Controlling the Black Bear Population in Maine

John Voyer, Ph.D.
Carl Lolar, MBA
Anya Cornell, MBA
Joseph Albert, MBA

University of Southern Maine

Abstract

What are the best methods for controlling a population of black bears? Some advocate for a "natural" approach, based on the carrying capacity of the bears' ecosystem and unassisted hunting. Others argue that bear population control requires large amounts of bait to assist hunters in harvesting. These issues came to a head in an unsuccessful 2014 referendum that sought to ban the use of bait in the State of Maine, an area with a large black bear population and a long history of using bait to hunt them. We simulated these issues and concluded that even though using bait increases the black bear population to very high levels, balancing population control with the interests of the bear hunting industry is difficult.

Key Words: Black Bears, Bear Hunting, Bear Baiting, Maine

Introduction

On November 4, 2014, the residents of Maine went to the polls to vote for the future of bear hunting in Maine. The ballot included a proposal to ban bear hunting by trapping, baiting, and using dogs – methods that account for 90% of the bear harvest (Calvert, 2014).

Opponents of the ban argued that the three hunting methods were necessary to control the bear population properly. The proponents insisted that the methods were inhumane, and that the State of Maine could control the bear population by other means. They also questioned whether the current "bear control" was effective, given that the bear population in Maine has been rising over the last decade (Mainers for Fair Bear Hunting, 2014).

Controlling the bear population has been a topic of debate in many other states (Otto, 2009) as well as other countries. Russia, which has arguably the largest population of bears in the world, allows many methods of bear hunting, including baiting and shooting of bear cubs. Russia has a bear population of 160,000 black bears on record, and documents about 10,000 bears as killed each year (Once Voice, 2013). Until 2011, even den hunting was legal – that is, the hunters were allowed to shoot bears in their dens during the hibernation period. In addition, in 2013, Russia legalized polar bear hunting to solve the problem of polar bears that are migrating south into human-populated territory because of the degradation of their habitat by climate change (Once Voice, 2013).

The primary point of the issue stems from an article with the headline that reads, "Maine bear management program releases data, says baiting, trapping, and hounding necessary to control bear population" (Sarnacki, 2014). In 1994 and 2004, similar referenda were on the Maine state ballot; citizens voted down these referenda by narrow margins. The conflicting nature of information presented by both sides of the referendum and the recurring nature of this problem led us to believe this problem would be a good candidate for a system dynamics analysis.

Maine Black Bear Facts

According to the State of Maine Department of Inland Fisheries & Wildlife website, the estimated carrying capacity (Sayre, 2008) for bears in the state of Maine is 32,000 bears. A Maine black bear has a typical lifespan of 20 years and while they can become sexually mature at age 2, they typically do not start breeding until age 3. Historical data indicate the typical black bear litter is two cubs born bi-annually; however, recent data show many bears have started to reproduce annually and the litter size has increased to three cubs. For simplicity's sake, we developed our model using these recent data, which suggest sexually mature bears produce three cubs annually.

Black bears are omnivores and they are opportunistic gatherers of food. In the spring, they typically feed on early vegetation, and in the summer, they subside mostly on abundant fruits and berries. The fall is the critical time for bears, as they must gorge on enough food to produce enough fat reserves to allow them to hibernate during the colder months from November to April. In the fall, black bears will forage for food up to 20 hours per day, which is

significant to our study because this is when the baiting season occurs, adding large amounts of food to the bears' ecosystem.

What is Bear Baiting?

Bear baiting is a method of hunting black bears that involves placing large amounts of discarded fatty foods, such as donuts, spent cooking oils, and other carbohydrates, in a specific area near a hunting camp. The State of Maine allows hunters to place bait in the forest up to 30 days before the start of the 27-day hunting season, which occurs from late August through most of September. There is no regulation as to the amount of bait that guides or hunters can place in the forest, so there are no hard data specifying the amount of bait available to the bear population. However, Nemitz (2014) estimates the amount to be approximately 7 million pounds per year. This figure represents roughly 8% of the estimated 158 billion calories consumed annually by the Maine black bear population. A more disturbing component of the 7 million pound estimate is that guides and hunters place all of this auxiliary food in the forest over the 2-month period when the bears are actively gorging to build fat reserves, which increases the availability of food by 45% during that period.

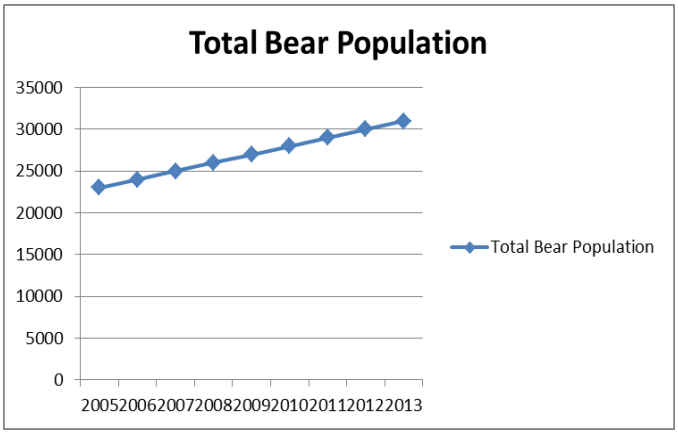

Figure 1. Total Bear Population in Maine
Source: Maine Department of Inland Fisheries and Wildlife. (2014) Harvest Information 2005-2013.

