uh, that might come out because occasionally, you do end up with, with, uh, plant materials, that is roughly the same size and roughly the same weight as the seed.

You
I see.

Participant
Uh, that, that sometimes we can't separate that easily.

You
Yeah.

Participant
Uh. Uh, Yeah, I don't, I don't know how whether, whether, you know, AI can just go through and go remove

You
Yeah.

Participant
that and keep that. A little conveyor belt that keeps going

You
Yeah.

Participant
round and round. I don't know, I don't know. Uh, that's, that's the main, main issue that we have. Uh, even with very tiny seeds that we play with, the seeds tends to separate most

You
Cool. Are there any obstacles you have to navigate within that process?

Participant
Ah. It's mainly season, uh, seasons and and finding uh, sufficient sea quantity. Uh, yeah, so some years it's just, it's just not worth uh, chasing some

You
Oh,

Participant
species.

You
yeah.

Participant
And other times, yeah, it's, it's better, but then we, this years, it's really good, but we don't have the resources to go across the state to try and chase them

You
Yeah.

Participant
all. So, yeah, so there's that where, uh, yeah, it's part of it is funding as well because

You
Right.

Participant
we're sort of uh, project

You
Oh,

Participant
funded. Uh,

You
yeah.

Participant

You
Yep.

Participant
We quantify them and we keep, we keep a, a, uh, card for each seat collection that we make to make sure we can track them along the process that we don't get the

You
Yeah.

Participant
species confused

You
Yeah.

Participant
or the, the, uh, bags confuse. And then once it's all clean and we quantify, it goes into our climate control room, which is set at 15 degree, uh, is it 15 degrees, 15 degrees and 15% humidity, and to to reduce the seed moisture, uh, for long-term storage. So that sits in there for at least uh, 3 months or

You
Oh,

Participant
so uh,

You
yeah.

Participant
for the, yeah, for it to dry down and then it goes into our freezer for long-term storage.

You
Ooh, and how long are

Participant
Hmm.

You

Participant
Mhm.

You
seed collecting from, like, a product point of view? Would these products only

Participant
Yeah,

You
really been used

Participant
yeah.

You
for this?

Participant
Yeah, our, uh, it's quantity, whereas commercial, they do very big, big

You
Yeah.

Participant
quantity, uh, because usually they, they get purchased for direct seeding, whereas ours, it's more specialised. Uh, and also the species that we collect, you probably can't do it

You
Yeah.

Participant
commercially because of the quantity. So, and also the end product, we, it's more specialised for us as well. We try. We try not to just germinate a whole heap of them and put them

You
Yeah.

Participant
out there. We take more care with the translocation of these plants

You
Oh,

Participant
species into

You
yeah.

Participant
bag. Uh, but occasionally you do because uh, again, with orchids, uh, it's very hard to, to ID a species from when they're in pods. So even though we go there early, when it's in flower, and we work out where they are, we we pin each individual plant to go back to collect the pods. But in the process, you might get another orchid pop up nearby, uh, a different species that that set pods roughly at the same

You
Oh,

Participant
time.

You
yeah.

Participant
And occasionally we do get those sort of stuff. Uh, an orchid species. Once we clean the seat, the seats are so similar that we can't split them either.

You
Ah, yeah.

Participant
Where, where, whereas if somebody mistakenly collect, uh, uh, capsule something, acacias or something from another species. There's a, there's a difference between them that we can, we can remove them when we come to the cleaning

You
Yeah.

Participant
process. Uh, yeah, so, so if, uh, if we collect stuff from the ground for some species, you get grass seats and all those

