APPENDIX 5 - Population Modeling, Challis HMA

To complete the population modeling for the Challis HMA, version 1.35 of the WinEqqus program, created April 2, 2002, was utilized.

All simulations used the survival probabilities and foaling rates supplied with the WinEqqus population model for the Garfield Flat HMA. Survival data was collected by M. Ashley and S. Jenkins at Garfield Flat, Nevada between 1993 and 1999. Marked individuals were followed for a total of 708 animal-years to generate these survival probabilities.

Foaling rate data was collected by M. Ashley and S. Jenkins at Garfield Flat, Nevada between 1993 and 1999. Marked females were followed for a total of 351 animal-years to generate these data on foaling rates.

Survival probabilities and foaling rates are summarized in the following tables.

Survival Probabilities and Foaling Rates

Age Class	Survival Probabilities		Foaling Rates
	Females	Males	
Foals	.919	.877	--
1	.996	.950	--
2	.994	.949	.52
3	.993	.947	.67
4	.990	.945	.76
5	.988	.942	.89
6	.985	.939	.76
7	.981	.936	.90
8	.976	.931	.88
9	.971	.926	.91
10-14	.947	.903	.81
15-19	.870	.830	.82
20	.591	.564	.75

Initial age structure of the herd in 2002 was created based on an average of age/sex ratios collected within the Challis HMA during gathers from 1992 through 2000. Gatecut gathers have been used exclusively in the Challis HMA, so a high percentage the herd was not sampled each time. However, enough of the herd was sampled each time (at least 30%) to get a representative sample. The 2002 herd size is estimated at 271 horses based on last year's census (232) and an annual increase of 17%. The following table displays the data utilized to determine the initial age/sex structure in 2002:

Initial Age Structure Challis HMA Population Modeling

Age Class	Average age/sex ratios (1992-2000 gather data)		% of herd by age class
	Females	Males	
Foals	50.65%	49.35%	19.95%
1	70.00%	30.00%	2.38%
2	46.35%	53.65%	26.29%
3	50.77%	49.23%	7.94%
4	63.92%	36.08%	8.83%
5	46.33%	53.67%	5.85%
6	63.33%	36.67%	6.01%
7	68.07%	31.93%	4.88%
8	59.44%	40.56%	4.44%
9	30.00%	70.00%	1.50%
10	33.33%	66.67%	1.46%
11	52.22%	47.78%	3.76%
12	53.33%	46.67%	2.14%
13	87.50%	12.50%	1.09%
14	0.00%	100.00%	0.15%
15	87.50%	12.50%	1.56%
16	100.00%	0.00%	0.31%
17	50.00%	50.00%	0.55%
18	100.00%	0.00%	0.30%
19	100.00%	0.00%	0.25%
20+	50.00%	50.00%	1.44%

The following table displays the initial age and sex structure for the 2002 wild horse population input into the model. Total: 147 mares (53%); 129 studs (47%), for a total of 276* horses. (*Different than the 271 estimated due to rounding).

Initial Age Structure, 2002

Age Class	Challis Initial Age Structure 2002	
	Females	Males
Foals	27	27
1	5	2
2	33	38
3	11	11
4	15	9
5	7	9
6	10	6
7	9	4
8	7	5
9	1	3
10	1	3
11	5	5
12	3	3
13	3	0
14	0	0
15	4	1
16	1	0
17	1	1
18	1	0
19	1	0
20+	2	2

The following table displays the gatecut and modified removal criteria used with the model.

Removal Criteria utilized with Population Modeling, Challis HMA

Age	Percentages for Removals Modified removal criteria Proposed Action		Percentages for Removals Gatecut Alternative	
	Females	Males	Females	Males
Foal	50%	50%	100%	100%
1	50%	50%	100%	100%
2	50%	50%	100%	100%
3	50%	50%	100%	100%
4	50%	50%	100%	100%
5	50%	50%	100%	100%
6	--	--	100%	100%
7	--	--	100%	100%
8	--	--	100%	100%
9	--	--	100%	100%
10-14	--	--	100%	100%
15-19	40%	100%	100%	100%
20+	100%	100%	100%	100%

Different simulations were completed to explore the range of possible results from utilizing the gatecut removal criteria verses the modified criteria. The minimum age of sanctuary-bound wild horses was also changed from 10 years of age to "not applicable" after the decision was made to evaluate modified removal criteria. Different gather intervals were also evaluated, and simulations completed for gathering on specific years or a regular interval, and at a 4-year interval.

Population Modeling Criteria/Management Options
In the end, the final simulations to analyze the alternatives were based on the following:

Simulations were run for four years with 100 trials each.
No minimum age for sanctuary-bound horses was set except for trial IIc (10 years).
The modified removal criteria were utilized.

The following summarizes all other management options selected for all of the modeling efforts completed for Alternatives I and II.

