Factors explaining the decline of black-tailed deer: A comparative study on public and private lands in northern California

Agreement #: P0880013 between the University of California and the California Department of Fish and Game

Project Progress Report
Submitted October 2012

DRAFT – INTERNAL USE ONLY

Prepared by:

Heiko U. Wittmer (PI), Tavis Forrester & Max Allen

Department of Wildlife, Fish, & Conservation Biology
University of California
One Shields Ave.
Davis, CA 95616
Phone: 530-754-7640
Email: huwittmer@ucdavis.edu

Progress report until September 30, 2012

1) Adult deer

Summary:

The total number of collared female deer >1 year of age captured over the duration of the project currently stands at 60 individuals (2009 = 15, 2010 = 14, 2011 = 13, 2012 = 18; Table 1). One additional doe was darted but subsequently not fitted with a GPS collar because the collar was found to be incorrectly programmed prior to being deployed. Of the 60 individuals fitted with GPS collars, 3 deer died of capture related injuries. Our effective sample thus consists of 57 individuals. In addition, the GPS collars of 5 individuals malfunctioned and we were consequently either unable to retrieve the collars or any location data from the collars. Note that individuals with collars that failed may still be used for some analyses (such as survival rates based on ground telemetry/monitoring), but no location data have been recovered for these deer. The 8.8% (5/57) collar failure rate seems exceptionally high (but not uncommon) and we are currently investigating the probable causes for these failures. All deer have been collared on public land. Including capture related mortalities, we have recorded 21 mortalities during the current project for an overall mortality rate of 35% (21/60). Predation is the most common cause of mortality of females >1 year of age followed by unknown causes. As of September 30, we have 17 remaining deer >1 year of age with active GPS collars. Since a previous CDFG project led by David Casady collared an additional 23 adult female deer in the area (note that ID 5740 collared during the first project was recaptured and re-collared during the second project), data from a total of 82 deer >1 year of age will be available for analyses. Since none of the 23 deer captured during the earlier project died during capture the overall combined capture related mortality rate for the project is 3.6% (3/83).

1a) Status of adult collared deer 2009-2012:

Since captures began in June 2009, we have successfully captured 60 female deer older than 1 year of age (Table 1). All 60 individuals have been captured on public land and were fitted with GPS collars (Telonics and Lotek).

During the first year of the study (2009), we captured a total of 15 individuals. We have recorded 8 mortalities from this cohort, and 7 deer survived for 2 years, after which the GPS collars automatically dropped off before exhausting their battery life. The mortality rate of 53.3% in this cohort is exceptionally high for adult female deer (Forrester & Wittmer, *in press*). A total of 22,625 GPS locations were recovered from GPS collars.

An additional 14 individuals were captured in 2010 to increase our sample of collared animals and to replace animals that died during the previous year. Of these 14 deer, 7 have died of natural causes (50% mortality rate), and 1 died from capture related causes. The collars of 3 individuals failed and were not recovered. A total of 20,613 GPS locations were retrieved from the GPS collars we were able to recover.

During the 2011 summer field season an additional 13 individuals were captured to replace mortalities and to maintain optimal sample size. One of these deer died from capture related causes and 2 deer died from natural causes for an overall mortality rate of 23% (Table 1). A total 12,203 GPS locations have been recovered for this cohort.

During the 2012 summer field season, 18 additional deer were captured. One deer died from capture related complications and the remaining 17 deer were alive as of September 30, 2012. Since all collars from deer captured prior to 2012 had been programmed to drop off in summer/fall 2012 (the original end date of the study), the 17 individuals still alive from the 2012 capture cohort are the only collars currently still active and monitored in the field.

Table 1: Status of adult black-tailed deer Mendocino black-tailed deer project; updated September 30, 2012.

No	ID	Group	Capture Date	Age (Est) [1]	Age (cementum)	Weight (lbs)	Last Date Observed Alive	Date Heard on Mortality	Actual Mortality Date from Collar	Date Mortality Retrieved	Number GPS Fixes	Status
1	**8796**	M1	8-Jun-09	3	6	115	26-Sep-09	10-Oct-09	Telonics	10-Oct-09	492	dead
2	**5740**	M1	9-Jun-09	7	pending	98	16-Nov-09	4-Jun-10	Telonics	4-Jun-10	1049	dead
3	**8805**	M1	9-Jun-09	2	3	95	18-Mar-10	19-Jun-10	Telonics	19-Jun-10	901	dead
4	**8809**	M1	9-Jun-09	3	3	123	30-Mar-11	NA	NA	NA	no data	dropped
5	**8810**	M1	9-Jun-09	5	3	115	18-May-11	NA	NA	NA	1943	dropped
6	**8801**	M1	10-Jun-09	4	3	104	7-Apr-11	NA	NA	NA	2661	dropped
7	**8808**	FH7	10-Jun-09	2	pending	72	7-Aug-09	8-Aug-09	Telonics	8-Aug-09	366	dead
8	**8798**	FH7	10-Jun-09	4	6	115	7-Apr-11	NA	NA	NA	2730	dropped
9	**8803**	FH7	11-Jun-09	2	2	82	30-Mar-11	NA	NA	NA	3106	dropped
10	**8804**	FH7	11-Jun-09	4	10	105	12-Feb-10	1-Jun-10	Telonics	2-Jun-10	1466	dead
11	**8800**	FH7	11-Jun-09	5	4	132	7-Apr-11	NA	NA	NA	no data	dropped
12	**8802**	M1	8-Aug-09	2	3	106	3-Jun-10	10-Jun-10	8-Jun-10	10-Jun-10	1334	dead
13	**8835**	M1	13-Aug-09	2	3	101	18-Mar-10	4-Jun-10	30-Mar-10	20-Sep-	1963	dead
14	**8817**	FH7	14-Aug-09	1	na	92	11-Aug-11	NA	NA	NA	2914	dropped
15	**8834**	M1	21-Dec-09	5.5	11	150	18-Nov-10	18-Jan-11	16-Dec-10	27-Jan-11	1700	dead
16	**8815**	FH7	20-Jun-10	4	5	108	6-Dec-10	28-Feb-11	13-Dec-10	23-Jul-11	391	dead
17	**7584**	FH7	21-Jun-10	3	4	90	6-Dec-11	22-Jun-11	NA	NA	NA	C. failure
18	**8820**	FH7	21-Jun-10	3	3	115	5-Jul-11	9-Jul-11	8-Jul-11	14-Jul-11	1772	dead
19	**7586**	M1	22-Jun-10	3	3	80	6-Dec-11	NA	NA	NA	NA	C. failure
20	**8821**	FH7	22-Jun-10	2	pending	75	9-Jul-11	NA	NA	NA	NA	C. failure
21	**7597**	FH7	23-Jun-10	4	10-11	95	3-Jun-11	5-Jun-11	5-Jun-11	17-Jul-11	1629	dead
22	**8823**	FH7	24-Jun-10	4	3	85	15-Sep-11	19-Sep-11	17-Sep-11	25-Sep-	1498	dead
23	**7588**	FH7	24-Jun-10	6	5	105	10-Jun-12	NA	NA	NA	2901	dropped
24	**8826**	FH7	25-Jun-10	7	10	114	29-May-12	15-Jul-12	16-Apr-12	25-Aug-	2876	dead
25	**7585**	M1	16-Jul-10	6	5	112	17-Jun-12	NA	NA	NA	2692	dropped
26	**7583**	FH7	28-Jul-10	4	3	96	29-May-12	22-Jun-12	7-Jun-12	21-Jul-12	2654	dead
27	**8811**	FH7	24-Aug-10	6	9	109	24-Aug-10	25-Aug-10	NA	NA	NA	dead
28	**8819**	FH7	24-Aug-10	5	6	106	10-Jun-12	NA	NA	NA	2807	dropped

