

4.0 Results

4.1 Desktop Audit of Application Maps

Errors in the application maps were visually identified on early maps and the proposed bait transects were adjusted to datum GDA94. The line widths were set at 1.0 mm by georeferencing and digitising the centre of each proposed transect.

4.2 Site Means (%) of the Aircraft Flight Log

The Site means are listed in Table 3. While the first and subsequent buffer interval show a variable result for the VFR treatments, the GPS, apart from one Site, shows a consistent improvement in the percentage of the aircraft flight log within 100 m of the proposed bait transect.

Number code for Sites in Table 3	
Westbrook	1
Hebden	2
Mt Hungerford	3
Ellerston	4
Barnard River CNLHPA	5
Niangala CNLHPA	6
Barnard River NELHPA	7
Niangala NELHPA	8
Yarrowitch	9
Jeogla	10
Glenrock	11
Moona Winterbourne	12
Steinbrook	13
Red Range Pinkett	14
Torrington	15

Table 3 Site means (% aircraft flight log) (raw data)

Treatment	Site	Buffer Interval Midpoints										
		50	150	250	350	450	550	650	750	850	950	1050
VFR	1	30.97	22.50	15.19	9.51	7.39	9.80	4.48	0.16	0.00	0.00	0.00
	2	11.97	11.12	10.61	10.86	9.54	11.07	10.36	6.25	4.90	2.85	10.46
	3	15.42	14.65	17.41	12.58	7.51	4.58	3.70	3.01	2.54	1.75	16.96
	4	21.42	21.79	14.01	9.72	7.34	4.88	4.09	2.59	2.20	2.81	9.10
	5	29.03	14.82	10.51	7.14	5.06	5.59	5.28	2.41	2.18	1.97	16.00
	6	5.28	4.07	5.99	10.18	16.50	7.17	5.04	4.49	5.79	3.78	31.70
	7	29.66	22.48	14.67	8.78	5.79	3.94	3.14	2.06	1.75	1.38	6.35
	8	16.48	18.19	14.99	12.60	6.90	4.90	4.64	4.01	2.35	2.26	12.97
	9	8.43	10.73	31.74	9.77	5.26	4.04	4.39	3.40	3.39	4.02	14.84
	10	17.68	17.74	15.67	12.13	6.09	3.92	2.99	3.10	1.78	2.14	16.75
	11	7.69	11.72	10.35	8.19	5.96	6.64	6.20	4.52	3.81	3.15	31.78
	12	21.97	20.53	13.97	10.30	8.05	4.21	3.65	3.72	2.99	4.59	6.01
	13	8.42	8.90	8.64	9.26	8.59	7.80	6.56	6.96	5.52	4.19	25.17
	14	28.05	22.98	12.33	8.29	4.22	3.59	2.93	2.81	1.81	1.42	11.58
	15	7.32	10.63	9.83	6.57	8.64	9.93	8.75	4.79	4.12	3.55	25.86
Mean		17.32	15.52	13.73	9.73	7.52	6.14	5.08	3.62	3.01	2.66	15.70
GPS	1	62.17	19.46	5.24	4.56	2.61	4.13	1.60	0.10	0.10	0.04	0.00
	2	62.65	12.24	4.75	4.03	2.24	2.60	2.69	1.95	1.98	2.20	2.67
	3	75.27	15.08	4.74	1.05	0.88	1.05	0.21	0.16	0.19	0.30	1.00
	4	76.96	15.01	4.35	2.50	0.56	0.53	0.09	0.00	0.00	0.00	0.00
	5	57.89	19.22	7.74	4.87	2.56	2.25	1.34	1.25	1.91	0.96	0.00
	6	68.36	19.62	4.69	1.97	1.56	1.01	1.01	0.43	0.24	0.19	0.90
	7	63.17	22.79	8.39	2.23	1.52	0.57	0.41	0.33	0.33	0.26	0.00
	8	71.05	18.27	5.77	1.78	0.95	0.29	0.12	0.20	0.18	0.01	1.38
	9	65.13	29.56	4.37	0.42	0.29	0.05	0.05	0.06	0.06	0.01	0.00
	10	36.37	31.03	17.89	8.30	4.04	0.99	0.39	0.28	0.31	0.25	0.16
	11	50.60	29.91	15.47	3.41	0.61	0.00	0.00	0.00	0.00	0.00	0.00
	12	71.06	14.88	4.88	0.77	0.70	0.16	0.16	0.17	0.17	0.17	6.87
	13	59.51	25.39	9.43	3.28	1.42	0.26	0.12	0.11	0.23	0.06	0.18
	14	44.66	28.73	15.05	5.50	1.76	1.10	1.16	0.85	0.19	0.20	0.81
	15	49.94	29.95	13.90	4.06	1.36	0.66	0.14	0.00	0.00	0.00	0.00
Mean		60.99	22.08	8.44	3.25	1.54	1.04	0.63	0.39	0.39	0.31	0.93

Table 4 Predicted values for Site means from ASREML model (% aircraft flight log)

Treatment	Site	Buffer Interval Midpoints										
		50	150	250	350	450	550	650	750	850	950	1050
VFR	1	21.93	17.57	14.42	11.05	8.64	6.84	4.62	2.19	0.89	0.29	11.57
	2	12.59	11.12	10.56	9.39	8.66	8.41	7.73	6.09	4.85	3.95	16.65
	3	19.19	14.87	11.88	8.54	6.19	4.89	3.94	2.89	2.37	2.12	23.14
	4	23.11	16.83	12.46	8.47	5.91	4.56	3.61	2.57	2.11	1.97	18.39
	5	18.88	15.23	12.70	9.73	7.67	6.55	5.56	4.21	3.45	3.03	12.99
	6	10.55	9.61	9.39	8.42	7.47	6.57	5.58	4.29	3.58	3.18	31.36
	7	23.26	18.17	13.99	9.47	6.42	4.78	3.71	2.63	2.11	1.87	13.59
	8	19.53	15.68	12.73	9.16	6.54	5.07	4.08	2.99	2.38	2.07	19.77
	9	15.27	14.36	12.77	8.97	5.96	4.43	3.62	2.85	2.62	2.70	26.45
	10	13.24	15.79	16.84	13.97	10.07	7.03	4.90	3.23	2.46	2.14	10.32
	11	11.70	12.50	12.34	9.64	6.96	5.36	4.29	3.16	2.60	2.34	29.11
	12	20.61	15.79	12.29	8.61	6.11	4.75	3.92	3.09	2.82	2.91	19.11
	13	12.40	12.13	11.77	9.78	7.85	6.56	5.54	4.33	3.63	3.23	22.77
	14	18.78	17.46	15.41	11.25	7.73	5.69	4.37	3.07	2.35	1.95	11.95
	15	10.81	12.01	12.45	10.52	8.47	6.99	5.57	3.89	2.91	2.35	24.03
Mean		16.79	14.61	12.80	9.80	7.38	5.90	4.74	3.43	2.74	2.41	19.41
GPS	1	66.82	26.66	8.36	3.07	1.54	0.85	0.30	0.03	0.00	0.00	0.00
	2	54.95	18.91	5.47	2.24	1.55	1.42	1.29	1.00	0.80	0.59	11.76
	3	63.66	23.47	6.43	1.85	0.68	0.33	0.18	0.10	0.09	0.08	3.12
	4	68.12	25.80	6.87	1.82	0.60	0.27	0.13	0.06	0.06	0.06	0.00
	5	63.30	23.91	7.05	2.41	1.17	0.76	0.53	0.36	0.32	0.28	0.00
	6	51.84	17.01	4.64	1.80	1.09	0.76	0.54	0.38	0.36	0.32	21.26
	7	68.29	27.35	8.03	2.28	0.75	0.31	0.15	0.07	0.06	0.05	0.00
	8	64.08	24.44	7.07	2.14	0.78	0.37	0.20	0.11	0.09	0.07	0.65
	9	58.71	22.86	7.10	2.05	0.62	0.25	0.14	0.09	0.13	0.19	7.85
	10	55.90	24.57	10.26	4.71	2.17	0.91	0.36	0.15	0.10	0.08	0.78
	11	53.63	20.61	6.78	2.36	0.92	0.43	0.23	0.14	0.12	0.12	14.65
	12	65.34	24.57	6.74	1.88	0.66	0.31	0.17	0.13	0.17	0.24	0.00
	13	54.67	20.16	6.36	2.43	1.23	0.76	0.53	0.39	0.37	0.34	12.75
	14	63.17	26.53	9.13	3.18	1.19	0.51	0.25	0.12	0.09	0.06	0.00
	15	52.26	20.02	6.86	2.80	1.47	0.90	0.53	0.28	0.18	0.12	14.58
Mean		60.32	23.12	7.14	2.47	1.10	0.61	0.37	0.23	0.20	0.17	4.28

More information on individual sites is located in the data files

4.3 The Logistic Regression Model

The variables in the data were Site (15 WDCA locations), Treatment (VFR and GPS) and Year (1, 2, 3).

The problem of independence between buffers meant it was difficult to fit a model to the data. This proved problematic in the analysis because, while the data looked multinomial, there were more segment lengths in the first distances and less, as the aircraft flight log (AFL) went further from the proposed flight line (PBL). While WDCA sites were independent, the first or 0 – 100.00 m buffer interval determined the percentage left in subsequent buffer intervals because they were constrained to add up to 100 %.

Therefore the scores for each buffer interval were not independent of others within that site. While it may seem preferable to include all values, in the early years there were many values in excess of 2000 m and a pilot study showed most buffer intervals in excess of 1000 m contained zeros so a decision was taken to use 1000 m as the cut off. To simplify the analysis, scores in excess of 1000 m were given the value 1050 m. Because the aerial baiting is an annual event the VFR and GPS treatments were randomised temporally, with years 2004 - 2006 VFR and 2007 - 2009 GPS navigation. For each Site and Year the percentage of bait transect in each distance class were calculated and used as a dependent variable in the statistical model.

The model fitted was:-

$$\text{Proportion_distance} \sim \text{Track_error} * \text{Year} + \text{Track_error} * \text{Site} + \textit{spline}(\text{Track_error}) + \\ \textit{Year:spline}(\text{Track_error}) + \textit{Site:spline}(\text{Track_error})$$

The spline terms, in italics, are fitted as random terms in the model. Using this model all the fixed terms except Site are significant ($p < 0.001$). The random interaction or spline terms are also significant. There is a different interaction between Site and Treatment and the shape of the curve is different for the years grouped 2004 - 2006 and 2007 - 2009. The predictions from this model are illustrated in Figure 9. The

graphs show the track error on the X axis, this is the predicted value of the error at respective distances from the proposed bait line and the Y axis shows the number of occurrences of that error in percentage of the total aircraft flight log for each Year. There were no significant differences between Sites and individual results for WDCA's are illustrated in Figures 10 to 24 respectively.

Table 5 Analysis of Variance for VFR and GPs Navigation

Terms added sequentially; adjusted for those above

	Df	Sum of Sq	Wald statistics	Pr(Chisq)	Signif.
(Intercept)	1	52.3	7545.3	<2.2e-16	***
GPS	1	0.9	131.1	<2.2e-16	***
Track error	1	21.6	3116.4	<2.2e-16	***
Site	14	0.1	12.6	0.5575	n.s.
GPS:Year	2	0.2	23.2	9.033e-16	***
Track error:Site	14	0.5	75.9	1.612e-10	***
GPS:Track error:Year	3	3.9	556.0	<2.2e-16	***
Residual(MS)	0.006936				

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 'ns' not significant

SED = 0.02531736 (on the predicted value scale)

This graph shows the change in technology from visual navigation in years 2004 -2006 and adoption of Global Positioning Systems technology for navigation from years 2007-2009. Overall the track error decreased when the navigation system changed from visual navigation to global positioning systems navigation from 2004 to 2009.