Sex ratio at birth: 58% male
Starting Year: 2002
Initial gather year is 2002
Foals are included in the AML
Percent of the population that can be gathered: 75%

The following summarizes all other management options selected for the modeling efforts:

Alternative I, Fertility Control Alternative

Gather interval: regular interval of four years
Gathers for fertility treatment only occur if population exceeds threshold.
Gathers continue after removals to treat additional females to be released.
Percent effectiveness of fertility control: Year 1: 90%, Year 2-5: 0%
Percentages of released mares treated: 0-1 year old: 100%; 2-9 years old: 50%; 10-20 years old: 100%.

Alternative II, Gatecut Alternative
Gather interval: The model was run with two intervals, a two year gather cycle and a four year cycle.
Threshold population size for gathers is 253. Target population following removals is 185.

The parameters utilized within the modeling are displayed in the table below.

Alternative	I	IIa	IIb	IIc
Range	185-253	185-253	185-253	185-253
Fertility control?	Yes	No	No	No
Gather interval: regular, or specific?	Regular	Specific	Specific	Specific
Gather years	4	2	4	2
Gather for fertility control regardless of size?	--	--	--	--
Gather for f.c. only if threshold exceeded?	Yes	--	--	--
Gathers continue after removals to treat additional females?	Yes	--	--	--
Minimum age of sanctuary bound animals?	NA	NA	NA	10
Standard removal criteria or modified?	modified	gatecut	gatecut	modified
Other info	4 year run	4 year run	4 year run	4 year run

Population Modeling Summary, Challis HMA

Objectives of Population Modeling

Review of the data output for each of the simulations completed with the population model provided many useful comparisons of the possible outcomes for each alternative. The creator of the modeling program, Stephen Jenkins stresses that it is important to think about the range of possible outcomes, not just focus on one average or typical trial. Some of the questions that needed to be answered through the modeling include the following:

- Do any of the Alternatives "crash" the population?
- What effect does fertility control have on population growth rate?
- What effects do the different alternatives have on the average population size?

Population size in five years

Out of the 100 trials in each simulation run, the model tabulated minimum, average and maximum population sizes that were obtained. The model was run for a period of four years from 2002 to 2006, and gives output through 2006 (which is actually five years). These numbers are useful to make relative comparisons of the different alternatives, and potential outcomes under different management options. The data displayed within the tables is broken down into different levels. The lowest trial, highest trial and several in between are displayed for each simulation completed. This output, together with the summary graph of population sizes, is probably the most important representation of the results of the program in terms of assessing the effects of the management plan because it shows not only expected average results but also extreme results that might be possible. The data is for all horses from 0 to 20 years of age.

Population Sizes in 5 years - Minimum

Alternative	I	IIa	IIb	IIc
Lowest Trial	170	144	163	168
10th Percentile	208	184	196	200
25th Percentile	228	194	206	211
Median Trial	**248**	**201**	**218**	**226**
75th Percentile	266	210	228	242
90th Percentile	288	221	235	253
Highest Trial	316	229	246	325

This table shows that in five years and 100 trials for each alternative, the lowest number of 0-20 year old horses ever obtained was 144 under Alternative IIa. Half of the trials were greater than the median and half of them less than the median. Additional interpretation may be made by comparing the various percentile points. For example, only 10% of the trials resulted in fewer than 208 wild horses as the minimum population under Alternative I, while 10% of the trials resulted in a minimum population larger than 288 for Alternative I. In other words, 80% of the time, one could expect a minimum population between these two values for Alternative I, given the assumptions about survival probabilities, foaling rates, initial age-sex distribution, and management options made for this simulation.

None of the results obtained for any of the alternatives indicate that a crash of the population would occur if the alternative were implemented. The gather criteria seem to have more of an influence on minimum population size than fertility control or gather frequency. It is clear that gatecut gathers every two years would produce the lowest minimum population, and a gather with modified criteria every two years would produce the highest minimum population.
The lowest population sizes obtained are lower than the low range of AML which is 185. This occurs due to the assumptions made by the model, which include census accuracy, effectiveness of the gather, and mares that foal following the gather. These are all realistic assumptions and result in simulations that are closer to real world situations rather than making predictions based on finite numbers.

Population Sizes in 5 years - Average

Alternative	I	IIa	IIb	IIc
Lowest Trial	248	208	212	219
10th Percentile	274	236	268	243
25th Percentile	294	244	285	250
Median Trial	**315**	**249**	**297**	**264**
75th Percentile	337	257	314	279
90th Percentile	363	269	323	295
Highest Trial	422	288	350	380

This table displays the average population sizes obtained for the 100 trials run for each alternative. The average population size across five years ranged from a low of 208 under Alternative IIa to a high of 422 under Alternative I. Again, Alternative IIa reflects the lowest overall average of all four alternatives. Alternative IIb is the second lowest, followed by IIc and I with the highest average

population size after five years. In comparing the alternatives, Alternative IIa is the only one in which the average median trial stays within the upper range of AML (253). Alternative IIc is relatively close at only 4% over. Alternative IIb and I are over AML by 17% and 25% respectively.