Key Historical Data

To generate reference modes for our model, we collected data for the annual Bear Harvest in Maine for the last 10 years (Maine Department of Inland Fisheries and Wildlife, 2014). Maine officials estimate the current bear population to be about 30,000, and it has grown steadily since 2005 (Figure 1). The annual number of permits is over 10,000, but the success rate is only about 28%, so the annual bear harvest is approximately 2800 bears. Most of the bears killed are adult bears, and of those, the majority are male bears.

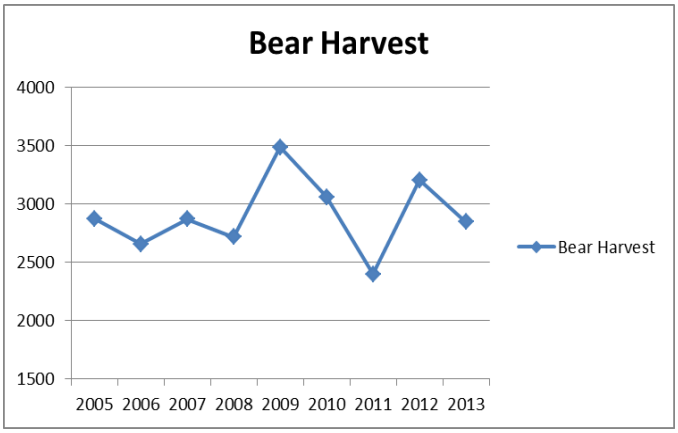

Figure 2. Bear Harvest in Maine
Source: Maine Department of Inland Fisheries and Wildlife. (2014) Harvest Information 2005-2013.

Figure 2 shows the data for bear harvest by bear type and hunting type, as well as length of hunting season and food supply. Taken together, Figures 1 and 2 reveal that, despite some short-term fluctuation, the harvest has remained roughly constant, unaffected by hunting seasons or changes in hunting methods, but the bear population has been continuously

increasing. This suggests that the birth rate of bears has been increasing (since the population is increasing while death rate is staying the same).

The data also show that the availability of the bears' primary natural food source (beechnut) is cyclical, as the beechnut grows one year and does not grow the following year (Jakubas et al., 2005). However, the bear population does not reflect this cyclicality. This again suggests a supplemental source of food (other than the natural beechnut) that is driving the bears' population growth.

Finally, the trends of harvest by hunting method (Figure 3) and bear type (Figure 4) show that most of the bear harvesting occurs using baiting/hounding/trapping methods, with over 70% of all bears killed using baiting as the primary method. The most targeted type of bear was adult male, with female bears accounting for fewer than half of the bears killed, and cubs being fewer than 10% of the overall harvest. These data are easily explained by how baiting is the easiest of all hunting methods (it does not require chasing the bear across the forest), and adult male bears are the most prized target (because they are larger than female bears or cubs). At the same time, the data suggest an interesting side effect: since baiting feeds all types of bears (including females and cubs), but only adult bears are being harvested, then the well-fed cubs are surviving and adding to increased reproduction rates.

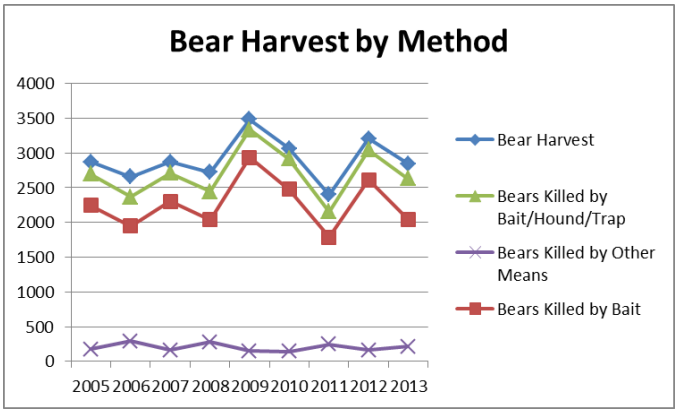

Figure 3. Bear Harvest by Method
Source: Maine Department of Inland Fisheries and Wildlife. Research and Management Reports, 2006-2014.

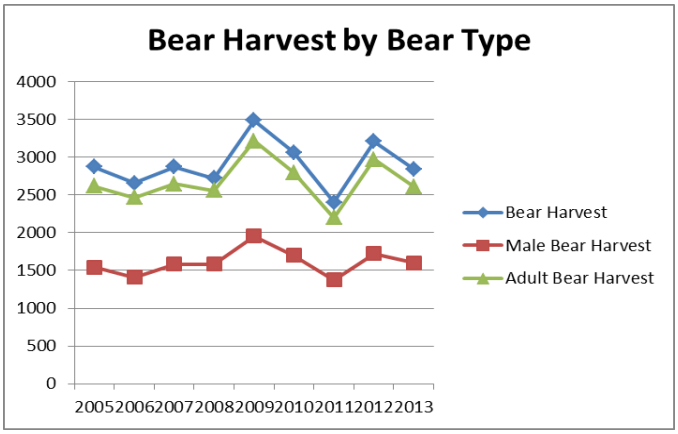

Figure 4. Bear Harvest by Bear Type.
Source: Maine Department of Inland Fisheries and Wildlife. Research and Management Reports, 2006-2014.