29	**7885**	FH7	26-Aug-10	3	2	88	27-Sep-10	5-Jan-11	9-Dec-10	10-Jul-11	1393	dead
30	**8828**	M1	21-Jun-11	4	pending	110	11-Oct-11	24-Oct-11	12-Oct-11	24-Oct-11	487	dead
31	**8816**	M1	21-Jun-11	4	pending	99	17-Jun-12	NA	NA	NA	1767	dropped
32	**7879**	M1	22-Jun-11	7	pending	115	22-Jun-11	23-Jun-11	NA	NA	NA	dead
33	**7893**	M1	22-Jun-11	3.5	pending	88	20-Aug-12	NA	NA	NA	2037	dropped
34	**8833**	M1	22-Jun-11	1	na	61	27-Jul-12	NA	NA	NA	NA	?
35	**8822**	M1	25-Jun-11	3	pending	120	10-Aug-12	NA	NA	NA	2178	dropped
36	**8813**	M1	25-Jun-11	6	pending	84	19-Jun-12	NA	NA	NA	1594	dropped
37	**7037**	M1	25-Jun-11	3	pending	75	8-Feb-12	23-Mar-12	28-Feb-12	24-Jun-12	1277	dead
38	**7884**	M1	26-Jun-11	5.5	pending	94	23-Jun-12	NA	NA	NA	1525	dropped
39	**8797**	M1	26-Jun-11	8	pending	100	9-Nov-11	NA	NA	NA	NA	C. failure
40	**7308**	M1	6-Jul-11	4	pending	88	20-Aug-11	22-Aug-11	21-Aug-11	29-Aug-	173	dead
41	**7079**	FH7	9-Jul-11	6	pending	105	4-Jul-12	NA	NA	NA	1165	dropped
42	**7882**	FH7	9-Jul-11	5	pending	78	11-Sep-12	NA	NA	NA	NA	C. failure
43	**7685**	M1	4-Jun-12	3	pending	97	NA	NA	NA	NA	NA	dead
44	**7276**	M1	5-Jun-12	3	pending	95	12-Sep-12	NA	NA	NA	NA	alive
45	**7303**	FH7	6-Jun-12	7	pending	103	12-Sep-12	NA	NA	NA	NA	alive
46	**8829**	M1	7-Jun-12	5	pending	107	9-Sep-12	NA	NA	NA	NA	alive
47	**7331**	FH7	8-Jun-12	5	pending	87	8-Sep-12	NA	NA	NA	NA	alive
48	**7216**	FH7	12-Jun-12	4	pending	130	8-Sep-12	NA	NA	NA	NA	alive
49	**7227**	FH7	13-Jun-12	5	pending	98	8-Sep-12	NA	NA	NA	NA	alive
50	**7449**	M1	15-Jun-12	4	pending	110	12-Sep-12	NA	NA	NA	NA	alive
51	**8818**	FH7	16-Jun-12	4	pending	106	8-Sep-12	NA	NA	NA	NA	alive
52	**7298**	FH7	12-Jul-12	5	pending	94	12-Sep-12	NA	NA	NA	NA	alive
53	**1485**	FH7	12-Jul-12	1	pending	115	12-Sep-12	NA	NA	NA	NA	alive
54	**8812**	FH7	13-Jul-12	6	pending	94	12-Sep-12	NA	NA	NA	NA	alive
55	**7318**	FH7	13-Jul-12	7	pending	102	12-Sep-12	NA	NA	NA	NA	alive
56	**7314**	FH7	13-Jul-12	3	pending	78	12-Sep-12	NA	NA	NA	NA	alive
57	**7274**	M1	7-Sep-12	1	pending	66	12-Sep-12	NA	NA	NA	NA	alive
58	**7447**	FH7	10-Sep-12	7	pending	94	11-Sep-12	NA	NA	NA	NA	alive
59	**7616**	M1	9-Sep-12	1	pending	65	12-Sep-12	NA	NA	NA	NA	alive
60	**7285**	FH7	10-Sep-12	6	pending	105	12-Sep-12	NA	NA	NA	NA	alive

[1] Age at capture estimated from tooth wear and replacement; confirmation using cement-annuli from extracted tooth pending where indicated

1b) Survival rates & cause of mortality assessment:

Using data presented in Table 1, we conducted a preliminary Kaplan-Meier survival analysis (Pollock et al., 1989) to determine annual survival rates of deer older than 1 year. Annual survival for the first 3-years of the project (May 09 – May 2012) averaged *0.65* ± *0.08*. Note that this survival rate would be among the lowest survival rates recorded for adult female mule and/or black-tailed deer across their distribution (Forrester & Wittmer, *in press*). Survival would increase slightly if capture related mortalities would be excluded from the analysis. No attempts have been undertaken to investigate possible relationships between survival, age or environmental covariates. Such analyses will be conducted once all data has been retrieved (including confirmation of age from cement-annuli methods).

Cause of mortality is assessed in the field by trained crews based on track and sign, scat, tooth punctures and feeding evidence, evidence of carcass caching, and disposition of the carcass. Additionally swab samples are taken to identify predator and scavenger species through DNA analysis.

