**IS THE NEVADA BEAR POPULATION REALLY GROWING?
IF SO, HOW FAST?**

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NDOW justification for claiming that the Nevada bear population can sustain an annual harvest of about 8% of the population.

1. Dr. James S. Sedinger (Univ. of Nevada at Reno) recently completed an analysis estimating that as of 2008, Nevada had a bear population of 250 ± 50 adults, and that the population was growing at a rate of 16% per year (Lackey 2011).

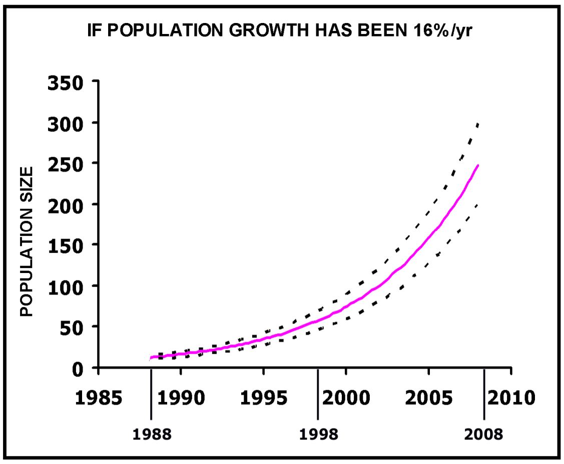


Figure 1. **16% growth.** A 16%/yr population growth rate is analogous to a 16%/yr annual compound interest rate on a loan. If you had borrowed \$11 in 1988, by 1989 your debt would have grown to \$11.00*1.16 = \$12.76. By 1990 it would have grown to \$12.76*1.16 = \$14.80. By 2008 it would have grown to \$250.00. Likewise, if a population with 11 bears in 1988 grew at 16%/yr it would now have 250 bears.

This "1.16" multiplier is what biologists call lambda λ, the "finite rate of increase." λ -1 = r (e.g., 0.16 = 16%) is the population's annual growth rate.

2. <u>Sustainable Yield</u>
   a. Sustainable yield means that you can't harvest any more bears each year than the maximum rate by which the population could grow if there were no harvest. NDOW used the estimate of 16% growth rate per year to calculate that if 16% per year were harvested, population size would stay the same each year. This is analogous to spending the interest on a savings account each year but never touching the principle. By contrast, if you don't spend all the interest, your savings grow. Likewise, if you don't harvest all of a bear population's "interest" each year, the population can grow.

   b. Assuming that there were 250 ± adult bears in 2008, NDOW calculated that 16% of 250 = 40 adults. They set the harvest quota at half that, 20, so that the population could keep growing, even if a disproportionate number of females were killed, and as a hedge against error in calculating population size or growth rate.

Justification for arguing that the State has not met it's burden of proof that this population is robust enough to withstand repeated sport hunting without its viability being seriously jeopardized

1. **Population Size**:
   Beckmann & Berger (2003a) concluded that the bear population had two patterns of habitat use. Some bears spent over 90% of their time on the margins of towns. We can call these "suburban" bears, even though some spent up to 10% of their time in wilder habitat. Other bears, which spent over 90% of their time in the wilds were called "wildland" bears. Apparently there were virtually no bears that divided their time more equally between the two types of habitat.

   In that paper, Drs. Jon Beckmann and Joel Berger estimated size of the Nevada bear population at 180 $\pm$ 117 adults – that is, somewhere between 63 and 297 adults – 40% lower than Sedinger's figure for 2008. A 40% increase over 9 years is equivalent to 3%/yr.

2. **Population Growth Rate**:
   Beckmann & Lackey (2008) reported that bears in the wildlands were dying off as fast as they were reproducing; their population growth rate was $\geq$1.00. The size in any year multiplied by 1.00 equaled the same size next year. By contrast, suburban bears were being killed by vehicles and other anthropogenic influences faster than they were reproducing. Their population tended to shrink about 25% per year. The only reason that the suburban population didn't disappear was because their population kept being replenished as garbage and other anthropogenic foods lured new bears into the suburbs from the wildlands.