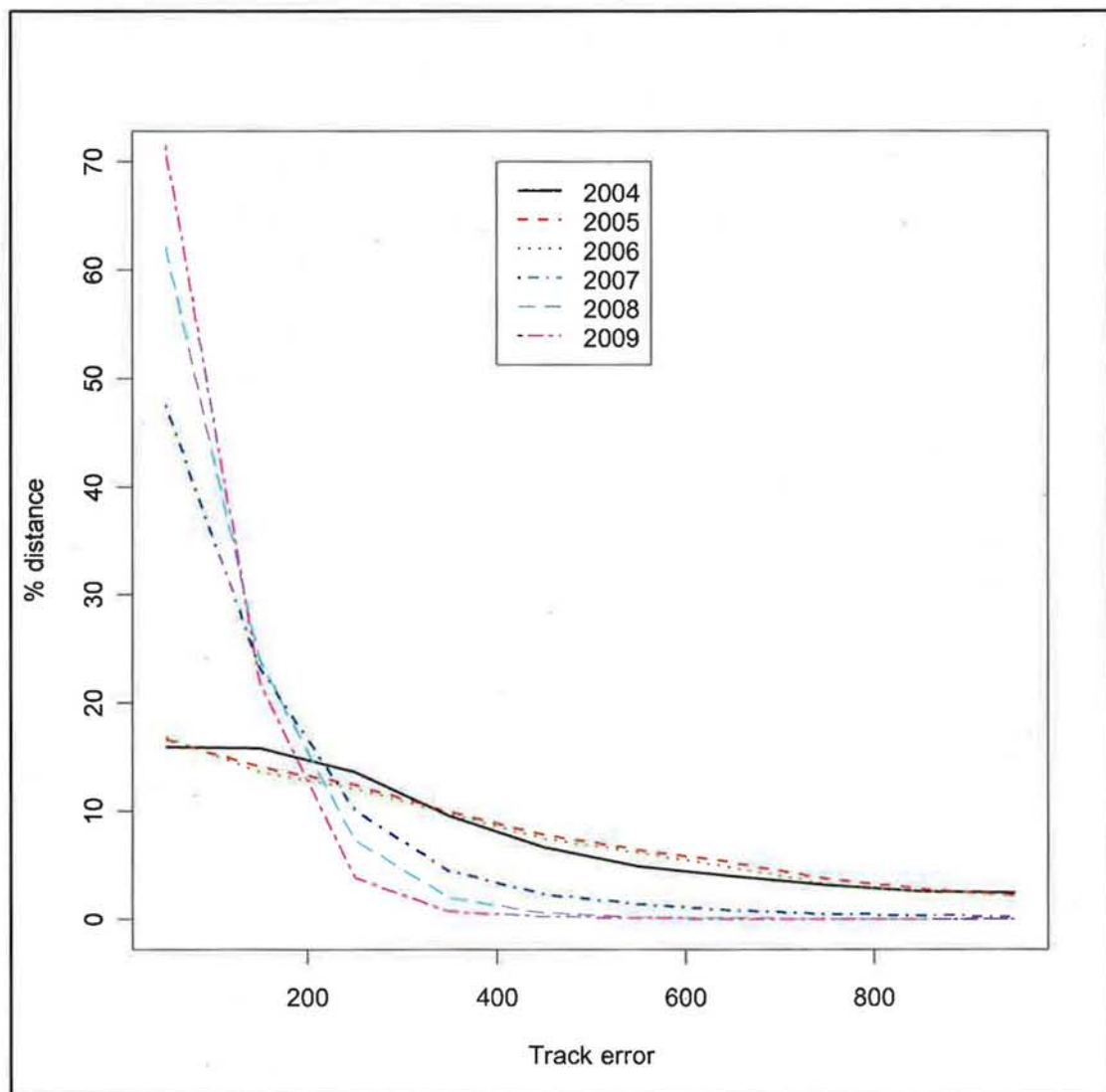


Figure 8. Predicted track error by Year, all Sites

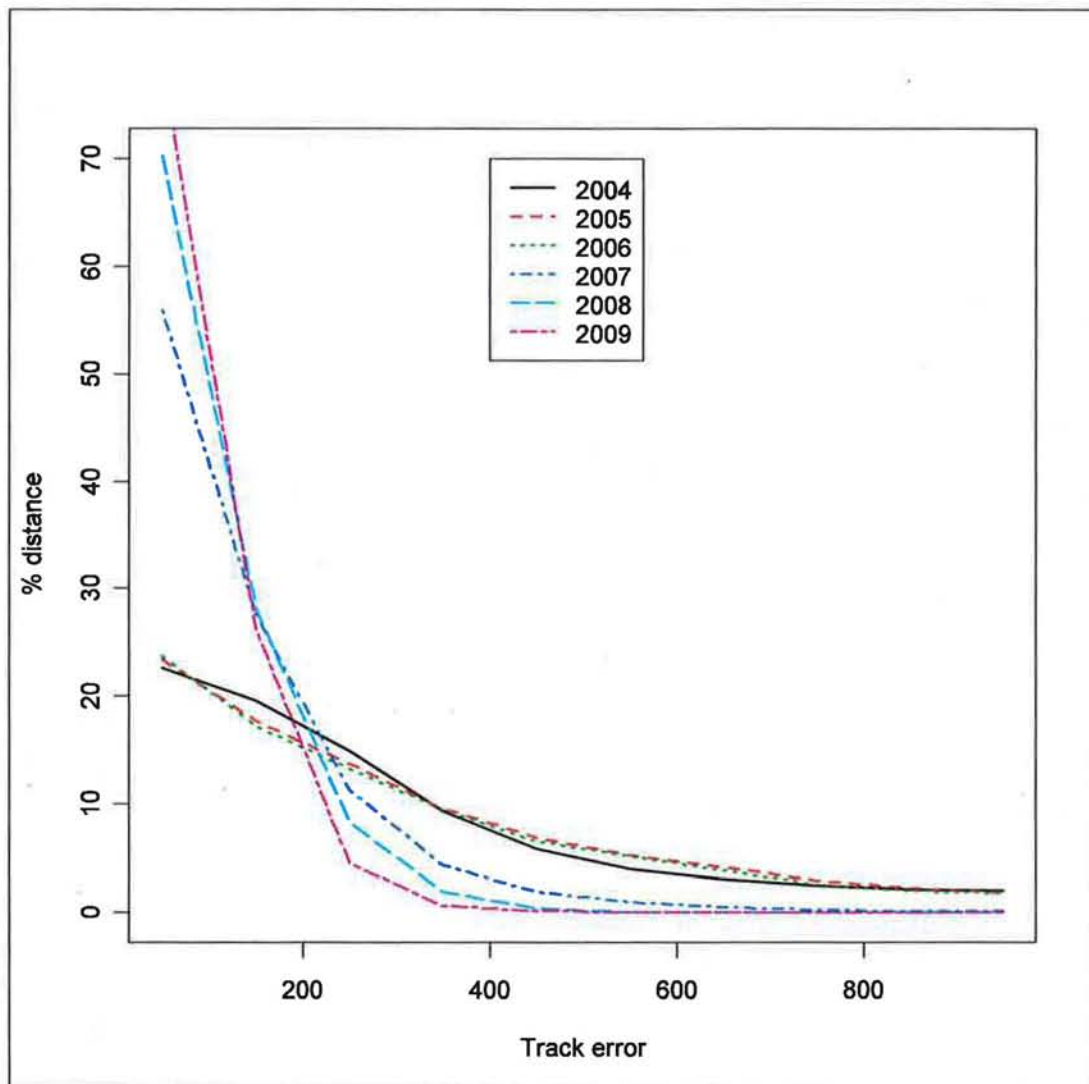


Figure 9. Predicted track error by Year, Barnard River WDCA NELHPA

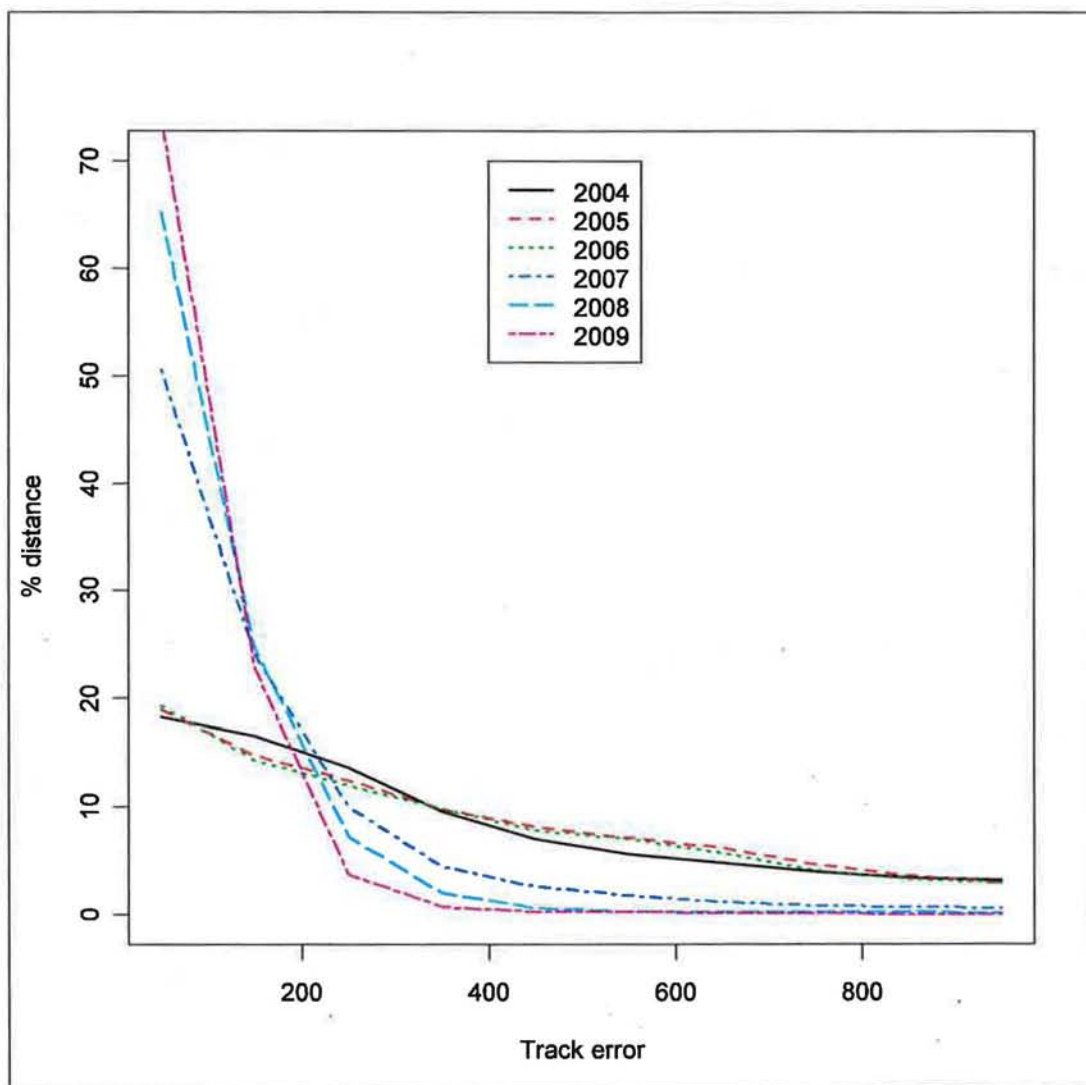


Figure 10. Predicted track error by Year, Barnard River WDCA CNLHPA

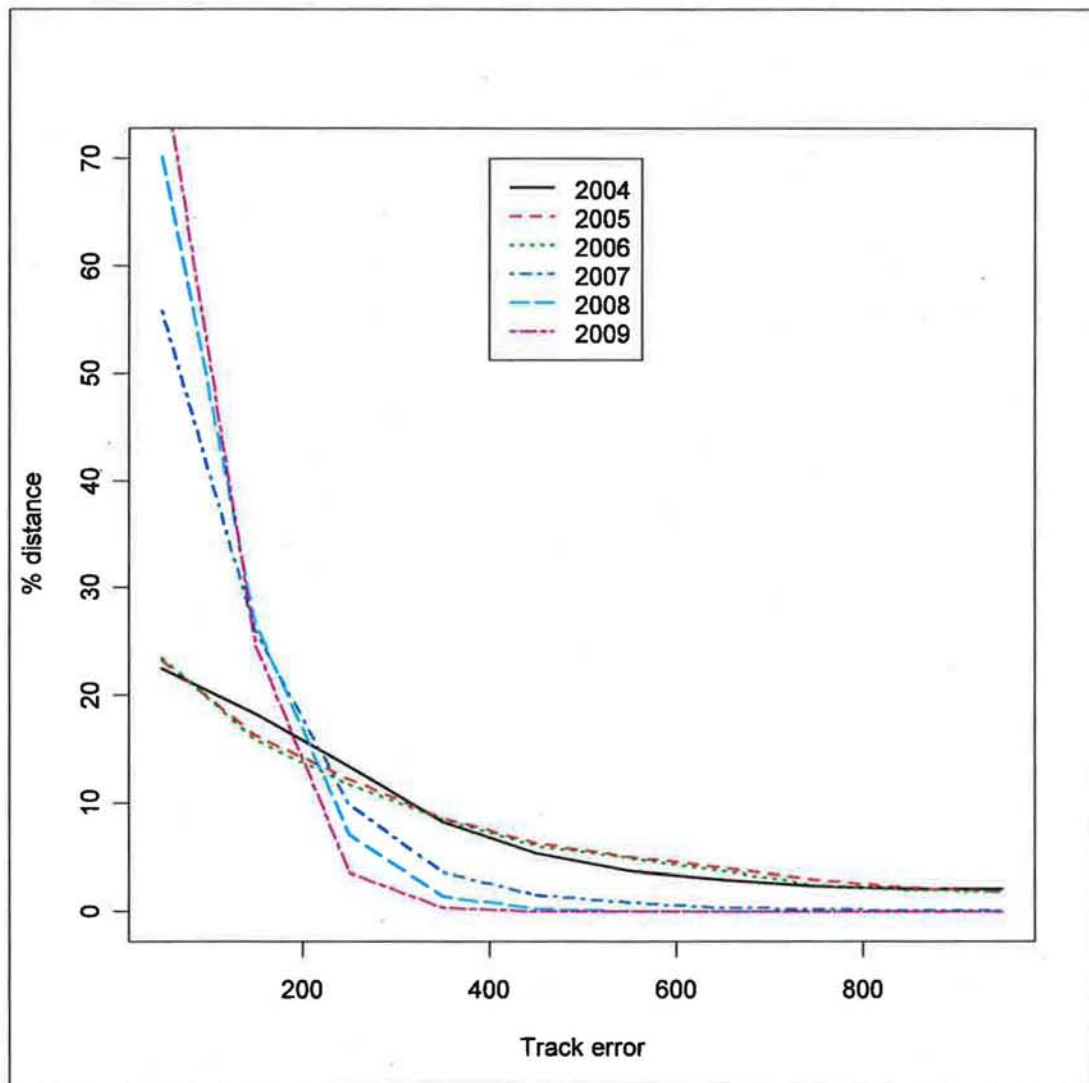


Figure 11 Predicted track error by Year, Ellerston WDCA MCLHPA

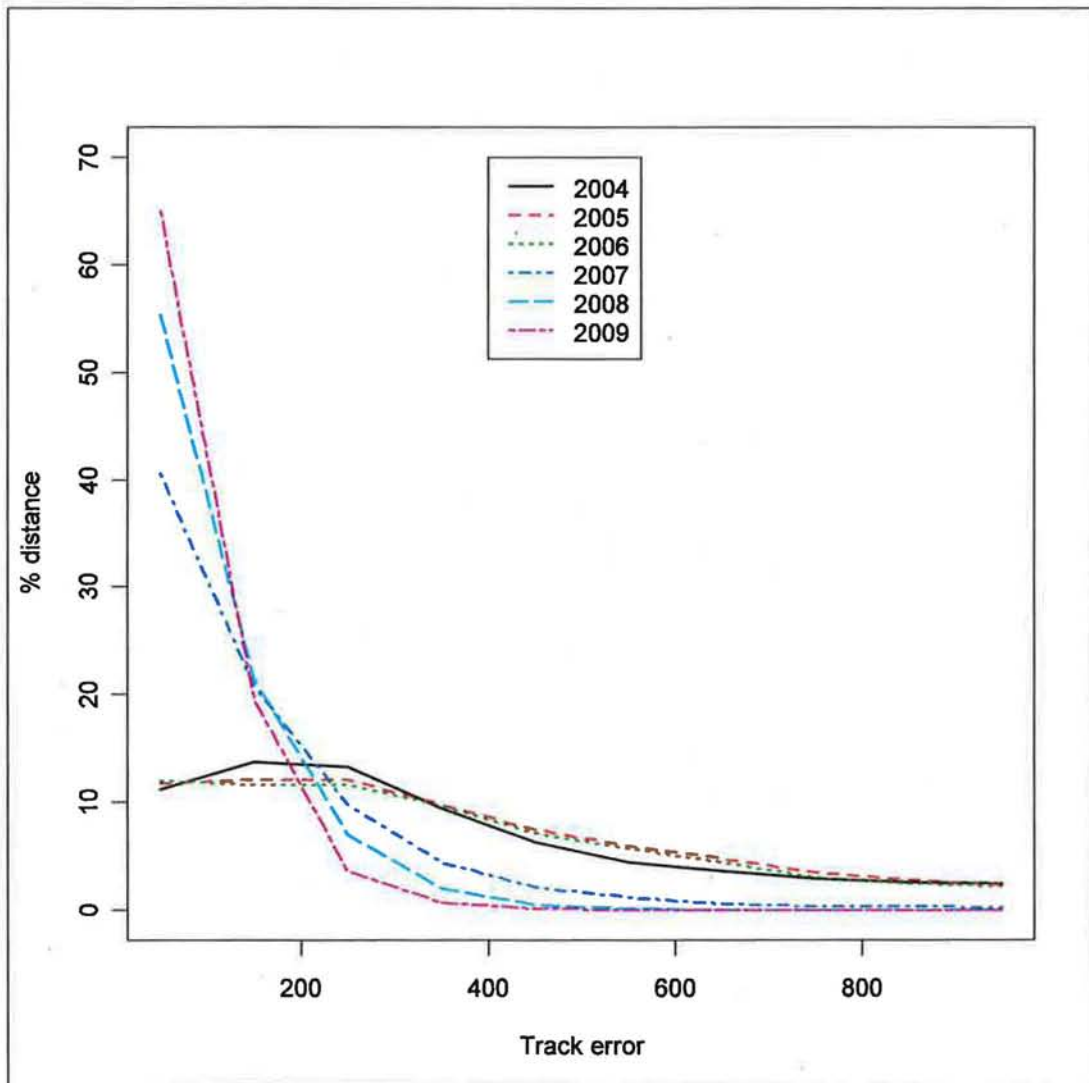


Figure 12 Predicted track error by Year, Glenrock WDCA NELHPA

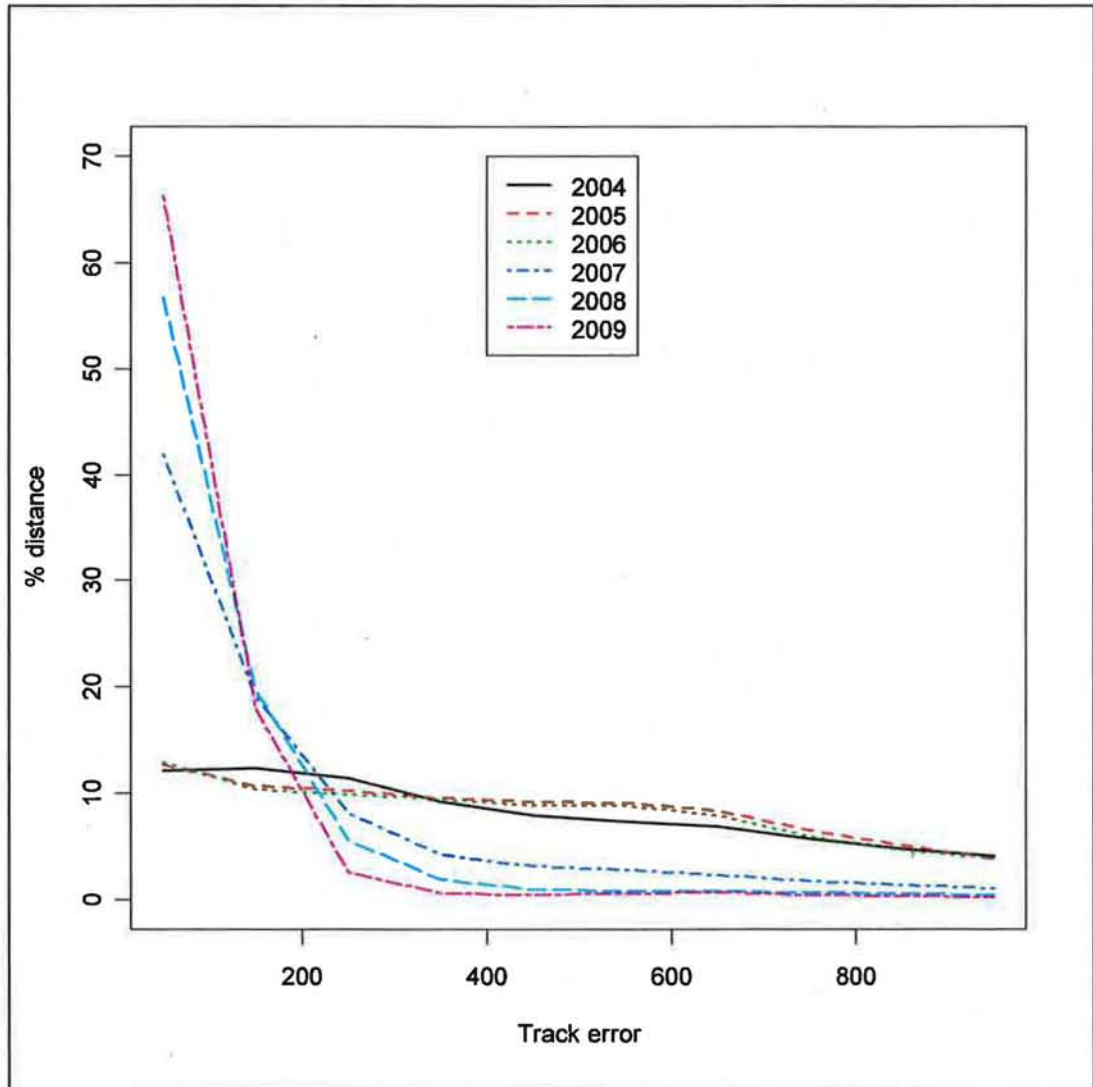


Figure 13 Predicted track error by Year, Hebden WDCA MCLHPA

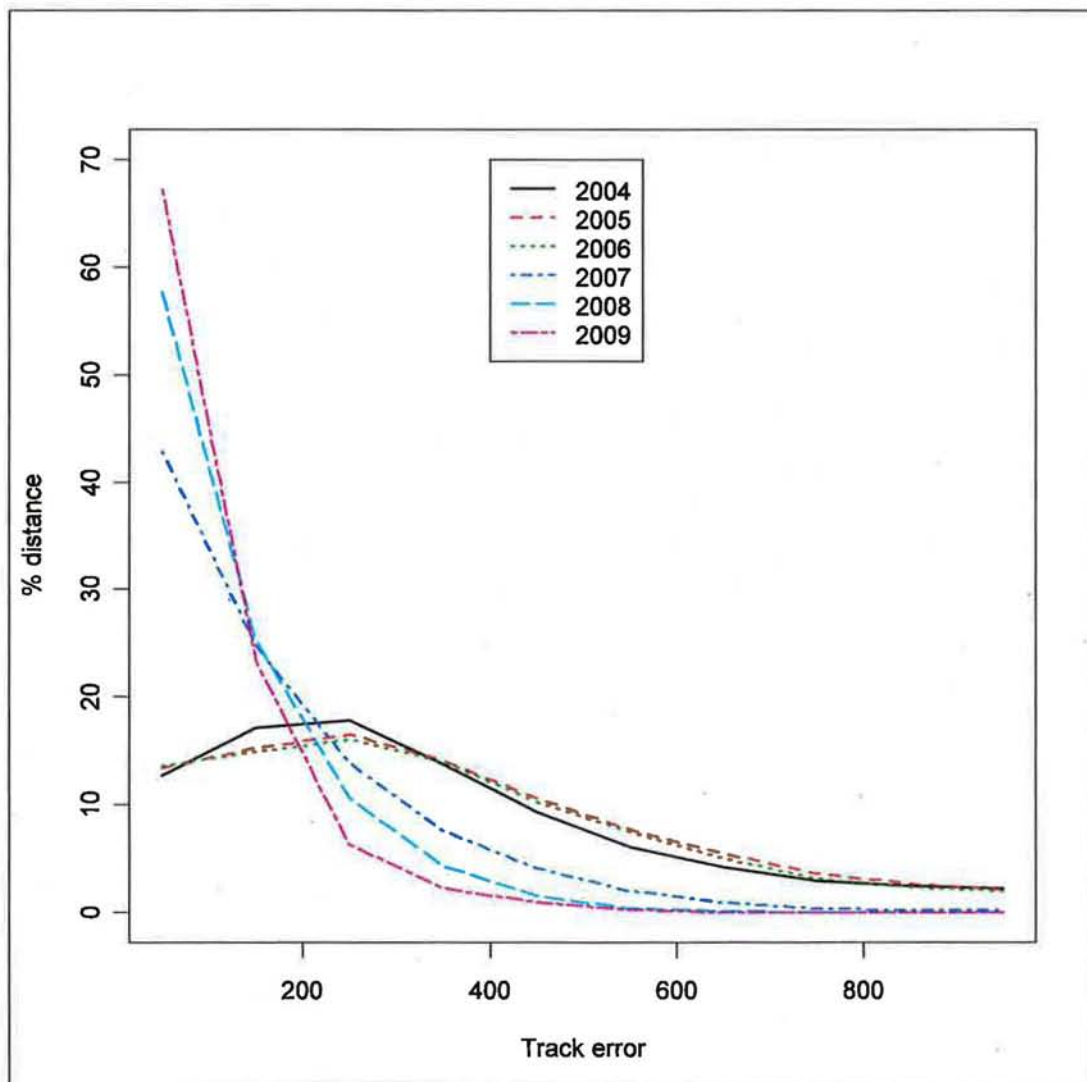


Figure 14 Predicted track error by Year, Jeogla WDCA NELHPA

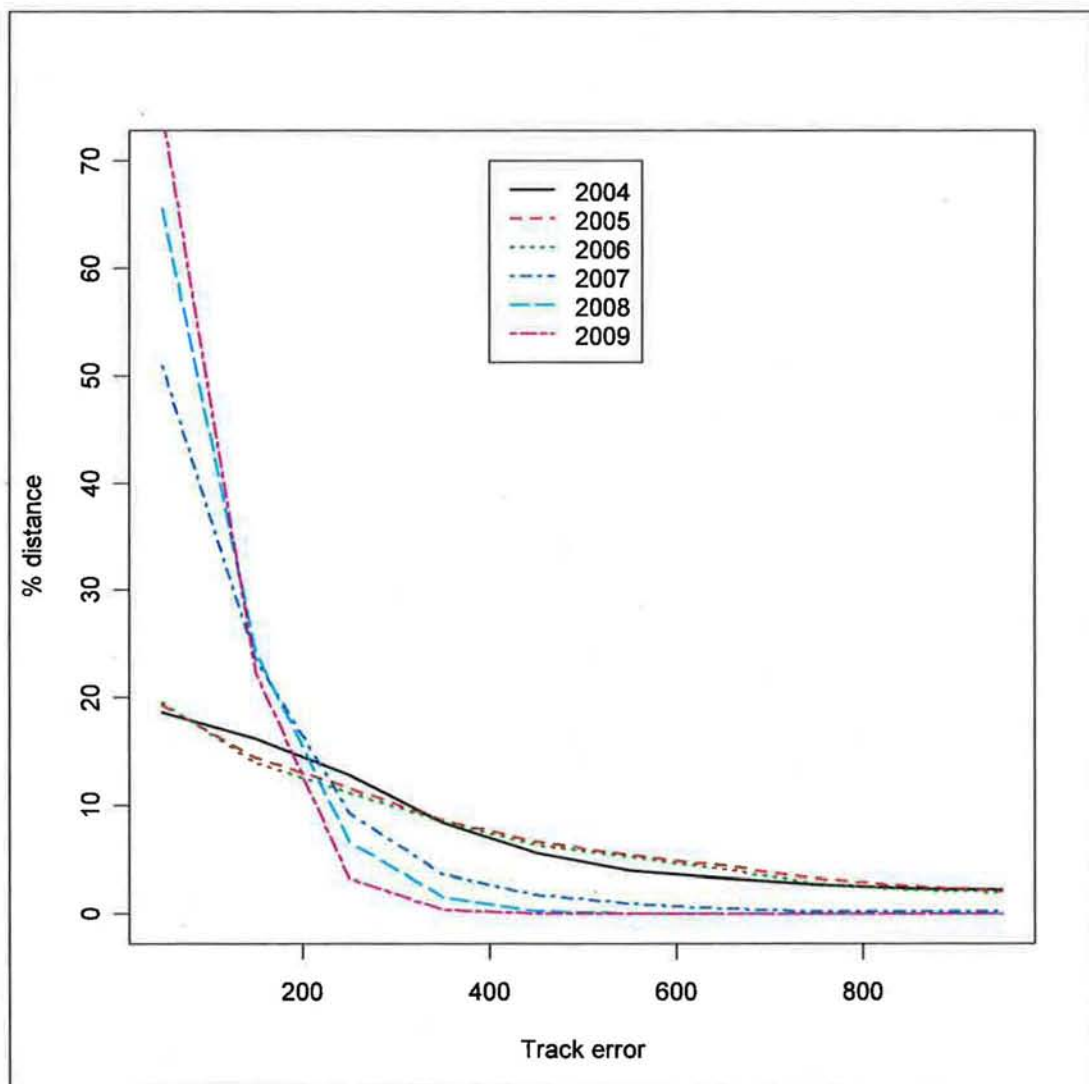


Figure 15 Predicted track error by Year, Moona WDCA NELHPA

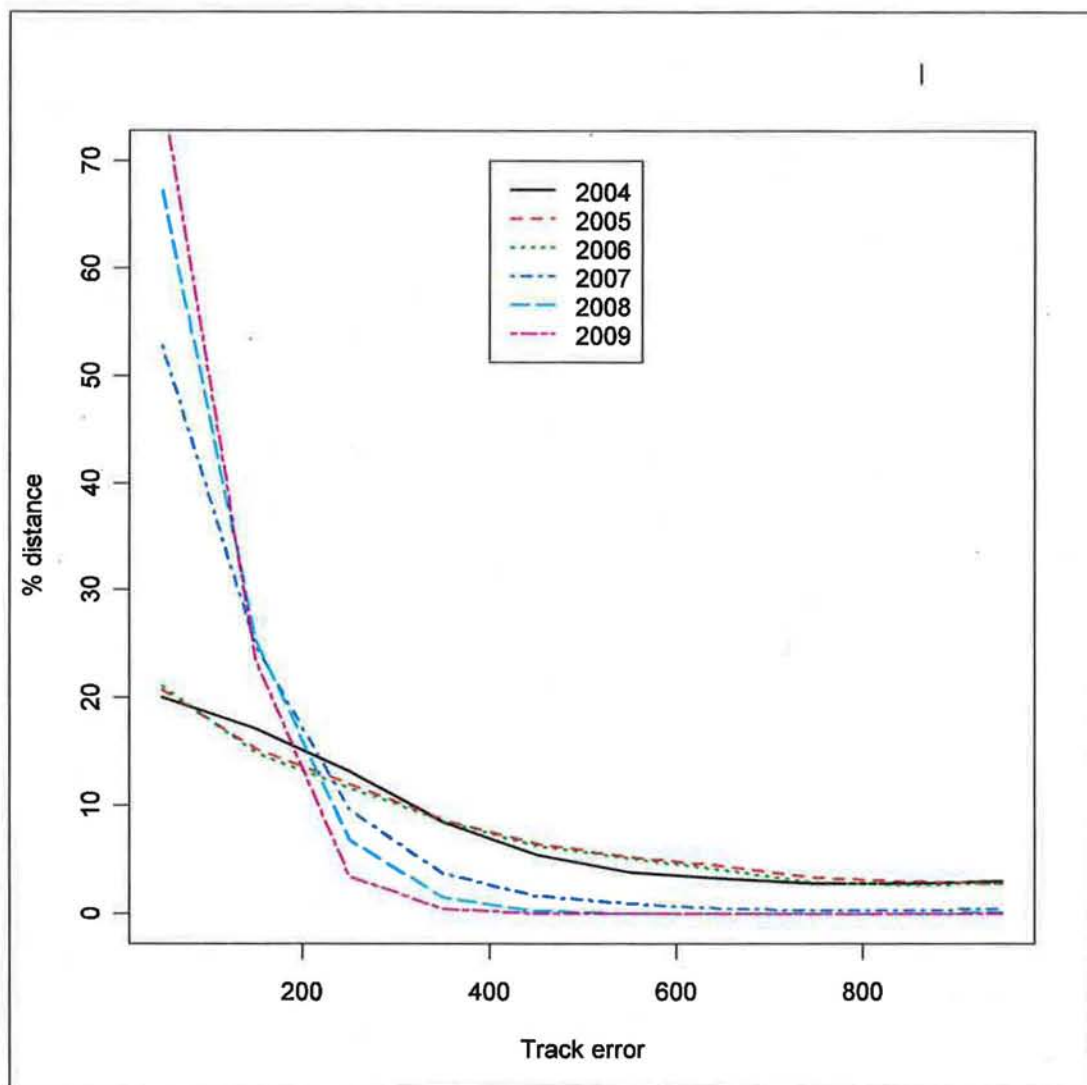


Figure 16 Predicted track error by Year, Mount Hungerford WDCA MCLHPA

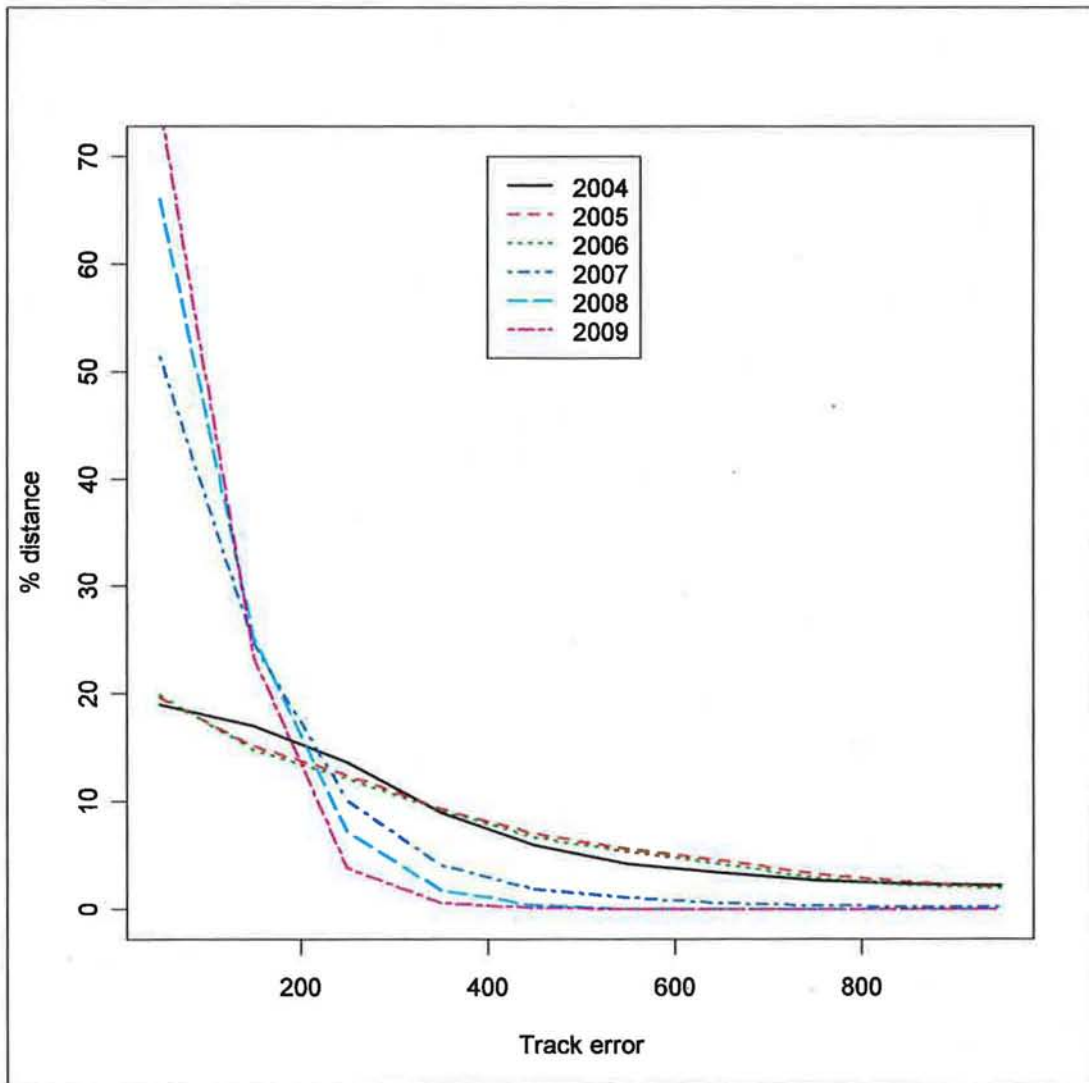


Figure 17 Predicted track error by Year, Niangala WDCA CNLHPA

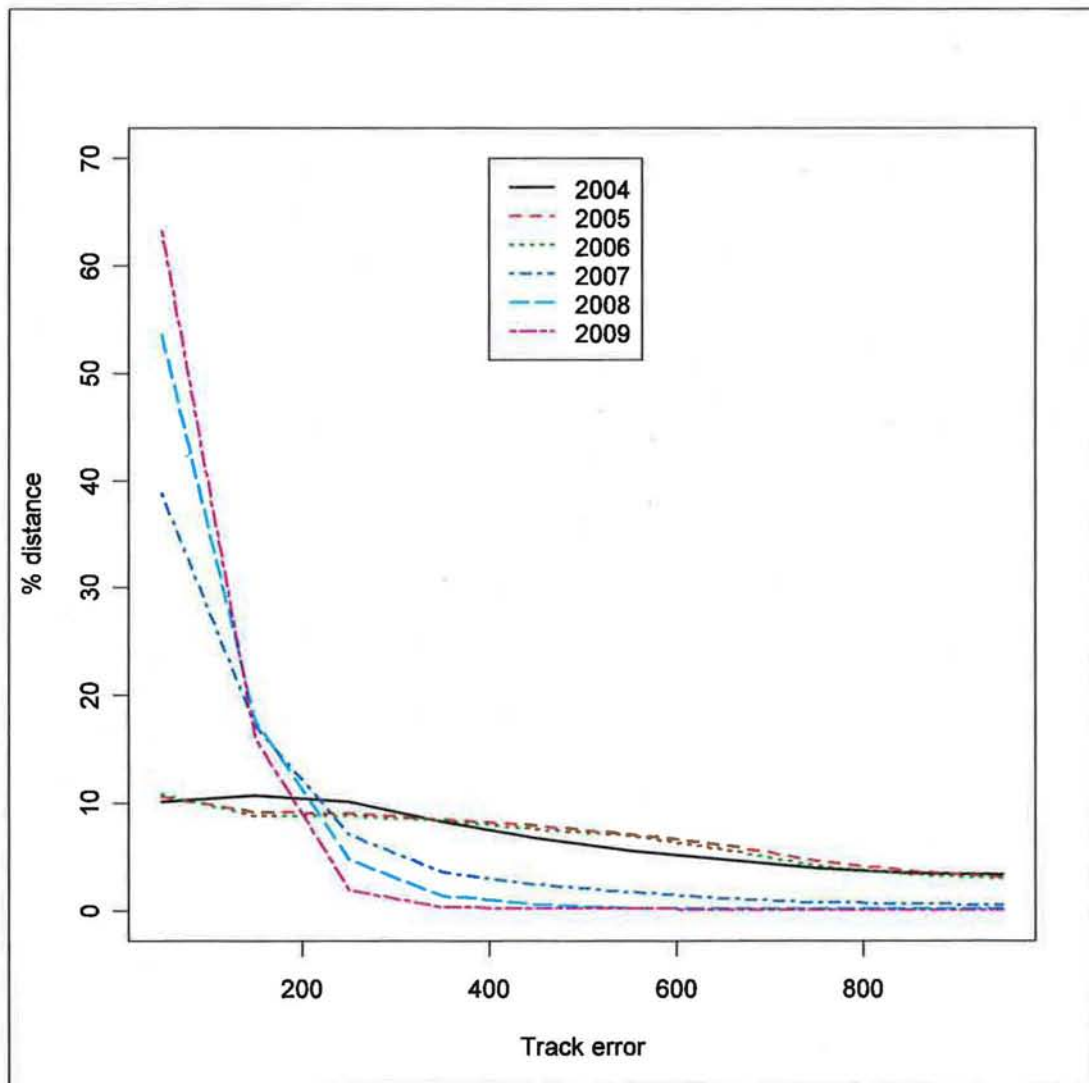


Figure 18 Predicted track error by Year, Niangala WDCA NELHPA

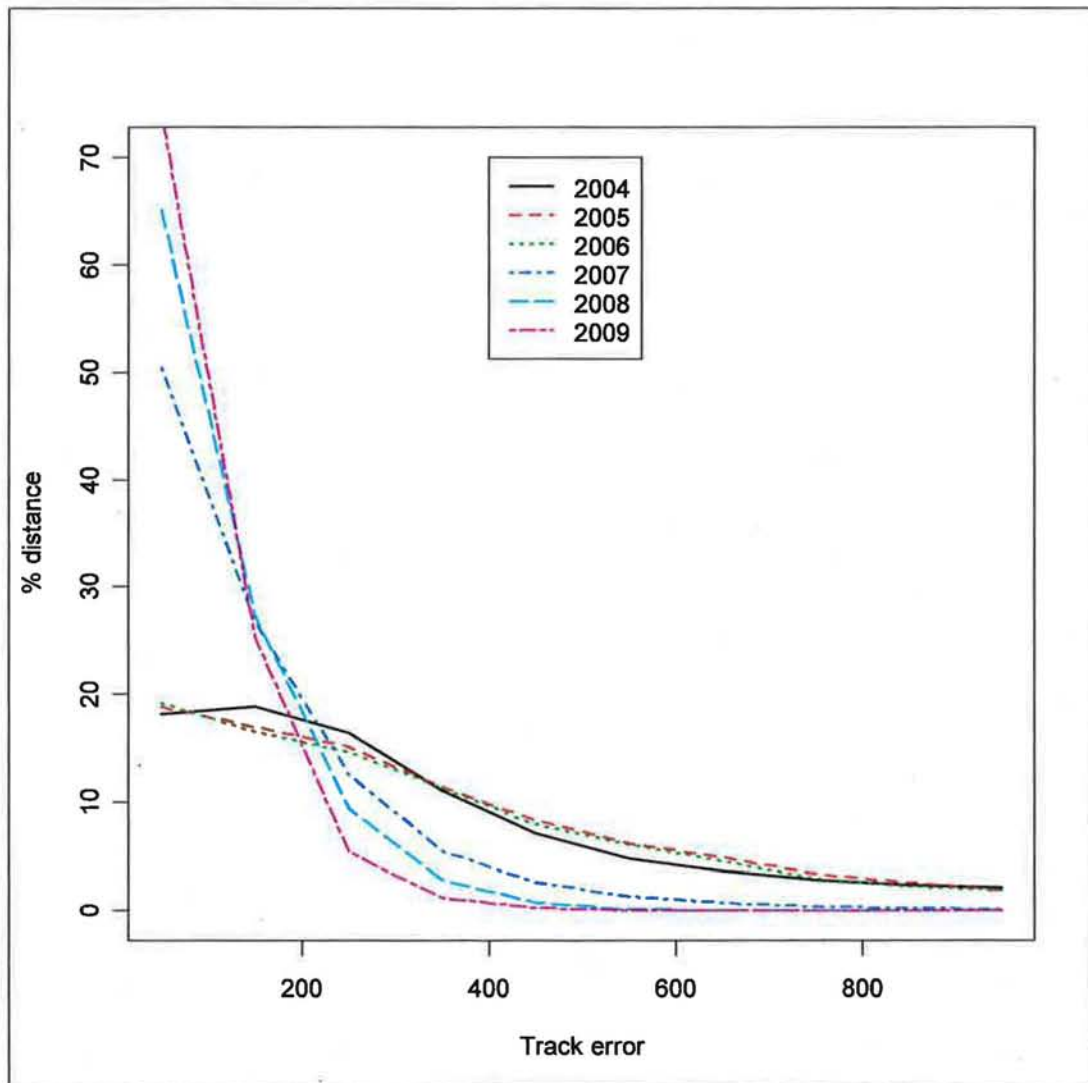


Figure 19 Predicted track error by Year, Red Range WDCA NELHPA

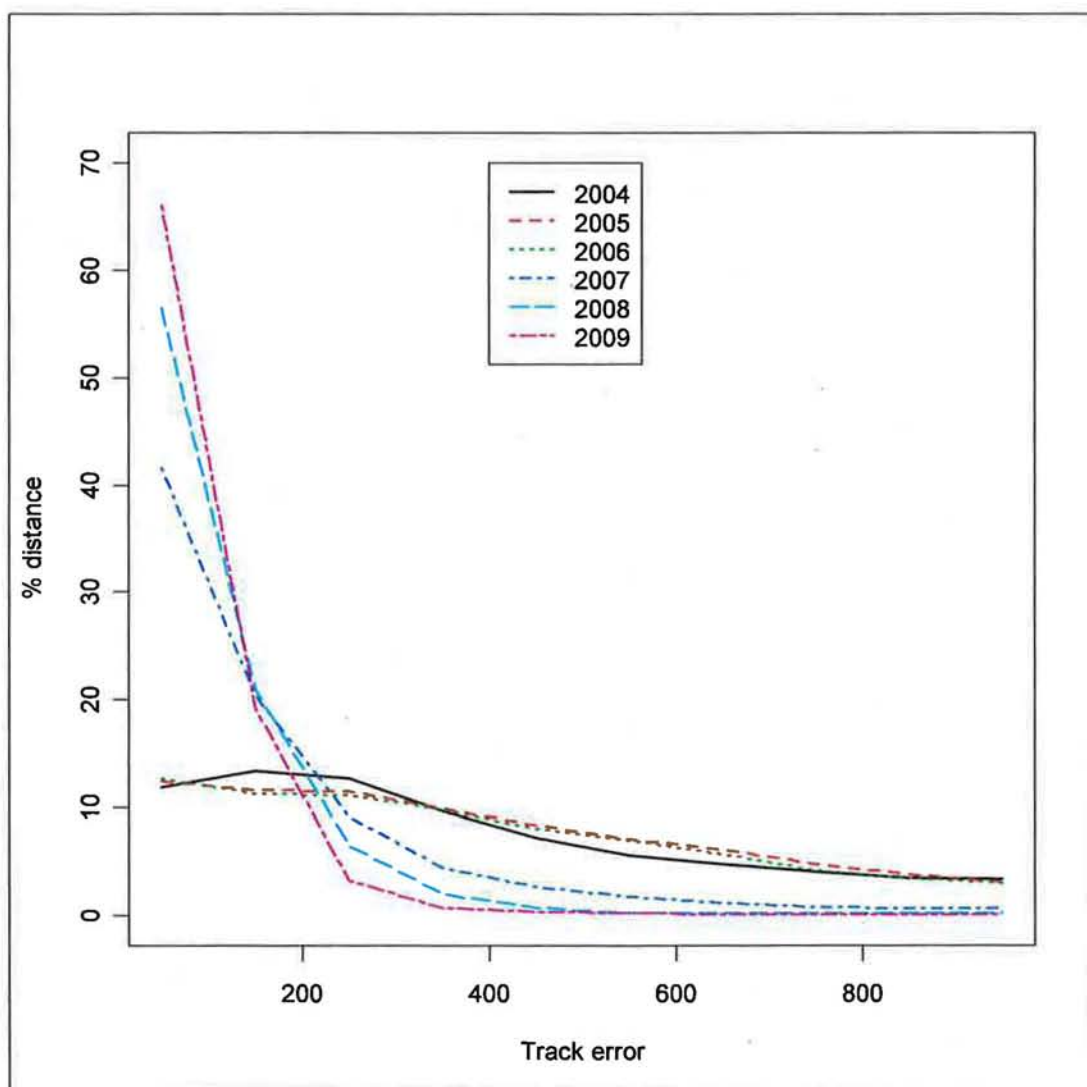