Population Sizes in 5 years - Maximum

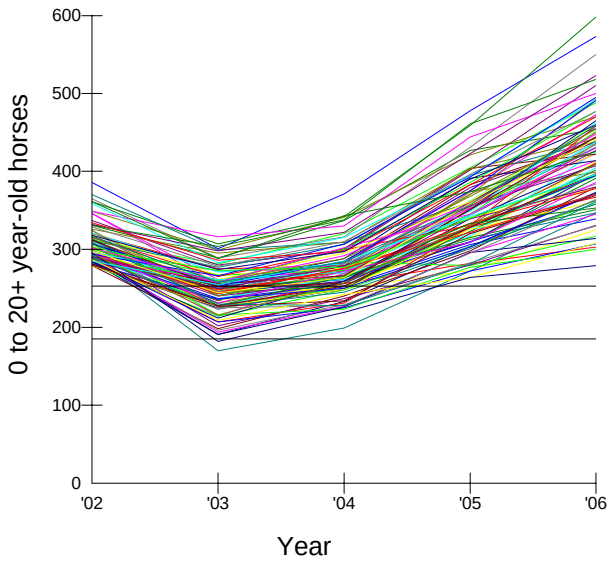
Alternative	I	IIa	IIb	IIc
Lowest Trial	296	279	286	276
10th Percentile	335	286	331	286
25th Percentile	370	296	358	292
Median Trial	**414**	**308**	**382**	**304**
75th Percentile	454	326	418	319
90th Percentile	492	340	446	338
Highest Trial	598	400	475	459

This table displays the largest populations that could be expected out of 100 trials for each alternative. All figures are very similar because under all of the alternatives, the same starting population, and gather efficiency etc., is assumed. The numbers vary due to randomness and assumptions inherent to the modeling program. The following graphs and charts display the data within these tables:

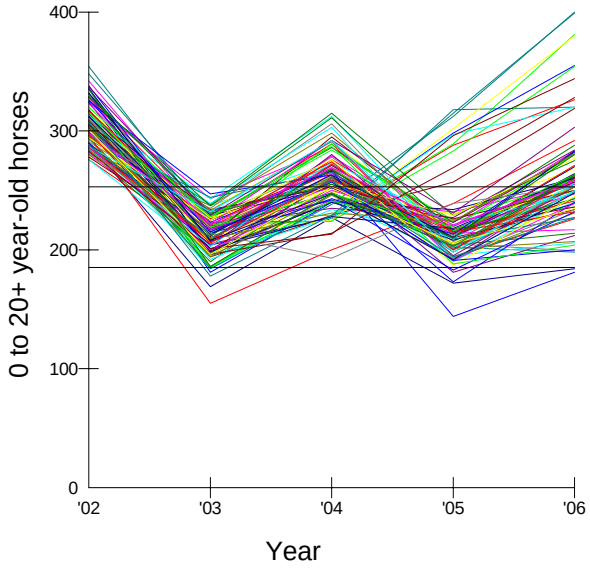
Time Series Graph (Spaghetti Graph)

This graph shows how population size changes over time for each trial. Each colored line represents one of the 100 trials for the simulations completed for each alternative. The two horizontal lines located in the graphs represent the threshold for gather and the target population size. Threshold for gather for all alternatives is 253, which is the upper range of AML. The target population is 185.