interview 2

I think I have to pay for it to record on here, so I'll just record from my phone if that's all good. All good. So I'm just gonna be asking you four questions if that's all good. Then I'll have, like, some full-up ones based on your answers. Yep, no worries. Cool. All right, we'll start with the 1st one. What role do you play in the seed banking process? So, look, the I'm the manager of the seed bank, but essentially I'm the only member of staff. Oh, wow. So, um, so basically I cover all duties. I have volunteers to assist me. But I'm involved in virtual tasks around the operation of the seed bank. Wow. And, how long have you been involved in the seed bank industry? So I've been involved in seat banking since 1997? Wow. Have you seen any changes since then? Um, oh goodness, yes. So, um, But yeah, so the the types of technologies that involved in seed processing have changed a bit. Uh, you know, the standards around how we operate have changed as well. Um, But yeah, like the, Because of the nature of native seed, um, Banking, um, there's only so much more automation as possible. When you turn at things like the agricultural industry, you know, some degree refinement on machinery can be achieved. But with wild crops, with, say, wild species, there's only so much automation that's really, you know, uh, suitable. So, you know, we. So a lot of what we still do, what we do is still done by hands Um, just because nature of the work we do. So, yeah, it's, Yeah. You know, there's there's slight refinements, better understanding. You know, learning from mistakes. Um, But I think ultimately the technique for it we use to approach the Um, the things you tackle are fundamentally the same. Oh, yeah. Yeah. Cool. I'll go onto the next question. Can you explain the stages of the endagency collection process? So, I mean, what are you asking? You asking, well, how we generally deal with creating a or, you know, Banking an endangered species? Yeah, so like starting from like surveying to like replanting. Yeah. So, So, with me, each season we start by developing a collecting plan. We'll look at, you know, what we're actually currently holding, you know, in the quality of those collections. We'll also look at what we don't hold. Um, There might be some feedback from other bodies to say, that something you prioritising, um, or, you know, certain key species are having a good year. And then we'll start drafting our directing plan. We go out. So we'll be going out in around about, well, now, September, October, to survey. Looking at flying populations, you know, and try to identify decent sized populations, which certain species our knowledge of them isn't particularly good. A lot of people will record presents for a plant, but they very seldom record the size or extent of a population. So, um, you know, so sometimes it's coming in and actually looking at, you know, or, you know, maybe maybe the last time I'm going to start with survey was 20 years ago. So the actual population will have changed my day. So we go out, we'll have a look what the operations doing and then decide whether the connection make a collection. Um, seeding in Tasmania begins around about mid of December, uh, in the lowlands, and then sort of reaches its peak around by Christmas time. So late December and January, spent the bulk of London species being intercede, and then that saving season starts progress with altitude. So it will carry on all the way through to about March, and then we have a few species that stagger into April and May. I took a

couple of species of fairly late seeding. Um, so that's, you know, basic art trading season. So we're going out, we're making our collection, so we'll be collecting from usually we try about from about least 50 individuals. Oh yeah. Uh, one with sampling. We try to collect about 10 to 15% of what's available all the day. Um, And you know, so the idea is to is to collect fairly gently but very broadly across population. So we're not impacts more natural recruitment. Um, and We're aiming generally we're trying to get to 10 to 20,000 seats per collection. Oh, yeah. For a conservation seed bank. That's not always achievable. I think an average size collection for us about 5000 seats. Oh yeah. Yeah, but some, you know, some of our collections are in are in the tens of Harrisons. You really just depend on where they should be planned. For some things, it's very easy to achieve those numbers and other things are actually incredibly difficult. So we'll get this collections in, we claim to have various specimen. We get those collections back. Her various specimens are handed over to the herbarium for identification. Our collections are going to our drawing room, if they're back for it. They're processed immediately. So we extract seeds out of fleshy berries or droops pretty much as soon as possible. We'd like to do that within days of collecting. Um, Everything else just goes into the trying room. We have a room that's running at 15% range of humidity, 15 degrees centigrade. That dries down the material, and then we'll start to process that material. With things like orchids, we try to get those processed and banked in 10 days. As we know that basically maintains the viability of this collections, with other things, we don't really have that much information. There's possibly some other material that needs to be processed much more quickly. But it's really a, um, Because often we're very busy collecting in, you know, January, February. So the actual processing and banking doesn't start until March, April, and sometimes we don't get a lot of directions banked until, you know, September, October. in certain cases. So... So that's once we get anything banked. So we are holding our collections in full laminates. Uh, and placing them into subzero storage in a -20 um, Freezer? Uh, once regarding banks, will then look to assessing um, viability through a germination test. Well, it performed a cut test on a sample, the collection. to get a rough idea of the quality and also to help us work out whether we've reached a suitable endpoint in the cleaning. The ones we we think we've got, is the collection's key as possible, get banged, and then basically, you know, we'll know this collection is until full, and to extent, that's true. And then when we get round to doing the germination testing, that's when we actually test to see the protections alive a lot. So the germination testing is a another can of worlds. A lot of species are very easy to germinate and will go fairly readily. Um, but a large proportion of what we get in, it tastes tight. Some things we can probably get to germinate within about a year or 2 of working with. But there are a about 30 to 40% species we handle are have very complex dormancies and can take whatever a decade. To resolve, if not more. We had world connection that took 4.6 years to terminate. Wow. Uh, Yeah, that's that's at a single test. Um, But generally, um, you know, they're families that we have in Tasmania, uh, which we're, we're into, I think we're into, you know, 50, nearly 15 years of work, uh,

