Supplementary Material

Current and emerging feral cat management practices in Australia

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Supplementary Material

Land-use type definitions

Table S1 *Land-use type definitions provided to experts during the workshop based on definitions from "The Australian Land Use and Management Classification Version 8" (ABARES, 2016).*

Land-Use Type	ABARES Land Use	ABARES Definition
Natural	Conservation and natural environments (PRIMARY CLASS)	Land used primarily for conservation purposes, based on maintaining the essentially natural ecosystems present (e.g., National parks, conservation areas, forest reserves). Land that has a relatively low level of human intervention. The land may be formally reserved by government for conservation purposes or conserved through other legal or administrative arrangements. Areas may have multiple uses, but nature conservation is the prime use. Do not include water reserves or wetlands in this category.
Production	Production from relatively natural environments (PRIMARY CLASS)	Land used mainly for primary production with limited change to the native vegetation (e.g., grazing in native vegetation; native forestry). The land may not be used more intensively because of its limited capability. The structure of the native vegetation generally remains intact despite deliberate use, although the floristics of the vegetation may have changed markedly. Where the native vegetation structure is, for example, open woodland or grassland, the land may be grazed.
Agricultural	Production from dryland agriculture and plantations (PRIMARY CLASS)	Includes land that is used principally for primary production, based on dryland farming systems. Native vegetation has largely been replaced by introduced species through clearing, the sowing of new species, the application of fertilisers or the dominance of volunteer species. The range of activities in this category includes plantation forests, pasture production for stock, cropping and fodder production, and a wide range of horticultural production
Rural Residential	Rural residential (SECONDARY CLASS)	Rural allotments with houses built (or being built) and agricultural activity at the sub-commercial and/or hobby scale (excluding backyard/domestic garden areas or livestock as pets). Rural residential generally refers to areas with blocks larger than 0.2 ha that are located in a rural setting (away from the main urban setting), with agriculture unlikely to be the main form of income. If agricultural activities are

		larger than 2 ha, they should be included separately under the production from dryland agriculture class.
Urban Residential	Urban residential (SECONDARY CLASS)	Land with houses, flats, hotels and so on within urban areas. This class may be used for land which is zoned for urban residential development where houses or apartments have not yet been constructed but infrastructure, such as roads and streetlights, is in place and it is clear that the intended land use is urban residential.
Wetlands	Wetlands, Lakes, Reservoirs, and Rivers (PRIMARY CLASS)	Wetlands are areas of permanent or periodic/intermittent inundation, whether natural or artificial, with water that is static or flowing, fresh, brackish or salt, excluding estuary and coastal water. Lakes are a natural or human-made body of mainly static water surrounded by land. Reservoirs are a body of water collected and stored behind a constructed barrier for some specific use. Rivers are a natural channel along which water may flow from time to time

Qualtrics Survey Questions

1. Which ecoregion would you like to focus on for the purpose of this survey **(choose one)**?

   ☐ Deserts and xeric shrublands

   ☐ Mediterranean forests, woodlands and scrub

   ☐ Montane grasslands and shrublands

   ☐ Temperate broadleaf and mixed forests

   ☐ Temperate grasslands, savannas and shrublands

   ☐ Tropical and subtropical grassland, savannas and shrublands

   ☐ Tropical and subtropical moist broadleaf forests

2. In which Australian state or territory do you have the most experience **(choose one)**?

   ☐ NSW

   ☐ ACT

   ☐ VIC

   ☐ QLD

   ☐ TAS

   ☐ WA

   ☐ SA

   ☐ NT

   ☐ Other (specify):

Answer the following questions assuming that a **10,000-ha** patch of land is being managed under the land use type "Conservation and natural environments" within your ecoregion. Use the definition of "Conservation and natural environments" from ABARES (2016) "The Australian Land Use and Management Classification Version 8":

Conservation and natural environments -- land used primarily for conservation purposes, based on maintaining the essentially natural ecosystems present (e.g., National parks, conservation areas, forest reserves). Land that has a relatively low level of human intervention. The land may be formally reserved by government for conservation purposes or conserved through other legal or administrative arrangements. Areas may have multiple uses, but nature conservation is the prime use. Do not include water reserves or wetlands in this category.

3. For each of the following management activities, provide realistic estimates for the reduction in the feral cat population you would expect **one month from the start of a management program**? Use the agreed upon group definition of the management program for your ecoregion defined earlier in the workshop (frequency, return interval,

season, etc). Here assume 100% is total removal of population following action and 0% is none removed.