   When migration to the suburbs is taken into account, the suburban population wasn't really shrinking very fast, if at all; it may still be growing. However, the wildland population was shrinking, as evidenced by the increased difficulty trapping bears in wildland areas, compared to Goodrich's success roughly a decade earlier. For instance virtually no bears could be trapped during recent years in wildland areas of the Carson Mountains. Hunting wildland bears could just aggravate this problem. Migration into the suburbs plus being hunted, might have already depopulated wildland habitat, but for immigration into those wildlands by bears from California.

   Beckmann & Lackey (2008) did not reveal whether loss of wildland bears to the suburbs is fully compensated or over-compensated by gain of immigrants from California. So it is not yet clear whether their results differ significantly from the 3%/yr rate growth rate I calculated by comparing the population size estimates by Beckmann & Berger (2003) with that by Sedinger.

   In any event, no sooner had the above findings by Beckmann and Lackey been published than Lackey (2011) changed his tune and began claiming that the Nevada bear population (apparently including residents of both suburban and wildland habitats) is actually growing at 16%/yr.

The discrepancy between reporting stability as of 2006 but rapid growth as of 2008 has not been explained. Granted, NDOW claims that the more recent analysis by Dr. Sedinger was based on a larger set of data. However, much of that data was discarded because it did not meet certain criteria set by NDOW. These criteria are not described, so we are left to wonder how differently the results might have turned out had all the data been used.

There are two ways to assess the validity of Dr. Sedinger's conclusions. The first involves scientific critiques so complex that only an expert can assess them, and that might take days. The second relies on common sense and takes only minutes.

3. **Estimating past sizes of a population growing at 16%/yr**
   a. Earlier, we saw how a loan debt or a wildlife population could grow from year to year. We can do the same kind of calculation backwards to estimate how much smaller a debt or population was at any time in the past. A growth rate of 16% per year means that, if the size of the population in 2008 is divided by 1.16, this equals size of the population in 2007. If we do that same calculation year after year, we can follow the population's growth trajectory back for decades to the sizes it would have had to be in 1998, when Beckmann did his study, and back to 1988, when Goodrich first assessed size of the Nevada bear population (Figure 1, Table 1). Of course this kind of backtracking yields only ballpark estimates of population size in each past year. But even Sedinger's most recent estimate (200-300 adults) is equally rough. Fortunately though, even ballpark figures can reveal whether his 16% estimate makes sense.

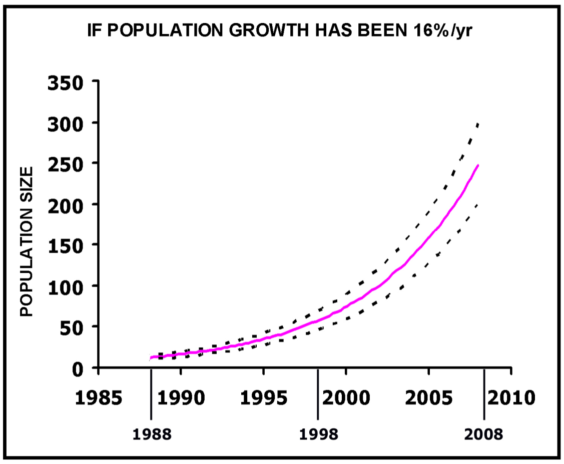


Figure 1b and Table 1: **Projection backwards from 2008 to estimate how large the population would have been in earlier years if it had been growing at 16% per year to reach 250 ± 50 bears in 2008.**