be uh, A soil, sand, clay particles. So when you're collecting some very small annual herbs, frequently you're picking whole plaids and unless you're very careful with getting all the debris off the roots, what you end up getting in the sea collection is a collection filled with tiny seeds and very small silk particles or clay particles, and you just, again, there's no way of separating them out. You just have to little bit. Um, there's, you know, like they're gravimetrically, uh, and uh, The way they're saying, they, they're the same size. We can draw the sipping and aspirating we want to do. We kept this again. There doesn't need to be way around that. Um, The, um, I say there's no way around that. I believe there are machines that can do that, like, you know, um, uh, You could probably use light refraction and stuff like that for a being likely, just feeding things in. You can sort it that way, but, you know, we don't have machinery like that in the organisation here. So we levered that as well. And then we just make a note when we're sewing material. We know that we need to be sorting the collection beforehand to get the debris as the collection. So we just sowing seeds. Oh yeah. Um, They, the earth other contamination is contamination with other species. Um, and that... That's more variable. Sometimes you can actually, um, pick out this, you know, if you, if the car, contaminate is not that similar, they're often ways to separating Arabs, so sometimes they contaminate smaller, lighter, or heavier. And so we're able to, you know, we have things like sieves, aspirators, but able to actually move that material. So that's sometimes navigable. Um, Sometimes, you know, it's on if the collection's not that big, we can often do a physical sorts. We just lay the collection on the bench and just have somebody looking at them and just sorting them through on the bench. And that's also been aware of removing the contaminant as well. But we only really do that if the collection is smaller than us. to actually warrant that. If the collection's really big, then it's, it's, you know, well, again, we'll tackle it when we come around to actually sewing the material. We'll just sort that out loud. And then so that. So, I mean, that, that curves it, yeah, like, you know, foreign seeds, uh, saw contaminants, and then, um, you know, to breathe, that's naturally produced by the plants. I mean that's the 3 main categories. Yeah, um, so, is there any risk towards the seeds when they have that physical debris in the soil and that, in one of these storage? So, we do know, look, so if one of the things we do know is that if the if the purity of the collection is lower, We tend to see a much more rapid drop in viability in time. So, the higher percentage of empty season collection, um, You know, the, The, the quicker the viability we just over time. Whether inert things like glass or clay particles would also impact on the collection's viability, I don't know. Honestly. Um, I'm trying to think if there's a mechanism for that. I mean, part of the reason why the MTE or disease material might impact collection viability and storage is often to do with, um, I think it's a reflection on how well you've cleaned it or the actual viability collection to begin with. So, it's, it's, you know, if, The collection's very, very clean, then, so, well, more certainly time, much more high digger viability to begin with, and that's why you're getting better storage over time. Um, So, Yeah, it's it's always preferable to get your collections as clean as possible. But there's all, it's just, you know, the sheer pragmatism you have to have, like you can't lavish, you