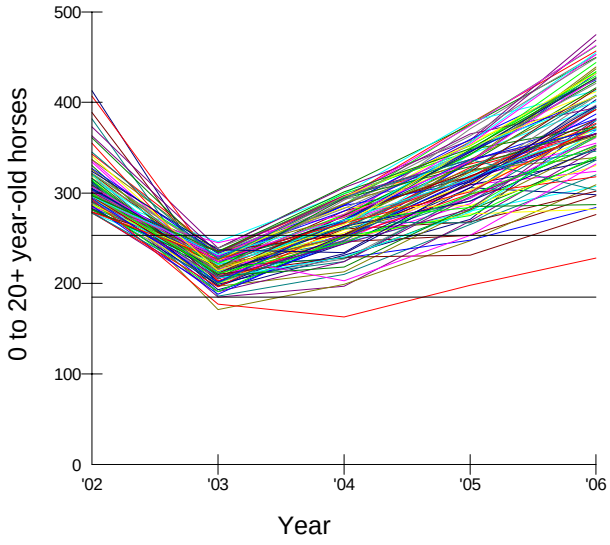
Alternative I



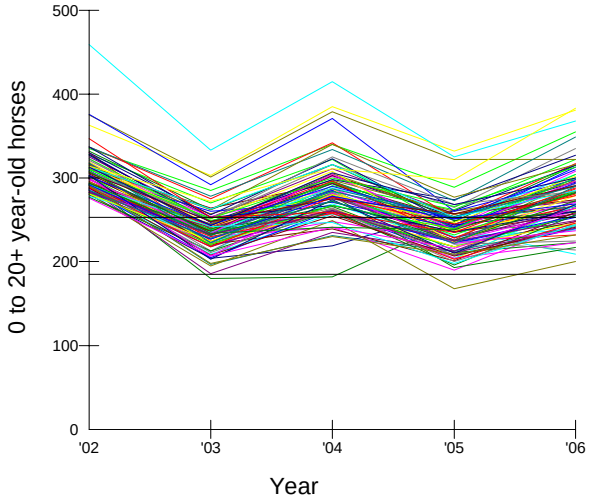
Alternative IIa



Alternative IIb



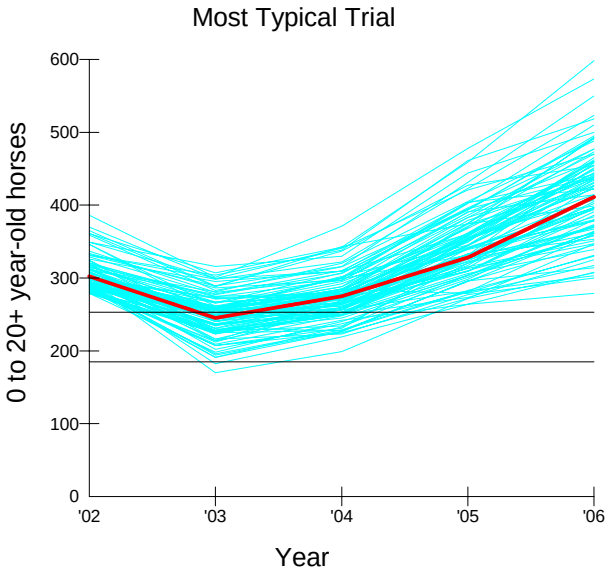
Alternative IIc



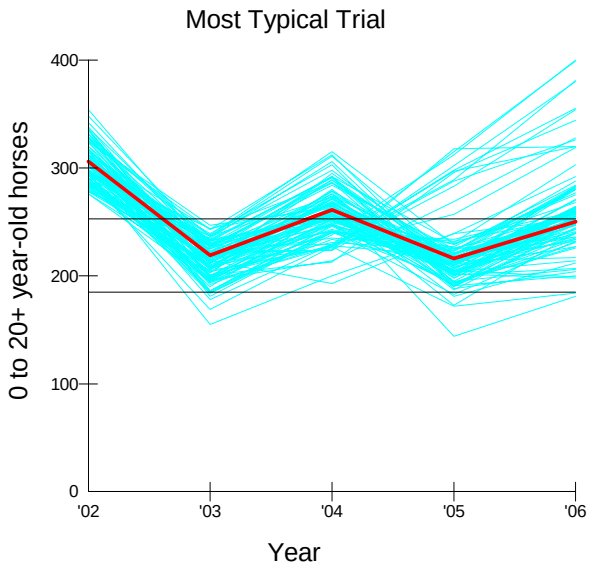
Most Typical Trial

This is the trial that is most similar to each of the others run during the simulation for each alternative. It will generally fall in the middle of the cluster of lines on the spaghetti graph.