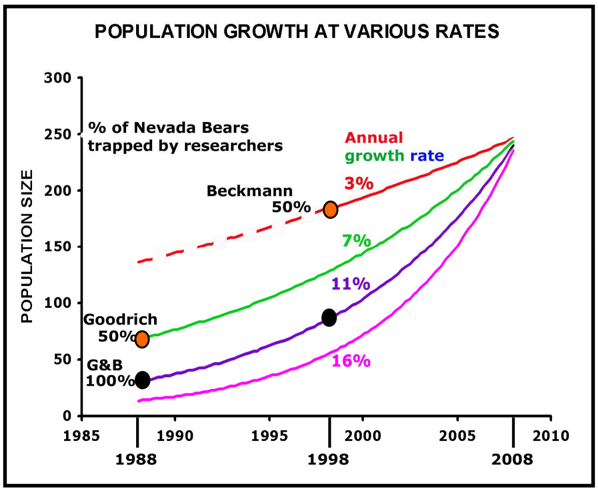
Calendar Year	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998
Upper confidence bound	300	223	192	166	143	123	106	92	79	68	59
Mean estimate	250	186	160	138	119	103	88	76	66	57	49
Lower confidence bound	200	149	128	110	95	82	71	61	53	45	39

Calendar Year	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988
Upper confidence bound	51	44	38	32	28	24	21	18	15	13
Mean estimate	42	36	31	27	23	20	17	15	13	11
Lower confidence bound	34	29	25	22	19	16	14	12	10	9

a. Dr. Beckmann's study followed up on research done by Goodrich a decade earlier, i.e. from 1987-1989. If this population had been growing at 16%/yr since 1988 (the mid-point in Goodrich's study), the population could have been no larger than 13 adults at that time. Nor could there have been more than 60 adults in 1998, the mid-point in Beckmann's research (Figure 2). If Goodrich or Beckmann documented more than these maximum numbers of bears during their studies, then growth rate from that time until 2008 could not have been as high as 16% .

b. In 3 years of trapping bears, Goodrich captured 29 adults. In 5 years of trapping, Beckmann captured 3-fold as many, or roughly 90 adults. Granted, all of those bears might not have been alive at once. Some may have died during the study; but they could have been replaced by juveniles maturing into adulthood. So 29 and 90 adults are reasonable ballpark figures of absolute minimum numbers of bears, not counting any of the bears neither of them managed to capture.

   For a population growing from 29 in 1988 or from 90 in 1999, to reach 250 ± 50 adults in 2008, it could not have been growing faster than 11%/yr, not 16% (Figure 2)



Again, 11%/yr assumes that each biologist caught virtually 100% of the bears in Nevada (blue line in Figure 2). If, however, each biologist only caught half the state's bears – as Beckmann thought he had done – then growth rate until 2008 could not have been faster than 7% since 1988 (green line) or 3% since 1998 (red line).

● = Number bears if captures only 50% of total
●=Number bears known to be there.

Summarizing: If we consider just the numbers of bears caught during these studies, growth rate until 2008 could not have exceeded 11%. If we assume that the trapped bears constitute only half the Nevada population, growth rate could not have exceeded 3% in the decade leading up to 2008.

5. **How could NDOW have overestimated growth rate and harvestable yield?**
   a. With any kind of modeling effort, whether using pure mathematics or computers, one runs the risk of **garbage in, garbage out.** If your data aren't sound, or if you don't use the right model, the results it spits out are garbage.

b. <u>Computer models and programs</u>: Estimating size and growth rate of a wildlife population is so complex and difficult that numerous kinds of computer models have been developed to do the calculations. A kind of model that works well for one bear population might do poorly with another bear population. Dr. Sedinger's choice of MARK software to run a version of the Jolly Seber model might be the best choice available. But "best" doesn't mean "good enough" unless Nevada bears meet the assumptions of the Jolly Seber model.

c. <u>Closure assumptions</u>: One of the main assumptions of MARK software is that the population is closed – that no more bears emigrated from Nevada to California or any other state, than migrated in. That is, no net loss or gain occurred. In real life, few bear populations are truly closed unless they are on an island, such as Kodiak island in Alaska. However, so long as net movement in and out for each age-sex class is only a small fraction of that class in the whole population, this doesn't lead to bad errors in estimating population size or growth rate.

   However, if a lot of bears just visit an area, then move out, this can greatly inflate estimated population size and growth rate for that area.