The DNA analysis from 2009 and most 2010 adult mortality sites has been completed by Dr. Ben Sack's lab at UC Davis. However, due to the fact that many adults died in the late winter and early spring (i.e. adult mortality appears highest on winter and transitional ranges), the preliminary DNA results need to be analyzed with both the kill site assessment and body condition assessment (from bone marrow fat) before being reported. Heavy scavenging by black bears in the study area has likely resulted in some DNA tests being confounded between predator and scavenger identity. Black bear scavenging can make it difficult to identify the actual cause of death and determine whether it was predation, starvation, or disease. However the combination of field assessment, DNA analysis, measuring body condition from femur marrow fat levels, and comparing collared deer mortality sites to known mountain lion predation sites from collared mountain lions that have been scavenged by bears allows a reasonable assessment of cause of mortality (Figure 1). The predominant cause of mortality is currently *predation*. Our main challenge remains reaching winter mortalities within a reasonable time resulting in a high proportion of *unknown* causes of mortality.

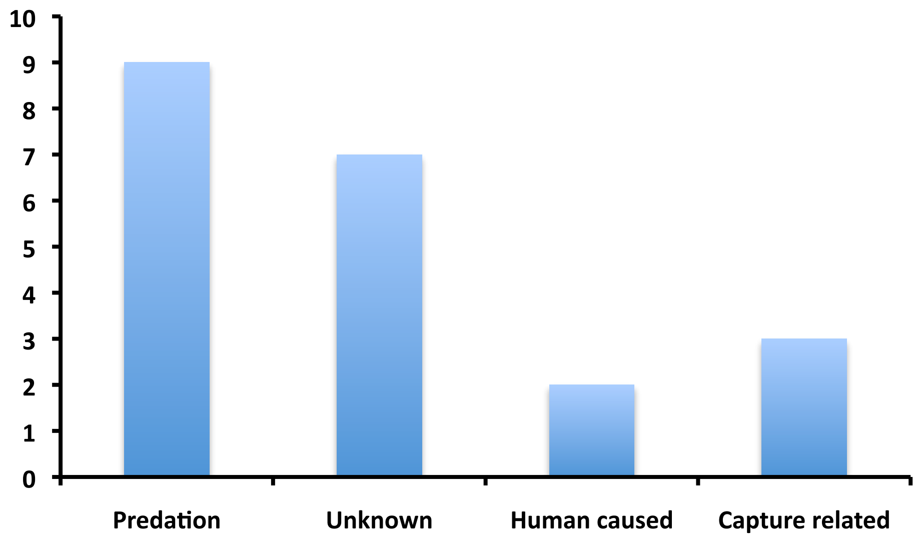

Figure 1: Preliminary assessment of causes of mortality of 21 female black-tailed deer >1 year of age in the Mendocino National Forest.

1c) Monitoring:

Monitoring remains a challenge due to the enormous wear and tear on field vehicles. The project currently has only one DFG truck remaining. Additional field vehicles have been rented from UC Davis at high costs to ensure continuous monitoring of the remaining deer.

Winter access to the study area to monitor deer and retrieve mortalities has been a challenge during the first 3 years of the project. As a consequence, a large number of deer that died during the winter months have been attributed an *unknown* cause of mortality (Figure 1). This is potentially a severe project limitation as it makes it potentially impossible to determine if winter mortality is additive or compensatory. Therefore every effort needs to be conducted this year to get to adult mortalities faster to determine the cause of mortality of deer that die during the winter months. This requires snowmobiles and support personnel for safety during mortality retrieval in winter conditions. Options and schedules for telemetry flights and snowmobile use are currently being discussed and finalized with David Casady.

2) Fawns

Summary:

Over the duration of the study, a total of 137 fawns have been captured and fitted with VHF ear-tags (Table 2). Annual survival for the first 3-years of the project (June 09 – May 2012) averaged *0.27* ± *0.12*. Causes for low observed fawn survival are currently being investigated based on DNA samples and evidence collected at the mortality sites.

2a) Monitoring & status 2009 cohort:

Of the 15 fawns (5 males/10 females) captured and tagged during 2009, only 2 survived to become yearlings (Table 2). VHF ear-tags of both these fawns are no longer active and thus their status can no longer be monitored. The overall mortality rate for the 2009 cohort was 86% (12/14).

2b) Monitoring & status 2010 cohort:

During 2010, we captured and tagged 26 fawns (12 males/14 females) (Table 2). Higher capture success was due to a combination of increased capture efforts as well as experience of the capture crews. Of the 26 fawns captured, 18 died, 7 survived to become yearlings, and 1 was last heard in the winter of 2011 and its status is unknown. The batteries in the VHF ear tags of this cohort are not active and they can no longer be monitored. The overall mortality rate for the 2010 cohort was 72% (18/25).

2c) Monitoring & status 2011 cohort:

During the 2011 field season we captured 45 fawns (24 males/21 females) (Table 2). This was a significantly higher sample size than previous years. The higher capture success was due to increased capture efforts during a week of combined fawn and adult deer captures, experienced capture crews, and the rental of a third project truck. Capture success is heavily linked to capture effort, and the increased effort and experience resulted in higher sample size. Of the 45 fawns that were captured, 27 have died, 16 survived to become yearlings and the status of 2 fawns is unknown. The overall mortality rate for the 2011 cohort was 63% (27/43).

2d) Monitoring & status 2012 cohort:

During the 2012 field season we captured 51 fawns (25 males/26 females) (Table 2). Capture success was a consequence of very high capture efforts and resulted in the largest sample to date. As of September 30, 2012, 26 fawns (51%) have been confirmed dead.

Table 2: Status of black-tailed deer fawns Mendocino black-tailed deer project; updated September 30, 2012.

