CARRYING CAPACITY LITERATURE REVIEWS

When measured accurately, carrying capacity can be very helpful in environmental management practices. The purpose of this assignment was to gain further knowledge of carrying capacity to improve current methodologies. Each student was assigned to research and prepare a literature review on a different aspect of carrying capacity. The topics were defined as follows:

The result of this research is not an invention of the most effective methodology; rather a clearer understanding of the many variables involved and the inconsistencies between methodologies. The main theme found throughout the literature of carrying capacity was perception. Each literature review touched upon perception because it seemed to be a recurring theme. What this means is that the person measuring carrying capacity must first decide what it is that needs to be measured; that person's perception will significantly affect the outcome of carrying capacity. For example, both an environmentalist and a businessman can measure the carrying capacity of the lake; however, they will probably produce different answers. This is because an environmentalist might perceive the carrying capacity of the lake as it affects the quality of water and biotic/abiotic life. A businessman, on the other hand, might perceive the carrying capacity of the lake as it affects the amount of recreation that can occur and profit made.

The perception of the person measuring carrying capacity significantly impacts the outcome, which is why it is important for a community to first decide how they should perceive carrying capacity before making any major decisions. Through these literature reviews we were able to gain a better understanding of the complexities of carrying capacity; however, this is only a study on what is already known, there is still much to be discovered on the subject.

Defining Carrying Capacity **Sarah Young**

Carrying capacity is a term of measurement. It measures both living organisms and non-living objects, and relates to the maximum amount of an organism or object that can be supported by a given amount of space. This limit depends on a large number of variable environmental factors. Carrying capacity can be concerned with population growth of humans and other species of living organisms (Paehlke 110). In the ecological sense, carrying capacity is related to the "study of population dynamics" (Paehlke 110). When a species grows rapidly over the carrying capacity of its environment (i.e. overpopulation) it results in problems (Dashefsky 40). When the species crowds its environment (i.e. ecosystem, habitat, etc.) resulting in diminished resources, its "growth will decline" (Paehlke 110). When this occurs the population of the species will "level off and eventually cease to grow or even suffer from a severe decline" (Paehlke 110). In addition, carrying capacity is a "key concept in the management of rangelands, referring specifically to the number of animals that can graze in a particular area, while allowing the environment to maintain or improve itself" (Frank 49).

The article, *What is carrying capacity for fish in the ocean? A meta-analysis of population dynamics of North Atlantic cod*, by Ransom A. Myers, is a compilation of studies by several researchers rather than an individual study. The question of the article is 'what is the carrying capacity for fish in the ocean?', but focuses is on North Atlantic cod. Other questions (i.e. objectives) of the article are derived from the main question. These include: "(*i*) introduce the alternative statistical methods to improve spawner-recruitment parameter estimates for individual stocks and (*ii*) use these methods to begin comparing carrying capacities in different ecosystems" (Myers 1465).

In this article, there were three hypotheses. One hypothesis was: "…these statistical relationships are uncertain, derived biological reference points are also uncertain and it can be difficult to forecast the consequences of reduced stock size" (Myers 1464). Another hypothesis was that there were alternative statistical methods (i.e. meta-analysis and Bayesian approaches) that 'borrow strength' from other population or stocks can be used to improve parameter estimates for a given stock" (Myers 1464-1465).

The different approaches mentioned in the report included alternative methods for arriving at carrying capacity. First, stocks of twenty-one species of North Atlantic cod were modeled "assuming that the maximum reproductive rate and the carrying capacity per unit area respond to random variables" (Myers 1464). Each variable was used to find its effect on the carrying capacity and the reproductive rate of cod (Myers 1464). The results showed, for instance, that the "carrying capacity of cod declines at higher temperatures, which, to our knowledge, no one researching cod in the North Atlantic has suspected…(the) main conclusion is that appropriate statistical methods can use information from other studies (of stocks) to estimate spawner-recruitment parameters for stocks where these are poorly defined" (Myers 1471). A second conclusion was that "these statistical methods have enabled us to compare carrying capacities and maximum lifetime reproductive rates in different geographical regions occupied by cod stocks" (Myers 1472). So, these cod stocks can be related to the conditions in the 'local region' (Myers 1472). In the end, the "analysis showed that the carrying capacity per unit area varied by more than 20-fold among populations and that much of this variation was related to temperature" (Myers 1464).

Even though cod is not found in Lake Sunapee, this article can relate to Lake Sunapee in terms of fish population. When the population of fish in the lake gets too high to be sustained, it may quickly dwindle down, creating poor fishing and recreational use. The people who fish in this lake recreationally may eventually not get a sufficient amount of fish even if some environmental variable increases the fish population in the short run. This means that all environmental changes need to be carefully examined for both short- and long-term effects. If we are dealing with an invasive species like milfoil then, even if it provides shelter for fingerlings, temporarily increasing fish population, this could later backfire if the fish population then exceeds Lake Sunapee's carrying capacity. In order to make sure that data is accurate it must be collected regularly.

In the article, *how many people can the earth support*, Joel E. Cohen provides a view of carrying capacity relative to human population. Carrying capacity can be defined in different ways if we consider different variables (ecological, cultural, social, etc.). Variables can include the supplies of materials (i.e. food, clothing, water, and shelter), and natural constraints on the population like climate (Cohen 20). Birth and death rates and other aspects of demography (i.e. family structure, marriage and migration) also influence human carrying capacity (Cohen 21). It is impossible to predict future constraints of nature like unexpected climate change, and unpredictable consequence may also arise from human nature, like war. (Cohen 22).

In *Carrying Capacity*, Elizabeth A. Viau provides information regarding the carrying capacity of environments for both humans and animals. Territory plays a key role in animal existence and that of animal hierarchies. A rule of nature is kill or be killed, and it's a dog eat dog world for animals in their habitat. In the Encyclopedia of Environmental Science, John Mongillo and Linda Zierdt-Warshaw support this rule of nature when they mention the existence of competition among species and individuals for the "availability of resources in an environment" (70). Even though humans may not have to kill in order to survive, but they do have to maintain jobs to increase their income, which provides them with the basic necessities: food, clothing, water and shelter. In the Lake Sunapee Watershed, there is an abundance of businesses, which are the lake's stakeholders and take an active interest to the Lake Sunapee Watershed.

Looking back to animal issues, these living organisms need territories that may be "large enough to provide food for the reproducing adults and their young, what" (Viau). The carrying capacity of an environment for a given species will be the size of that environment divided by the territory needed by each individual of that species. Males defend the territory needed by each family group, and females pick the male that seems most likely to do it well. A large territory or powerful appearance may entice a female to join a particular mate. To determine the right of individual animals to a territory contests often occur (Viau). Even domestic animals (i.e. horses, dogs, and poultry) have such contests to see who is the strongest or most dominant in their group.

Life is not easy for animals, plants or humans, since status and survival depend on will, stamina, and endurance. Since carrying capacity is not elastic, if the carrying capacity of an environment is exceeded for humans, other animal species, plants, or other organisms in general will decline. If that happens the whole ecosystem may be harmed and may not recover (Viau). Much like in the winter around the Lake Sunapee Watershed, "there may be a population crash as the animals compete with each other and

(the) food runs out" (Viau). By understanding carrying capacity, we can avoid these types of problems in the future.

Sources

Cohen, Joel E. "How many people can the earth support." Sciences 35 (6): 18-23.

Dashefsky, H. Steven. Environmental Literacy. : Random House, 1993.

Frank, Irene & David Brownstone. "Carrying capacity." The Green Encyclopedia. 1st ed. 1992.

Mongillo, John & Linda Zierdt-Warshaw. "Carrying capacity." Encyclopedia of Environmental Science. ed. 2000.