   Is there any evidence that such transient visitation has occurred in Nevada? Yes, indeed. When faced by famine, bears wander far afield, moving way beyond their normal home ranges, in search of food. If they pass through a place with plenty of food, such as a town with lots of garbage, they may stick around for awhile, perhaps permanently. However, if they find themselves in even worse habitat, such as that bordering the Great Basin, they probably return to California.

   2007 had a severe famine due to drought. This occurred near the end of the period covered by the data that Dr. Sedinger analyzed. Drought likely caused a large number of bears to temporarily pass from California into Nevada and back again (Ann Bryant, pers. comm.). This alone might account for the inflated estimate of population growth rate and harvestable yield.

   I would therefore recommend that harvest management of the Nevada bear population be based on an assumed growth rate of 3%/yr unless and until a higher rate can be proven. Proof would require adjusting demographic analysis for effects of greatly increased mobility of bears during famines. Necessary mobility data could probably be gathered this year (2012) which is shaping up to be an even worse drought than in 2007.

6. **<u>Has Growth Rate Accelerated Recently?</u>**

   NDOW could argue, of course, that the population didn't start growing at 16%/yr until the turn of the century -- which would not contradict the figures for trapped bears if the population grew at only 3%/yr from 1988-1998 (Figure 3). However, there are three serious problems with that argument.

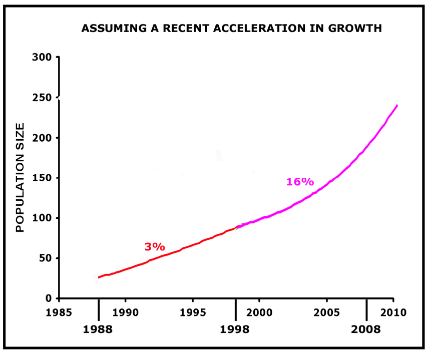


Figure 3. **Hypothetical altered growth rate since 1998**.

a.   2007 not only falls within the “recent” time span, but near its end. That is a precisely the stage when a surge in transient visits by bears would have been most likely to exaggerate apparent size and growth rate of the population.

b.   Of course, if the famished bears didn’t merely visit Nevada, but became permanent residents, this would be true growth of the population. But it is not the kind of growth that is repeated every year or even every 3 years (the time span over which NDOW accesses harvest impact). So using data inflated by a transient influx of bears during 2007 as a basis for setting harvest quotas could soon lead to serious overharvest. Again, until proven otherwise, long term growth rate should not be assumed to exceed 3%/yr.

c.   In fact, even assuming 3% per year growth could be too high. For the actual effect of the 2007 drought would have been to reduce population growth rate. Malnourished bears produce fewer cubs and those cubs have especially low rates of survival (Stringham 1983, 1985, 1986, 1990a,b; Rogers 1987). Adult mortality rates probably rose too due to increased conflicts with humans and vehicles.

d.   If sustainable growth rate of the population had suddenly increased, something in the environment of the bears would have had to change enough to cause a dramatic increase in either or both reproductive rate and survival rate.

Analyses by Beckmann & Lackey (2008) show that adults have very low rates of natural mortality. Those that die before old age have usually been killed by people. So the population’s death rate could not have declined markedly unless human-caused mortality factors such as road kills have shrunk drastically overall, despite the surge in 2007. But NDOW has presented no evidence that this is the case. On the contrary, available information suggests that road kills have been increasing. Beckmann & Lackey (2008:81) state that “there has been a 17-fold increase in bear mortalities due to bear–vehicle collisions since the late 1980s (Goodrich 1993). During the late 1980s, before bears became conditioned to human food, no bears were destroyed because of safety concerns (Goodrich 1990). In contrast, 27 bears were euthanized because of safety concerns during the 10 years of our study.”