The scientific and practitioner literatures support trends. While state officials cannot estimate the bear population with certainty, all sources agree that the population is on the rise (Vashon, 2014). Sources also agree that baiting is overwhelmingly the primary method for killing bears in Maine (Kevin, 2014). Some sources say that the amount of bait food utilized for bait hunting has been increasing, becoming as high as 6.9 million pounds of food each year (Nemitz, 2014). Other sources even suggest that baiting contributes to the rising bear population, because it increases the survival of cubs (Rogers, 1993). McLaughlin (1999) reports that in the years prior to baiting's introduction,

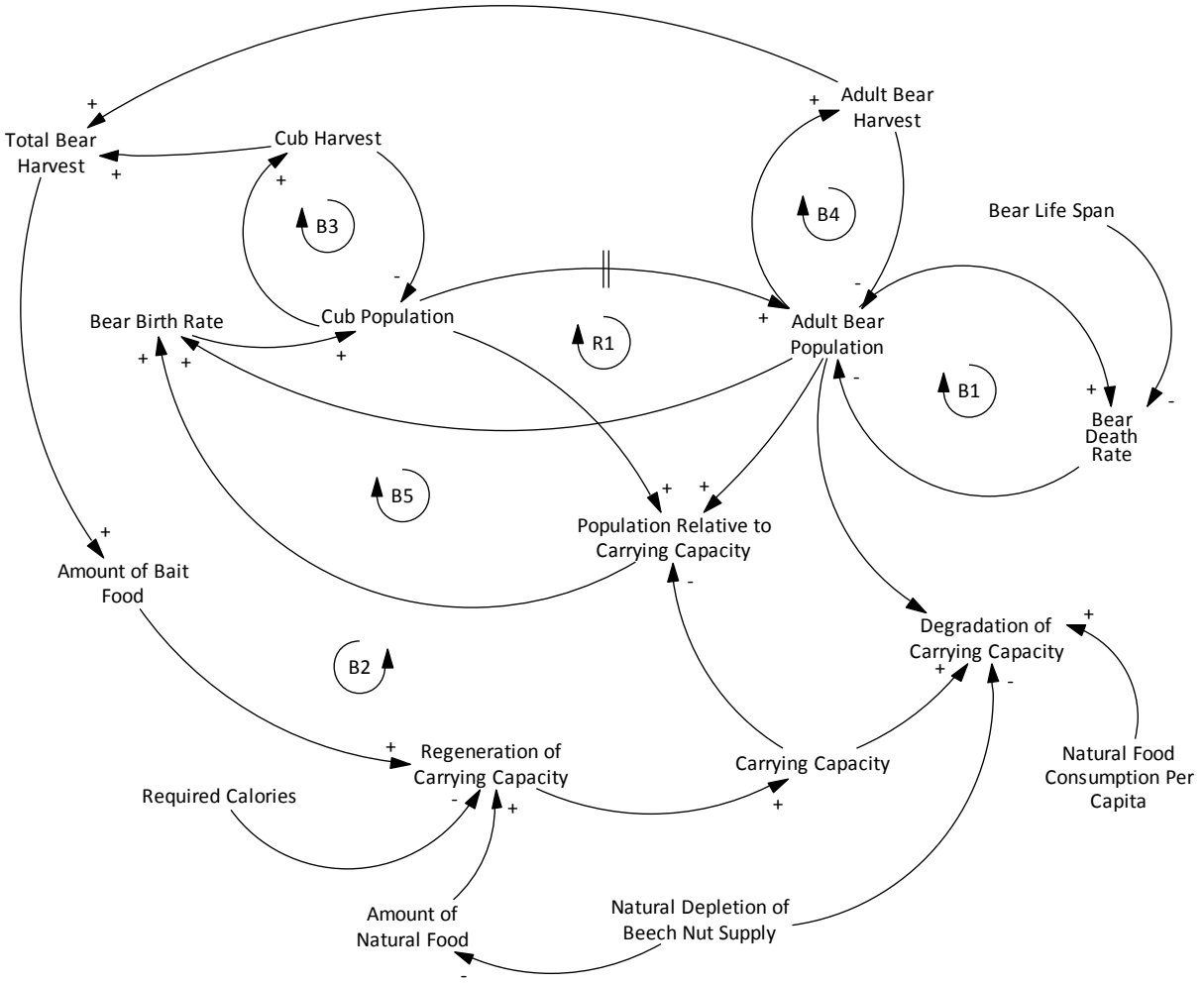

Figure 5. Causal Loop Diagram of Maine Bear Population and Hunting

cubs were born every other year, following the cyclical nature of beechnut supply. However, biologists have found that female bears are now giving birth every year, despite the lack of beechnut crop (Jakubas et al., 2005).

Dynamic Hypothesis

The causal loop diagram in Figure 5 is our dynamic hypothesis, and highlights the feedback loops of the bear population and its capacity.

There is only one reinforcing loop in our dynamic hypothesis. The loop titled “R1” is the relationship between the birth rate and the population level. As the population increases, so does the number of births, which in turn increases the population, and so on. This is a classic reinforcing feedback loop.

There are five balancing loops in our hypothesis. “B1” has to do with the natural death of bears reducing the population. As the population increases, the rate of natural deaths increases, bringing the population back down to lower than it otherwise would have been.

Loops “B3” and “B4” are essentially the same, but they have to do with the harvesting (i.e. death via hunting) of, respectively, cubs and adult bears.

“B2” has to do with the population adjusting itself to meet carrying capacity. Carrying capacity can increase or decrease for several reasons, but the population level will tend to adjust, with delays, towards being consonant with carrying capacity.

“B5” has to do with the relationship between the rate at which bears are born and the population relative to the carrying capacity. As the population level increases towards the carrying capacity, the fractional birth rate decreases, which reduces the birth rate.

Stock and Flow Diagram

We will examine our model in three sections: the aging chain section, the population capacity section, and the full model that ties the two sections together.