know, day's worth of attention on a single collection. You know, at some point you just, you have, you get to a, a pragmatic endpoint. You get a collection as keen as you, you know, realistically could, given time constraints, and then you store it. All righty. Well, I'll go on to the last question. This is about like tools and products and systems. So have you, what sort of like tools do you use mostly? To like. So clean. So there's 2 main pieces of equipment that we're utilising. One is, um, sips, so we have a whole lot of Endicott sips. Yeah. of various different gauges. I think we have About 20. Yep. Differences sizes from, you know, from very small microns to, you know, Centimetre app. differences. The other thing that we have is a zigzag aspirator. Oh, yeah. So that's a piece of equipment built in the Netherlands. It was built for the ornamental flower industry. But they've been very readily taken on by the native sea bank industry. history because they're pretty versatile. Oh yeah. Um, So, we have one now. I think a couple of the mainland seabank programs have them as well, and I know the QC bank hacking has 4 units in their facility. And they're getting used which every single day. So, yeah, so that's the 2 main piece of equipment. Other things we use, these bits of paper. Um, A piece of stiff paper. We often just use rope. We can roll collections on, so if seeds are pretty round and smooth, and the debris fairly flat, you can generally roll the collection, basically shake a collection, roll roll the seeds out of it. Um, We... First, the collecting is done, most of the cleaning is done, dry. We went, we went, wet fruit, fleshy berries, we tend to be using sieves under the sink. to wash out the fruit pop. Um, Very occasionally, I've actually treaded on, you know, some of the really large stones, um, species. Ill just pull up and just thought we were pair of Wellingtons. Uh, and that basically just, um, just, you know, uses the stones to braid the fruit pop. and mash it all up and then I wash it out. So, So yeah, but we don't. Um, A little rubber bone on a surf to break up the material. Oh, and then very occasionally we'll use things like actually a cloth bag or a Ziploc bag. So with seeds with a fairly um, fragile papace, often shaking the material in a inflated Ziploc bag. Uh, with just a bit of plat debris or maybe some pieces of paper. Can often just break up the purpose, and then we can, uh, Vibrate it, get the the heavy seed to settle at one end of the bag, and then just take up all the purpose, and that can get the... So when that works, that works very well. It's a technique that, uh, I think, um, uh, forest fish shoes have used to clean uh willow collections in Europe. Um, Start to be very effective. Um, Sometimes I can just raw corrections in a bag. You know, just repair gloves on. Uh, just by breading material. Again, that tends to be worked with seeds which are hardest. I think like acacia seeds or large stone fruit species. We can just use the material to upbraid each other and then work everything down into a fine powder and get the stones out intact. And the rest of the debris is just crushed up and then we can separate it using a sieve or the aspirator. Generally both. We'll use the system to get a defined debris before we put it in the aspirator. Um, yeah, and I think that's uh, essentially it. I think it's. Uh, Sitting, aspirating, and crushing by basically via hand. Ah, yeah. Or by foot, on occasion. Um, So if you were looking for a new product on the market, what would your, how would you evaluate that? If you were like searching for something new, what would

you want? Specifically for endangered seeds? Good question. Um... So one of the things I have seen being run, like there are machinery that can actually separate, um, uh, scenes based on physical appearance. I know these things do exist. But they tend to be (a)my bulky and pretty expensive. You know, our facility here is pretty small. Yeah. So we don't actually have a little lab space and we don't have a particularly big budget. So anything that's, that's, um, fairly small. And relatively inexpensive. would be, you know, key. So, you know, ability just to set up, you know, fill a collection and going to separate the units. By their physical appearance would be would be great. That still would save a lot of time. Um, The. There are certainly activities whereby the equipment we have is adequate or dealing with the collection. So, one of the things, um, that we often have to deal with is, um, uh, surgically processing the collections to get them to tubulate. We have stone frigid seeds, which are, you know, Sometimes we need to extract them. Uh, and extract the seeds from the stones and not damaging the seeds inside. is extremely difficult. Ah, yeah. But the problem is we've, we've, What, what, part of the problem, what makes a, a native seabank so difficult to deal with? is the shapes and sizes and nature of these collections is unbelievably variable. Yeah. So, automating that process of a piece of machinery, I would imagine, is immensely complicated. You know, that's why automation is possible in the crop industry because you've got a fairly limited number of things and off the machine is specialised for that crop. You know, you can't really have that in a native CPAC that's just the sheer range and range of the cheer you get in. It's just too variable. Yeah. So I, yeah, I think at a certain point, you know, there's not a huge amount, uh, We can really do with some of this stuff. Um, You know, I don't know like an ability to notch, um, Um, a thick coated fruit or seed, to a certain degree. Uh, um, would be, um, really useful. I recently just saw actually a sort of a... So a little documentary about how consumers are processed. Oh, yeah. And certainly, um, that was quite interesting because they have a machine that basically notches the uh, the fruits at the uh, at the end of the app port to actually help break it, so they can break the fruits, get the cashuna down. Uh, I thought, oh, that's, you know, like, you know, so again, like, I don't know how variable casuals are. So whatever, you know, and it was a pretty complicated and big piece of machinery. So, okay, not something that, you know, uh, uh, a small C bank clad could accommodate. So, yeah, so I don't know. Like that, they, like, you know, other than, other than like the, the, um, physical separating machines that I think are already kind of available. Um, yeah, that's, um, Yeah. Are there any other options? Oh. When it comes to geno contamination, that's really more. Okay. Oh, yeah. Well, that's all the questions I have for you. Would you like to add anything? No, I think I, I think I've, I've pretty much covered everything that's, you know, driving to, to your, The subject, um, Yeah, like, uh, generally, like when we're at collecting, we do try, do try to be careful not to get contamination. But, you know, sometimes it's just unavoidable. Like, you know, I say, I'm a number of staff, I have volunteers who assist me. And again, you know, when I'm out in the field, I try to make sure that everybody's clear about what the target is and how to identify it. to stop that. But, you