Figure 20 Predicted track error by Year, Steinbrook WDCA NELHPA

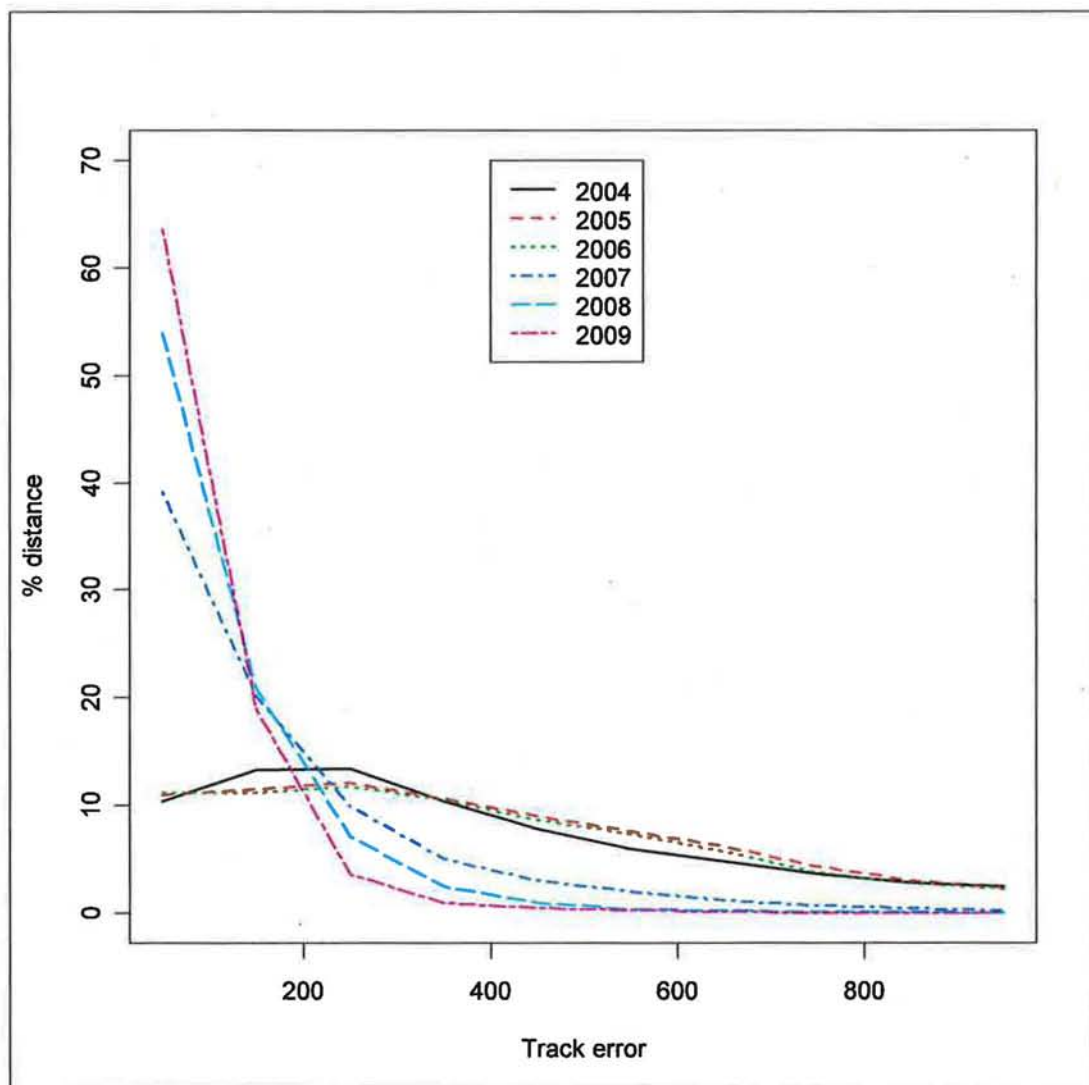


Figure 21 Predicted track error by Year, Torrington WDCA NELHPA

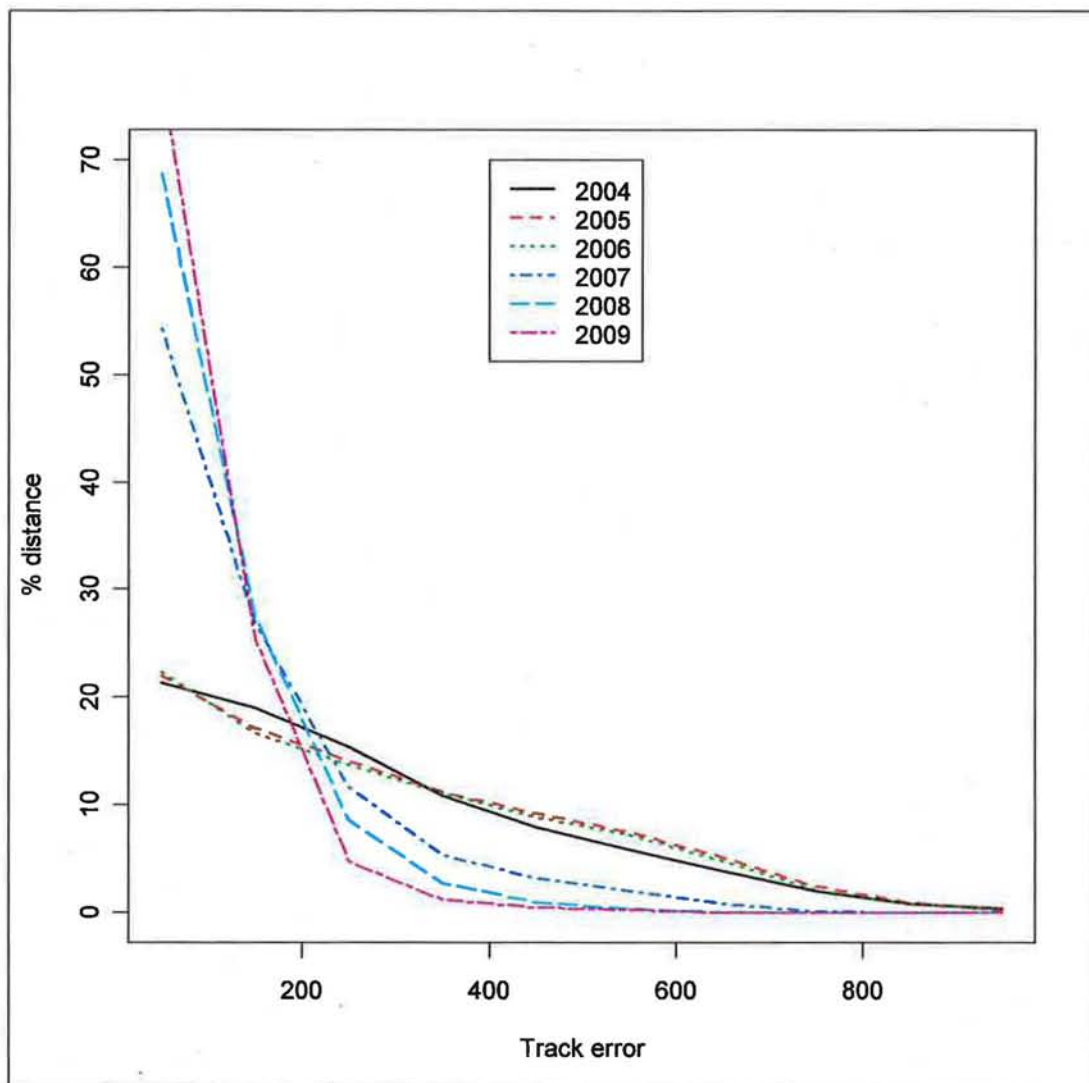


Figure 22 Predicted track error by Year, Westbrook WDCA MCLHPA

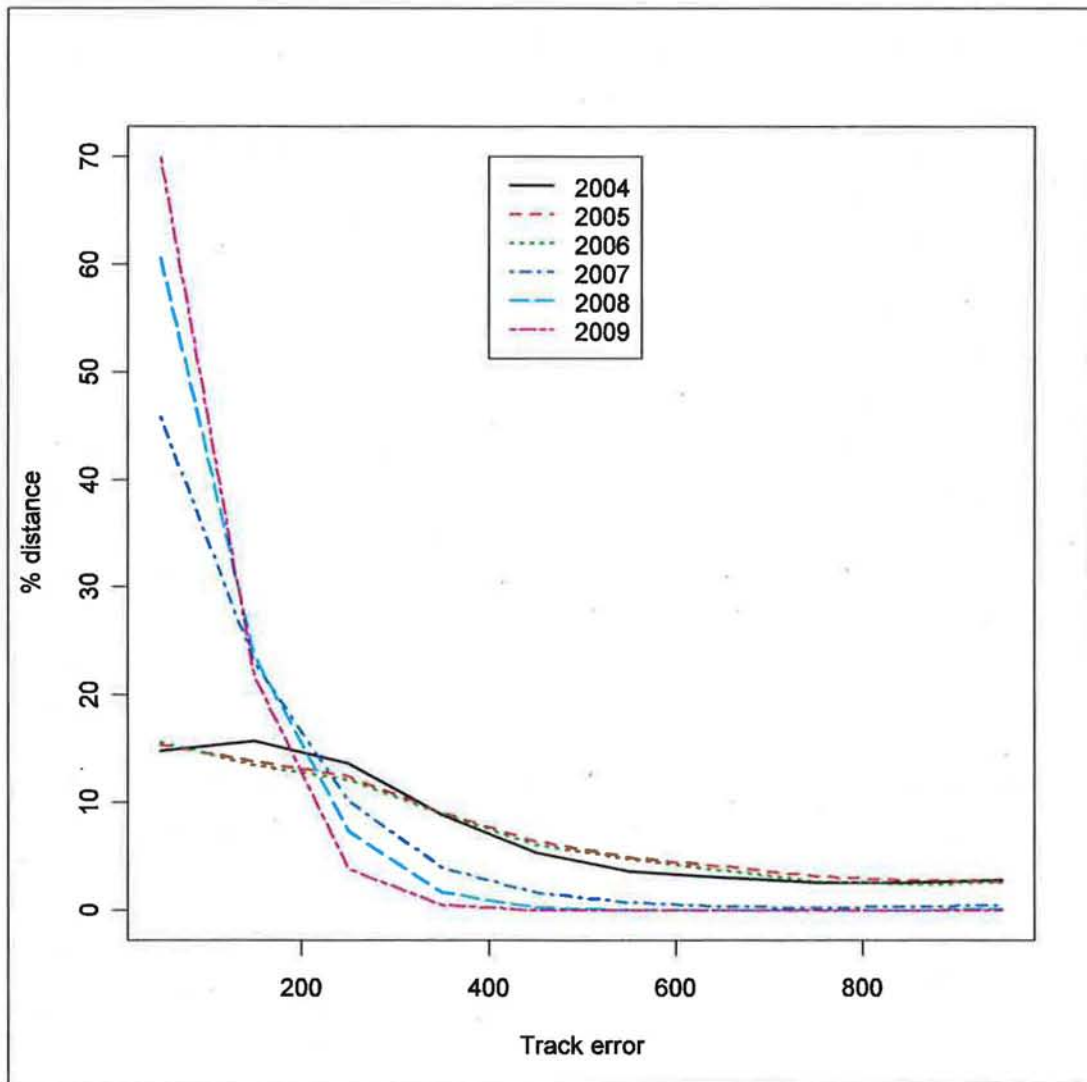


Figure 23 Predicted track error by Year, Yarrowitch WDCA NELHPA

5. Discussion

The track error of aerial baiting using helicopters by VFR in comparison with navigation by GPS under field operations was quantified over very long distances. The study showed only 16.79 % of the aircraft flight log was within the 0 – 100 m buffer interval using VFR compared to 60.32 % using GPS. Further learning undoubtedly influenced that ongoing improvement from 62.1 % and 71.3 % of aircraft bait line within 0 – 100 m of the proposed line in 2008 and 2009 respectively. Burns (1997) makes the point that once a subject has been exposed to an activity it is virtually impossible to return that subject to a naive state.

There were no significant differences in track error between sites possibly because of the variability of the data or the methodology was unable to capture and define this level of variation. Following release of the results there was an acceptance that the previous system of VFR was unsuitable for current management purposes compared