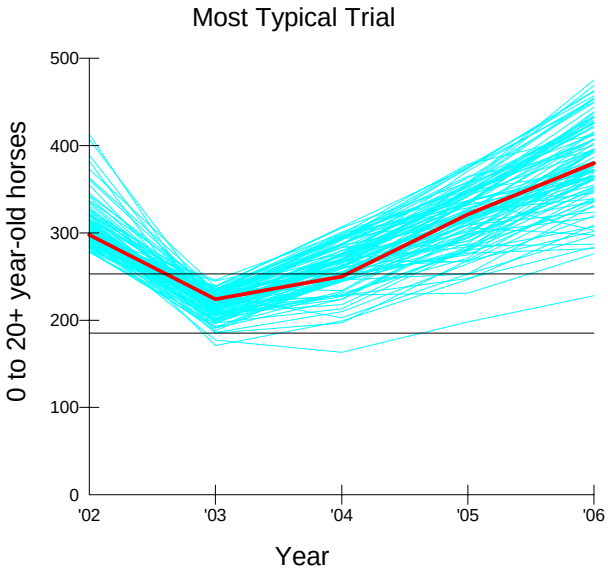
Alternative I



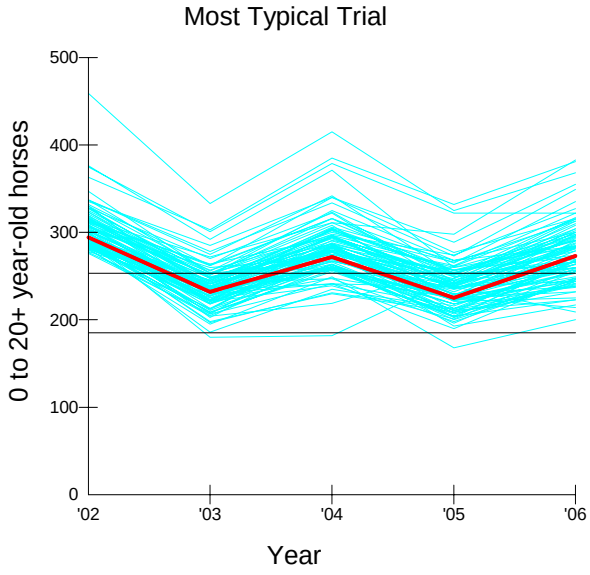
Alternative IIa



Alternative IIb



Alternative IIc

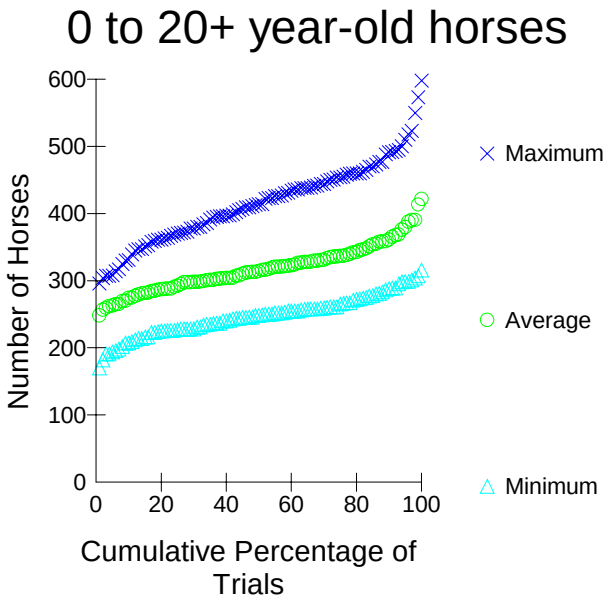


Population Size – Summary Graph

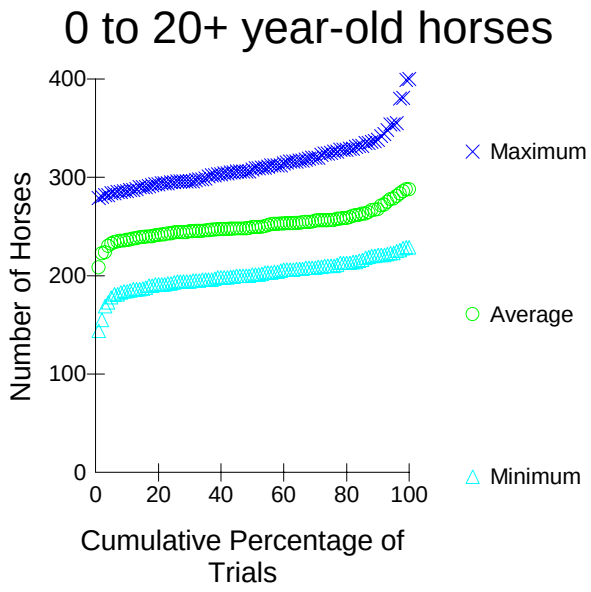
The summary graph shows cumulative frequency distributions across trials of minimum population sizes, average population sizes, and maximum population sizes. The graph shows 100 points in a light blue color, each point representing the minimum for one trial. These points are arranged in order from smallest to largest, so the leftmost point of this sequence is the minimum of the minima of population sizes, or the smallest population size ever seen in four years of 100 trials.

The distribution of maximum population sizes is defined similarly. The average population size for each trial is the average across the years of that trial, and so the distribution of average population sizes is the full set of these averages.