interview 3

Yeah, of course I was just sending you. I can say one, which I think, but I just signed. Thank you. Alrighty. Well, um, so I've got 4 main questions for you and I'll just have some like follow-up ones based on your answers. Alrighty. Um, so the 1st one, uh, what role do you play in the seed bank process? Sure. So my role here at the National Seed Bank, which is in the Australian National Botanic Gardens, is as the seed testing manager. So I'm responsible for the programs that we run in getting initial viability assessments for all of our state collections, um, and On that gleaning and developing germination protocols for each of the native species that... Cool. How long have you been involved in the C bank industry? I guess my moment started in 2015, so... And have you seen any changes since then? Yes. Yeah, I mean, I think I can speak from at least the institution where I work and definitely over that time. Um, there has been like a significant um, investment in seed banking as a really powerful tool for plant conservation. And as a result, our seed bank has grown in terms of its capacity and resourcing and stuffing over that time greatly. Um, And As there continues to be improvements and ships in the methods that we use as standards, um, right across Australia, in the same banking world, but also um, internationally. So I guess there's In ways, research and development and information informing the best ways, best practice for us to collect and store and Germany. Is it cool? All right, um, what does like a typical day look like for you in your role? I guess it would be different like every day, but like, Um, Day, it looks like, well, I'll talk about my typical best day where I get to do the most seed science and the least administrative public servanting because we do kind of struggle both worlds. Um, So I will um, arrive by work with my technician, Pip Alperetz, um, you know, a little seed testing world, and we will check in with each other. Um, I spend a lot of time Looking through the collections that are coming up for testing, so that have gone through the 1st stages of the scene banking processing process. So our collections come in from the field. Through the field season, then they get processed, they get cleaned, counted, um, and imaged, and we have a big team of volunteers who do that, so it'd be often a part of my days is interacting with our volunteers who come and help with different parts in that process and we have volunteers who help. Check on germination tests, so I'll check in when the volunteers hook. And kind of set up their work for the day. I will look through incoming packets of seeds to figure out what's ready for a germination test and then start to think about what conditions we need to put those seeds in, depending where the seats have come from, what Emily, that, what kind of dormancy they might have, what treatments they need to apply. Um, and I'll kind of put that in a format that then can be communicated to Pip, who does a lot of the setting up of the experiments and to any volunteers or student interns or people who we have around helping in that work. Um, I might spend some time doing, on experimental work myself, so doing, Setting up tests or looking at saint Domancy assessments, and for example, I, Now I need to go and take a measurement for an efficient test in the lab, so I'm kind of in and out of the lab. Um, doing some experimental work and then I also do a lot of data input and entry and maintaining our records or the new nation that we get. Um, And also spend time, you know,

reporting on various projects or collaborating with external partners about seeing banking work that we might be doing collaboratively. It's probably in some most things I'll do in a day. Um, So the next question, um, you sort of kind of explain this, but it's about the stages of the banking process. And do you think yours is like any different to any of the other seed banks or like? Um, I mean, we do adhere to kind of best practice and standards, which are pretty, um, Uniform is not the right word, but kind of Or facilities that are dedicated to conservation seatbase. Most facilities will have access to the similar kind of conditions that we use. So that's Um, initial storing conditions for drying seed collections down. So this is specifically orthodoxy banking as well. So, I'm not sure how to know you are with seed banking science, then seeds in general, but, We categorise you as kind of either orthodox or recalcitrant and orthodox seeds are those that can withstand the drying and freezing process and that's the best way to increase their longevity in storage. So that's how we process and stock all those seats. There are also a group of seats called recalcitrant seats who we cannot treat that way, so we can't put them through those processes. So in order to bank and conserve the products that have seats like that, we have to use the whole other series of processes. But I'll just talk about orthodoxy beckon because it's the most of what we do and it keeps that a bit more of a simple story. So as far as orthodoxy banking, mostly institutions, that at least I have interacted with, use very similar conditions to dry their seed and then to get them into long-term storage at -20 degrees by orthodox. seeds. -18 to -20, I reckon it's more people. Yeah, I have heard a lot of -20, yeah. Um, do you think there's a difference between commercial sea banking and endangered seed banking? Or like sort of like seed processing for like farms and things. Is there like a major difference? Yes, I mean, kind of, In general, the conservation seat banking that we do, so that's not necessarily endangered species. Well, we do often have a focus on things that are under some kind of threat. Any kind of native plant conservation work. Um, takes its roots from agriculture. So that's where sea banking was. And was around agriculture. So we have adapted all of those techniques or negative plant banking. But, There are ways that we need to handle our collections and considerations we need to make for our collections that are very different. So for example, In agricultural banks, the seat collections are pretty homogeneous, so they're, We did, we design, have designed crops to put on seed all at the same time, for example. The collecting seed is usually a big, like, you know, singular event and a huge harvest and the seeds are often quite uniform and Of like, often aren't don't have seen dormancy considerations, so that's a big part of kind of native sea biology as the dormancy that they naturally have to help them persist in the landscape. So that's a big consideration in our work is Considering, understanding, alleviating dormancy to germinate the seeds. That's the less common agricultural seabats. Um, And then, yeah, just like, for example, cut the collecting event itself, like we are collecting wild plants that might not put on seed in one big event. their population that could be quite spread out. The quality of a seed collection will be quite varied depending on the season, the maternal, um, conditions that like in the landscape. And so we deal