with GPS. If there had been significant differences between sites, each WDCA could have argued that the results may not apply to them. Therefore, the lack of significant differences between sites served to illustrate the deficiencies in the VFR navigation system rather than reveal any deficiencies between the WDCA's. Thus, the response to GPS navigation from landholders was generally positive because landholders could argue that a system was now available that could measure the track error of bait placement. The government agencies that manage National Parks and State Forests were able to accept the results as robust, independently collected and defensible for the management of the park and forest estate.

One source of error in the methodology was caused by dividing the aircraft flight line into segments within the buffer intervals. As each segment was placed within a buffer interval it was effectively removed from the total length of the line and using percentage scores in this method ensured the segments

were not independent of others in the buffer intervals. An alternative method was to have corresponding vertices interpolated in the bait transects and measure the distances between the lines, however, the circuitous routes in Figure 24 demonstrated why such a procedure would not permit this to occur. With the method of analysis used in the study there was no need to know whether vertices coincided, only that the aircraft flight lines were within buffer intervals, the closer to the proposed bait line, the less the proportion of track error.

The circuitous routes illustrated in Figure 24, however, present another source of error because some small portions of the aircraft flight log cross into buffer intervals of other lines. These errors were checked by visual examination of the data and given that the total length of the transects were about 1000 - 1200 km each year, these errors amounted to less than 20 km per year spread over the 15 sites and such a small error was thought to be insignificant in the final analysis.

Another source of error was associated with those portions of the proposed bait line not receiving poison baits. While this may be a concern for local wild dog management, however, the purpose of this study was to measure track errors between VFR and GPS navigation. In addition, it was quite common for WDCA's to apply for bait lines on properties of absentee landholders who had baited in the past, knowing that the required permission to bait would arrive in time for the baiting to commence. If approvals were not received those proposed bait transects were removed from aerial baiting prior to the operation but may