**2.0 Methods**

**2.1 Literature Synthesis**

Our systematic literature search is reported partially following the preferred reporting items for systematic reviews and meta-analyses (PRISMA) (Page et al., 2021). We searched the Web of Science (**version??**) between 15/11/2022 and 15/12/2022 using the “Topic” search term: “(mammal OR marsupial OR ungulate OR deer OR macropod OR possum OR wallaby OR kangaroo) AND (audio OR sound OR laser OR fencing OR repellent OR deterrent OR non-lethal) AND (browsing) AND (control OR damage)” across all databases.

We initially screened the 339 results by reading all titles and abstracts. 150 papers were excluded including 4 reviews. This produced a shortlist of 189 papers likely to contain relevant information. Shortlisted papers were scrutinised further creating a list of papers containing relevant data (146 papers). Throughout both screenings papers were excluded based on specific criteria:

1. No duplication – results that appeared multiple times were reduced so each paper appeared once. Moreover, where conference proceedings and journal articles reporting the same data occurred the journal article was retained and the proceedings excluded so that the same data were not reported twice (for example: Morgan and Woolhouse, 1993 and Woolhouse and Morgan, 1995).
2. Browsers must be mammalian – where papers reported data on mammalian and other browsing damage the paper was retained but data were only extracted for the mammalian browsing control.
3. Control measures must be related to trees – data were only included if the control measures were directly related to trees. Studies tested repellenceby applying compounds to a pellet diet (for example: Arnould and Signoret, 1993) and measuring differences in intake, or to an area (for example: Cox et al., 2012) and measuring aversion behaviours. These were excluded. While trialling repellents in this way is useful to shortlist effective compounds, the trade-offs between repellence and attractiveness of forage are not directly transferable between a treated area or pellet diet and treated seedlings. Animals make foraging decisions at different scales based on the relative attractiveness of foraging patches (Engen and Stenseth, 1984) and the relative quality of foods within those patches (Langvatn and Hanley, 1993; McArthur et al., 2000). As such, repellents that may be effective at deterring access to an open area may not retain their efficacy if the area was planted with seedlings which alter the patch quality. Therefore, to optimise the utility of this review’s results for growers, data were excluded if control measures were not related to trees.
4. Variables measured must be linked to browsing – studies quantified browsing by measuring numerous variables. For plant traits, such as height, it is easy to link a reduction in trait X to increased browsing. However, some variables cannot be easily tied to browsing. Where browsing altered species diversity it is difficult to say whether a reduced or improved species diversity is an improvement or worsening of browsing damage. To avoid confusion, data showing changes in species diversity or equivalent variables were excluded.

We considered papers in the cited literature of the 4 reviews identified in the initial search (Adams, 1975; Guerisoli and Pereira, 2020; Nolte and Wagner, 2000; Redick and Jacobs, 2020). The reference lists were subjected to the same exclusion processes as the Web of Science search results. 28 papers were identified and added to the list for data extraction.

(**worth doing a catch up search? – initial search was a while ago**)

**2.2 Data Extraction**

We compiled a database of effects from the list of 174 papers. An effect consisted of a unique pairwise comparison between application of a browsing control method and a control. Data were extracted as either:

1. Mean, sample size and estimate of variation (standard deviation/standard error/confidence intervals), hereafter SMD effects.
2. Sample size and a value (proportion/percentage/count) that exhibited a given response. For example, survived or were browsed. Hereafter, log odds effects.

Where adjusted means and raw data were reported the raw data was used. Where raw data was unavailable adjusted means were **converted/acknowledged and separated from the “raw” data…**

For SMD effects all estimates of variation were converted to standard deviations before effect size calculation. For log odds effects all values were converted to count data. We contacted authors where clarification, raw data or summary statistics were required. Where relevant data could not be supplied papers/effects were excluded. In instances where sample sizes were not clearly reported but other data (survival/mortality/density) was available sample sizes were computed from available information. Additionally, where an estimate of variation was not available a standard deviation was imputed… (**not clear on how this is done yet**)

**2.3 Effect size calculation**

After exclusion based on author responses, **XXX** papers contributed effects to the final data set.

**SMD effects**

**Log odds effects**

**Flipping of signs for certain variables needs to be accounted for here.**

**2.4 Moderator variables**

There was high heterogeneity across studies for control methods, browsing animal, tree genera and variables measured. In addition to collecting effect size data, we collected information pertaining to a number of moderator variables that we predicted would explain variation in effect size or were of interest from a land management perspective:

1. Control method and sub-type – papers conducted experiments with different control methods. We predicted that control method would significantly impact effect size. Where repellents were used the different methods of application were recorded as different control methods. Fencing was split into three categories: exclusion fencing, fencing and electric fencing, as the costs of each can vary substantially. Equally, the level of exclusion they provide is variable; a well-maintained exclusion fence will completely exclude browsers, whereas barrier or electric fences, while intended to be exclusionary, can be crossed by browsers if the animal is persistent (Statham, 1994and personal obs.)
2. Browsing animal – animal data was recorded in broad taxa, for example deer. Where multiple browsers were being controlled without delineation between the animal groups they were recorded as a mixed group, for example Moser (2002) studied browsing of deer and elk. **Likely to impact effect size – quantity of intake etc (references)**.
3. Genus of tree being protected – where specified the genus of trees being protected were recorded. Mixed assemblages where the species were specified were recorded as specified, where the genera were not specified the treatment was recorded as “various”.
4. Scale of treatment application – Experiments were classified as occurring at a plant, coupe or landscape scale. This was dictated by the experimental design: one test site = plant, multiple test sites within the same coupe/stand = coupe, multiple test sites spread across multiple coupes = landscape.
5. Time – the time interval between establishing the control method and the collection of data. Treatments that used pre-existing exclosures were estimated based on available information or were recorded as “Not stated”. Many studies used repeated measures. The retention of control efficacy over time is of high importance for growers, however inclusion of all time points increases the non-independence of effects. A compromise was struck by including up to 3 effects for each pairwise comparison with time points chosen at first measurement, last measurement and an intermediate measurement as close to the median time as was available.
6. Country – forest systems exist globally. One goal of this study is to provide a guide for growers to identify optimal non-lethal mammal control methods. For growers, the utility of the results presented here will rely on literature being synthesised from their respective growing scenarios. Collecting country of experiment will enable geographical gaps in the literature to be identified.
7. Variables measured **and unit** - what variables were used to quantify browsing damage in the experiments. For example, plant height, biomass or percentage of foliage removed.
8. Confounding factors –

**2.5 Meta-analysis**

**To be written…**

**2.6 Publication bias**

Publication bias arises when statistically insignificant results are more likely to be omitted from published papers or whole studies with statistically insignificant results are less likely to be published. Borenstein et al. (2021) describe how publication bias can impact the sample of studies available for meta-analyses and the subsequent effects that may have on the results of those analyses. As an initial countermeasure, where an email could be sourced, we contacted the authors of all 174 papers that were marked for data extraction asking whether there were data collected during their experiments that was not included in the final manuscript.

We also conducted… **ask Dan about pub bias tests.**