with a lot more variability in our collections at every stage, then... Cool. All right, I'll move on to the 3rd question. This is about contamination. So how would you define contamination in your organisation? Oh, well, I think there are a few. I think of contamination in a future kind of categories. So when I think about contamination of a steed collection that would have come from the field. Like a local seed collecting event. I would think contamination could be potentially other seed that has been accidentally collected in the bag. Maybe there was a plant close by and somebody just wasn't careful enough with their processes and accidentally grew up to a bit of extra state, so I would consider on the plant material that's not from the plugged. that we are collecting because we collect individual. But, um, I would consider that contamination that could occur in a pocket. Um, It could then contamination could occur because of the way that packet was then handled once the collecting event was made, so there could be contamination at the collecting event. There could be contamination from the early processing. So if, For example, it was really wet when we were collecting and we weren't able to get the packets dried down quickly and there was moisture retained in the scenes. That could then the seeds could get mouldy and I would consider that mould contention. That's another, I guess, type of contamination. We could also find insect like contamination, which we often do and see collections that we make, whether it's insects that have been living in the seed. a really common practice in collecting wild seed is to actually put a bag over, unlike fruit, because catching the seed at point of dispersal is quite typical when it's quite load and you get them out, so if we find fruits that are unlikely pollinated, we might put a bag on it, so that then we can come back later and know that we've captured the seat and it hasn't fallen to the ground. Often we get contamination, then in those bags with lots of insects and other things, so then we have cleaning elements. The insects as soon as possible so that they don't cause damage to their seeds. Um, I think those are the main types of contamination at the same packet, phase, and then my world is germination testing. And so for that contamination is on my germination plates, in the environments that I'm actually wanting to, um, Borrow the seeds to determine whether they are viable and if we [illegible] Typically, in my work, we do that on an agar medium, so it's water acre. We sterilise it, so it's as clean as possible, but contamination can happen in the plating up process and things falling on the plate. But most of the contamination we see in our germination plates comes from the seed and that's kind of to be expected. But the most part, it's not too damaging, but sometimes that can then can't get a good germination as well because we have mould and bacteria that is coming on the seed. But then it's a lovely, nice, moist warm condition to grow in. And so that is most the contamination that I deal with is that kind of like mould in the germination environment. Oh yeah. Um, So with that mould, what protocol do you have for like treating that or is it just sort of like a rejecting thing? So if we suspect a culture will be mouldy because of a number of reasons, or it could even just be that that species tends to get quite mouldy. We will often do a bleaching pre-treatment, so we use quite a low concentration, not just your standard bleach, um, to wash the seeds and