Myers, Ransom A., et al. "What is carrying capacity for fish in the ocean? A meta-analysis of population dynamics of North Atlantic cod." 21 June 2001. NCR Research. 16 Feb 2004. http://cifas.nrc.ca

Paehlke, Robert (ed.). "Carrying capacity." Conservation and Environmentalism. ed. 195.

Viau, Elizabeth A. "Carrying capacity." 1999. California State University. 14 Feb 2004. http://curriculum.calstatela.edu/courses/builders/lessons/less/biomes/carryingcap.html

Determining Carrying Capacity **Jenni Beaulieu**

Carrying capacity, environmentally speaking, refers to the size of a population that can live indefinitely in an environment without doing that environment any harm. Once a carrying capacity is determined, it can be used as a helpful tool to make important decisions, but calculating carrying capacity is more complex than one might imagine. Everything in the world is linked together, which means, one thing affects every thing. This makes carrying capacity difficult to determine because it is near impossible for one to measure the effects of every thing that disrupts carrying capacity; therefore, the first step is to specify what variables to measure that may effect a particular population. From there, one must measure the carrying capacity by measuring how the variables effected the population and to what extent do they become unsustainable in that environment.

There are many ways to measure carrying capacity because of the many variables that effect populations in certain environments. Scientist Pulatsu performed a study on the effects of phosphorus on the carrying capacity of rainbow trout in Kesikkopru Dam Lake. Pulatsu used a phosphorus budget model previously established by scientists Dillon and Rigler to estimate the amount of phosphorus in lakes (Pulatsu 1127-1130). This can be used to calculate carrying capacity because phosphorus is the basic restrictive element in lakes. This means scientists can measure phosphorus to test a lake's nutrition and make assumptions as to its productivity and with the use of certain equations the carrying capacity can be determined. "The concept of nutrient loading may initially be applied on elements such as nitrogen and phosphorus which determine the eutrophication spectrum and productivity of the lake (Pulatsu 1127-1130)." This information can be applied to Lake Sunapee because it is oligotrophic and nutrient loading is a possible option to make it eutrophic.

While Dillon and Rigler's phosphorus budget model may appear accurate, it makes assumptions which create inaccurate results. This model is not alone, most early models for carrying capacity are known to make assumptions which may give inaccurate results that are over- or underestimated (van Gils *et al.* 197-204). van Gils *et al.* worked on the study entitled, *Carrying capacity models should not use fixed prey density thresholds: a plea for using more tools of behavioral ecology,* where they modified existing models and added new dynamics to make up for the lacking assumptions. The model they initially used was a "standing stock" type model, where it assumed that resources were not renewed after consumption and that the initial number of prey and the rate of prey consumption determine the time a population of foragers could live in an area. Without the modifications, this model would not be accurate because it assumes animals and nature are predictable. Realizing it is difficult to measure carrying capacity correctly, this study works to teach others how to improve existing models. They advise to include behavioral yields into the model because "animals generally do a good job;" their perception of the environment is reliable (van Gils *et al.* 197-204). It is also important to include site-independent quantification of the functional response and of the rates of energy expenditure in all patches in the study area because this isolates each site; thus, minimizing discrepancies (van Gils *et al.* 197-204).

In a study by Squires *et al.*, carrying capacity was determined with the use of an Environmental Resource Assessment and Management System (ERAMS). This was a study on land capability assessment and estimation of pastoral potential of semiarid

rangeland in South Australia (Squires *et al.* 25-37). ERAMS is a computer-aided system developed to determine present and potential pastoral productivity of arid and semiarid regions. This model bases its calculations on soil-water availability to determine the land sustainability so that land resources are used within their capability. This model is terrestrial based; however, the same idea would work to figure out the carrying capacity of Lake Sunapee. Since the lake is oligotrophic, fish harvesting is a possible option to fix that. In order to introduce fish into a new environment it is vital to calculate the carrying capacity of the lake so that the new fish use their resources within their capability. In the ERAMS model, soil-water availability is used as the basis for measurement, for Lake Sunapee, the model might use phosphorus and nitrogen levels; as was used in the Kesikkopru Dam Lake study.

Another study measuring carrying capacity was based on the influence of rainfall on zebra population dynamics so that a management program may be initiated. The model used for this study was by Pascual *et al.* who used it for a study on Serengeti wildebeest populations. Pascual *et al*. used a wide variety of qualitatively different models and showed that they could be made to reproduce observed fluctuations in total numbers, provided the means of variable measurement was the same (Georgiadis *et al*. 125-137). This model proved true as the model data fit the observed data. In order to determine a management plan, this model could be applied to different components of the population, thus reaching carrying capacities regarding each component (Georgiadis *et al*. 125-13). Similar to van Gils *et al.* study, Georgiadis *et al.* advises one to base their carrying capacity models not only on the specific limiting factors, but also on how those factors affect real populations; i.e. behavioral ecology. This idea could also be applied to Lake Sunapee, which was brought up in an article about New Hampshire lakes and their overpopulation. Author Bob Sanders of the article, *Limit on the number of boats on NH lakes could be coming,* states that there are three thresholds impacting the carrying capacity of lakes in NH: "One depends on the environmental and biological state of the lake. The second depends on its size and depth. And the third depends on how much people will put up with, the social capacity (Sanders 1-3)." If these are included in a carrying capacity model, perhaps an accurate estimate can be made regarding the boating carrying capacity of Lake Sunapee.

Carrying capacity is very difficult to measure accurately due to the innumerable variables that effect population sustainability in certain environments. To get a most accurate estimate it is best to focus on one variable that has had a noticeable effect. Measure the presence of that variable as it already exists and use a model to measure to what extent that variable can exist while sustaining a healthy population within that environment. It is important to also take into account behavioral aspects of the animal population being studied. It seems the most accurate estimations are ones that did not simply find a model and use it; rather, they found a model that best fit the study and altered it to specifically address the study at hand, thus avoiding inaccuracies and miscalculations. Remember that there is no one equation for carrying capacity, it requires both quantitative and qualitative analysis and multiple models for the most accurate estimates.

Sources

Amissah-Arthur, Abigail, Bernard Mougenot, and Maud Loireau. "Assessing farmland dynamics and land degradation on Sahelian landscapes using remotely sensed and socioeconomic data." International Journal of Geographical Information Science September 2000: 583-600.

Georgiadis, Nicholas, Mace Hack, Katherine Turpin, and . "The influence of rainfall on zebra population dynamics: implications for management." Journal of Applied Ecology February 2003: 125-137.

Hakoyama, Hiroshi, Yoh Iwasa, and Junk Nakanishi. "Comparing Risk Factors for Population Extinction." Academic Press 2000: 327-336.

Palmer, A.R. "Ecological Footprints: Evaluating Sustainability." Environmental Geosciences December 1999: 200-205.

Pulatsu, Serap. "The Application of a Phosphorus Budget Model Estimating the Carrying Capacity of Kesikkopru Dam Lake." Turkish Journal of Veterinary & Animal Sciences May 2002: 1127-1130.

Sanders, Bob. "Limit on the number of boats on NH lakes could be coming." New Hampshire Business Review August 1999: 1-3.

Squires, V.R., and F. Bennett. "Land Capability Assessment and Estimation of Pastoral Potential of Semiarid Rangeland in South Australia." Arid Land Research and Management March 2003: 25-37.

Suttles, Jennifer B. "Watershed-Scale Simulation of Sediment and Nutrient Loads in Georgia Coastal Plain Streams Using the Annualized AGNPS Model." Transactions of the ASAE Sep/Oct 2003: 1325-1336.

van Gils, Jan, Pim Edelaar, Graciela Escudero, and Theunis Piersma. "Carrying capacity models should not use fixed prey density thresholds: a plea for using more tools of behavioral ecology." Oikos 2004: 197-204.