No	ID	Group	Capture date	Sex	Weight (kg)	Last Date Observed Alive	Date Mortality Retrieved	Status
1	R1130	M1	30-Jun-09	male	2.7	30-Jun-09	12-Jul-09	dead
2	Y10	M1	1-Jul-09	female	3.1	6-Jul-09	7-Jul-09	dead
3	R1110	M1	1-Jul-09	female	4.5	1-Jul-09	NA	unknown
4	R1123	M1	1-Jul-09	female	3.1	1-Jul-09	4-Jul-09	dead
5	R1125	M1	2-Jul-09	female	4.3	22-Sep-09	26-Sep-09	dead
6	R1109	M1	3-Jul-09	male	2.3	4-Jul-09	8-Jul-09	dead
7	R1121	M1	3-Jul-09	female	2.3	9-Jul-09	12-Jul-09	dead
8	R1071	M1	6-Jul-09	male	3.9	16-Nov-09	19-Jun-10	dead
9	R1119	FH7	7-Jul-09	female	3.5	29-Jul-09	1-Aug-09	dead
10	R1068	M1	8-Jul-09	female	3.1	14-Sep-09	22-Sep-09	dead
11	R1116	M1	9-Jul-09	female	2.7	15-Aug-10	NA	survived
12	R1054	M1	9-Jul-09	female	3.9	10-Jul-09	17-Jul-09	dead
13	R1055	M1	11-Jul-09	female	4.1	24-Jul-10	NA	survived
14	R1191	FH7	12-Jul-09	male	5	25-Aug-09	27-Aug-09	dead
15	R1185	FH7	14-Jul-09	male	4.4	14-Jul-09	16-Jul-09	dead
16	Y13	FH7	21-Jun-10	female	4.5	21-Jun-10	28-Jun-10	dead
17	Y14	FH7	22-Jun-10	male	3.6	22-Jun-10	23-Jun-10	dead
18	Y21	FH7	22-Jun-10	female	3.2	5-Jul-10	6-Jul-10	dead
19	Y15	FH7	22-Jun-10	male	5.4	9-Jul-10	14-Jul-10	dead
20	Y16	FH7	22-Jun-10	female	4.7	13-Jul-10	17-Jul-10	dead
21	Y71	FH7	23-Jun-10	male	2.2	9-Jul-10	13-Jul-10	dead

22	Y4	FH7	25-Jun-10	female	2.4	9-Jul-10	10-Jul-10	dead
23	Y52	FH7	26-Jun-10	female	2.6	22-Jun-11	NA	survived
24	Y5	FH7	26-Jun-10	male	3.3	7-Dec-10	10-Jul-10	dead
25	Y6	FH7	26-Jun-10	male	3.4	22-Jun-11	NA	survived
26	Y7	M1	30-Jun-10	female	2.7	9-Aug-10	10-Aug-10	dead
27	Y1	M1	30-Jun-10	female	2.8	5-Jul-11	NA	survived
28	Y8	M1	30-Jun-10	male	4.4	9-Jul-10	12-Jul-10	dead
29	Y9	M1	3-Jul-10	female	3.1	22-Oct-10	21-Apr-11	dead
30	Y12	M1	5-Jul-10	female	2.9	28-Feb-11	19-Jun-10	dead
31	Y10	M1	7-Jul-10	female	4.1	6-Jan-11	NA	unknown
32	Y19	FH7	8-Jul-10	male	2.9	2-Jul-11	NA	survived
33	Y11	FH7	8-Jul-10	female	2.8	2-Jul-11	NA	survived
34	Y23	FH7	8-Jul-10	female	2.8	29-Jul-10	30-Jul-10	dead
35	Y20	FH7	9-Jul-10	female	3.15	15-Jul-10	18-Jul-10	dead
36	Y24	FH7	9-Jul-10	male	3.4	9-Jul-10	11-Jul-10	dead
37	Y22	FH7	10-Jul-10	male	3.9	18-Jul-10	19-Jul-10	dead
38	Y86	FH7	12-Jul-10	male	3.6	12-Aug-10	14-Aug-10	dead
39	Y25	FH7	12-Jul-10	female	3.2	22-Jul-11	NA	survived
40	Y85	M1	15-Jul-10	male	5	24-May-11	NA	unknown
41	Y18	FH7	19-Jul-10	male	3.1	7-Aug-10	9-Aug-10	dead
42	Y68	M1	15-Jun-11	male	3.63	21-Sep-11	NA	unknown
43	Y64	M1	16-Jun-11	male	2.80	5-Jul-12	NA	survived
44	R1118	M1	19-Jun-11	male	3.00	8-Jul-12	NA	survived
45	Y87	M1	19-Jun-11	female	3.63	21-Jun-11	25-Jun-11	dead
46	R1115	M1	20-Jun-11	female	4.20	10-Jun-12	NA	survived
47	Y62	M1	20-Jun-11	female	3.50	6-Jul-11	12-Jul-11	dead
48	Y73	M1	20-Jun-11	female	2.00	18-Aug-11	19-Aug-11	dead
49	Y56	M1	20-Jun-11	male	2.20	20-Jun-11	26-Jun-11	dead
50	Y54	M1	20-Jun-11	male	3.40	25-Jun-12	NA	survived
51	Y57	M1	21-Jun-11	female	4.08	15-Jul-12	NA	survived
52	Y95	M1	21-Jun-11	male	4.20	21-Jun-11	2-Jul-11	dead
53	Y11	M1	22-Jun-11	male	4.54	22-Jun-11	NA	unknown
54	Y96	M1	22-Jun-11	female	2.72	23-Mar-12	23-Jun-12	dead
55	Y75	M1	23-Jun-11	female	2.90	1-Feb-12	19-Jun-12	dead
56	Y92	FH7	23-Jun-11	male	3.63	2-Apr-12	19-Apr-12	dead
57	Y32	M1	24-Jun-11	male	4.31	11-Jul-11	19-Jul-11	dead
58	Y94	M1	24-Jun-11	male	4.08	25-Jun-12	NA	survived
59	Y97	FH7	24-Jun-11	male	2.31	31-Jul-11	1-Aug-11	dead
60	Y98	M1	25-Jun-11	female	2.49	30-Jun-11	11-Jul-11	dead
61	Y100	M1	25-Jun-11	male	4.08	12-Sep-12	NA	survived
62	R1117	M1	26-Jun-11	female	2.49	25-Jul-11	26-Jul-11	dead
63	R1106	M1	27-Jun-11	female	3.18	4-Aug-11	7-Aug-11	dead
64	R1072	M1	27-Jun-11	male	2.95	29-Sep-11	11-Oct-11	dead
65	Y53	M1	28-Jun-11	female	3.90	6-Dec-11	29-Jan-12	dead