For "Best" provide your best guess if you had to put a single figure on your opinion of the reduction in the cat population that will occur

For "Highest" provide the highest plausible value for the reduction in cats that occurs when you think of all the factors that make this cat population reduction likely to happen

For "Lowest" provide the lowest plausible value for the reduction in cats that occurs when you think of all the factors that make this cat population reduction likely to happen

4. For each of the following management activities, provide realistic estimates for the reduction in the feral cat population you would expect 12-months from the beginning of a management program? Use the agreed upon group definition of the management program for your ecoregion defined earlier in the workshop (frequency, return interval, season, etc). Here assume 100% is total removal of population following action and 0% is none removed

   For "Best" provide your best guess if you had to put a single figure on your opinion of the reduction in the cat population that will occur

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   For "Lowest" provide the lowest plausible value for the reduction in cats that occurs when you think of all the factors that make this cat population reduction likely to happen

5. What would you estimate is the cost of implementing this management technique for one-month (provide estimate as multiples of $10,000's for example, 5 = $50,000)?

Answer the following questions assuming that a **10,000-ha** patch of land is being managed under the land use type "Production from relatively natural environments" within your ecoregion. Use the definition of "Production from relatively natural environments" from ABARES (2016) "The Australian Land Use and Management Classification Version 8":

Production from relatively natural environments -- land used mainly for primary production with limited change to the native vegetation (e.g., grazing in native vegetation; native forestry). The land may not be used more intensively because of its limited capability. The structure of the native vegetation generally remains intact despite deliberate use, although

the floristics of the vegetation may have changed markedly. Where the native vegetation structure is, for example, open woodland or grassland, the land may be grazed.

6. For each of the following management activities, provide realistic estimates for the reduction in the feral cat population you would expect **one month from the start of a management program**? Use the agreed upon group definition of the management program for your ecoregion defined earlier in the workshop (frequency, return interval, season, etc). Here assume 100% is total removal of population following action and 0% is none removed.

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   For "Lowest" provide the lowest plausible value for the reduction in cats that occurs when you think of all the factors that make this cat population reduction likely to happen

7. For each of the following management activities, provide realistic estimates for the reduction in the feral cat population you would expect 12-months from the beginning of a management program? Use the agreed upon group definition of the management program for your ecoregion defined earlier in the workshop (frequency, return interval, season, etc). Here assume 100% is total removal of population following action and 0% is none removed

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   For "Lowest" provide the lowest plausible value for the reduction in cats that occurs when you think of all the factors that make this cat population reduction likely to happen

8. What would you estimate is the cost of implementing this management technique for one-month (provide estimate as multiples of $10,000's for example, 5 = $50,000)?

Answer the following questions assuming that a **10,000-ha** patch of land is being managed under the land use type "Production from dryland agriculture and plantations" within your ecoregion. Use the definition of "Production from dryland agriculture and plantations" from

ABARES (2016) "The Australian Land Use and Management Classification Version 8":

<u>Production from dryland agriculture and plantations</u> -- Includes land that is used principally for primary production, based on dryland farming systems. Native vegetation has largely been replaced by introduced species through clearing, the sowing of new species, the application of fertilisers or the dominance of volunteer species. The range of activities in this category includes plantation forests, pasture production for stock, cropping and fodder production, and a wide range of horticultural production.

9. For each of the following management activities, provide realistic estimates for the reduction in the feral cat population you would expect **one month from the start of a management program**? Use the agreed upon group definition of the management program for your ecoregion defined earlier in the workshop (frequency, return interval, season, etc). Here assume 100% is total removal of population following action and 0% is none removed.

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10. For each of the following management activities, provide realistic estimates for the reduction in the feral cat population you would expect 12-months from the beginning of a management program? Use the agreed upon group definition of the management program for your ecoregion defined earlier in the workshop (frequency, return interval, season, etc). Here assume 100% is total removal of population following action and 0% is none removed

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    For "Highest" provide the highest plausible value for the reduction in cats that occurs when you think of all the factors that make this cat population reduction likely to happen

    For "Lowest" provide the lowest plausible value for the reduction in cats that occurs when you think of all the factors that make this cat population reduction likely to happen

11. What would you estimate is the cost of implementing this management technique for one-month (provide estimate as multiples of $10,000's for example, 5 = $50,000)?