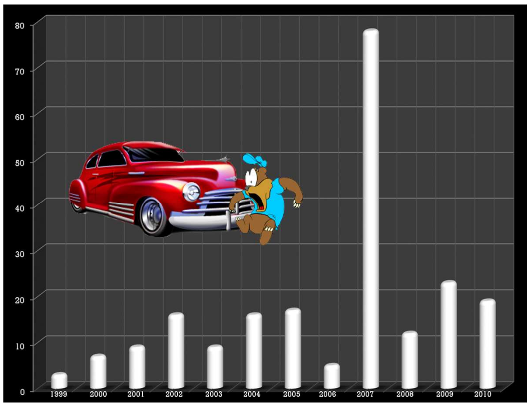


Figure 4. **Road kills on the California side of the Tahoe Basin.** Data compiled by the BEAR League. Note the general increase in road kills, even ignoring 2007.

e. That leaves only one possible explanation for an alleged surge in population growth rate – a dramatic increase in reproductive rate. Either a lot more females are giving birth each year, or they are producing much larger litters, or both.

Not only doesn't NDOW provide any evidence for this, but any surge in reproductive rate would require a surge in nutritional status, and thus in the quality or quantity of food available to Nevada bears. What evidence is there of this? Has production of berries, acorns or pinyon nuts suddenly doubled or tripled over the past decade? If so, how? Have the number of Manzanita, huckleberry oak, and pinyon pines suddenly increased? Have existing plants started producing a lot more mast?

Perhaps the only way that productivity of those plants could increase dramatically is if droughts and/or late spring freezes had been much less common during the past 5-8 years than before Beckmann's study. But the worst drought in decades occurred in 2007. And weather data for the Tahoe Basin reveal no dramatic improvement in growing conditions during the other years post 1998.

g. ***Snowfall***: Given that there is little or no rainfall during summers, growth of wild bear foods depends for water on melting snow. As can be seen in the following charts, the 2007 drought began when only 120" of snow fell in the Tahoe Basin (winter 2006-2007) – the lowest snowfall that decade. Snowfall was also low during 3 years of the previous decade. But the snowfall peaks were also higher during that decade. So conditions then were ***not*** dramatically better after 2000 than previously.

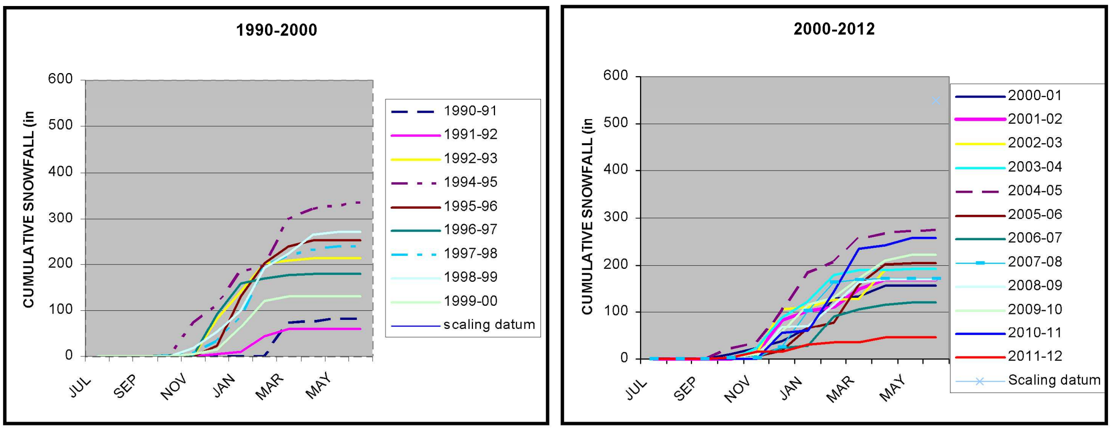


Figure 5. **Annual snowfall July – June 1990-2012 in the Tahoe Basin (website wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca8758)**

h. ***Temperature***: The other major weather influence on natural food supply is temperature.