still appear on the application map. There were also cases where navigators and bait droppers underestimate the application rate, and there was insufficient poisoned meat bait available to finish particular bait transects before the helicopter moved to another area. If a particular line was not aerially baited there would be other techniques used to reduce wild dog predation such as ground baiting, trapping and shooting. .

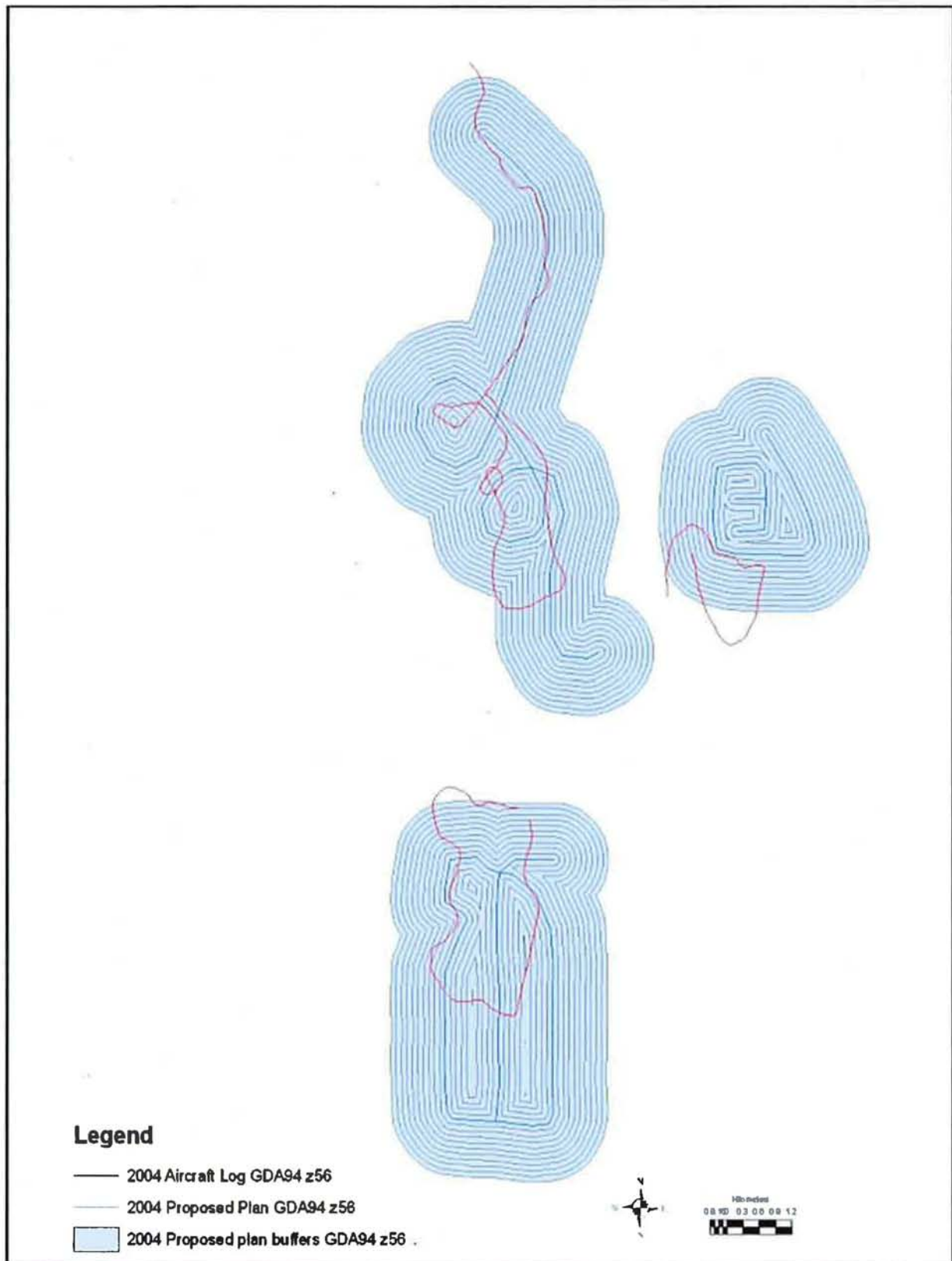


Figure 24 Circuitous routes of proposed baiting lines Ellerston WDCA MCLHPA 2004

It may have been possible to determine whether particular navigators were consistently more accurate than others. It was likely that those inexperienced with aerial bait dropping and navigating may have been less accurate and individual differences in abilities may be one source of error in the results. If the current situation of using untrained personnel navigating bait transects had continued such a proposal could have been addressed in future studies, however LHPA have changed their policy and there are now minimum training requirements for aerial baiting that will exclude most landholders.

As a result of the study, Environmental Protection Agency changed the Pesticide Control Order for 1080 liquid concentrate and bait products (Anon 2010) to put more conditions on the use of aircraft for all aerial baiting. In addition, Mid Coast LHPA employed a contract navigator and LHPA rangers were used for bait dropping. As a result there has been a continuing reduction in track error to >90% of aircraft flight line within 0 – 100 m of the proposed bait line in Mid Coast LHPA in 2010.

Thompson et al (1990) studied the differences between using fixed wing aircraft and helicopters to improve accuracy of aerial baiting. The study concluded that helicopters operating at low altitude in rugged terrain using VFR navigation were able to drop simulated baits within 10 m and were more accurate than fixed wing aircraft. Thompson et al (1990) tested helicopters at 50 knots using visual navigation along the same ridge line, multiple times to achieve the accuracy of ± 10 m and dropping bags of lime at 250 metre intervals. Robley (2011) used similar techniques at 1 km intervals with similar results. That level of replication was not possible during an aerial baiting operation where expensive helicopter time is a vital limiting factor and the increased bait frequency of one per second makes very strenuous work for the bait dropper. The findings by Thompson et al (1990) were applied across all eastern areas of New South Wales without further testing of the accuracy of the operation under typical field conditions.