Viau, Elizabeth Ann. "Carrying Capacity ." 1999. California State University. 01 Mar 2004. http://curriculum.calstatela.edu/courses/builders/lessons/less/biomes/carryingcap.html

Management of Carrying Capacity **Tamsen Bolte**

The management of carrying capacity, K, cannot be defined by specific guidelines or protocols. The ways in which managerial practices for carrying capacity are designed and instituted depend on the situation and subjects at hand. Once K has been determined, a decision making process must be utilized to establish the most appropriate practices to effectively manage K. First K needs to be understood; it is "the amount of change that a process or variable may undergo within that system without driving its structure and function over acceptable limits," (Ming). Carrying capacity is a subject specific concept, and as a result requires for each case to endure its own decision-making processes based on potential effects on the involved stakeholders. Decision makers "have to incorporate uncertainty and unpredictability in management into the decision-making process" (Matsuda, 2002, 366). When it comes to lake systems, such as Lake Sunapee, there are a variety of perspectives that be taken when inquiring about K managerial practices. The human and biological standpoints can both have carrying capacity defined. The difference lies in the value and importance of what K represents to the lake, and then to people.

A recreationally active lake system will ultimately deal with issues concerning carrying capacity in relation to visitor use and types of use. People who need to make management decisions to accommodate for the publics opinion, must also incorporate the future of the ecosystem into their decision-making processes. "Recreational carrying capacity management for large land/water areas can be viewed as not one decision but several interrelated decisions, often about different parts of the area and different people there. Recreational capacity decisions are decisions about people's access to opportunities and the quality of their experiences there", (Chilman). In conjunction with an area that is open to the public, resource managers develop managerial plans that are compromises to the human perspective and the environmental perspective. While there is not always a fair compromise, the most compromising will be instituted. There is a process called the Visitor Experience and Resource Protection Process, developed by the National Park Service, as a way to identify "desired ecological and social conditions, and not the maximum number of people that can be accommodated in a particular area" (Carrying Capacity). Today managers are using zones as a way to help protect natural processes of both the land and water. Although management zones are not specifically for water, there are usually water sources with the lands that have been given such zone names as: natural, historic, developed, or special use ("Management Zoning").

In an analysis of carrying capacity on Lake Mead, the limits of acceptable change and visitor impact management were explored through comparing indictors of safety, shoreline accessibility and social carrying capacity (LMNRA). The Bureau of Outdoor Recreation suggested that safe boat operation could occur in the range of 9-18 acres per boat. This figure can change depending on the setting of the lake and how lake managers want the lake to be used. While safety is always an issue, the social carrying capacity is a reflection of the lake, the surrounding area, and permanent and temporary residents. Lake managers have to establish what their standards are for quality in order to develop a manageable and effective plan. Controversies over the recreational carrying capacity have conjured up long debates about how to manage boats. If and when lake

managers make a decision to manage boat access to a lake, there will be supporters and protestors involved.

The concept of human carrying capacity has become a major issue and concern for resource managers. Finding a balance between man and nature is becoming more and more of a challenge, with humans being the dominant force. In today's society, with increase modes of transportation, mobility has been a major contributing in influencing the tourism industry. People are seeking new opportunities to travel and explore, but the conflict arises between at what cost should the environment have to suffer? Tourism is not all necessarily bad, as long it can be properly managed. Without such management, it "can be and engine of destruction rather than a force of human development," (Eberlee). Tourism managers constantly ask the question of, how many is too many? An expert on international tourism sustainability states "it is only through government control, management of the industry, and self-policing that you can begin to counter that [downward spiral]" (Eberlee). By downward spiral he is referring to the degradation that can occur to an area without proper management.

Defining human carrying capacity can take many directions, however when it comes to defining ecological carrying capacity, researchers have a better grasp on, as afar as figures and predictions. People use K as a means of managing herds, to enhance productivity and ultimately income. For example cattle ranchers and fish farmers use carrying capacity estimates to maximize their return by understanding food resources, area, and animal requirements. Every manager will use carrying capacity estimates slightly differently to gain similar results. "As long as the appropriate limiting factors are monitored, the choice of method for estimating carrying capacity is a matter of operator preference," (Hinshaw).

The answer to the question on how to manage carrying capacity, is a matter of perception. What are the goals of the managers and what visions do they see for what they are managing? While there can be standards and guidelines for K management, exceptions and specific inquires must be administered for every situation. What worked on Lake Mead, may not have any effect on Lake Sunapee, however having this comparison can assist in making the best decisions.

Sources

"Carrying Capacity." 7 Dec 2001. University of Arizona. 01 Mar 2004. http://rangelandswest.org/az/inventorymonitoring/carryingcapacity.html

Chilman, Kenneth, John Titre, James Vogel, and Greg Brown. "Evolving Concepts of Recreational Carrying Capacity Management." http://www.prr.msu.edu/trends2000/pdf/chilmanCC.pdf

Eberlee, John. "Managing Tourism with a Sustainable Carrying Capacity." IDRC Reports 6 12 1998. 02 Mar 2004 http://web.idrc.ca/en/ev-5541-201-1-DO_TOPIC.html

Hinshaw, J. M (2000). Trout farming: carrying capacity and inventory management. *Southern Regional Aquaculture Center*, 222. http://srac.tamu.edu/222fs.pdf

Lake Mead National Recreational Area (LMNRA). "Lake Management Plan". http://www.nps.gov/lame/planning/appen_b.htm

Managment zoning and carrying capacity monitoring. *National Seashore Managment Zoning*.

http://www.nps.gov/caco/management/gmp/MANAGEMENTZONINGANDCARRYINGCAPACITY.pdf

Matsuda, H., & Katsukawa, T. (2002). Fisheries management based on ecosystem dynamics and feedback control. *Fisheries Oceanography*, 11(6), 366-370.

Ming, Chou Loke, and Nancy Bermas. "Defining and Applying the Concept of Ecological Carrying Capacity to Coastal Management: Report of a PEMSEA Workshop." The East Asia Sea Congress Dec 2003. http://www.pemsea.org/downloads_pdf/abstracts/B2/s2/1Chou%20Bermas_Defining%20and%20applying.PDF

Biology/Ecology/Habitat **Emily Goodrich**

Carrying Capacity is "the number of individuals of a given species that can be sustained indefinitely in a given space, area or volume," (Miller, 199). This means that carrying capacity is determined by the size of the area and the number of species that are in the area. For instance, take the New Hall Seminar room. This area can only hold a certain amount of people in it. If we were to add more then the area would be crowded, forcing people out of the room. There is a comfortable norm of about 12 to 15 people in this room; any more would cause the room to be over populated. Other factors that may affect an area of carrying capacity are: "(1) competition within and between species, (2) immigration and emigration, (3) natural and human-caused catastrophic events, and (4) seasonal fluctuations in the supply of food, water, hiding places, and nesting sites," (Miller, 201) Each of these features ties into the biological and ecological habitats that a species can obtain.

In each of the articles, they have all explained different ways of testing for carrying capacities in areas around the world. The article by Swenson, Sandegren and Soderberg called, Geographic Expansion of an Increasing Brown Bear Population: Evidence for Presaturation Dispersal, explains how "the distribution of brown bears expanding in to suitable habitat in Sweden following near extermination" has affected the species around the country. By using three predictions they were able to find that male brown bears were more apt to disperse themselves from the core areas than the females were. This is because the core areas, female concentration areas, are safer due to the fact that more of the females stick around in one area to ensure safety and help from other bears.