66	Y55	M1	28-Jun-11	female	3.80	15-Sep-11	21-Sep-11	dead
67	Y74	FH7	28-Jun-11	male	3.63	26-Jun-12	NA	survived
68	R1120	FH7	28-Jun-11	female	2.50	9-Jul-11	10-Jul-11	dead
69	Y93	FH7	28-Jun-11	male	2.70	18-Jul-12	NA	survived
70	Y59	M1	29-Jun-11	female	3.86	30-Jun-11	1-Jul-11	dead
71	Y66	M1	29-Jun-11	male	2.95	2-Jul-11	3-Jul-11	dead
72	Y90	FH7	29-Jun-11	female	3.20	5-Jul-11	30-Aug-11	dead
73	Y88	FH7	30-Jun-11	male	6.30	1-Jul-11	2-Jul-11	dead
74	Y67	M1	1-Jul-11	male	3.86	20-Jun-12	NA	survived
75	Y61	FH7	1-Jul-11	female	4.20	7-Jul-11	10-Jul-11	dead
76	Y60	FH7	1-Jul-11	male	4.10	7-Jul-11	11-Jul-11	dead
77	Y50	FH7	1-Jul-11	male	3.50	16-Jul-11	18-Jul-11	dead
78	Y48	FH7	1-Jul-11	female	4.10	4-Jul-12	NA	survived
79	Y99	FH7	1-Jul-11	male	4.40	3-Jul-11	28-Aug-11	dead
80	Y69	FH7	1-Jul-11	male	3.30	23-Jun-12	NA	survived
81	Y49	FH7	2-Jul-11	female	3.00	5-Jul-11	6-Jul-11	dead
82	Y63	M1	3-Jul-11	female	4.99	15-Jul-12	NA	survived
83	Y46	FH7	3-Jul-11	male	3.50	4-Jul-12	NA	survived
84	Y65	FH7	4-Jul-11	male	4.20	26-Jun-12	NA	survived
85	R1052	M1	7-Jul-11	female	3.40	10-Jun-12	NA	survived
86	Y89	FH7	9-Jul-11	female	3.86	17-Jul-11	18-Jul-11	dead
87	O12	FH7	6-Jun-12	female	3.9	12-Sep-12	NA	alive
88	O13	FH7	6-Jun-12	female	3.2	12-Sep-12	NA	alive
89	O14	FH7	6-Jun-12	male	3.2	6-Sep-12	8-Sep-12	dead
90	O18	M1	7-Jun-12	female	3.4	12-Sep-12	NA	alive
91	O17	M1	10-Jun-12	male	4.3	11-Jun-12	16-Jun-12	dead
92	O16	M1	13-Jun-12	male	2.9	22-Jun-12	23-Jun-12	dead
93	O20	FH7	15-Jun-12	female	3.2	15-Jun-12	18-Jun-12	dead
94	W23	M1	18-Jun-12	male	4.1	12-Sep-12	NA	alive
95	W4	M1	20-Jun-12	male	4.3	23-Jun-12	25-Jun-12	dead
96	W2	M1	20-Jun-12	female	3.4	12-Sep-12	NA	alive
97	W19	FH7	20-Jun-12	male	3.2	25-Jun-12	13-Aug-12	dead
98	W21	FH7	20-Jun-12	male	3.4	25-Jun-12	27-Jun-12	dead
99	W15	M1	21-Jun-12	female	3.4	28-Jul-12	1-Aug-12	dead
100	W3	M1	21-Jun-12	female	3.4	7-Jul-12	9-Jul-12	dead
101	W40	M1	21-Jun-12	female	5.7	12-Sep-12	NA	alive
102	W32	FH7	21-Jun-12	female	2.3	8-Jul-12	15-Jul-12	dead
103	W10	FH7	21-Jun-12	female	5.7	12-Sep-12	NA	alive
104	W11	FH7	21-Jun-12	male	4.3	12-Sep-12	NA	alive
105	W24	M1	21-Jun-12	male	3.9	12-Sep-12	NA	alive
106	W28	M1	22-Jun-12	male	4.1	22-Jun-12	25-Jun-12	dead
107	W25	M1	23-Jun-12	female	3.4	12-Sep-12	NA	alive
108	W1	FH7	24-Jun-12	male	3.5	12-Sep-12	NA	alive
109	W27		24-Jun-12	male	4.1	24-Jun-12	26-Jul-12	dead

110	W37	M1	25-Jun-12	female	2.5	12-Sep-12	NA	alive
111	W38	M1	25-Jun-12	female	2.4	25-Jun-12	27-Jun-12	dead
112	W22	FH7	25-Jun-12	female	2.7	5-Jul-12	8-Jul-12	dead
113	W33	M1	27-Jun-12	male	3.5	12-Sep-12	NA	alive
114	W34	M1	27-Jun-12	female	4.0	28-Jun-12	3-Jul-12	dead
115	W20	M1	27-Jun-12	male	3.5	23-Aug-12	26-Aug-12	dead
116	W5	FH7	27-Jun-12	female	7.0	11-Sep-12	NA	alive
117	W7	FH7	27-Jun-12	female	3.4	4-Jul-12	5-Jul-12	dead
118	W17	FH7	27-Jun-12	male	3.9	11-Aug-12	13-Aug-12	dead
119	W8	FH7	27-Jun-12	male	2.6	12-Sep-12	NA	alive
120	W41	FH7	27-Jun-12	female	2.9	8-Jul-12	10-Jul-12	dead
121	W29	FH7	27-Jun-12	female	2.8	12-Sep-12	NA	alive
122	W39	M1	28-Jun-12	male	3.5	28-Jun-12	1-Jul-12	dead
123	W36	FH7	28-Jun-12	female	3.2	15-Jul-12	15-Jul-12	dead
124	W26	M1	28-Jun-12	male	5.7	9-Jul-12	12-Jul-12	dead
125	W35	M1	28-Jun-12	female	5.4	12-Sep-12	NA	alive
126	W42	M1	28-Jun-12	male	6.5	12-Sep-12	NA	alive
127	W6	FH7	28-Jun-12	female	3.4	12-Sep-12	NA	alive
128	W31	FH7	28-Jun-12	female	3.7	12-Sep-12	NA	alive
129	W30	M1	29-Jun-12	female	3.9	12-Sep-12	NA	alive
130	W50	M1	30-Jun-12	male	5.4	30-Jun-12	2-Jul-12	dead
131	W49	FH7	2-Jul-12	female	5.4	12-Sep-12	NA	alive
132	W44	FH7	2-Jul-12	male	3.6	12-Sep-12	NA	alive
133	W43	FH7	2-Jul-12	male	3.0	12-Sep-12	NA	alive
134	W48	FH7	3-Jul-12	male	4.0	19-Aug-12	22-Aug-12	dead
135	W13	M1	5-Jul-12	male	3.0	12-Sep-12	NA	alive
136	W45	FH7	5-Jul-12	female	3.6	13-Jul-12	23-Jul-12	dead
137	W46	M1	8-Jul-12	male	3.8	15-Jul-12	18-Jul-12	dead

2e) Survival rates & cause of mortality assessment:

Using data presented in Table 2, we conducted a preliminary Kaplan-Meier survival analysis (Pollock et al. 1989) to determine annual survival rates of black-tailed deer fawns in the Mendocino National Forest. Annual survival for the first 3-years of the project (June 09 – May 2012) averaged *0.27* ± *0.12*. As expected, fawn survival appears more variable than adult survival (Gaillard et al. 2000). Overall, fawn survival appears lower than long-term averages reported from other studies (Forrester & Wittmer, *in press*) and may be insufficient to compensate for the low survival of females >1 year of age reported for this study. This preliminary assessment should be viewed with extreme caution and the results for the 2012 cohort are essential to substantiate this interpretation. Future analyses of fawn survival need to evaluate the effects of variation in sample size and environmental covariates among years for the observed variation in fawn survival. What is clear, however, is that the bulk of fawn mortalities occur on the summer ranges during the first 3 months of life.