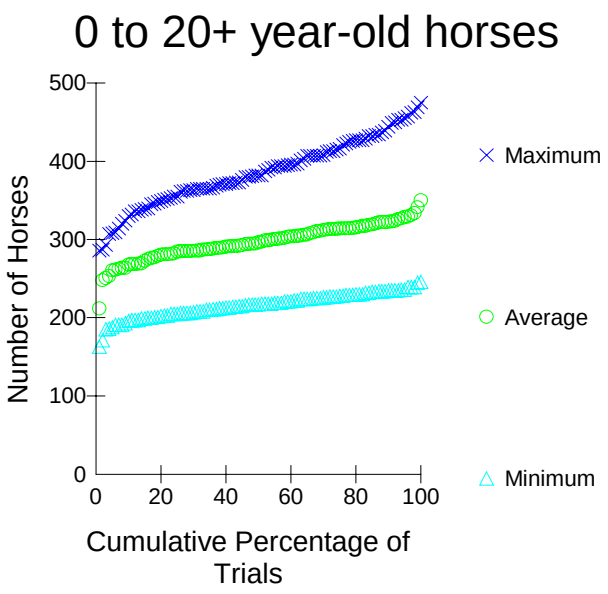
Alternative I



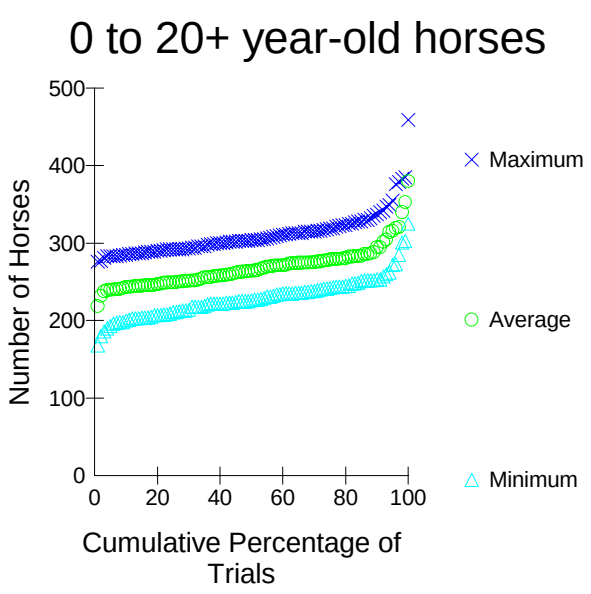
Alternative IIa



Alternative IIb



Alternative IIc



Average Growth Rates in 5 years

As with all of the output data obtained from the model, average growth rates were obtained from running the model for 100 trials for four years under management options for each alternative. The following table displays the results obtained from the model:

Average Growth Rate in 4 Years

Alternative	I	IIa	IIb	IIc
Lowest Trial	9.7	9.7	6.6	15.1
10th Percentile	15.7	16.9	15.7	18.7
25th Percentile	18.8	19.6	19.7	21.2
Median Trial	**21.4**	**22.1**	**22.0**	**23.4**
75th Percentile	23.4	24.4	24.9	25.7
90th Percentile	24.6	25.9	26.9	27.8
Highest Trial	27.3	31.5	29.2	32.8

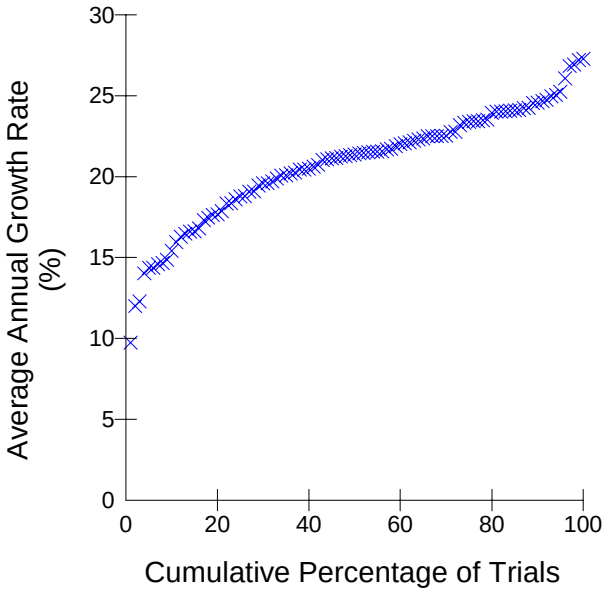
As expected, the alternative implementing fertility control reflects the lowest overall growth rate. The type of gather (gatecut vs modified) seems to have minimal impacts to the growth rates as there are little differences between Alternatives IIa, IIB, and IIc. The lowest trial growth rate of 6.6 within Alternative IIb is not a direct result of the management options, but reflects the random nature of the model and the ability to show extremes in possible outcomes. The one particular trial that resulted in this low growth rate must be reflecting a "bad" year. The range of growth rates are reasonable and do not indicate that any of the alternatives would result in growth rates that are so low as to put the population at risk.

The following graphs illustrate the results obtained from the model for growth rates for each alternative:

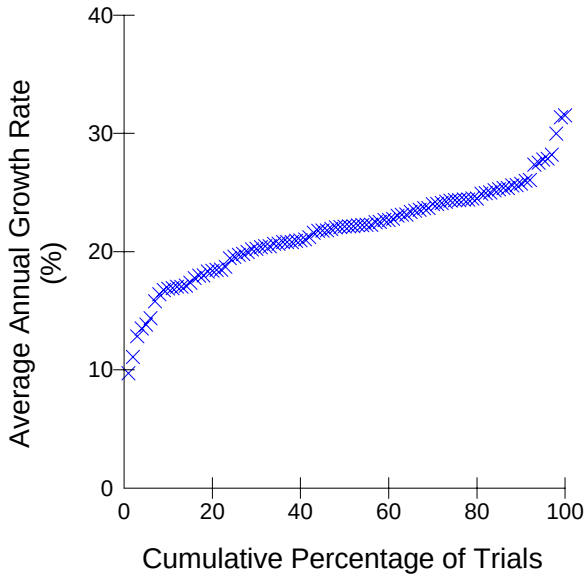
Growth Rates

This shows the distribution of average population growth rate across all trials in graphical format. Each point on the graph represents one of the 100 trials run for each simulation.