Goss-Custard, Stillman, Caldow, West, and Guillemain made a study on, Carrying Capacity in Overwintering Birds: When are Spatial Models Needed? The authors stated that we need to predict the amount of bird-days that can be sustained by the quantity of the food supply used by migratory birds outside of the breeding season. This article states that carrying capacity usually uses the daily ration model (DRM). This model is "the total biomass of accessible food, aggregated across all patches of differing food density, is divided by an individual's daily requirement." The researchers decided to also test the spatial depletion model (SDM). This is when the patches of food density are treated individually. They found that "a DRM and a SDM of wildfowl eating seagrass in a nature reserve produced similar predictions for the number of bird-days supported intertidally before the birds switched to farmland," (Goss-Custard, etal). In the end they found that DRM can be used instead of SDM to find the carrying capacity of the predicted bird-days. They said that "this study should help nature managers to predict the bird-day carrying capacity of a site in the simplest way yet available," (Goss-Custard, etal)

Fagan, Meir, Prendergast, Folarin and Karieva's, Characterizing Population Vulnerability for 758 Species explains how they found associations between life history traits and character population dynamics. The authors made three classes of populations: "1. weakly varying populations with such high growth rates that long-term persistence is likely, 2. populations with such low growth rates that average population size must be large to buffer them against extinction in a variable environment, and 3. highly variable populations that fluctuate so dramatically that dispersal or some other refuge mechanism

is likely to be key to their avoidance of extinction," (Fagan, etal) By using the 758 species from the Global Population Dynamics Database the researchers found that large percentages of species cannot be buffered against extinction by large carrying capacities because they are so likely to change. And so, they concluded that species in carrying capacity-reliant areas would benefit in larger habitats, (Fagan, etal)

Singer, Zeigenfuss and Spicer's Role of Patch Size, Disease, and Movement in Rapid Extinction of Bighorn Sheep, explains the correlation of bighorn sheep population size and persistence time. Their study showed that persistence time was strongly correlated in larger patch sizes of bighorn sheep, as well as population growths and migratory movements. They say that "habitat carrying capacity defines the upper limit to population size, clearly the amount of suitable habitat in a patch is ultimately linked to population size," (Singer, etal) They concluded that management should put more effort into increasing bighorn sheep populations in larger habitats rather than in small isolated patches of habitat, because the smaller areas cannot hold anymore sheep, (Singer, etal)

By now reading and analyzing these articles, it can be seen why researchers take the time to do these tests. Some make more sense than others. The ones that made the most impression on me were: Carrying Capacity in Overwintering Birds and Geographic Expansion of an Increasing Brown Bear Population. These were more convincing about how carrying capacity can affect an area. Looking at what Lake Sunapee can hold and realize that the biological and ecological habitats are very important in the carrying capacity aspect. The issue as to whether the lake can hold anymore fish comes to mind. Cane Lake Sunapee hold much more, and if so, what species? If we were to stock the lake with an invasive species, we might get ourselves in trouble with over population. So we need to make sure that whatever the choice will be, it will be well decided one.

Sources

Fagan, William F., Eli Meir, John Prendergast, Ayoola Folarin, and Peter Karieva. "Characterizing Population Vulnerability for 758 Species." Ecology Letters 4: 132-138.

Giesel, James T. The Biology and Adaptability of Natural Populations. St. Louis: The C.V. Mosby Company, 1974.

Goss-Custard, J.D., R.A. Stillman, W.G. Caldow, A.D. West, and M. Guillemain. "Carrying Capacity in Overwintering Birds: When are Spatial Models Needed?" Journal of Applied Ecology 40: 176-187.

Miller Jr., G. Tyler. Living in the Environment. 12 ed. : Wadesworth Group/Thomson Learning, 2002.

Odum, Howard T. Environment, Power, and Society. : John Wiley & Sons, Inc, 1971.

Shrader-Frechette, K.S., and E.D. McCoy. Method in Ecology. Cambridge: Cambridge University Press, 1993.

Singer, Francis J., Linda C. Zeigenfuss, and Leslie Spicer. "Role of Patch Size, Disease, and Movement in Rapid Extinction of Bighorn Sheep." Conservation Biology 15 (5): 1347-1354.

Swenson, Jon E., Finn Sandegren, and Arne Soderberg. "Geographic Expansion of an Increasing Brown Bear Population: Evidence for Presaturation Dispersal." Journal of Animal Ecology 67: 819-826.

Gordon Krantz

Issues of human development and Carrying capacity around Parks and Lakes

What is urban sprawl and carrying capacity by definition? According to the University of Buffalo, "(Urban) sprawl has no one definition."(A working Definition of Sprawl-Sprawl: An Overview-Publications and Presentations 1). Sprawl has been loosely defined as low-density development which is distanced from population centers (A working Definition of Sprawl-Sprawl: An Overview-Publications and Presentations 1). The Carrying Capacity Network a non profit advocacy group describes carrying capacity as, "…The number of individuals who can be supported in a given area within the natural social, cultural and economic environment for present and future generations…" (Carrying Capacity Network 1). Both these definitions of sprawl and carrying capacity are connected. They are connected because Urban sprawl development uses up existing land that organisms need in order to sustain their lives. If there lives are not sustained by the land, the organisms will begin to die off and their carrying capacity will be reached. The public must be aware of the dangers of sprawl because Urban sprawl is real and occurring in New England as we speak. When it comes to urban sprawl we don't even have to look very far to see were it is occurring. According to the EPA Urban sprawl is responsible for developing and using up1,200 acres of wetlands farms and open space each week in New England, and two acres an hour in Massachusetts(EPA 1). To the researcher these statistics seem frightening and the reality of sprawl becomes more real as land disappears at and alarming rate.

As Urban sprawl become a very real issue researcher need to look at different studies that have been done at other areas across the world in national parks, lakes and bodies of water. These studies will help in understanding the effects of recreation and human development. Studies may provide us with answers as to how a national park or lake can sustain human development and encroachment without degrading the environment.

Robert E. Manning, William A. Valierie, and Benjamin Wang of the School of Natural Resources at the University of Vermont in cooperation with Charles Jacobi from Acadia National Park helped complete a study examining human development. It specifically looked at how much human encroachment Acadia National Park could sustain without destroying the natural resources in the park, and degrading the aesthetic value of the park. They assessed human encroachment by studying how carriage roads make travel in the park more accessible to tourists which results in more tourist traffic on carriage roads. In order to do this assessment they devised four methodologies completed each year for three consecutive years (Manning, William, and Wang 101).

Four methodologies of this research study were used and each method of this study was conducted differently taking into account and compiling information from different stakeholders and visitors. The first methodology was a quantitative approach, which took into account the number of people that were visiting the park and how many people were encountered on each carriage road. (Manning, Vallerie, and Wang 101).

In the second method, visitors were interviewed and asked specific questions as to how they felt about the crowding on the carriage roads. In the third method a sample of 400 carriages road visitors were interviewed and shown specific pictures of the carriage

roads to assess what they thought represented too much crowding. The final fourth method of the study involved local residents that were interviewed and questioned as how the carriage roads should be managed in the town. Also in the fourth method questionnaires and cameras were set up which took pictures of the density of people on different roads. The pictures were then incorporated into a questionnaire, which included questions as to what people thought of each photo and how crowded each carriage road looked (Manning, Vallerie, Wang 101).

The conclusion of this study described that the researchers found measurements crowding norms to be differed substantially depending on which measurement they used whether it was quantitative, or through interviews of visitors and town stakeholders. They also found that resulting data from the three year study yielded more information from visuals, questionnaires and interviews than information that could be used in a short study that was numerically done (Manning, Vallerie Wang112).