Answer the following questions assuming that a **10,000-ha** patch of land is being managed under the land use type "Rural residential" within your ecoregion. Use the definition of "Rural residential" from ABARES (2016) "The Australian Land Use and Management Classification Version 8":

Rural residential -- rural allotments with houses built (or being built) and agricultural activity at the sub-commercial and/or hobby scale (excluding backyard/domestic garden areas or livestock as pets). Rural residential generally refers to areas with blocks larger than 0.2 ha that are located in a rural setting (away from the main urban setting), with agriculture unlikely to be the main form of income. If agricultural activities are larger than 2 ha, they should be included separately under the production from dryland agriculture class.

12. For each of the following management activities, provide realistic estimates for the reduction in the feral cat population you would expect **one month from the start of a management program**? Use the agreed upon group definition of the management program for your ecoregion defined earlier in the workshop (frequency, return interval, season, etc). Here assume 100% is total removal of population following action and 0% is none removed.

    For "Best" provide your best guess if you had to put a single figure on your opinion of the reduction in the cat population that will occur

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13. For each of the following management activities, provide realistic estimates for the reduction in the feral cat population you would expect 12-months from the beginning of a management program? Use the agreed upon group definition of the management program for your ecoregion defined earlier in the workshop (frequency, return interval, season, etc). Here assume 100% is total removal of population following action and 0% is none removed

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For "Lowest" provide the lowest plausible value for the reduction in cats that occurs when you think of all the factors that make this cat population reduction likely to happen

14. What would you estimate is the cost of implementing this management technique for one-month (provide estimate as multiples of $10,000's for example, 5 = $50,000)?

Answer the following questions assuming that a **10,000-ha** patch of land is being managed under the land use type "Urban residential" within your ecoregion. Use the definition of "Urban residential" from ABARES (2016) "The Australian Land Use and Management Classification Version 8":

Urban residential -- land with houses, flats, hotels and so on within urban areas. This class may be used for land which is zoned for urban residential development where houses or apartments have not yet been constructed but infrastructure, such as roads and streetlights, is in place and it is clear that the intended land use is urban residential.

15. For each of the following management activities, provide realistic estimates for the reduction in the feral cat population you would expect **one month from the start of a management program**? Use the agreed upon group definition of the management program for your ecoregion defined earlier in the workshop (frequency, return interval, season, etc). Here assume 100% is total removal of population following action and 0% is none removed.

For "Best" provide your best guess if you had to put a single figure on your opinion of the reduction in the cat population that will occur

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For "Lowest" provide the lowest plausible value for the reduction in cats that occurs when you think of all the factors that make this cat population reduction likely to happen

16. For each of the following management activities, provide realistic estimates for the reduction in the feral cat population you would expect 12-months from the beginning of a management program? Use the agreed upon group definition of the management program

for your ecoregion defined earlier in the workshop (frequency, return interval, season, etc). Here assume 100% is total removal of population following action and 0% is none removed

For "Best" provide your best guess if you had to put a single figure on your opinion of the reduction in the cat population that will occur

For "Highest" provide the highest plausible value for the reduction in cats that occurs when you think of all the factors that make this cat population reduction likely to happen

For "Lowest" provide the lowest plausible value for the reduction in cats that occurs when you think of all the factors that make this cat population reduction likely to happen

17. What would you estimate is the cost of implementing this management technique for one-month (provide estimate as multiples of $10,000's for example, 5 = $50,000)?

Answer the following questions assuming that a **10,000-ha** patch of land is being managed under the land use type "Wetlands, Lakes, Reservoirs, and Rivers" within your ecoregion. Use the definition of "Wetlands, Lakes, Reservoirs, and Rivers" from ABARES (2016) "The Australian Land Use and Management Classification Version 8":

Wetlands, Lakes, Reservoirs, and Rivers--Wetlands are areas of permanent or periodic/intermittent inundation, whether natural or artificial, with water that is static or flowing, fresh, brackish or salt, excluding estuary and coastal water. Lakes are a natural or human-made body of mainly static water surrounded by land. Reservoirs are a body of water collected and stored behind a constructed barrier for some specific use. Rivers are a natural channel along which water may flow from time to time

18. For each of the following management activities, provide realistic estimates for the reduction in the feral cat population you would expect **one month from the start of a management program**? Use the agreed upon group definition of the management program for your ecoregion defined earlier in the workshop (frequency, return interval, season, etc). Here assume 100% is total removal of population following action and 0% is none removed.