The aging chain section of our model (Figure 6) captures the various stages of the bear’s lifecycle and their respective birth, harvest, and death rates. It is a familiar, standard aging chain.

The population capacity sector (Figure 7) of our model captures the resources available to maintain the bear population, and captures how these resources increase and decrease. We based it on the basic “carrying capacity model” familiar to system dynamics modelers (see Sterman, 2000). Carrying capacity defines the maximum sustainable population. It is consumed in proportion to population, with slower consumption as capacity diminishes.

In our model, the “carrying capacity” stock is the carrying capacity for bears in Maine as dictated by the availability of food. The inflow to the stock is “regeneration of carrying capacity” as determined by the amount of natural food as well as bait food, affected by the calorie requirement for bear survival. The outflow of the stock is “degradation of carrying capacity,” which in this case is determined by the food consumption of the bears. The maximum degradation of the carrying capacity is set by the minimum time to deplete the beechnut supply

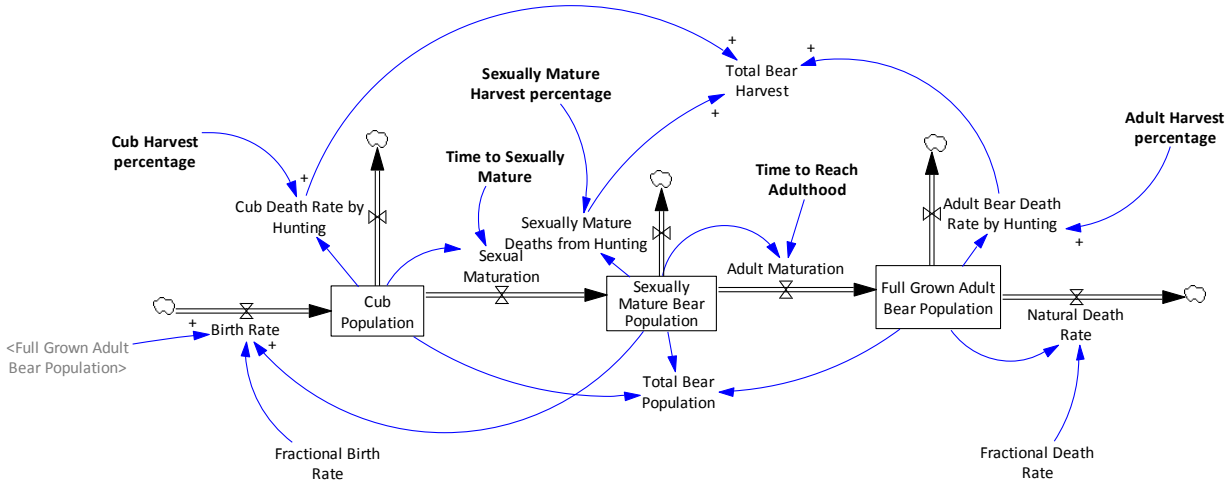

Figure 6. Aging Chain Sector of Bear Baiting Model

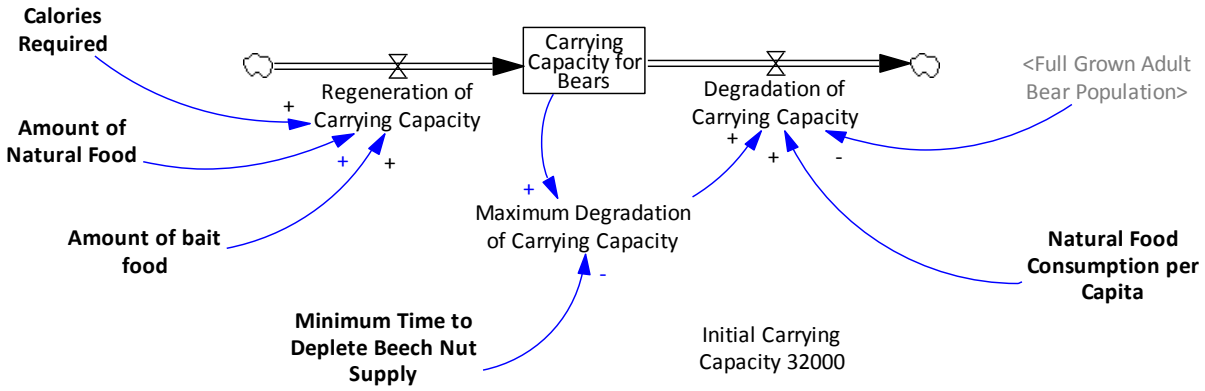

Figure 7. Carrying Capacity Sector of Bear Baiting Model

(so the bears cannot eat more beechnut than is naturally available).

The carrying capacity sector of our model is in equilibrium when the amount of natural food generated is equal to the amount of natural food consumed (the capacity remains stable). However, once guides and hunters introduce bait food, the system is no longer in equilibrium and the carrying capacity stock begins to grow. This will cause the overall bear population to grow as well. We show a diagram of the carrying capacity section of our model in Figure 8 below.

Now, we include a section to the model that ties these two parts together so they can interact with each other dynamically. The variable "Population Relative to Carrying Capacity" is the start of this connection. We create a ratio of the population level and the current carrying capacity level to show the utilization of the carrying capacity. We then use this ratio as input to a table function that adjusts the fractional birth and death rates.

The formulation of the fractional birth rate is a logistic function. As the population relative to carrying capacity ratio increases, the fractional birth rate decreases. This fractional birth rate is limited by the variable "Maximum Fractional Birth Rate," which is currently set at 33% (based on data from Wikipedia, 2015). The equation prevents the fractional birth rate from exceeding this value regardless of how low the population gets, and modelers can tweak the value as assumptions change.