Late Spring Freezes: Minimum temperatures have to be moderate enough from April through June that frosts don't destroy crops of berries or nuts. Comparing temperature data from the 1990's with more recent years provides no obvious indication that recent temperatures have been dramatically better. On the contrary, changing climate has probably made conditions worse for bear foods. According to Carl Lackey, the minor famine in 2010 was due to late spring freezes eliminating most berry and nut production that year. The critical month appears to be May, which is marked in the following graphs with a vertical dashed line. Horizontal lines mark 15 degrees F and 32 degrees F. As we can see, during May of both 2000 and 2010, *extreme* minimum temperatures dropped down below 18 degrees – 5 degrees colder than during any year of the previous decade. *Average* minimum temperatures were also lower after 2000 than during the previous decade.

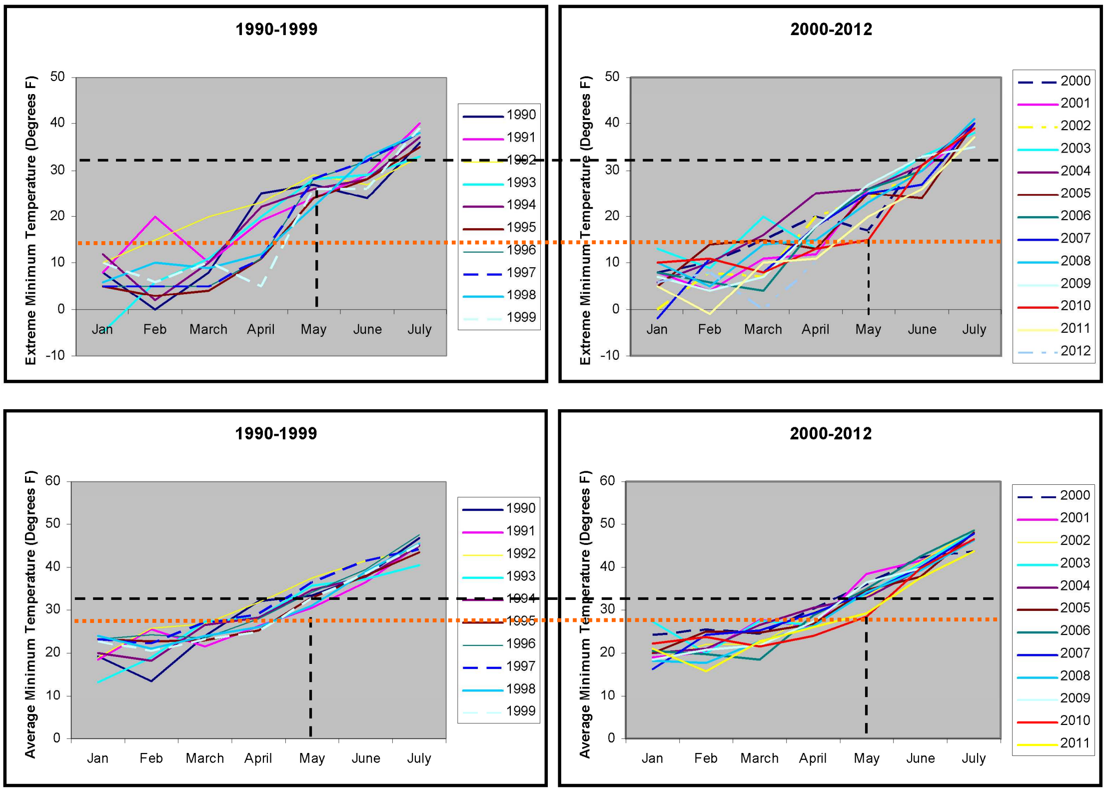


Figure 6. **Extreme and average low temperatures 1990-2012 in the Tahoe Basin (website wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca8758)**

Rate of snow melt: Making matters worse, summer temperatures tended to be higher after 2000, causing the relatively low amounts of snow that fell to melt faster than in the previous decade. For bear food plants to flourish, snow not only has to fall, but it has to melt slowly, throughout the summer and into autumn, not in a rush during June or early July.

In summary, weather conditions appear to have been poorer, not better since 2000, for growth of bear food plants. So it is doubtful that wildland bears have been better nourished. This too contradicts the speculation that growth rate of the bear population has accelerated over the past decade.