The track error of GPS navigation in this study has some serious implications for management of aerial baiting along property boundaries. The current limitations states that 1080 wild dog baits must not be laid within 10 m of a property boundary by helicopter (Anon 2008). While GPS navigation may reduce the

likelihood of accidental baiting of the wrong properties, Thompson et al (1990) established that baits were consistently directed to the left side of the aircraft by down wash from the rotors (clockwise rotor direction) and other aerodynamic forces (Fleming pers comm.). Given that scenario, it would be possible to fly along a boundary fence at a given height, drop fresh meat baits on the right side of the aircraft where the chute is located, the GPS data is plotted on the correct side of the boundary and the baits would land on the other side of the boundary. This analysis shows that 10 m is an inadequate buffer zone along a property boundary and New England LHPA has increased the buffer to a minimum of 100 m. The use of differential GPS may assist with further reducing track error. Both aircraft companies were using standard GPS receivers and were not receiving correction signals from a radio nor were the data corrected during post flight processing. However, the data correction capability of differential GPS may reduce multipath errors associated with flying in steep terrain assuming that the terrain allowed for a beacon signal to be received and correct the GPS. Some landholders are adamant that the aircraft flight log plotted by the GPS in the helicopter is not the path plotted on the maps and there is some circumstantial evidence to support them, in one case the GPS line plotted on the application map should follow the distinct edge of a cliff top and the aircraft flight log does not. To further complicate the issue, it was evident in the early years of this study that some property owners only had a vague idea of their property boundaries, particularly where the terrain was steep and inaccessible. Some had 'give and take' boundaries where the boundary fences were placed on the most accessible route rather than the official state cadastre. So it was possible for landholders to bait an area of land for which they had no legal ownership. To overcome some of these issues the participating landholders and LHPA staff could ground truth some of the contentious flight lines and determine if multipath errors, 'give and take' boundaries or location of actual boundary lines could be a factor and if differential GPS would solve the problem.

Those individual issues aside, uncorrected GPS was adequate for most of the task even if the GPS signal was 100 - 200 m above the terrain when the meat baits left the chute. The location where the bait lands and comes to rest may or may not coincide with the GPS data point. Newton's second law states a body

will remain at rest or continue to move unless acted upon by a net force. The forces on the meat bait as it leaves the aircraft are gravity, air resistance, speed and direction. The meat bait will continue to move at the speed and direction along a vector imparted by the aircraft until it rolls and achieves rest. Given the topography consecutive meat baits may be hundreds of metres apart. Thompson et al (1990) used 250 gram bags of lime for visibility because fresh meat baits dropped from an aircraft are exceedingly hard to find on the ground and the current GPS data point from the aircraft rarely, if ever, coincides with the location of the bait.

Aerial baiting for wild dog control in New South Wales is mostly an annual event in May and June in the north and June or July in the south. Some LHPA's in southern NSW aerial bait twice per year with a second baiting in October or November. There are other programs in Queensland, Northern Territory and Western Australia. In the broad scale of rural activities the programs are infrequent and there is little time for pilots to become accustomed to the details of the operation. With the relatively small amount of aerial baiting work available it is difficult for pilots to get the necessary experience in aerial baiting and an 'agricultural rating', the minimum requirement for aerial baiting in New South Wales, is an expensive adjunct to a pilot's license. Most pilots are contracted for short periods of time and while this study mostly had one consistent pilot for some areas, there was also a constant turnover of pilots across the two aircraft companies. One other issue faced was the perceived lack of information technology (IT) awareness among the various pilots. Without backup personnel, some pilots, while excellent at flying and with thousands of hours experience were completely stumped with computerised operations. One of the reasons there were only 15 WDCA's in the study sample, out of a potential of 40 sites, was that many sites had missing data caused by GPS malfunction and pilot error. In many cases of pilot error, it appears, the pilot had either forgotten to press the button or was too busy safely flying the aircraft to either activate the GPS control that designated the drop zone or turn off the track line at the end of the drop zone. Education of pilots in information technology will probably resolve itself over time as many of the current

pilots reach retirement age and younger individuals with the necessary technological skills take their place.

Some pilots, new to aerial baiting, chose to fly at the maximum recommended baiting speed of 80 – 90 km per hr from the outset, instead of flying much slower to achieve the required experience before increasing speed. A further recommendation is for aircraft to fly much slower to achieve an acceptable track error but that may add substantially to the cost of aerial baiting (2009 cost was \$1100 per hr + GST).

One recommendation out of the study is a trial of a light activated switch or mechanically activated micro switch in the drop tube so bait drop locations can be more accurately recorded by bait falling through the recording device and not relying on the pilot to activate a switch in the cabin. A light activated switch may not work due to dust or debris such as blood or vomitus from the dropper; however, it may also encourage a change to either drier meat baits or manufactured bait products. Changes such as these need relatively expensive trialling and software programming, together with air safety approval and unfortunately, aircraft companies are reluctant to spend money on the testing required unless there are significant income incentives. If trials are successful legislation may be required to enforce use.

The development of an automatic bait dropper may lead to more accurate placement of baits. Automatic droppers are used in the USA and Canada for dispensing baits containing rabies vaccine to wildlife (Rosatte et al 2008). These machines are large and cumbersome and fit inside the body of a fixed wing aircraft and are generally unsuitable for aerial baiting in the terrain in northern New South Wales. Due to the irregular size, shape and high fluid content, fresh meat is also unsuitable for use in an automatic bait dispenser. Fresh meat baits contain approximately 50% to 60% water even when drained. Following injection, baits are placed in plastic bags where they tend to sweat. Occasionally delays of a few days due to unsuitable flying weather lead to rancid meat with high water content. The hopper in the helicopter holds about 200 kilograms of fresh meat baits or 800 by 250 gram baits, sufficient for about 20 kilometres; consequently, there is frequent replenishment with high occupational risks associated with multiple landings each day. Manufactured baits available in Australia are admirably suited to automatic

distribution. Due to their smaller size, (35 to 60 g) many more manufactured baits could be carried, total take off weight could be reduced and the helicopter would be more manoeuvrable and more capable of following complex bait transects. At 60 g per bait there would be approximately 3333 baits in a 200 kg load, sufficient for 80 kilometres, however this would need to be reduced by the weight of the dispenser. An automatic distributor for manufactured baits would need to fit inside a medium size helicopter such as the Bell Jet Ranger and be stable enough to operate under the forces of speed and direction encountered during aerial baiting. Much less time would be required for loading and cleaning, currently a very messy job with associated work health and safety risks from poison residues and contaminated meat. Some areas in Queensland have changed completely from fresh meat to manufactured baits and manufactured baits have been used successfully at Mudgee in Central North and Mid Coast LHPA in 2010 and it is anticipated this trend will continue. The other positive about automatic bait distribution is that the distributor could be connected to the GPS of the aircraft and programmed to start and stop on particular bait lines. Coupling the automatic bait distributor to the airspeed would further reduce the error associated with manual dropping of baits and a set baiting rate per kilometre could be programmed into the software. The Canadian rabies baiting program (Rosatte et al 2008) already uses similar software. The seed sorting industry uses a rotating indented cylinder to separate good seeds from other seeds, the designated seed is raised to a tray where they are discharged out of the machine, a relatively simple solution that could be used for uniform sized baits and should be further investigated in another study.

The development of another toxin, Para-aminopropiophenone (PAPP), deemed to be more acceptable on animal welfare grounds than 1080 may lead to more use of aerial baiting to control wild dogs. PAPP does have an antidote, methylene blue, and could be used on accidentally poisoned pets if given within an hour of poisoning. Because of the necessity to encapsulate PAPP, this product may only be available as manufactured bait (Ballard pers comm. 2011). While it may not increase the accuracy of aerial baiting it may be used as an alternative to sodium fluoroacetate (1080) and assist wild dog control particularly for those who find the symptoms of 1080 poisoning objectionable.

Effective aerial baiting is the result of a synergy between land manager, pilot, navigator, bait dropper and navigation system. Acceptable track errors when aerial baiting for wild dog control through steep gorge terrain using standard GPS navigation in NSW is about ± 300 m, however, constraints of safety always override aspects of accuracy and sometimes diversions may need to be made to avoid unacceptable risk. The aerial baiting policy at LHPA was recently changed so landholders will no longer be used as navigators or bait droppers unless they have been trained to the minimum standards expected of aircraft companies. While this policy change may reduce track error it may not lead to an improvement in wild dog control. In New South Wales, there is a relatively long timeframe between planning for aerial baiting and statutory approvals for the operation by government, therefore aerial baiting for wild dog control is unsuitable for reactive baiting in response to an attack. In these cases other methods of control such as ground baiting, trapping and shooting may still be required.

The use of improved electronic navigation systems while reducing track error across variable topography may not reduce the impact of wild dogs on predation of domestic livestock if those dogs do not consume the poison bait. Bait placement of baits on the tracks, roads and pathways discussed in the review requires accurate bait dropping. The use of GPS substantially reduced the track error of bait placement but will only lead to reduction in wild dog activity if the animal is at the location and eats the poisoned meat before it decomposes due to microbial, insect or non target activity. It is difficult, therefore, to conclude that use of GPS will reduce predation of domestic livestock and increase control of wild dogs.

Changes in land ownership, attitudes to pesticides in general, and the toxin sodium fluoroacetate, in particular, coupled with concerns about the impact of 1080 on native non target animals are continuing to lead to a decline in the use of aerial baiting as a means of wild dog control. This continuing trend coupled with alienation of rural land means that those who previously actively participated in aerial baiting have declined because they have changed enterprises, left the area, no longer have a financial interest in wild dog control or no longer know how to apply for it.

5.1 Conclusion

The analysis of aerial baiting data using the methodology outlined in this study is currently applied to assist in training, extension and compliance. Aerial baiting is one effective tool for management of wild dogs and it is important that all participants know that the data may be checked and verified when the task is completed. This method of assessing aerial baiting is relatively simple to implement and allows detractors of the process to see compliance with the regulations.

Wild dog management is highly dependant on reliable data collection and while there were 53 WDCA's available for study, unreliable equipment, pilot error or poor data collection made 38 of them unsuitable. Unfortunately, if data is not collected already or the collection is not seen as important, it is unlikely to be collected or accurate. There have been tomes written recommending and encouraging more effective data collection (Fleming et al 2000; Rogers et al 1995). There are no simplistic solutions apart from seizing the opportunities for using the data when it becomes available. With the current changes in EPA regulations and LHPA aerial baiting policy this study was a snapshot into a rapidly changing industry when regulations on use of GPS navigation systems were implemented. Such an opportunity is unlikely to be available again in NSW.

This study demonstrated that under operational conditions, aerial baiting using GPS technology has a much lower track error than navigation by VFR, the errors in map making have been identified and corrected and a method of quantifying track error has been developed and applied. The conclusion of this study was that helicopters, when navigated using visual flight rules (VFR) exhibited highly variable track error and after adoption of navigation by global positioning systems (GPS) there was a substantial and sustained improvement in the capability to follow designated flight paths.

The recommendation of this study is that:

1. Pilots should be trained in data logging of bait lines prior to an aerial baiting operation
2. Speed of operations should be the maximum necessary to maintain accuracy

3. To reduce operator error GPS data logging should be connected to a sensor in the drop tube of the aircraft so that the position of an object is logged to data storage each time it passes the sensor.
4. Those areas where GPS location errors may be present should be investigated by ground truthing the proposed bait transects.
5. An automated bait delivery device should be designed and developed for aerial baiting of pest animals..

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7. Appendices

See data files on attached DVD

Appendix 1. Application maps

This folder contains application maps submitted by the 15 Wild Dog Control Associations for aerial baiting for wild dog control in the three Livestock Health and Pest Authority covered in the thesis.

Appendix 2. Shapefiles

This folder contains proposed or draft aerial baiting plans and aircraft flight log data in ESRI® shapefile format for 15 Wild Dog Control Associations in New England Livestock Health and Pest Authority, Central North Livestock Health and Pest Authority and Mid Coast Livestock Health and Pest Authority for the years 2004 to 2009.

Appendix 3. Sites

This folder contains the abbreviations and numbers used for the 15 Wild Dog Control Associations in .csv format.

Appendix 4. Data 2004 - 2009

This folder contains the percentages of the aircraft flight log within a given buffer by Site and Year or treatment, VFR: 2004 – 2006 and GPS: 2007 – 2009

Appendix 5. ASREML

This folder contains the Predicted values of track error and the summary of R Code used for the analysis.