The DNA analysis from 2009 and most 2010 mortality sites has been completed by Dr. Ben Sack's lab at UC Davis. However, the preliminary results need to be analyzed with the kill site assessment before being reported, as heavy scavenging by black bears in the study area has resulted in some DNA tests being confounded between predator and scavenger identity. Preliminary results indicate that the use of both DNA analysis of mortalities that were recovered within 48 hours and our mortality site assessment will result in an accurate assessment of cause of mortality and predator identity.

3) Vegetation surveys

During the 2010 field season we conducted vegetation surveys to assess deer habitat quality and composition in fawning areas. Vegetation surveys were conducted during July and August. Habitats on ridgelines near Forest Highway 7 (east of the Black Butte river drainage) and near forest highways M1 and M61 (west of the Black Butte river drainage) were included in survey efforts.

In the 2011 field season we surveyed vegetation on summer range outside of fawning areas to compare the vegetation type and quality between fawning areas and other areas of the range. Habitats surveyed included lower elevation oak meadow complexes, ponderosa pine forests, and true fir forests.

During the 2012 field season we re-surveyed herbaceous vegetation inside and outside of fawning areas to establish a relationship between the yield of herbaceous vegetation and precipitation in the study area.

Vegetation surveys were located by selecting a random starting point within the survey area and spacing transects systematically from this starting point, allowing systematic coverage of the area and preserving random selection assumptions necessary for statistical analysis.

Three types of surveys were conducted in 2010 and 2011 years (see Table 3). First, *line intercept surveys* were used to determine the cover and volume of shrub species. Second, *comparative yield (CY) and dry weight ranking methods (DWR)* (0.25 m^2 quadrat surveys) were used to estimate the available biomass and composition of forbs and grasses. Third, *twig count surveys* (1x3 m strip transects) were conducted to estimate available shrub browse biomass. All surveys are established and well tested methods. In 2012 only CY and DWR surveys were conducted. Surveys were conducted by UC Davis research personnel, interns, and CDFG scientific aides.

Table 3: Vegetation survey effort 2010-2011

Year	Survey Type	Surveys Completed
2010	Line Intercept Transects	96 transects (100 meter transects)
	Grass/Forb Quadrats (CY & DWR)	960 quadrats (0.25 m^2)
	Twig Count	288 strip transects (1x3 m)
2011	**Survey Type**	**Surveys Completed**
	Line Intercept Transects	84 transects (100 m transects)
	Grass/Forb Quadrats (CY & DWR)	840 quadrats (0.25 m^2)
	Twig Count	252 strip transects (1x3m)
2012	**Survey Type**	**Surveys Completed**
	Line Intercept Transects	0
	Grass/Forb Quadrats (CY & DWR)	290 quadrats (0.25 m^2)
	Twig Count	0

Approximately 15 species of shrubs occurred regularly on survey transects, including two species of Ceanothus, three species of Arctostaphylos (Manzanita species), three species of Prunus (e.g. bitter cherry), two species of Symphoricarpos (snowberry), two species of Ribes (e.g. gooseberry), a Rubus species (black-cap raspberry), and a species of Holodiscus (ocean spray). Grasses and forbs were divided into broad categories, including exotic annual grasses, bunchgrasses, and forbs. Several genus of interest were also noted including Madia (tarweed species), Taeniatherum (medusa head grass), and several invasive Bromus species (e.g. ripgut brome).

Samples of key browse species, including Quercus genus species, Ceanothus genus species (i.e. mountain whitethorn ceanothus (*Ceanothus cordulatus*)), Prunus genus species (i.e. bitter cherry), and Arctostaphylos species (i.e. common Manzanita), were also collected across the study area from browsed and unbrowsed plants to be tested for forage quality.

4) Diet analysis

Deer pellets were collected from fawning areas in August 2010, August and September 2011, and in July, August, and September in 2012. The diet results from 2010 and 2011 are summarized below and pellets from 2012 are currently being analyzed. This diet analysis shows that the summer range diet of deer in the study area is low in forbs and very high in shrubs, particularly oak species (Table 4). This diet composition is highly unusual for black-tailed deer and the consequences of this diet will be explored in future survival analyses.

The results of this diet analysis will be used with the results of the vegetation surveys to compare selected forage to available forage, potentially for an estimation of the carrying capacity of summer ranges in the area, and to calculate forage variables for a detailed survival analysis. Diet analysis will also be compared to rain and snow patterns to assess possible weather effects on diet composition and quality.

Table 4: Summer Range Diet Composition (values are percent of total diet)

Deer Diet	2010 Average	2011 Average
All Shrubs	76.38	72.88
Quercus spp. only	**39.27**	**31.39**
All Conifers	3.10	3.85
All Forbs	7.20	6.00
All Grasses	3.73	1.53
Other	9.60	15.75

5) Camera traps

Passive infrared trail cameras were deployed throughout black-tailed deer summer range in 2010 and 2011 to determine predator composition and abundance during the fawning period within key fawning areas. Cameras were placed using randomly selected cells within a grid centered on known fawning areas. Once the randomly selected point was located cameras were placed within 250 meters of the original point at a location most likely to capture photographs of predators (e.g. game trails, scrapes, springs, etc.). No bait was used. Cameras were deployed three times during the field season.

During the 2010 field season cameras were deployed from late May through late October, except a 2-3 week period in June due to intensive fawn capture efforts. In the 2011 and 2012 field seasons cameras were deployed from mid to late June to mid October.