In light of this research it seems to directly apply to how the LSPA could study the relative impact of development and how the Acadia National Park study formally assessed the carriage roads for human encroachment. The LSPA could sample the density of people at specific locations around the lake at the height of the tourist season, and gather insights from people who on the shores of the lake or near by. Then the LSPA could figure out how much human encroachment the lake could sustain before environmental degradation occurs. The LSPA could observe the study of the carriage roads in Acadia National Park and construct a similar study for the roads leading to the lakes beaches or trails around Lake Sunapee by gathering information on road use and how it leads to human encroachment and development on the shores of Lake Sunapee. The LSPA could benefit from understanding or using certain methodologies like the longitudinal study used in Acadia National park. The LSPA may also consider the positive results of a longitudinal study and how it takes into account crowding norms and other variables (Manning, Vallerie Wang 98, 112). The LSPA may also consider how recreation can be managed without environmental degradation. Crowding norm and human encroachment may be important to devising a plan that address the sustainability of Lake Sunapee, but residential and commercial development along the sores of lake are another concern in terms of how the lakes environment is effected. The next article summary discusses specifically how an organization in Ontario Canada addresses this issue of development around its lakes. One can draw a connection between how development is being managed in Ontario and how the LSPA can work with developers to sustain the natural beauty and environment around Lake Sunapee.

Randy French, and Ian Gilmour write about a non profit organization in Ontario Canada which is geared towards education with specific goals of protecting and preserving lakes. This organization emphasizes Lake Plans and official Plans. The definition of a Lake Plan is a plan that evolves “a Comprehensive lake-wide approach to ensure development fits the context of a lake environment.”(French Gilmour 1-2) There specific criteria for a Lake plan:

- “Identifies the special character of the Lake”
- “Consolidates information about past and current state of the lake”
- “Produces future direction concerning lake development”
- “Educates lake community members.”

- "Produces policy that may be used in a municipal level official plan" (French Gilmour 1-2)

This organization not only views lake plans as the only way to protect lakes but it also offers another plan which acts as a contract for residents and land owners around the lake. This official plan is a contract that residents and landowners make with municipal counsels and developers to decide were and how development will be structured around the lake. This proactive approach of involving residential and commercial stakeholders may increase the communication between the stakeholders and may lead to projects which benefit the community as well as the developers. This approach may be pertinent to how the LSPA works with stakeholders around Lake Sunapee. If the LSPA can help town residents and developers communicate directly in a civil manner, then development projects could be changed and made to address the needs of developers as well as the residents. Too often the residents are unable to effectively communicate with developers and sometimes developers do not even want to listen to the townspeople. Working together with the developers and the townspeople will help to ensure that sustainable development is built around Lake Sunapee (French Gilmour 1-2).

This site also mentions carrying capacity as a one of the factors that determines how much development or recreational activity a lake can sustain before environmental degradation of The lake occurs (French Gilmour 1-2).

This article seems to place a great deal of emphasis of focusing on a comprehensive plan for stakeholders and local government to direct, limit and describe how development will occur. Both official and lake plans address the development pressures at a local level.

After reading this article one realizes that this methodology may be good for the LSPA to look at when assess and manages future development within the watershed. Issues from continued development will most definitely cause the LSPA to formulate new ways of working with the residents of each town within the watershed and the developers in focusing were development would occur and formulate new policies at the municipal level. Along with initiating new policies the Acadia Study may provide incites into how much crowding lake Sunapee can sustain without degrading the environment for visitors. Analyzing the best tools and methods for measuring crowding norms in the Acadia National Park Study could yield a study similar to one on Lake Sunapee.

The Literature in the Study of Acadia National Park Recommends that many different studies yield good results for determining crowding norms such as the quantitative approach, the number of people in a given areas, or qualitative approach, interviewing and surveying people who live or vacation to Acadia. but they emphasize a study that includes a visual approach showing pictures of crowding in the park to people and having them determine what they believe is too much crowding. The Visual approach consisting of surveys and Interviews with people along with asking them questions that pertain to how much crowding they tolerate yields the best results for determining crowding norms and give the researcher a better feel as to which areas of the park need to be protected.

In order to further research of crowding norms, researchers might try this study in other areas of the United States or across the world to see what the results are. A comparison of different locations across the world would give researchers a better idea of how other populations in different areas of the world view crowding norms. The Acadia

National Park study may be good for areas like Acadia, but when compared to other national parks like Glacier National Park in Montana, Glacier's Parks crowding norms may differ from Acadia's or vise versa. If the conditions of this study are replicated in different areas of the world, then more analysis can be made of different susceptible areas around the planet.

Sources

"Addressing Concerns for Water Quality Impacts." Aug 1999. 08 Mar 2004. http://www.ijc.org/php/publications/html/aquaculture/summary.html

"A working Definition of Sprawl-Sprawl: An Overview-Publications and Presentations." 1998-2002. Institute for local Governance and Regional Growth, University of Buffalo. 29 Mar 2004. http://Regional-institue.buffalo.edu/publ/spra/defi.html

Brown , Mark Crisman,Thomas. "Sustainable Development/Appropriate Technologies ." 08 Mar 2004. http://www.cfw.ufl.edu/Environmental%20policy.htm

"Carrying Capacity Network Publications." 23 Mar 2004. Carrying Capacity Network. 29 Mar 2004. http://www.carryingcapacity.org/pubs.html

Chilman Kenneth, Titre john, Vogel James, Brown Greg "evolving concepts of recreational carrying capacity management." 08 Mar 2004. http://www.prr.msu.edu/trends2000/pdf/chilmanCC.pdf.

French Randy Gilmour Ian. "To Consult or Not to Consult" The Federation of Ontario cottage Associations. 08 Mar 2004.

Grapentine, Lee, Chris Marvin, and Scott Painter. "Initial Development and Evaluation of a Sediment Quality Index for the Great Lakes Region." Human & Ecological Risk Assessment Dec 02. 08 Mar 2004 http://search.epnet.com/direct.asp?an=8886106&db=aph

Manning, Robert, William Vallerie, and Benjamin Wang. "Crowding Norms: Alternative measurement Approaches." Leisure Sciences Apr 99. 08 Mar 2004 http://search.epnet.com/direct.asp?an=3860246&db=aph

Peyton, Fleming. "EPA New England Press Release." Feb 2 1999. Environmental Protection Agency. 29 Mar 2004. http://www.epa.gov/region1/pr/1999/020299.html

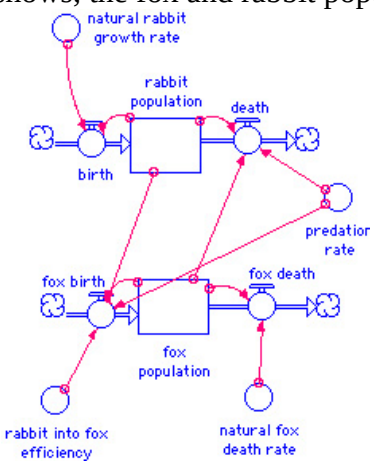
"Smart Growth - Environmental Impacts of Growth and Development." Jun 20 2001. 08 Mar 2004. <http://www.pca.state.mn.us/programs/smartgrowth/>.

The League of Women Voters of Michigan. 08 Mar 2004. http://www.lwvmi.org/p_glakes.htm

Population Dynamics **Paul Barrile**

Population dynamics is characterized as the study of how many variables affect a population of either a particular species or a few different species. Many variables go into determining what the carrying capacity of a population of a species can be in a particular area. More often than not these variables include the abundance of food, suitable habitat, competition with other species or populations, and effects caused by predators or prey.

Predator and prey are very closely related when it comes to their populations. One can not exist successfully [although they can exist] without each other. As this chart shows, the fox and rabbit populations are interrelated.



(Note how the arrows indicate that the rabbit death rate is a function of the fox population and the fox birth rate is a function of the number of rabbits available.)