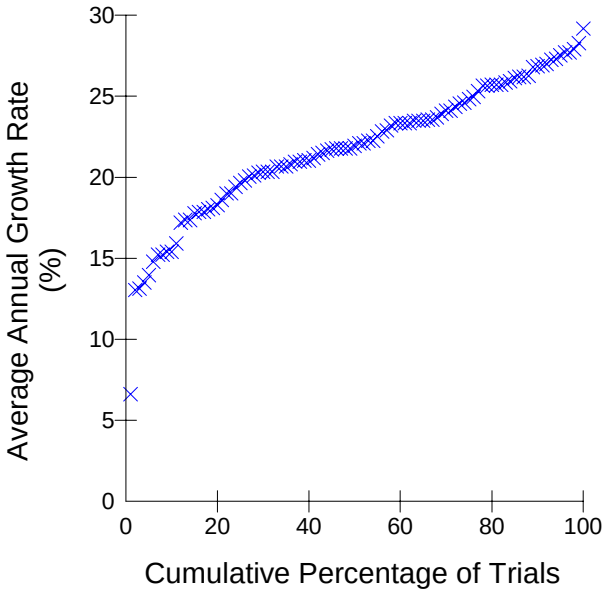
Alternative I



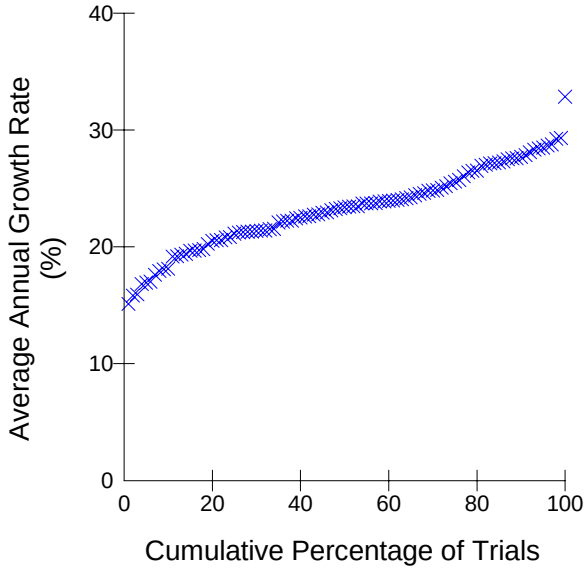
Alternative IIa



Alternative IIb



Alternative IIc



Totals in five years – Gathered, Removed and Treated

The same type of tabular data was obtained from the model for the numbers of wild horses gathered, removed and treated under each alternative. Those tables are displayed below:

Totals in 5 Years* -- Gathered

Alternative	I	IIa	IIb	IIc
Lowest Trial	436	168	106	398
10th Percentile	481	204	268	600
25th Percentile	508	266	300	617
Median Trial	**548**	**296**	**338**	**661**
75th Percentile	592	317	378	689
90th Percentile	632	340	396	730
Highest Trial	739	411	497	945

Totals in 5 Years* -- Removed

Alternative	I	IIa	IIb	IIc
Lowest Trial	164	159	102	148
10th Percentile	182	192	252	222
25th Percentile	192	250	286	238
Median Trial	**210**	**280**	**318**	**256**
75th Percentile	224	300	356	266
90th Percentile	240	320	374	283
Highest Trial	291	392	474	369

Totals in 5 Years* -- Treated

Alternative	I	IIa	IIb	IIc
Lowest Trial	79	NA	NA	NA
10th Percentile	86			
25th Percentile	92			
Median Trial	**100**			
75th Percentile	108			
90th Percentile	118			
Highest Trial	135			

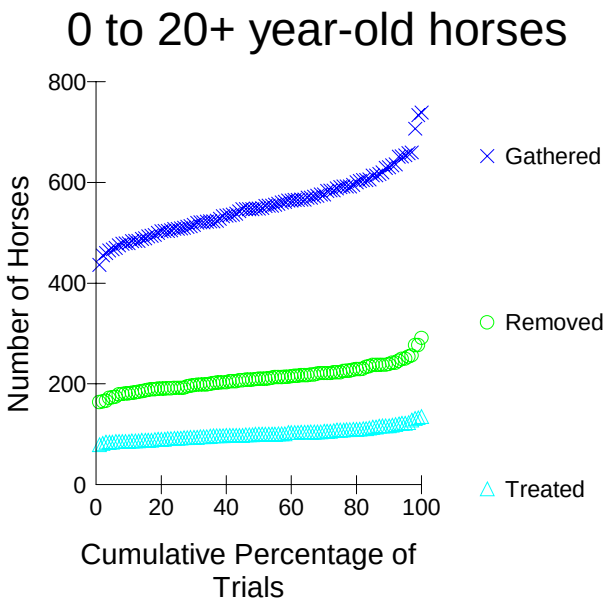
The number of horses gathered does differ greatly between alternatives because removal criteria are different between alternatives. The number of wild horses removed under the different alternatives also varies greatly. Under Alternative I (Fertility control) substantially less numbers of animals would be removed than under the other alternatives during the 5 year period. When removal criteria are applied, a much greater number of horses have to be gathered in order to obtain horses that fit the criteria.