Species detected included black bear, coyote, bobcat, black-tailed deer, mountain lion, elk, feral pig, grey fox, fisher, 2 species of skunk, raccoon, black-tailed jackrabbit, and human. Every major predator in the study area was photographed. The most notable events were detection of an elk (subspecies currently undetermined), and the low number of mountain lion detections. Elk have not previously been documented as occurring at this elevation in the Mendocino National Forest. Mountain lions were consistently detected in a single fawning area and not detected anywhere else on summer range. The low number of mountain lion detections may be due to lion territories that discourage high elevation habitat use. This hypothesis has been supported by the average elevation from a preliminary analysis of lion GPS collar data in the study area. The average elevation of collared mountain lions was 1151 +/- 102 meters while an average summer range elevation of several collared deer was 1704 +/- 302 meters. Mountain lion territories are also significantly larger than the camera trapping sample area, and this may have led to low detections.

Although the data is still being entered and analyzed, a preliminary summary of trail camera effort is included below in Table 5.

Table 5: Deer study camera trapping effort 2010-2011

Year	Metric	Estimated Effort
2010	Total Camera Deployments	90 deployments
	“Trap Nights” (24 hour period)	2,665
2011	Total Camera Deployments	89 deployments
	“Trap Nights” (24 hour period)	3,628
2012	Total Camera Deployments	96 deployments
	“Trap Nights” (24 hour period)	Approx. 2,688
TOTAL	*Camera Deployments*	275 deployments
	Trap Nights	8,980 trap nights

6) DNA capture-recapture deer density and adult sex ratio estimation

Field crews conducted a pilot study in 2011 to refine methods for black-tail deer density estimation using DNA from deer pellets. Sixteen transects (approx. 1.2 km per transect) were established in summer range areas. Methods for determining transects using random starting points and establishing transects on existing deer trails to increase pellet detection were tested in September of 2011.

Approximately 20.5 km of transect were established and sampled twice, and approximately 450 pellet samples were taken. The pilot study also allowed us to refine recommended field methods from other areas into a robust protocol that can be used in future research and for future deer density estimations in our study area.

In 2012 we established 26 pellet survey transects that were sampled 4 times each throughout the field season. Due to a forest fire in August that restricted access we were only able to sample three transects twice and established two additional transects that were sampled three times each. Approximately 120 km of transects were sampled (including all resampling) and 1063 pellet samples were collected.

All pellets have been submitted to the lab of Dr. Ben Sacks at UC Davis. A lab technician has been hired from the grant to expedite DNA analysis. Initial results indicate good DNA extraction rates from pellet samples (B. Sacks, personal communication). Due to the large amount of pellet samples collected (>1,500 for both years combined) final results are not expected prior to June 2013.

7) Mountain lion capture

We have captured 7 mountain lions to date. All captured mountain lions have been processed by either CDFG project lead David Casady or lead biologist Max Allen. Table 6 includes individual information for each captured mountain lion.

Our capture efforts have been more successful and efficient with the addition of Blue Millsap as houndsman. We will be removing the collars from the last mountain lions in November 2012, and we will use Blue Millsap for these final re-captures.

Table 6: Mountain Lions Captured

Mountain Lion	Original Capture Date	Number of Re-captures	Sex	Current Age (Years)	Weight (Pounds)
F1	6/24/2010	2	Female	Deceased	71
M36	4/21/2011	1	Male	Deceased	106
F23	6/10/2011	1	Female	Deceased	109
F17	8/6/2011	1	Female	Deceased	73
F19	8/8/2011	0	Female	5.3	72
M33	8/17/2011	2	Male	8.2	140
F43	4/20/2012	0	Female	3.7	84

8) Mountain lion predation on Black-tailed deer

We are using intensive monitoring methods to determine the predation patterns of mountain lions on Black-tailed deer. Our collars take GPS fixes every 2 hours, and upload the locations via satellite every 3 days. We then plot the locations and determine “clusters” of activity. The clusters are then investigated, using a grid search method, for signs of mountain lion predation. When a feeding site is found, the location and habitat characteristics are recorded, along with the health, sex, and age of the deer.

Our methods used for checking kill sites have been fine-tuned and are working very well. These methods allow us to find and document the kills made by mountain lions in the study area in a quick and efficient manner, including finding small prey items. To date, we have been successful in finding 350 feeding sites from the seven collared mountain lions.

The 350 feeding sites include numerous small prey items, though as expected, the majority of prey killed is Black-tailed deer (269 items). Of the Black-tailed deer, 24.5% of the kills have been fawns (<1 year of age). Of the 203 adult Black-tailed deer, we were able to determine the sex for 99, of which 70.8% were female. The overall results of diet by prey species are broken down in Figure 2. The non-deer prey species are further broken down by the sex of the mountain lion which killed them in Figure 3, and by season in which they were killed in Figure 4.