For "Best" provide your best guess if you had to put a single figure on your opinion of the reduction in the cat population that will occur

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For "Lowest" provide the lowest plausible value for the reduction in cats that occurs when you think of all the factors that make this cat population reduction likely to happen

19. For each of the following management activities, provide realistic estimates for the reduction in the feral cat population you would expect 12-months from the beginning of a management program? Use the agreed upon group definition of the management program for your ecoregion defined earlier in the workshop (frequency, return interval, season, etc). Here assume 100% is total removal of population following action and 0% is none removed

For "Best" provide your best guess if you had to put a single figure on your opinion of the reduction in the cat population that will occur

For "Highest" provide the highest plausible value for the reduction in cats that occurs when you think of all the factors that make this cat population reduction likely to happen

For "Lowest" provide the lowest plausible value for the reduction in cats that occurs when you think of all the factors that make this cat population reduction likely to happen

20. What would you estimate is the cost of implementing this management technique for one-month (provide estimate as multiples of $10,000's for example, 5 = $50,000)?

The following questions relate to other economic, social, and ecological impacts for each management technique.

21. Overall, what is a realistic estimate of the proportion of the budget over a 12-month period that is attributed to each management technique in your ecoregion (your total must equal 100)?

22. To what degree does each management action negatively impact non-target native species in the 12-months from the start of the management (place an X in one box for each row)?

23. What is the social acceptability of the treatment? Where low tolerance means people have strong negative feelings and resist the use of this management technique and high tolerance means people have no concerns with this management tool being applied.

24. Do you have any additional comments you would like to add?

Additional Results

Table S2 Summary of number of responses for each management technique in the different land-use types. N/A indicates more than 50% of experts responded the technique was not applicable for that land-use type. Low indicates fewer than 50% of experts provided estimates of the techniques' effectiveness. High indicates more than 50% of experts provided estimates of the techniques' effectiveness.

Technique	Land-Use Type					
	Natural	Production	Agricultural	Rural Residential	Urban Residential	Wetlands
Aerial baiting	High	High	Low	N/A	N/A	N/A
Ground baiting	High	High	Low	N/A	N/A	N/A
Leghold trapping	High	High	Low	N/A	N/A	Low
Cage trapping	High	High	High	High	High	Low
Shooting	High	High	Low	N/A	N/A	High
Tracking by Rangers	Low	Low	Low	N/A	N/A	N/A
Detector dogs	Low	Low	Low	Low	N/A	Low
Habitat modification	Low	Low	Low	N/A	N/A	Low
Resource modification	Low	Low	Low	Low	N/A	Low
Fencing*	High	Low	Low	N/A	N/A	Low

* Results for Fencing are not reported here as the questions were not framed well for this management technique leading to confusion on how to answer the question and variability in how this technique was considered.

Table S3 *Definitions of current and future management techniques identified as currently in use around Australia as provided by the workshop participants. We note that the definitions of the techniques may not reflect the views of all groups in Australia who manage feral cats.*

Technique	Description	Pros and Cons of Technique
Aerial Baiting	A lethal technique in which a helicopter or fixed-wing aircraft is used to deploy poison baits. Several different bait types exist. Used in difficult to access areas, although decisions around use are based on economics as well as size and topography of the landscape. Not affected by ecoregion. Legislation for use differs between states. Scale: variable (> 100,000 ha) Season: Typically winter Return Interval: Annual or Bi-Annual Monitoring: Difficult to monitor Tenure: Public, Private	Pros • Fast technique with large-scale of operation • Does not require road access throughout the deployment area • Can achieve reasonable cat population reduction (up to 50-90% decrease) Cons • Humaneness and risk to non-target species • Often ineffective – affected by weather conditions or prey availability • Seasonal use only • Permits and legislation are different in each state and difficult to navigate • Difficult to use for conservation in some regions for ecological or cultural reasons • Target species can develop bait avoidance or resistance • May lead to prey switching in cats
Ground Baiting	A lethal technique in which poison baits are deployed along tracks, roadsides, park perimeters or fire edges. Several different bait types exist. Use overlaps with aerial baiting, but it can be more targeted, and is more limited in scale. Legislation for use differs between states. Scale: 10,000 ha – 20,000 ha	Pros • Fast technique with large-scale of operation • Can achieve reasonable cat population reduction (up to 50-90% decrease) • Not as expensive as aerial baiting • Fewer baits per unit area than aerial baiting (reduces risk to non-targets) Cons • Humaneness and risk to non-target species – on track deployment means higher exposure to non-target species, in particular birds • Often ineffective – affected by weather conditions or prey availability