(Maher 3)

When looking at the effects of wolf recolonization on elk populations in the Banff National Park in Northwestern Canada, Hebblewhite, Pletscher, and Paquet considered many variables. With an area deemed high wolf density, mid density and low density, the group used variables such as snow depth, whether the Trans-Canada Highway was fenced or not in the zone, and human-caused mortality to determine what the effects of each was on the elk population growth rate. The carrying capacity of elk was 450(~10 elk/km^2). What was determined was that wolf predation was an important limiting role of the elk populations. Furthermore, the study showed that, "Snow only impacted elk in combination with predation and that increasing snow depths increased wolf kill rates," (Hebblewhite, Pletscher, and Paquet 3). The main limiting factors of the elk populations since wolf recolonization was found to be wolf predation and snow depth.

Another study that looked at predator-prey dynamics was done on the dynamics of small mammals and owls in semi-arid Chile taking into account the effects of climate. In this study by Lima, Jaksic, and Stenseth tried to determine if population dynamics of small mammals and predators was positively correlated with rainfall. What was found was that food was the ultimate determining factor for the small mammals at during times of high rainfall when food, such as insects were more abundant, the populations would grow tremendously, giving the owls more food as well and allowing their populations to thrive. (Lima, Stensteth, and Jaksic 280-281).

Population dynamics is not just limited to predator/prey interactions; it ca also be an association between a species and its habitat. Hayes, Ferreri, and Taylor looked at how the lake whitefish populations are related to the habitat available to them. Their goal was to, "Illustrate how changes in the fish habitat can be integrated with changes in fish

growth, survival and reproduction through a stock-recruitment relationship," (Hayes, Ferreri, and Taylor 383). They classified aspects of the habitat as consumable or non consumable. Consumable aspects would be aspects that can be depleted by fish usage such as prey resources while nonconsumable aspects would not be depleted by fish usage such as temperature. "In general consumable resources can control fish populations through density dependent regulation because as the amount of fish increases the amount of the resource decreases," (Hayes, Ferreri, and Taylor 384). The consumable resources will help to determine what the carrying capacity of a certain habitat area will be. If for instance young fish need thick cover to be able to hide from predators, and only a set amount of thick cover is available in a particular area, only a certain amount of young fish will avoid predation. Similarly if a certain temperature range or oxygen level is needed for eggs to properly develop and those two factors vary too much in one area but not as much in another, the first area may only produce a few fish while the second will produce more. What was found in this study was that, "For Lake Whitefish, the survival of eggs depends largely on substrate size and the amount of ice cover during the winter," (Hayes, Ferreri, and Taylor 387). The ice layer protects the eggs from waves that could send the eggs into open water where they would be quickly consumed by other fish trying to find food in the coldest months. Suitable areas are going to be seeked out by all fish however and not just the whitefish. Therefore the actual number of suitable habitat will be lower than what actually exist in the body of water because of competition form other species also trying to find areas that their eggs will be safe until hatching or where food is abundant.

Population dynamics is an interesting as well as challenging aspect to study. It attempts to take into consideration variables outside of the population in order to determine what the population will be. When looking at how predator and prey interact, it can be said, as is in the explanation of the Lotka-Volterra Model, that a prey species, without predation will grow exponentially and a predator species without prey will do the opposite.(Beals 1). Because of this each species needs the other to help and keep their populations constant. Although it seems that they are against each other at times, they benefit from having the other around. They in turn determine each other's population. When looking at how a population is linked to its habitat, it becomes obvious that without the right aspects the species can not live there and conversely if the population becomes too great the habitat will not be able to support the population. They both must find a common ground so that both habitat and the species living in the habitat can exist in numbers suitable for the ecosystem. Nothing on this planet can live completely without influence from other organisms and because of this, both plant and animal, predator and prey, must rely on each other to help keep constant the dynamics that help to make their respective populations.

When looking at Lake Sunapee and its watershed, carrying capacity and population dynamics can be helpful tools. When looking at the declining fish populations, it may be worthwhile to try and determine the relationship between the game fish, the baitfish, the amount of suitable habitat and the relations between game fish and rock bass. This may help to shed some light on why the game fish are having trouble building up there numbers. The relationship between the amount of people and the amount of forested land, which is the habitat to all the terrestrial animals found in the watershed holding all other variables constant, will most likely show a direct connection between an increasing

population of humans and a decreasing number of forested lands. As people become more common the habitat lessens for the animals. Although populations of animals may not be a problem right now, it could in the future and by determining what the carrying capacity will be for populations of people and the different animal species, we may be able to say at a certain point that no more development can occur in the watershed because it will start to have negative effects on the wildlife and the water quality in the watershed of Lake Sunapee

Works Cited

Beals, M., L. Gross, and S Harrell. "Predator-Prey Dynamics: Lotka-Volterra." Updated 1999. http://www.tiem.utk.edu/~gross/bioed/bealsmodules/predator-prey.html

Hayes, Daniel B., C.Paola Ferreri, and William w. Taylor. "Linking Fish Habitat to Their Population Dynamics." Canadian Journal of Fishery and Aquatic Science 53 (Suppl. 1) 1996.

Hebblewhite, Mark, Daniel H. Pletscher, and Paul C. Paquet. "Elk Population Dynamics Following Wolf Recolonization of the Bow Valley of the Banff National Park." http://www.ualberta.ca/~mh12/RLinks.pdf

Lima, Mauricio, Nils C. Stenseth, and Fabian M. Jaksic. "Food Web Structure and Climate Effects on the Dynamics of Small Mammals and Owls in Semi-Arid Chile." *Ecology Letters*, (2002) accessed via Ebscohost

Maher, Jr., Harmon D. "Population Dynamics and Carrying Capacity." http://maps.unomaha.edu/Maher/linked/week3/day8.html

Moloney, K. "A Menagerie of Population Dynamics." http://www.public.iastate.edu/~kmoloney/Shared/menagerie.html

Myers, Ransom A., Brian R. MacKenzie, Keith G. Bowen, and Nicholas J. Barrowman. "What is The Carrying Capacity for Fish in the Ocean? A Meta –Analysis of Population Dynamics of North Atlantic Cod." Can. J. Fish. Aquat. Sci. 58(2001). Accessed via Ebscohost.

Carrying Capacity: Sprawl, Density, and Development **Greg Van Steinburgh**

When examining the topic of carrying capacity, developmental trends such as sprawl and density are important characteristics. According to The David Suzuki Foundation "Sprawl has severe economic, social and environmental costs. Sprawl causes air pollution, water pollution, habitat destruction, climate change, congestion, traffic accidents and loss of productive farmland."

Recently, environmentally minded countries have begun to examine the problems associated with sprawl and development to try to save money. The editorial notes that the greater Toronto area will lose 69 billion dollars in the next 25 years to sprawl. The numbers are based on cleaning up pollution, improving transportation, and over 2 billion dollars a year from lost productivity from gridlock traffic. Canada also recognizes that sprawl costs can include: lost farmland, increased greenhouse gas emissions from cars and trucks, increased respiratory diseases, impaired lung function, and rising rates of asthma. Air pollution costs billions of dollars annually in hospital visits and services, as well as time missed from work (Toronto Star)

Hong Kong has also considered sprawl when looking into development for the future, and has taken appropriate measures to prevent pollution. With more than 6.8 million people crammed into an area smaller than the greater Toronto area, density is an important development technique. Housing developments can be up to 70 or more stories and house thousands of people, (Hume)

One way Hong Kong has worked to control this problem is the use of public transportation by its citizens. They based their infrastructure around public transportation and made it more costly and inconvenient to use cars. By doing this they greatly reduce pollution as well as making transportation more convenient. Less time is wasted sitting in traffic and more time is spent working, thus raising efficiency. Though utilitarianism has caused a lack of open space and parks, especially in the heart of the city.