24 bags 19 44 45 46 44 12 E C, B 47 48

rinse them really thoroughly before we plate them and that minimises can minimise the level of growth. And I mentioned we sterilise the media that we're growing things on to limit the amount of contamination that could be coming from other sources. Um, And yeah, for the most part, we can still get a germination result even if that mould. Is there? It's a bit of a tightrope because Maybe the seeds need those other microbes in their environment for them to germinate, like we're dealing with negative collections. We don't want it to be as, um, You know, like kind of homogeneous. Maybe. Modern culture as maybe you would in an agricultural bank where you want it to be clean and tidy, just want the plant, you know, it's a lot more factors going on. And then at the end of our experiments, when we cut all the seed that hasn't germinated in half to assess, whether it was viable or not. Once we've done that, we will then order club, every, all of the product from our germination test so that any contamination that has developed or growing in that process is auto club, sterilise, but what we dispose of it. So it's kind of, It contained within. Yeah. The experiment. Yeah, um, okay, so my next question is about the products that you use. So would you be able to tell me like sort of the main tools and things that you use in this like germination process? So, shop for the germination testing. So, as I said, mostly we've run our tests on patriot dishes, and, like, no, like, it will be traditions. With an agar, water agar, medium, so no nutrients or anything else out of it, just for Ava. Um, We will plate up seeds usually just with forceps that we clean between collections and between use, typically in like an 80% ethanol, for example, and when it's in reversal as much as water. Um, It's painting, we label our plates, we have sharpies, very important, or the labelling. Um, The seeds come from paper packets, I'm sure I think what other things we use in the process, if it's pretty simple. Um, we tape our plates up with either a parafilm or like a, um, Kind of like a clean film, like, Into seal in the moisture. Um, so for our germination test, we want to give seeds, moisture and light and temperature petitions, that kind of the 3 main factors that work. always thinking about for our seeds to grow. So we keep the moisture in that way. And that's really, yeah, prototypical test. Then we have lots of things that we might do to pre-treat ourselves that they've got a certain type of dorancy. So we could apply a hormone treatment with a gibralic acid, which is a naturally current platform and that we apply exogenously to seeds to illicit germination. Um, smoke water we might use to soak seeds in if we think that they respond up to fire. Um, we use ovens to um, mimic like high temperatures of fire. So to do heat treatments or at lower temperatures to, um, ripen the sea more quickly. Uh, we use. Appreciate there's scalpels for making seeds or sandpaper for rubbing, um, the seed coat. Um, physically dormant things. Those are the most common ones and then there might be other random special things, but those are kind of the more commonly used pre-treatments in chemicals and then older plates go into incubators, so we use growth chambers for actually applying the right temperature and light conditions or germination tests. I think that's all the kit. That's the main kit. Yeah. Cool. So before that, that's the cleaning and processing. Do you know any products that they would use there? Um, yes. Oops, yeah, they're all green. All sorts of fun, I've got gizmos

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and gadgets. Um, Because, you know, we are working with native seeds that are, you know, come in all shapes, sizes, the diversity of them is just as great as the plants you see around the world. So we have so many processes depending on the same type to process clean. and salt those seeds. See, it's got a whole series of scenes, we give bans and mats, a lot of, like, tweezers. And you have machinery like aspirating and like air benches to suck. And like window collections based on weight. Of an x-ray seed x-ray initiatives will be x-ray, LCs, which gives us an indication of seed fill, so it'll go a collection that's got a high number of empty seats. We might clean up Burma, try and aspirate it and get rid of that MPC that's lighter than the heaviest. Uh, Russians. But all like mechanical things to separate. The collections from the plant material that we don't want to store with our seed collections because that comes the risk of more contamination. from just the pure seed that we want. Yeah, researching. Cool. About these products. Do you sort of like borrow these products from sort of like other industries, other places like they aren't really made for seed collection or are they like specifically for seed banks and things? A lot of them are specifically for seat work and a lot of them come from the agricultural industry, so we have like cultural machines that do seat counting. That's all from the agricultural industry, but we can apply to most of our seats, but not all same as the aspirator. Um, There are really lovely, beautiful specific scenes, Sims that we use, but by the same token, if we're working remotely, which we often do, we can grab a sip from Bunnings and it does, you know, a similar job. So there's a real um, spectrum of the equipment, but a lot of it is, um, specific to the seed industry, and if it's not agriculture, then the restoration seed industry is growing in their opinion, things like, yeah. Um... So if you were sort of like looking for a product, how would you evaluate it? Like if you were looking for a new product on a market, like what would you be looking for? I guess it would be if we had identified a need. We were like, oh, working for us or it's 10 agents to do this thing, might wonder what else is. Available. Um. Typically, I would say we would probably be talking with other seabanks about the methods that they're using and if they have a bit of equipment that can do a certain thing that we don't have, you know, we would potentially be interested in that or even just understanding, you know, what other methods are used to do, the things that we're doing. But pretty well. established, like, you know, the methods that we use, have been tried and tested. So, I would say Not that we're not looking to include methods where we can, but like outside of identifying a need where something really isn't working, we're probably not like actively looking for like new perks and things tend to kind of come across our desk because we've noticed them. working in other spaces and we might investigate it. But yeah, I would say your question. Yeah, I guess you sort of answered this, but like, would there, do you see anything that needs to be improved within the seed bank? Are there anything that like, You really think? Needs to be improved. It's hard, I guess I don't have like an engineering mind to even really think about the possibilities. I mean, the x-ray is a wonderful tool, but, I think, and I think it's happening more and more, but like, Machines that are specifically for doing a course on really small things because it's