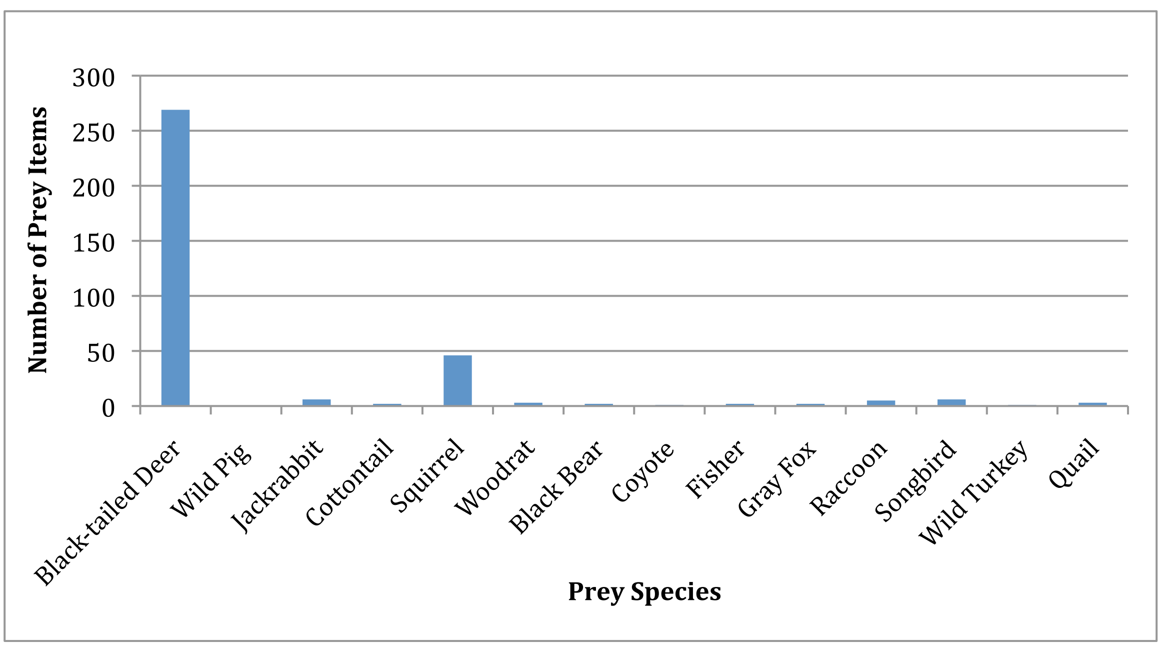

Figure 2: Mountain Lion Diet by Prey Species

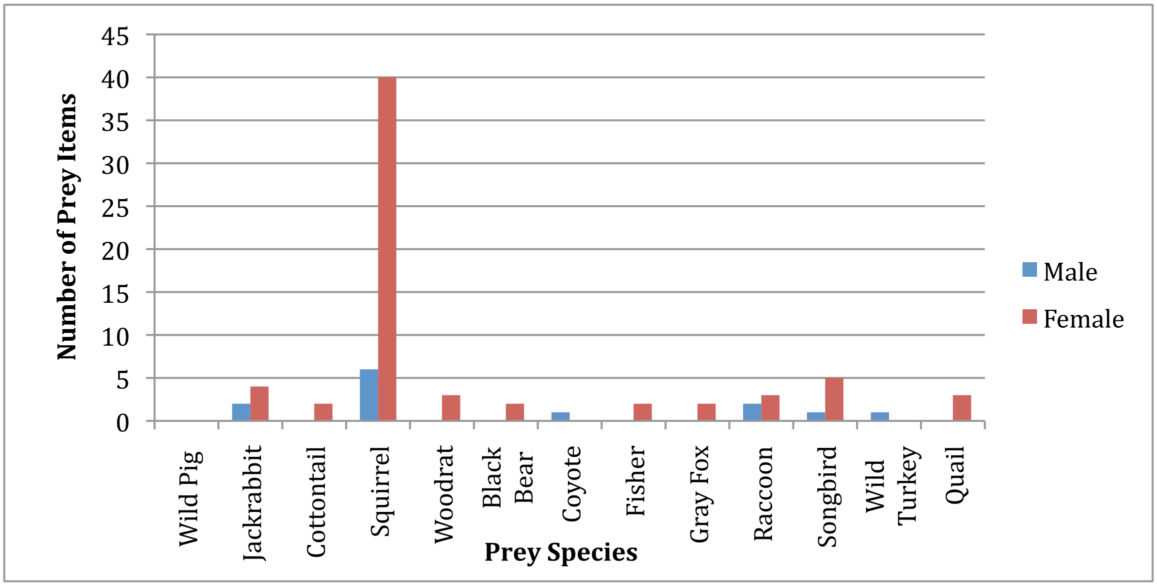

Figure 3: Non-deer Prey Species Killed by Male and Female Mountain Lions

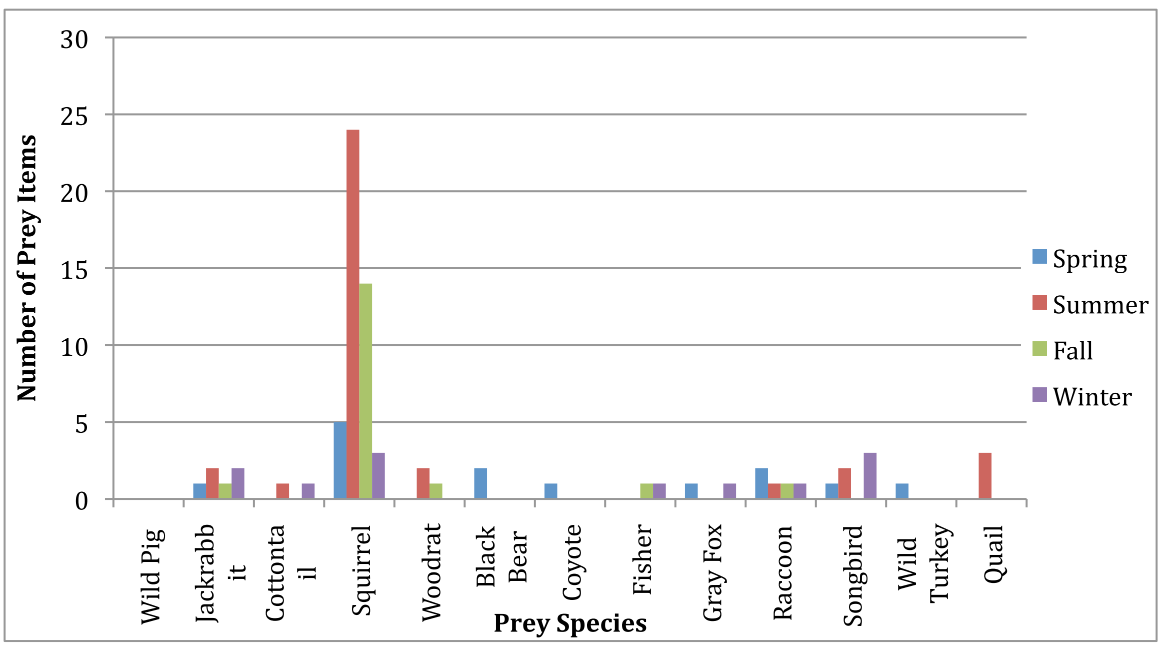

Figure 4: Non-deer Prey Species Killed by Season

9) References

Forrester, T.D. & Wittmer, H.U. (in press) A review of the dynamics of mule and black-tailed deer in North America. Mammal Review.

Gaillard, J.M., Festa-Bianchet, M., Yoccoz, N.G., Loison, A. & Toigo, C. (2000) Temporal variation in fitness components and population dynamics of large herbivores. Annual Review of Ecology and Systematics 31: 367-393.

Pollock, K.H., Winterstein, S.R., Bunck, C.M. & Curtis, P.D. (1989) Survival analysis in telemetry studies: the staggered entry design. Journal of Wildlife Management 53: 7-15.

10) Budget

All initial funding in the amount **of $454,580** allocated during the original grant in 2009 have been spent. A detailed list of all expenses has been submitted to David Casady in September 2012. An additional **$303,164** has been amended to the original budget and the project has been extended through June 2014. Currently **$198,129** remain – the project is well on track to stay within the proposed budget.