The formulation of the fractional death rate is a power function. As the population relative to carrying capacity ratio increases, the fractional death rate increases. Similar to the fractional birth rate, we use a flow of 5.5% (based on data from Wikipedia, 2015) for the fractional death rate, which we use to keep the death rate from falling below that value. Modelers can tweak this as assumption change, but the limitations on fractional birth and death rates seem to be reasonable for the current model.

Figure 8 shows our completed model, which ties together the aging chain and capacity sections of the model. The parameters shown in ***bold italics*** are the parameters we varied to

perform our analysis. To do this we studied the effects of each parameter on the total bear population. To achieve this, we made some simplifying assumptions.

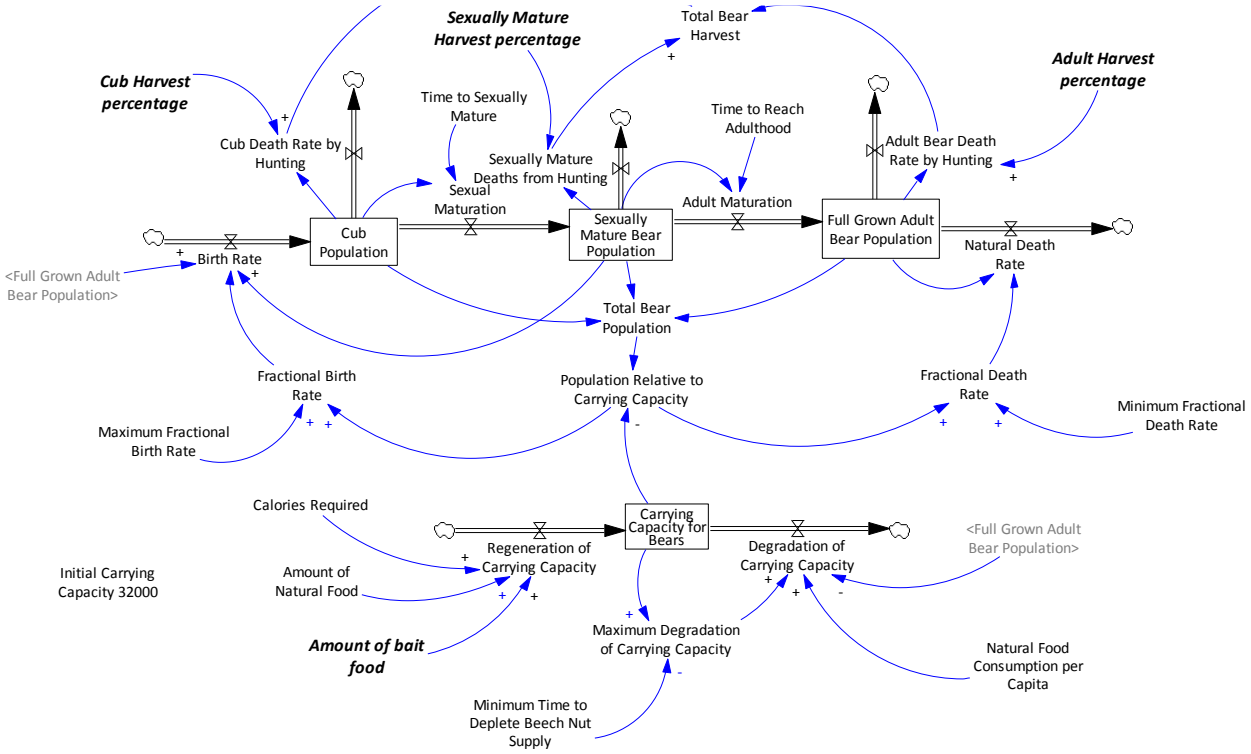

Figure 8. Complete Stock and Flow Model

Simplifying Assumptions

One key assumption we made was to use the black bear harvest as a percentage of population. We did this to account for the possibility that if the black bear population were to increase, the success rate of the individual hunters would also increase. One possible flaw to this assumption is there is likely a finite number of hunters willing to participate in black bear hunting and the harvest percentage could exceed that number if the black bear population grew too large.

Another important assumption we made was the fractional birth and death rates. For our analysis, we used 0.33 as the fractional birth rate and 0.055 as the fractional death rate. These were the default values of our base model, based on information from "American Black Bear" (Wikipedia, 2015). It is obvious that the fractional death rate must be lower than the fractional birth rate or the species would not survive. Hunter (2011) estimates that, on average, about 60% of bears survive to adulthood, but for simplicity, we omitted natural deaths in the cub and sexually mature population.

Finally, one key assumption that does have supporting data is the cyclic nature and regeneration time of the beechnut crop in the state of Maine. For the sake of simplicity, we looked at beechnut growth as a linear trend rather than accurately representing the 2-year

growth cycle. If time had allowed, we would have liked to address this with a SIN function or a table function; however, we are satisfied with our results based on the linear data. The regeneration time of the beechnut supply was a little more complicated than we expected and we arrived at the 50-year value by testing our model with varying parameters until our output best matched our reference modes.

Model Analysis

To complete our model analysis, we studied a time horizon of 100 years, from 2005 to 2105, with a time step of 0.25 years. Using this time horizon, we calibrated our baseline model to a point where its output (the early years shown in Figure 9) sufficiently matched our reference mode (Figure 1). We are confident that our parameter values provide a sufficient representation of reality. One element we underutilized was the harvest of sexually mature bears vs. adult (presumably non-breeding) bears. We would have liked to study this further, but research showed that while bears are able to breed until end of life, we did not have enough data to support an analysis of end-of-life breeding in the Maine black bear population.