Effects in the U.S. have been seen similarly, with many problems arising associated with sprawl, (Thomas) Architect Frank Lloyd Wright stated that the ideal human density would be 1 acre per person, far from many of the urban areas in the country. Although his plan seems ideal, many of the by products of this idea would be more traffic jams, strip malls, and fast food restaurants. So, being spread out really just encourages people to travel much more than they need to.

Oregon's Department of Land Conservation and development compiled statistics that help depict the problem of sprawl, (Staley). From 1970 to 1990, population density in the U.S. decreased by 23%. From 1969 to 1989, the population of the United States increased by 22.5 percent. The number of miles driven by that population, ("vehicles miles traveled" or "VMT") increased by 98.4 percent. This study focused heavily on the excess costs of sprawl, because there is more infrastructure to maintain. Sprawl is also often a result of poor planning, which can be costly in the future.

These figures have cause 19 states to form state management laws or task forces. The Clinton administration even felt that it was necessary to make the concept of development sprawl a federal issue. However, the National Center for Policy Analysis seemed to think that it had become less of a problem.(NCPA, 2001) They make many points to make the problem of sprawl and population density seem like it is no longer an

issue. The article focuses on how sprawl is a thing of the past and that in the future, planning will help prevent it. However, other statistics point in the opposite direction.

Sprawl and density are interesting topics when related to carrying capacity. There are many different perspectives about limitations and how many people are too many. Is it up to the people of the area to decide how their space will be developed? Or should their be federal regulations that restrict sprawl or restrict over density? In any case, sprawl has been directly linked to many financial problems as well as environmental issues. It may simply be the ideals of our nation that freedom and space are more important than sustainability.

Bibliography

Diskin, Colleen. "New Jersey Governor's Weapon vs. Suburban Sprawl: 1 Percent 'McMansion' Tax." The Record 02 25 2004. 08 Mar 2004 <http://search.epnet.com/direct.asp?an=2W63533350319&db=nfh>

Hume, Christopher . "Hong Kong's vertical villages an inspiration." Toronto Star 02 21 2004. 08 Mar 2004 <http://search.epnet.com/direct.asp?an=6FP2883152654&db=nfh>

O'Horan, Kevin. "Official Threatens Sarasota County, Fla., Proposed Village Development." The Bradenton Herald 02 20 2004. 08 Mar 2004 <http://search.epnet.com/direct.asp?an=2W61723277837&db=nfh>

"New Deal Needed for Sustainable Cities." Toronto Star 02 06 2004. 08 Mar 2004 <http://search.epnet.com/direct.asp?an=6FP1713803659&db=nfh>

Thomas, G. Scott. "Low density development sprawls across the nation." Washington Business Journal 06 08 2001. 08 Mar 2004 <http://www.bizjournals.com/washington/stories/2001/06/11/focus8.html>

"Indicators of Urban Sprawl." 05 10 1995. Oregon Department of Land Conservation and Development. 08 Mar 2004. <http://darkwing.uoregon.edu/~pppm/landuse/sprawl.html>.

Staley, Samual. "The Truth about Urban Sprawl." 03 24 1999. National Center for Policy Analysis. 08 Mar 2004. <http://www.ncpa.org/ba/ba287.html>.

Stacey Philbrook

Water and Trash: Problems Rise as the World Inches Closer to Global Carrying Capacity

Human carrying capacity is an immense issue facing the world today. As global population continues to grow each year, more concerns arise about the earth's limited space and natural resources. Optimists believe that technology will continue to save us from threats that exist about a so called 'carrying capacity' while skeptics feel we must take bold steps in order to allow ourselves a guaranteed future. Both groups, though having opposite opinions on the matter, agree that precious resources such as water must be managed properly because it is an essential part of human existence (Pulliam 1). Other issues are not so easily agreed on and it is hard to prove who is right until that irrevocable day arrives.

"Our water resource is no less important than oil and gas," explains Qazi Qumaruzzaman, chairman of the Dhaka Community Hospital in Bangladesh, a country that is feeling the effects of a decline in freshwater resources (Worldsources, Inc 1-3). Previous decisions on how to manage water in Bangladesh are beginning to fall short, leaving the country's people frantically trying to rectify the situation. Management of local surface water bodies and rivers will be imperative for Bangladesh to maximize utilization of this precious resource. Qumaruzzaman also believes that if rainwater is carefully administered it can potentially meet year round requirements. In addition to the shortage concern, arsenic is widely used in chemical fertilizers creating supplementary contamination problems. Water is not only indispensable for everyday life in Bangladesh but it also is the base of agriculture which is the countries leading commodity in the international market (Worldsources, Inc 1-3).

Another occurrence of the depletion of freshwater supplies in Palestine offers further supporting evidence for the skeptic viewpoint (Costanza 149-156). Palestine and its neighbor Israel have been in quarrel over water right usages since the late 1800's. Currently Israel takes 85% of Palestine's water that is produced by the West Bank aquifers and also denies Palestine's right to utilize the Jordan and Yarmouk Rivers, which both countries are riparians of (Isaac 13, 19). Overall Israeli per capita basis of water consumption is more than four times as much as Palestinians. The diminutive amount of water that Palestinians can access from the lower Jordan River is of very poor quality due to extremely high salinity and nitrate levels far exceeding the World Health Organization standards (Issac 13, 19). This situation seems to foretell what will happen when water resources are stretched to their ultimate limit. Smaller or less dominant countries will be forced to suffer the consequences of centuries of water misuse and waste (Harrison 1). This situation, should it arise, will confirm the fear that someday the earth will not be able to support an ever-increasing human demand on natural resources.

Another demand that humans put on the earth is the amount of trash that is produced around the globe. Products are constantly being designed for easy one time use and disposal. Instead of trying to reduce the amount of waste per person we are increasing it. So as population levels grow, an increase of waste is being confined to smaller and smaller areas.

In one such case, the Live Oak landfill in Atlanta only has one option and that is to build up. With limited space this landfill has become a towering mountain in order to make room for the tons of garbage that it receives. Several disgruntled locals have fought against the landfill and to their satisfaction have won a court order that will force the closure of Atlanta's largest dump at the end of 2004 (Curry 1-2). Patricia Curry, a local resident, who's home resides in a sub-division nearby is elated with the news. "This is not an area for a landfill…it's getting too residential," she explains (Curry 1-2). The stench of the landfill seems to be the number one compliant from locals but Brad Gardner, Vice President of Waste Management, claims the company has taken steps to correct this issue. He stresses that Live Oak works closely with the surrounding communities and has invested millions of dollars in new technologies to control the gases that cause odor. Gardner fears that closing the dump will only bring new problems to the community such as increased traffic and air pollution from the trucks that will have to carry waste outside the city (Curry 1-2).

No one wants a dump in his or her backyard, but as limited space will become more and more of an issue in the future, this may become unpreventable. Unless of course, technology can produce a solution. In the 1980's garbage incinerators where the new hype and a seemingly easy way to get around the issue of space needed for landfills. It wasn't until 1995 that the Environmental Protection Agency finally got a chance to crack down on these incinerators, which were releasing large amounts of nine different pollutants into the air (Environment CustomWire 1). Though these incinerators appeared to be an efficient solution at first, they too have negative health, aesthetic, and environmental affects. New rules were release by the EPA in 2000 after an appeal was made in 1996 pertaining to the industry's argument that there should be different standards for both small and large incinerators (Environment CustomWire 1). This translated means that the larger incinerators wanted to be allowed more leeway in its pollution control because it was costly to fix such problems.