In fact, the only possible indication of accelerated growth revealed by NDOW is limited to the suburban segment of the population – the segment which apparently will not be hunted (perhaps due to danger of people being shot by accident).

7. **Urban vs. Wildland Bears**
   a. Communities in the Sierra mountains are like "sinks" that keep draining bears out of wildland areas. How fast they are being drained was not revealed by Beckmann or Lackey. The number of suburban bears has apparently grown rapidly since the 1980's when they were so scarce and so shy that Goodrich did not capture any and may not have known they existed (Beckmann & Berger 2003)

   b. The only index of subsequent growth of the suburban subpopulation that NDOW has made public is growth over time in the number of bear complaints reported to NDOW.

      These were graphed by Mr. Lackey in his Big Game Status Report for 2010-2011, He groups his data in 4 blocks of 5-years each and 1 block of 3 years which excludes 2007 because it was abnormal, as well as 2011 because those data weren't in yet.

   c. I read values off his graph and re-plotted them (blue bars in Figure 1). I also calculated mean number of complaints per year, so that data in the 3-yr block could be better compared with data in the 5-yr blocks (purple bars).

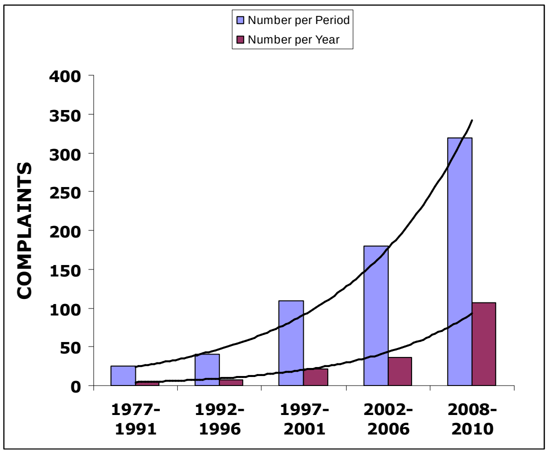


Figure 7. **Bear complaints received by NDOW**.

Complaints increased by an average of 115% from each year to the next. In other words, numbers of complaints have been more than doubling annually. That is about 7 times NDOW's 16% per year estimate for growth of the whole bear population and more than 30 times my estimate of 3%/yr.

Even a 7-fold discrepancy couldn't be attributed to increased reproduction and survival by suburban bears over the past decade. For the survival rates of suburban bears are so low, especially for juveniles, that death rate exceeds birth rate. This segment of the Nevada population would be declining at 25% per year but for immigration from wildlands (Beckmann & Lackey 2008).

So the suburban subpopulation could increase only through draining more bears from wildlands. But even the highest imaginable rate of influx by wildland bears into suburbs would be far slower than doubling each year.

Much of the increase in complaints is presumably due to other factors such as (a) growth of the human population, (b) individual suburban bears causing more and more problems, (c) a rising likelihood of people reporting complaints to NDOW, or to (d) a steady decline in availability of natural forage in the suburbs.

Nevertheless, until NDOW can prove that these other factors are sufficient to account for the surge in complaints, it is only reasonable to assume that the suburbs are continuing to drain bears out of wildlands at a rapid rate.

d. All of these considerations indicate that dynamics of this population, including growth rate and harvestable yield, cannot be reliably assessed unless and until demographic analyses are done separately for suburban vs. wildland bears, and for each geographic area. In habitat this diverse, demographic analysis *must* be spatially explicit to be reliable.

e. If suburbs are sinks, then all the growth of the population would have to be occurring in the wildland segment. For that segment to make the whole population grow at even 3%/yr would suggest that the wildland segment grow even faster, despite its low reproductive rate. But again, there is no reliable evidence that wildland bears are reproducing at such a high rate. So assuming even a 3% growth rate for wildland segment of the population – the segment exposed to harvest – markedly increases risk of over-harvest.

f. NDOW plans to guard against chronic overharvest by looking at various age-sex ratios at 3-year intervals. That approach might be adequate with populations large enough for each year's harvest to provide a statistically reliable index of age-sex ratios for the population as a whole. However, so few bears could be harvested from Nevada on a sustained yield basis that trends indicative of overharvest might not reach statistical significance for a decade or more, by which time the population could be seriously impacted. Until better methods are employed therefore, the risks of sport harvest appears to outweigh any benefits – benefits confined to one special interest group, trophy hunters.