Table 1 shows the key parameters used in our model to establish the baseline.

Cub Harvest = 0	Fractional Birth = 0.33
Sexually Mature Harvest = 0	Fractional Death = 0.055
Adult Harvest = 0	Calories Required = 100,000
Cub population = 1200	Amount of Natural Food = 65,000,000
Sexually Mature = 20000	Amount of Bait Food = 0
Full Grown = 2000	Minimum Time to Deplete Beech Nut = 50
Time to Sexually Mature = 4	Natural Food Consumption per Capita = 30,000
Time to Reach Adulthood = 11	Initial Carrying Capacity = 32,000

Table 1. Base Model Parameters

Model Output: Bear Population

Figure 9 shows the important results from five runs of the simulation. The baseline, curve 1 labeled “Base,” shows the simulated total black bear population in the state of Maine using the parameters from Table 1. We did not start the model at equilibrium because we wanted to demonstrate the recent growth of the black bear population in Maine. At the time of the 2004 bear baiting referendum, the estimated black bear population was 23,000 bears, so we used this initial value for our bear population. Curve 1 shows that the population rises to an equilibrium of a little over 40,000 bears, as the natural carrying capacity rises over time.

To demonstrate the effects of adding 7 million pounds of bait to the forest, we completed a second run of our model, which increased the amount of bait food from our base of 0 to 20,000,000 calories. Curve 2, labeled “Bait with No Harvest” in Figure 9, shows the result of this action. The graph clearly shows a profound effect of the increased carrying capacity, as the total population ultimately rises to over 50,000 black bears. Neither our “Base” nor the “Bait with No Harvest” graphs account for unnatural death due to hunting, but they demonstrate the effects of increased carrying capacity caused by supplementing the black bear’s diet with bait food.

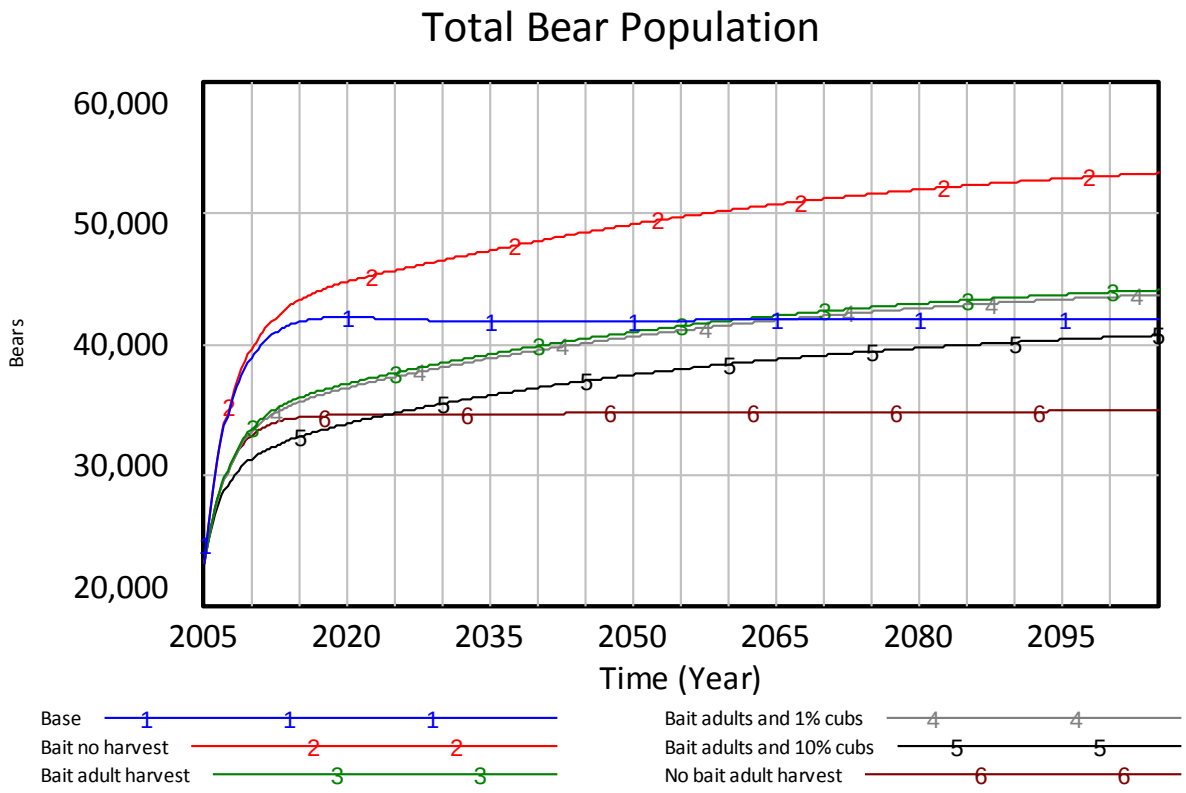

Figure 9. Total Bear Population, Simulated

To study the effects of successful bear harvesting, we changed the Sexually Mature and Full Grown bear harvests from the base run value of 0% to the new value of 10% for each sub-population. Figure 9 shows the result in curve 3, labeled "Bait with Adult Harvest." This curve shows that, with bait and adult harvest, the total black bear population remains below the natural carrying capacity that would have existed without supplemental bait, but continues to rise slowly until eventually surpassing the natural carrying capacity in approximately the year 2060. This happens because hunters generally seek to harvest the largest black bears, which are also typically full-grown adult male bears. This is significant because a full-grown adult male bear will have a lifetime of mating and his harvest will have less of an effect on reducing the population.