These two issues will be placed under higher stress as global population creeps closer and closer to carrying capacity levels. Technology will in some cases be able to present a solution but often times these new technologies create problems of their own. Resources such as water will become increasingly precious to countries for use by its citizens and their economies. Competition for this resource will most likely result in brute force and not civil negotiations.

Though these previous issues are very extreme, they do bring a message to the Lake Sunapee Watershed. The lake is a very valuable resource for many reasons, but in respect to human existence, it is a necessity. Being the second largest lake in the state, it will not only be looked on as a water resource for the watershed towns but for the surrounding communities as well. If, by extreme misfortune, New Hampshire is struggling to meet the water needs of its citizens, both Lake Sunapee and Lake Winnipesaukee will be heavily relied upon as a drinking source. For this reason, we must make sure that both lakes are used with caution and care, so that we do not pollute these valuable resources to the point where they will not be useful to us.

The same message can be taken away from the trash issue. The watershed does not want to put itself in a position where trash has this much of a negative effect on surrounding residents. Therefore we should make efforts to bring recycling to New Hampshire as a way to reduce the amount of trash produced. Also, residents should be

informed that wasteful practices should be minimized as a way to reduce the amount of effects excessive trash could have on the local waste management centers and their surrounding water bodies.

Sources

Applied Research Institute-Jerusalem . 05 Mar 2004. http://www.arij.org/pub/wconflct/

Costanza, Robert. "Managing Our Environmental Portfolio." Bioscience February 2000: 149-156.

"Court: Incinerator Rules Inadequate." Environment CustomWire 3 25 2004.

Curry, Patricia. "Analysis: Landfill closing in Atlanta." Morning Edition (NPR). Atlanta: National Public Radio, 3 18 2004: 1-2.

Greenpeace Australia Pacific. 05 Mar 2004. http://www.greenpeace.org.au/toxics/incinerators/

Harrison, Paul . Committee for the National Institute for the Environment. 05 Mar 2004. http://www.cnie.org/pop/3rev/blame.htm

Isaac , Jad . "The Essentials Of Sustainable Water Resource Management In Israel and Palestine." Arab Studies Quarterly Spring 2000: 13,19.

Pulliam, H. R.. 1994. Ecological Society of America. 04 Mar 2004. http://www.sdsc.edu/~ESA/bulletinhumanpop.htm

"Rachels Environment & Health Weekly." 24 July 1987. 05 Mar 2004. http://www.monitor.net/rachel/r35.html

“Water Issues.” December 1999. 05 Mar 2004. http://www.au.af.mil/au/aul/bibs/mideast/midest11.htm

Worldsources, Inc. "Water management need of the hour: seminar told." The (Bangladesh) Independent (2003). 04 Mar 2004: 1-3

Population Growth **Joe Jennings**

Carrying capacity is the "maximum number of species that can be supported indefinitely by a particular habitat, allowing for seasonal and random changes, without degradation to the environment and without diminishing carrying capacity in the future," (Hardin, 1). According to some organizations and experts, we as a country, and as a global population, have already exceeded our carrying capacity. Others believe that we still have a distance to travel before our carrying capacity will truly be tested and that technology will be able to find solutions to all our problems, such as lack of resources, and the degradation of the environment. Possible outcomes of an exceed in carrying capacity include the exhaustion of non-renewable resources (natural gas, oil, coal, etc.), desertification, overgrazing, degradation of the land, world-wide famine and water shortages, poverty, and the rapid decline in the quality of earth.

Current global population estimates exceed six (6) billion. The United States has a population of close to 300 million. Predictions indicate that at current growth rates, by 2050 the world population will have increased by more than 50%, and the United States could possibly have a population nearing 600 million within the next sixty years (Pimentel, Giampietro, 2). With these additional people, comes the need for more resources, i.e. shopping, food, transportation, etc. This is commonly referred to as an individuals "ecological footprint". This is an estimate on the number of acres an individual or country needs to support the lifestyle lived. Not surprisingly, Americans have the highest footprint in the world, at over thirteen acres needed per individual. This compares to Canadians needed just over eight acres to fit their lifestyle. The United States has roughly five (5%) percent of the world's population, but consumes over twenty-five percent (25%) of its resources. The United States also exhausts resources at a much higher rate than other countries and cultures of the world (Hardin, 3).

Presently, carrying capacity and the overpopulation of the world are very controversial topics. A method of setting a limit on population and an attempt to control/reduce the growth rate are debated by all. Major questions/concerns include, does a country have the right to disallow/limit the number of children an individual/couple can have? Is it more important to get national populations stabilized before the world as a whole? Or is it going to take a joint world-wide effort to lower populations and reduce the growth rate?

Or should the focus and prevention of further increased be focused on the immigration process of the United States? Currently, immigration accounts for around seventy percent (70%) of the yearly addition of three million people to the United States (NPG, 3). An increase in the number of immigrants entering the United States has risen steadily since the mid 20th century. People were simply not being turned away. The terrorist attacks on September 11, have helped to lower the number of immigrants let into the United States, but this number still needs to decrease to mid-20th century numbers which were roughly less than half of what they are today.

Another major concern is the fact that the majority of the world-wide population today is under twenty-five (25) years of age, meaning they haven't yet had children, or have just begun to have children. This is a cause for concern due to the potential of this younger generation reproducing in large numbers. Such a large number of new people

would further increase the amount of resources needed for survival as well as the ruining of vital farm land/forest/etc to make room for an expansion in population.

An organization called the National Population Growth (NPG) is a national membership organization that has been around since the early 1970s. Its goals are to educate the American public and political leaders about the detrimental effects of overpopulation on the environment, resources, and quality of life. The NPG has been studying the growth rate, the degradation of the environment, and the slow yet steady decline in quality of life. The NGP hopes to some how lower the population of the United States back down to less than 200 million, and lower the Earth's population to less than three (3) billion (NPG, 3). Both estimates are considered the optimal capacity for the earth to support, and ensure the sustainability of the earth for future generations. This would also help resources replenish themselves more regularly and without the strain of over yielding the land, crops, the water, etc.

At current rates, our world could be in a state of emergency in as little as 20 years. This is according to some, while others give the earth more than another 200 years before resources begin reaching dangerously low levels, food and water shortages, and the exceedence of our carrying capacity (Abernethy, 6). Something needs to be done to determine how many people are going to be too many people, because if we as a world-wide population wait for the outcome, we already would have sentenced our own deaths and the ruining of the world. Some effort needs to be given into finding possible reductions in the population and the amount of resources we all use and take for granted. If none is gives, we have sentences ourselves and future generations to death.

Sources

Abernethy, Virginia D. "Carrying Capacity and the Tradition and Policy Implications of Limits." Science and Environmental Politics 1 (2001). 06 Mar 2004 www.mnforsustain.org/abernethy_v_carrying_capacity_policy and_limits.html

Crump, Lyndsay. "Exceeding Carrying Capacity." Mixed Environment Committee. 06 Mar 2004 www.cowac.org/studyguidemecapr2003.html

Hardin, Garrett. "Ethical Implications of Carrying Capacity." 1977. 06 Mar 2004 www.dieoff.org/page96.html

Jaap, Walter C. "Florida Keys Carrying Capacity Study." (2003). 06 Mar 2004 www.pillar.saj.usace.army.mil/projects/julyatt_1.html

"NPG - FAQs." Negative Population Growth. 06 Mar 2004. www.npg.org/faq.html

Pimentel, Drs. David , and Mario Giampierto. "Food, Land, Population, and the U.S. Economy." Food, Land, Population, and the U.S. Economy Aug 2001. 06 Mar 2004 www.carryingcapacity.org/resources.html

"What is NPG?" Negative Population Growth. 06 Mar 2004 www.npg.org/faq.html