8. **Additional comments**:

a. Sustainable yield estimates should be:

- calculated separately for each segment of the population (suburban vs. wildland, and for each mountain range of wildland). All population analysis should be "spatially explicit." I can recommend experts to help at minimal cost.

  The fact that Beckmann had lower trapping success than Goodrich did in remote habitats suggested to Beckmann that bear numbers in the wildlands were shrinking as bears migrated into the suburbs. That might explain why so few bears were harvested during last year's hunt.

- calculated based on a reliable figure for growth rate that takes into account migration rates between suburban and wildlife habitats, including both permanent and transient migration from one suburb or mountain range to the next, as well as between Nevada and California.

- low enough to maintain a population in each island of habitat (i.e., each mountain range where they have lived in recent decades). The population in each island of habitat should be large enough to be self-sustaining and to mentor immigrants from the suburbs, who might not otherwise know how to flourish in the wild.

  Although bears have the ability to recognize some foods instinctively, there are other foods which they have to learn are edible, either by trial and error or by observing other bears. Cubs that I raised in the Alaska wilds learned some foods by observing me eat them. They learned sources of foods not only by trial and error or by following scents, but also by tracking other bears. Tracking also helped them learn hazards to avoid (Stringham 2002). Bears emigrating from suburban habitats into the wild may need all the help they can get by observing other bears in order to learn not only what can be eaten, but where and when (season) that it can be found despite variations in weather. Harvesting some foods also requires skills that are not easily learned by trial and error.

b. Beckman indicated that the Nevada population could be subdivided into two segments: those that spent at least 90% of their time within the suburbs versus those that spent at least 90% of their time outside of suburbs. No indication is given that *any* bear lived a more balanced lifestyle. Didn't such bears exist? If not, why not? Such a clearcut distinction between suburban vs. wildland bears does not necessarily exist in other bear populations. Indeed, recent radio-tracking on the California side of the Tahoe Basin suggests that some bears do use the two habitat types more equally (Bryant, pers. comm.)

c. Neither Beckmann nor Lackey has adequately accounted for the male-biased sex ratio among trapped bears, or why this bias was much higher in suburbs than in wildland habitats. NDOW should review literature from other populations, especially those which have used both observation-reobservation techniques and hair sampling, to determine how much sex-related capture bias exists in other populations, and how this varies with various conditions. Then NDOW should use that information to correct for bias in its own samples.

d. Trapping bias might be further minimized through hair sampling bears in Nevada and adjacent areas of California. Some expenses of hair sampling, including field work, could be minimized through better use of volunteers.

e. Mr. Lackey's report indicates that aside from salaries and certain other expenses, only about $5,000/yr were being invested in bear management and research by NDOW. That is a fraction of the amount invested in conserving bears by the BEAR League in the Tahoe Basin. NDOW should work more cooperatively with the League to the benefit of all concerned. Not only does the League invest far more resources in minimizing bear-human conflict, but it invests more in research. The quality of its research could be enhanced by more guidance and assistance from NDOW and associated scientists such as Dr. Beckmann. Differences over whether or not Nevada bears should be hunted should be subordinated to welfare of the bear population and of the humans sharing their habitat.

f. The analysis of source-sink dynamics by Beckmann (Beckmann & Berger 2003; Beckmann & Lackey 2008) is informative, but has significant weaknesses that could be overcome by a more thorough review of literature on social and population dynamics involving adult males, for instance in controlling access to food and in affecting rates of reproduction and recruitment. Attention needs to expand beyond black bears to also consider literature on grizzly/brown bears such as my own findings (Stringham 1981, 1983, 1985, 1986, 1989, 1990a,b)

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