	Season: Typically winter Return Interval: Annual Monitoring: Yes Tenure: Public, Private	• Seasonal use only • Permits and legislation are different in each state and difficult to navigate • Difficult to use for conservation in some regions for ecological or cultural reasons • Target species can develop bait avoidance or resistance • May lead to prey switching in cats • Not as effective as aerial baiting with lower encounter rates • If baits are buried, cats will not take them
Live Trapping – Leghold Trapping	Specialist technique using soft-jawed/ padded leghold traps, generally with a lure (e.g., olfactory, visual and/or auditory). Traps are checked daily. The placement and setting of traps are essential to the program success and to ensure non-target species captures are avoided. Requires a protocol for processing and euthanising the animal once it has been captured. Often used in areas where you cannot use baiting or used following a baiting program. Legislation for use differs between states. Scale: 10,000 ha – 60,000 ha Season: Year round Return interval: Variable Monitoring: Yes Tenure: Public or private land	Pros • Non-targets can be released unharmed • More effective than cage traps Cons • Cost and labour-intensive requiring experienced staff to implement • Can only be used at smaller spatial scales • Higher risk of injury to target and non-target animals, especially when used incorrectly • Can be seen as inhumane with issues around social license and acceptability • Site access can limit use • Cannot be used in urban interface • Permits and legislation are different in each state and difficult to navigate

Live Trapping – Cage Trapping	Specialist technique using cage traps in conjunction with scent or food-based lures. Traps are checked daily. The placement and setting of traps are essential to the program success and to ensure non-target species captures are avoided. Requires a protocol for processing and euthanising the animal once it has been captured. Typically used in areas where firearms or baiting programs are prohibited or are considered too risky (e.g., national park visitor areas). It can be used in area where domestic cats may be captured. Often used following baiting programs. <u>Scale</u>: 100 ha – 20,000 ha <u>Season</u>: Year round <u>Return Interval</u>: Variable <u>Monitoring</u>: No <u>Tenure</u>: Public, Private	<u>Pros</u> • Non-targets can be released unharmed • Easy and affordable method • Relatively urban friendly and good social licence • Aids in eradication from areas <u>Cons</u> • Time and labour-intensive method • Can only be used at smaller spatial scales • Low success rates, with trap avoidance likely • Non-target species frequently captured – food lures capture more non-targets • Site access can limit use
Shooting	A lethal technique in which a firearm is used to euthanise target animals. Can be either nocturnal or diurnal with the aid of either spotlights or thermally assisted visualisation. Often used in conjunction with other management techniques for the final animals remaining in an area.	<u>Pros</u> • Exact numbers of animals killed is known • Very good when used with other techniques – particularly for closed populations (e.g., islands, fences) • Good for specific cats that avoid cages • Many people licensed to shoot (e.g., farmers, natural resource managers, etc) • Less intrusive & can be more humane than other techniques <u>Cons</u>

	Scale: Localised around assets Season: Year round Return Interval: Variable Monitoring: No Tenure: Public, Private	• Requires permitting and legislation, with legislation limiting where shooting can occur • Requires vehicle or track access • Cost and labour intensive – cannot be applied broad-scale • Humaneness can be an issue depending on the skill of the individual • Needs to occur as part of a proper management program • Limited to non-urban landscapes • Low encounter rate
Tracking by Rangers	An extremely specialised skill in which Traditional landowners or rangers track cats in areas with sandy substrate. Currently limited to central and western Australia. Scale: Localised Season: Year round Return Interval: Variable Monitoring: No Tenure: Public, Private	Pros • Substantial social and cultural benefits including getting people out on country • Exact numbers of animals killed is known • Experienced trackers are faster and more efficient than shooters Cons • Requires extremely skilled trackers • Requires sandy substrate • Difficult to maintain an ongoing effort • Needs encouragement for rangers to keep going back to the same place • Little is known of the humaneness of the technique with potential welfare issues (e.g., stress of being hunted to exhaustion)
Detector Dogs	The use of dogs to detect where cats have been so baiting or trapping programs can be prioritised. Dogs can also be used to position (bail) cats so that they can be caught or shot. Should be considered a complementary technique rather	Pros • Very effective in smaller island habitats, including fenced areas • Allows the recapture of certain cats which you may not be able to recapture using other methods Cons • Success tends to be location specific