To test this theory, we added 1 % and 10% harvests to the juvenile "cub" population (whose members have not yet reached sexually maturity) to the 10% bear harvest from each adult population. Figure 9's curve 4 shows the results of a 1% cub harvest; as one might expect, this shows little difference from the harvest of adults only. However, curve 5 in Figure 9, which shows the simulated result of a 10% harvest, reveals a profound effect on the total black bear population—it stays well below the carrying capacity throughout the 100 years of the simulation. This result is predictable because if juvenile bears are harvested in large numbers before they reach sexual maturity, there is a ripple effect—it dampens the aging chain because, upstream, there are fewer bears available to reproduce.

Figure 9 also shows a simulation run, curve 6, where there is no bait deposited in the forest, but the state allows a 10% harvest of Sexually Mature and Full-Grown Bears. This curve, which rises quickly but levels off at the existing population of a little over 30,000 bears, suggests that Maine could maintain a steady black bear population, at an acceptable level, without using bait.

Model Output: Bear Harvest

The model accurately reflects the reference mode for bear harvest. Figure 10 shows the simulated bear harvest under three scenarios:

- Bait and harvest of Sexually Mature and Full-Grown Adults only (curve 1)
- Bait and harvest of adults and 10% of cubs (curve 2)
- No bait and harvest of adults only (curve 3).

Curve 1 depicts with reasonable accuracy the situation that currently exists in Maine (see Figure 3) under its current bear hunting policies—the harvest from baited bears is roughly 2,500 and

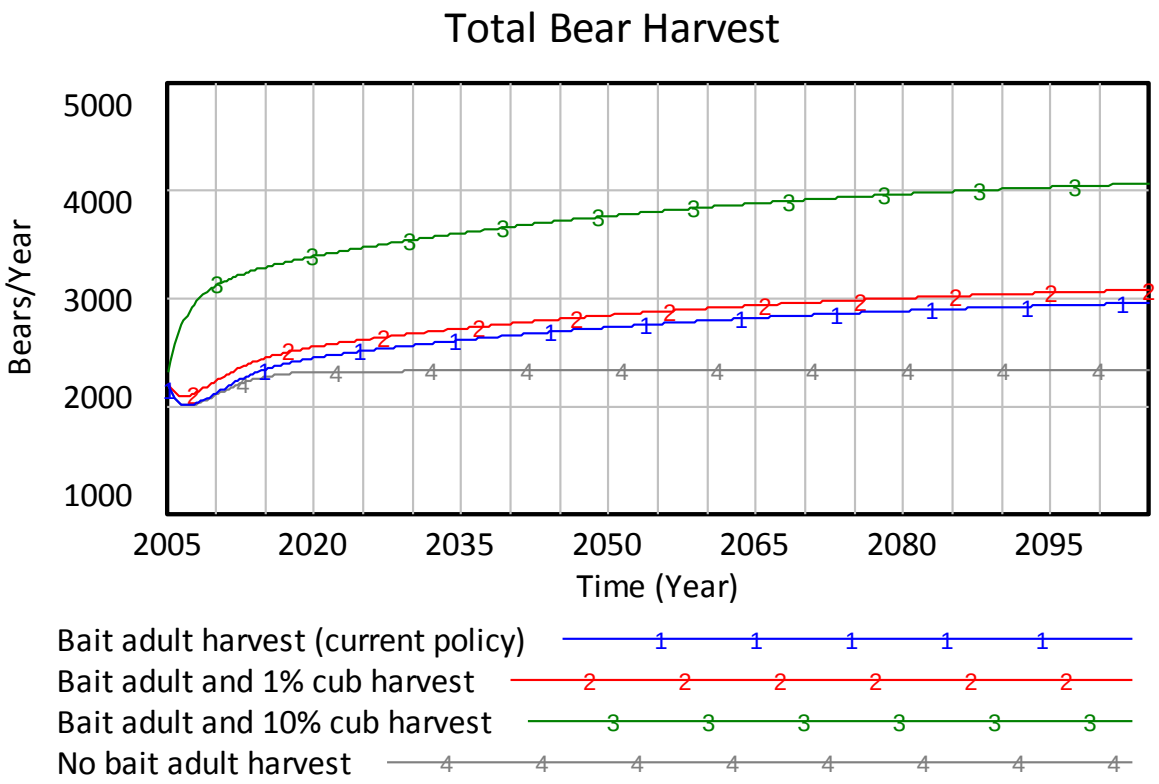

Figure 10. Total Bear Harvest, Simulated

shows the potential to rise to 3,000 by the end of the period. Curve 2 shows the modest increase in harvest from a 1% cub harvest, but curve 3 shows the dramatic increase from a 10% cub harvest. Recall from Figure 9 that the tradeoff for a 10% cub harvest is a much lower

overall black bear population, caused by fewer cubs early in the aging chain. Recall also that few hunters prize bear cub trophies, so a large cub harvest would mostly be for population control, not prize hunting. Lastly, curve 4 in Figure 10 shows the result of combining the policies of no bait and adult harvesting. The harvest levels off at about 2,300 bears per year, significantly lower than the 3,000 from using bait.