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APPENDIX 5: CONSENT FORMS

CONSENT FORM FOR QUT RESEARCH PROJECT
– Interview –

DNB311 ID7 Capstone Design Project

QUT Ethics Approval Number # 11424

Research team

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Statement of consent

By signing below, you are indicating that you:

- Have read and understood the information document regarding this research project.
- Have had any questions answered to your satisfaction.
- Understand that if you have any additional questions you can contact the research team.
- Understand that you are free to withdraw without comment or penalty.
- Understand that if you have concerns about the ethical conduct of the research project you can contact me on email ellen.greenhill@connect.qut.edu.au
- Understand that the research project may include an audio recording.
- Agree to participate in the research project.

Please tick the relevant boxes below:

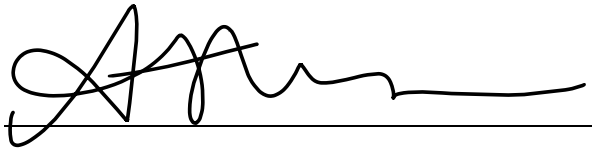
☒ I **agree** for the interview to be audio recorded.

Do you wish to have your comments attributed by name? yes ☒ no ☐

Do you wish to review a copy of the transcript? (this can be requested after the interview if needed)
yes ☐ no ☒
(if yes) please provide an email address:

Do you wish to request a summary of the findings of this study? Yes ☒ no ☐
(if yes) please provide an email address:

Name Millie Stevens

Signature 

Date 4/9/2026

Please return the signed consent form to the researcher. Ellen.greenhill@connect.qut.edu.au

UNOFFICIAL

CONSENT FORM FOR QUT RESEARCH PROJECT
– Interview –

DNB311 ID7 Capstone Design Project

QUT Ethics Approval Number # 11424

Research team

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Rafael Gomez r.gomez@qut.edu.au

Statement of consent

By signing below, you are indicating that you:

- Have read and understood the information document regarding this research project.
- Have had any questions answered to your satisfaction.
- Understand that if you have any additional questions you can contact the research team.
- Understand that you are free to withdraw without comment or penalty.
- Understand that if you have concerns about the ethical conduct of the research project you can contact me on email ellen.greenhill@connect.qut.edu.au
- Understand that the research project may include an audio recording.
- Agree to participate in the research project.

Please tick the relevant boxes below:

☒ I **agree** for the interview to be audio recorded.

Do you wish to have your comments attributed by name? yes ☒ no☐

Do you wish to review a copy of the transcript? (this can be requested after the interview if needed)
yes☒ no☐
(if yes) please provide an email address:

Do you wish to request a summary of the findings of this study? Yes☒ no☐
(if yes) please provide an email address:

Name Thai Te

Signature 

Date 27 August 2026

Please return the signed consent form to the researcher. Ellen.greenhill@connect.qut.edu.au

UNOFFICIAL

CONSENT FORM FOR QUT RESEARCH PROJECT
– Interview –

DNB311 ID7 Capstone Design Project

QUT Ethics Approval Number # 11424

Research team

Ellen Greenhill ellen.greenhill@connect.qut.edu.au

Jesse Goddard jesse.goddard@hdr.qut.edu.au
Rafael Gomez r.gomez@qut.edu.au

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Please tick the relevant boxes below:

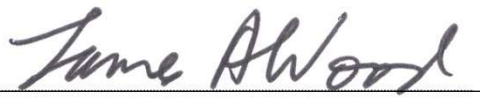
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Do you wish to review a copy of the transcript? (this can be requested after the interview if needed)
yes☒ no☐
(if yes) please provide an email address:

Do you wish to request a summary of the findings of this study? Yes☒ no☐
(if yes) please provide an email address:

Name James Alexander Wood

Signature 

Date _____

Please return the signed consent form to the researcher. Ellen.greenhill@connect.qut.edu.au