	than a main method of management. Scale: Localised Season: Year round Return Interval: Variable Monitoring: No Tenure: Public, Private	• Some regions detect scat/spoor really well, but have difficulty finding an actual cat • Lots of skill required, with substantial training and handling costs • Harder to use when baits are present • Harder if snakes are active • Can be a biosecurity risk
Habitat Modification	The use of fire or grazing to improve vegetation structure and minimise the impacts of feral cats. It is not specifically a cat management technique and to reduce cat density it should be used in conjunction with a direct-action management technique. Scale: N/A Season: N/A Return Interval: N/A Monitoring: N/A Tenure: Public	Pros • Improves the general landscape resilience • Can be relatively cost-effective addressing several pressures at once Cons • Not an effective technique to control cats specifically • Current evidence base is not substantial for all Australian environments and can be conflicting
Resource Modification	Targeted control of prey species with the aim of reducing the prey population to reduce the predator population. In particular, for use on rabbit populations. Scale: N/A Season: N/A Return Interval: N/A Monitoring: N/A Tenure: Public	Pros • Very cost-effective way to reduce cat populations over very large areas Cons • Risk of prey switching resulting in damage to native fauna populations
Fencing	A supplementary technique in which a fenced area is created to protect populations of threatened species from cat predation. Feral	Cons • Expensive • Restricts movement of other species and may cause issues with inbreeding

	cats are removed from within this fenced area using other management techniques. Scale: N/A Season: N/A Return Interval: N/A Monitoring: N/A Tenure: Public	
Gene Drive	Genetic modification of individuals (e.g., so all offspring are male) by affecting fertility or cat health. Not currently in use, but could be used everywhere	Pros • Broad application and widespread outcomes • Could be cheap one day • May eradicate island populations Cons • Development costs and time • Unachievable • Slow to spread • Impacts on pet cats and other felid species • Needs "off switch"
Felixer Grooming Traps	Grooming trap which uses Artificial Intelligence to target feral cats and deliver a gel-based toxin (1080). Currently still under development, being trialled on islands For use in conjunction with other methods	Pros • Good in hard to access places • Non-target species reduced • Passive sentinel • Set and forget method • Can be left in field for extended periods • Bait avoidance avoided Cons • Not suitable for all conditions (e.g., monsoon) • Not yet approved, still in development • Cost - expensive • Software issues - potential non-target issues • Cartridges unstable • Require training • Permits • Sensitivity • Humaneness –social issues around use of 1080