Conclusion

The analysis of our simulation runs suggests that adding additional food (in the form of 7 million pounds of bait) increases the bear ecosystem's natural carrying capacity, and, even with regular adult harvests, the overall black bear population will continue to increase and eventually will exceed its current level. Based on this finding alone, we can conclude that hunting black bears over bait in its current form is not an adequate method of controlling the black bear population in the state of Maine. Our analysis shows that if the goal is purely to control the black bear population, hunting over bait is not as effective as targeting juvenile bears along with adult bears. Furthermore, our analysis shows that, for bear population control, hunting over bait is not even as effective as using no bait and having an adult harvest, which is considerably less cruel and culling cubs.

Policy Recommendations

Our model analysis suggests three possible policy alternatives for effective control of the black bear population in Maine:

First, the state could prohibit the baiting of bears, to keep the carrying capacity and therefore the bear population from continuously increasing. This would be an ethical solution, but it would have financial consequences for the hunting industry in Maine. Annually, bear hunting produces $52 million in economic contributions from activity in the bear hunting industry (Southwick Associates, 2014). Figure 10 above shows the problem—without bait, the model produced a harvest of about 700 fewer bears. This could translate to $12 million in lost economic activity.

A **second** alternative would be to encourage the hunting of female bears and cubs, to break the increasing reproductive levels. This alternative violates some ethical considerations, as people generally consider the hunting of cubs cruel, and hunting female bears could leave orphaned cubs that would starve to death (Beck, 1995). The alternative to hunting female bears and cubs is also not sound financially, since most hunters would prefer to hunt large bears (the adult male ones), and may not be willing to pay for hunting the smaller-sized females and cubs. Therefore, Maine could still lose a significant amount of its bear-hunting-based economic activity. Figures 9 and 10 show the problems:

- In the early years, this policy would reduce the total black bear population to a level even lower than the one with no bait (Figure 9),
- A mild 1% cub harvest would have little effect on total harvest (Figure 10), and
- An aggressive 10% cub harvest would simply increase the taking of non-trophy bears (Figure 10), which is unlikely to lure hunters to Maine.

A **third** alternative, which is both ethical and financially sound, would be to continue bear baiting but to use natural beechnut as the baiting source. In this way, the hunters could continue to target adult male bears (the most ethical and financially satisfying target), while not introducing human food into the bears' diet (thereby not growing the carrying capacity for bears in the natural environment). There is another problem with using human food as bait for bears, which we have not yet mentioned, and that is that baiting with human food will teach bears to associate humans with food (Dunkley, 2003). This kind of association makes bears less afraid of humans (Inslerman, 2006), and causes them to raid bird feeders in people's backyards and trash cans in residential neighborhoods, which creates a safety concern (Sarnacki, 2014). Baiting with beechnut would solve all of these issues. One practical concern that some have voiced is whether bears will favor beechnut bait over doughnut bait. Brian Kevin answers this question: "Consensus among biologists is that if things like berries, tree fruits, beechnuts, or acorns are abundant, black bears are less likely to bother with human foods – even easily accessible ones" (Kevin, 2014).

Future Research

For future research, it would be very interesting to see research that attempts to find solution that addresses both ecological and economic interests. The 2014 political debate around bear baiting revolved almost entirely around ecological considerations, but it does not take much effort to see that the parties involved in the debate had their own agendas beyond simply maintaining the bear population. There are three very clear goals: economic, moral, and ecological.

The group on the side of preserving bear baiting as a legal option is called Save Maine's Bear Hunt, and they are backed by many groups including Inland Fisheries and Wildlife, hunting guides, snowmobile organizations, and the NRA. They have a very strong economic interest in preserving the status quo. Inland Fisheries and Wildlife receives over $5M a year in revenue from bear hunting licenses. Hunting guides make the majority of their annual income from the lucrative bear hunting season. Many businesses generate income, at least indirectly, from the bear hunting industry.

The group in favor of banning bear baiting as an option is Mainers for Fair Bear Hunting. They do not have any obvious economic interest, but they have a very strong moral interest. For example, they are backed by People for the Ethical Treatment of Animals (PETA) and the Humane Society of the United States. These groups base their interest in changing Maine's hunting laws largely on opinions about the morality of hunting in general, which brings a difficult aspect to any debate around the subject. Many people have very different and very strong opinions about how animals should be treated, ranging from one extreme to the other. Some may think all hunting of any kind is barbaric, and others may believe any form of hunting is completely acceptable and morally right. Because it is such a difficult and nearly impossible area to debate, we will focus our recommendations on the ecological and economic arguments. With that said, it is important to note that one side of this political argument does indeed care strongly about the moral implications of hunting, and that will have to be considered at least to some extent in the future.

In the political arena, arguing for the existence of a law solely on its ability to provide economic opportunity is clearly insufficient. Similarly, arguing about the morality of any particular law is going to be extremely difficult and heated, especially since morality is such a subjective and difficult topic in general. Therefore, even though these likely are the primary motivations of the two groups involved, the ecological argument seems to be the only one that could promote rational debates. In other words, the two groups may never come to terms on the morality, and the economic interests may not be of any help in reaching a compromise, but at least both sides can come to some agreement on the ecological impact of bears on the state, the environment, and the black bear population itself. A steady bear population helps the economic interests. A steady black bear population also reduces the suffering of the bears from starvation and any potential backlash from bear habitat overlapping with human habitat. Our recommendation for future research is to determine the ecological goals of both groups, and go a big step further to solve the economic goals as well. It could be completely possible to tie together the livelihoods of Maine residents with the maintenance of the bear population (and environment as a whole). We would like to see some in-depth research done on how to use the profit motive to get people to do what is best for everyone, including the black bears.

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