Graphs displaying the results follow:

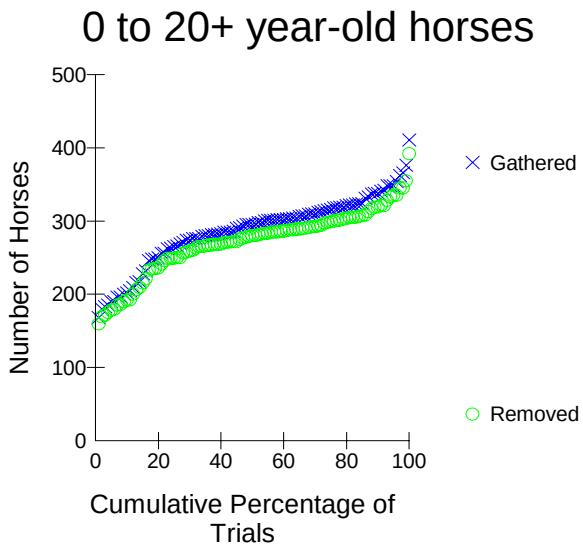
Gathers – Summary Graph

The graphs displayed here show two or three sets of points representing the distributions of total numbers of horses gathered, removed, and treated with a contraceptive across all trials. Each point on the graph represents one of the 100 trials completed for each simulation. Each simulation consists of 100 trials, and each graph has 100 points, arranged in order from smallest to largest number gathered, removed, or treated.

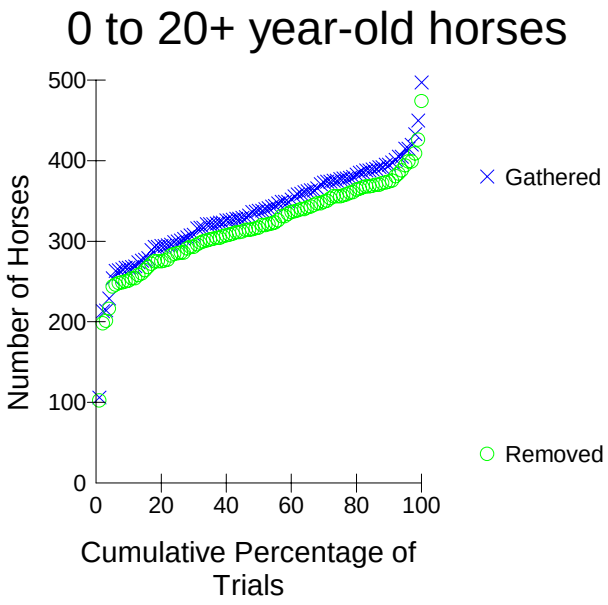
Alternative I



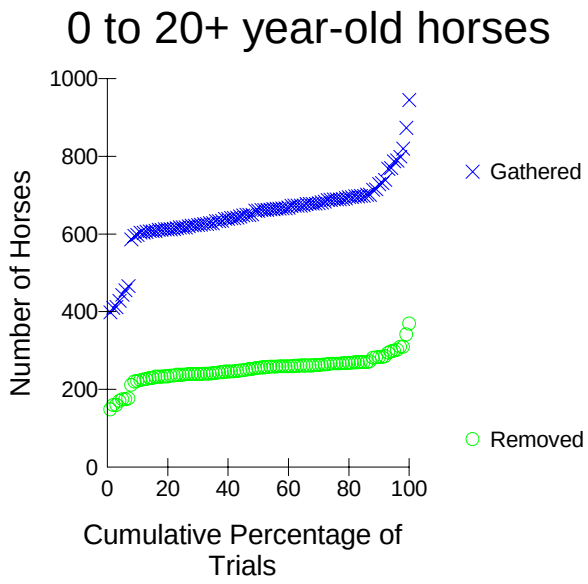
Alternative IIa



Alternative IIb



Alternative IIc



Population Modeling Summary

To summarize the results obtained by simulating the range of alternatives for the Challis HMA wild horse gather, the original questions can be addressed.

- Do any of the Alternatives "crash" the population?

None of the alternatives indicate that a crash is likely to occur to the population under any of the alternatives. Minimum population levels and growth rates are all within reasonable levels, and adverse impacts to the population are not likely.

- What effect does fertility control have on population growth rate?

As expected, the alternative implementing fertility control (I) reflects the lowest overall growth rate.

- What effect do the different alternatives have on the average population size?

Frequency of gathers seemed to have more of an influence on the population size than fertility control or the difference in removal criteria (gatecut vs. modified).