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Immuno-contraception	**No detailed discussion among experts**
	Generally considered as affecting immune system of feral cats to prevent them from producing offspring.
Trap-Neuter-Release	**No detailed discussion among experts**
	Generally considered as the process of live-trapping feral cats, having the neutered or spayed then releasing them back to the area they came from
Biocontrol	**No detailed discussion among experts**
	Generally considered as the method of controlling feral cats through competition, predation, or similar with other organisms (e.g., Tasmanian devils, *Sarcophilus harrisii* or dingoes, *Canis familiaris*) in the environment
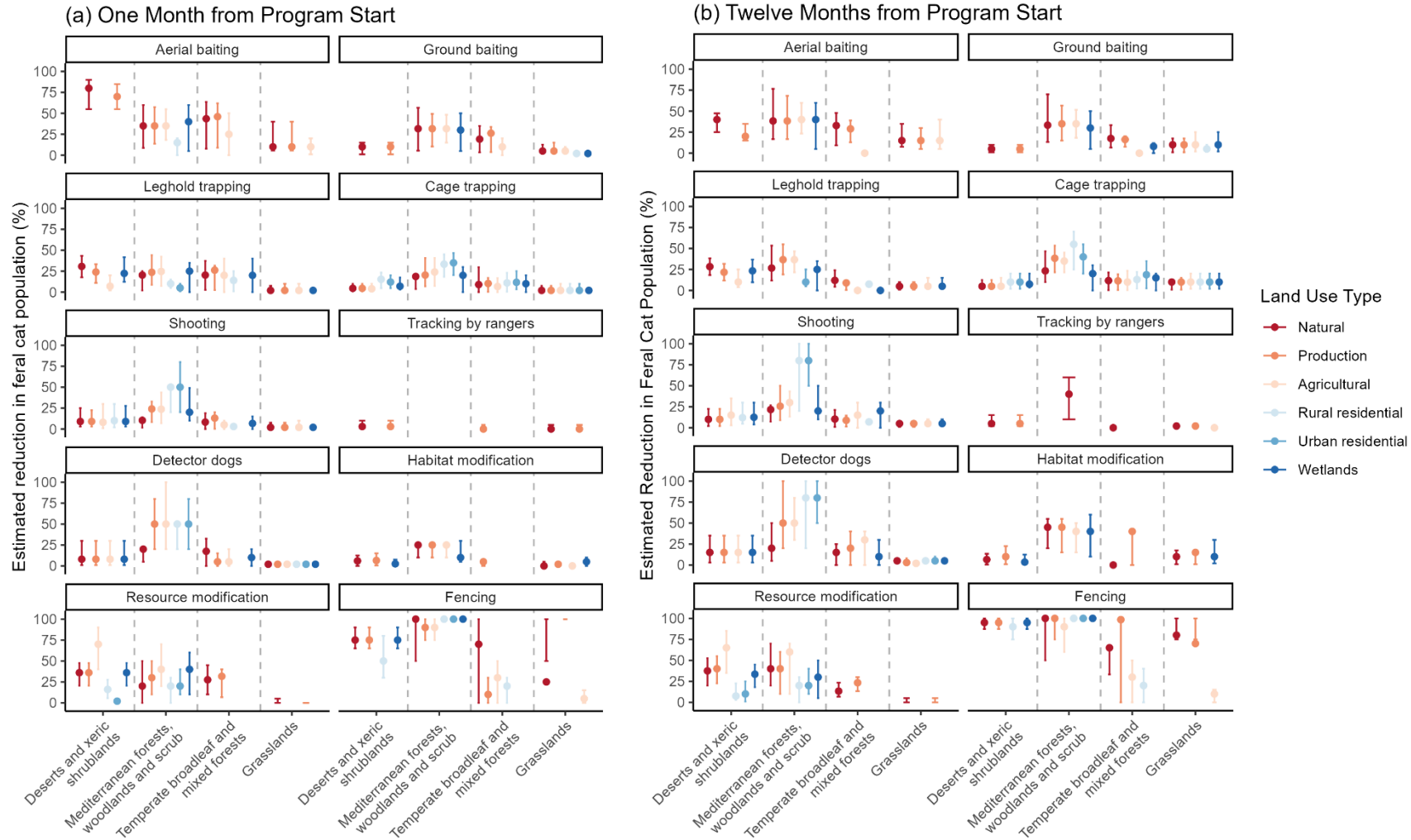
Figure S1 *Average best, lower and upper estimates from experts on the percentage reduction in feral cats (a) one month from the beginning of a management program and (b) twelve months from the beginning of a management program in different land-use types and ecoregions.*
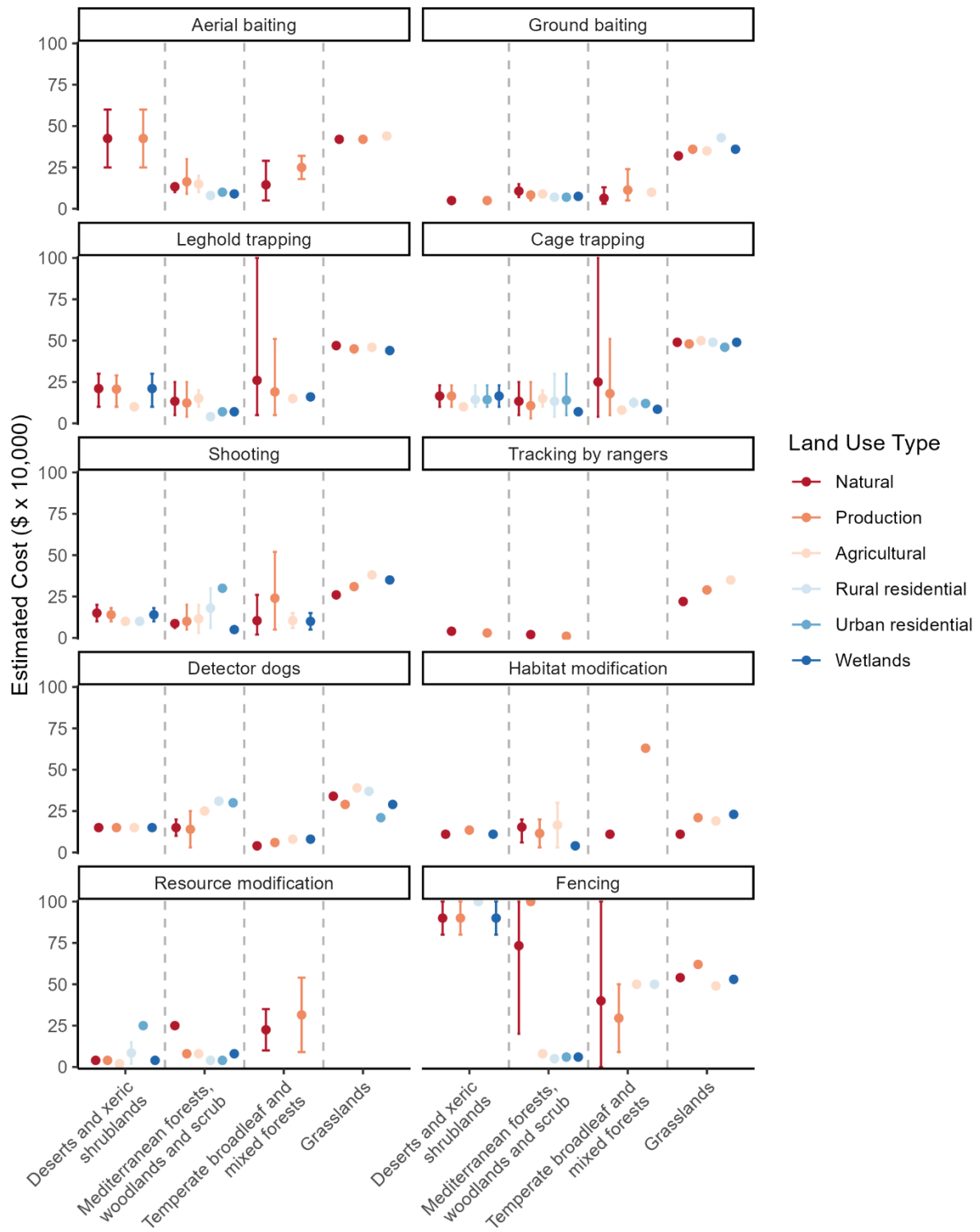
Figure S2 *Mean, maximum and minimum estimated costs of each management technique in different ecoregions and land-use types.*
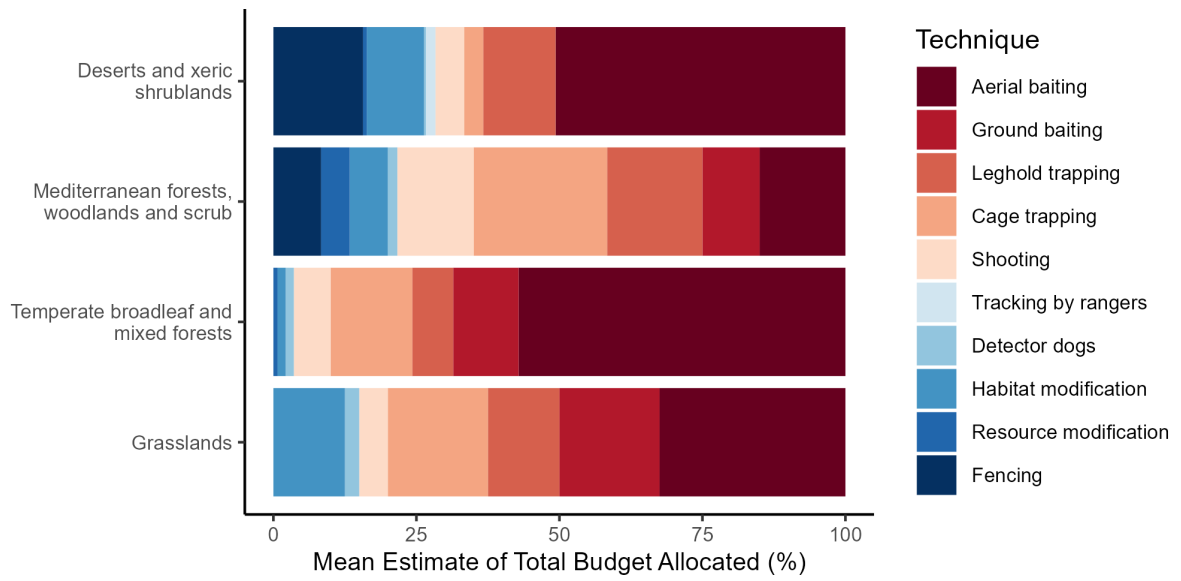
Figure S3 *Mean expert estimate of the proportion of the budget allocated in each ecoregion to different management techniques.*