Chapter 13 - Carrying Capacity

Highlights

This chapter discusses the concept of carrying capacity and its usefulness in setting limits or targets for goose populations. It contributes to Goal 5, integrating population, temporal, and spatial information and objectives into a strategic direction to inform management planning for the region.

Carrying capacity is often defined as the size of the population that can be sustained without degrading the health of the animal or its environment. It suggests there is an ideal number of animals, below which no damage would occur. It assumes that the environment establishes a limit to the growth of populations, and that populations grow until they stabilize at the limit. In practice, carrying capacity is very difficult to assess. Out of 342 sites identified as available goose habitat, geese were observed on only 232 of them, and flocks were frequently concentrated on only a handful of sites. Although mid-island estuarine marshes have been unable to sustain goose populations without degradation, it is unlikely that Canada Geese have exceeded the carrying capacity of the region, or that ecological factors will soon constrain the growth of goose populations.

We have likely exceeded our social carrying capacity for Canada Geese, as populations have adversely affected the tourism and agricultural sectors, sports and recreation, and the overall quality of life of community members.

Alternative measures to carrying capacity, such as Limits of Acceptable Change, Limits for Defining Change in Ecological Character, and Thresholds of Potential Concern, have been used in other jurisdictions to assess various environmental conditions and socioeconomic tolerance for change. These hold some promise for managing locally overabundant Canada Geese and affected resources or assets.

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13.1 Biological Carrying Capacity

Canada Geese on the lower Little Qualicum River estuary (upper) where tall sedges growing on a thick marsh platform have been replaced by Sea Milkwort *(Glaux martiima)* and algae over gravelly substrates (lower).

Some have suggested that the degradation of the marshes has occurred because the number of geese have exceeded the carrying capacity of the estuaries or the region, and recovery will require reducing populations to a capacity that these areas can support (e.g., Dawe & Stewart 2010; Dawe et al. 2011).

Carrying capacity is often defined as the size of the population that can be sustained without degrading the health of the animal or its environment (Wagar 1964 in Cole & Stankey 1997; Cole & Stankey 1997; Freedman 2004). Yet, it is an elusive concept (Price 1999). Do populations grow to carrying capacity, or far beyond them? How are the boundaries of this environment identified? What indicators and thresholds are used to establish that the health of the population or the environment is diminishing? When the population is distributed over several types of habitats, on what basis is carrying capacity determined? Social factors such as family sizes or age structure of the population influence distribution and abundance, so what effect do they have on carrying capacity?

There is inherent complexity in identifying constraints on populations, and how these constraints operate (Price 1999). Every population is restricted in its growth potential by a range of conditions, such as the food supply, competition, predation, disease, parasites, and environmental variability, as well as by the dynamic interactions of these factors (Williams et al. 2001; del Monte-Luna et al. 2004). What conditions are limiting our regional population or subpopulations, and how resilient are they to shifts in these conditions?

There are two major assumptions underlying the concept of carrying capacity: that the environment establishes a limit to the growth of populations, and that populations grow until they stabilize at the limit (Price 1999).

Canada Geese are 'leveling species', meaning that population sizes and densities tend to fluctuate within narrow limits but are otherwise relatively stable (Perrins & Birkhead 1983; Price 1999). Occasionally, leveling species grow wildly, such as when they are introduced into habitats with a vast abundance of resources but few predators or parasites. In these cases, populations tend to grow until resources are exhausted, causing them to crash (Price 1999).

Quebec's Greater Snow Goose Management Round Table reported, "these species [i.e., overabundant Greater Snow Geese] are not subject to nature's regulation; that is, their populations are not controlled by the carrying capacity of their environment, by competition or predators, or by the impact of human activities such as hunting or habitat encroachment" (Anonymous, 2013, p. 1). Truth or rant, this could also apply to Canada Geese.

It is also questionable whether the local environment establishes a limit to the growth of goose populations.

In their study of the carrying capacity of marshes for moulting geese in Greenland, Madsen et al. (2011) directly linked the condition of the marshes to carrying capacity, and certainly, few ungrazed areas and the loss of the marsh platforms are evidence of excessive numbers of geese on our estuaries. It is possible that the number of birds the area can support is limited by the condition of the estuarine marshes. These marshes are used year-round, and the greatest numbers of geese coincide with the highest levels of primary productivity on the estuaries, i.e., during the moult. Most upland sites are vacant at this time.

In a study of freshwater wetlands in Ohio, Brasher, Steckel, and Gates (2007) found that energetic carrying capacity for waterfowl declined each year by more than 80% between autumn and spring migration, a direct result of granivory (i.e., feeding on seeds and grains) and vegetative decomposition. While we have not investigated precisely when most grubbing of marsh platforms occurs, we expect the overwintering and spring migration periods are key times. Estuarine marshes are critical habitats when other areas are frozen.

Carrying capacity may be more broadly limited by the availability of freshwater, which in our area is restricted to select streams, springs along the foreshore, freshwater marshes, lakes, ponds, and estuaries. Although we have not classified estuaries as a freshwater habitat, they are of course linked to streams and also have a freshwater lens on their surface that diminishes towards the marine environment. Canada Geese need freshwater for drinking and depend on these habitats for critical life stages, such as nesting and moulting. Barker, Cumming, and Darveau (2014) found that the abundance and distribution of most waterfowl species can be predicted most frequently by hydrological variables.

Yet, outside of the moulting period, our estuarine sites are part of larger 'habitat complexes' that include nearby meadows or lawns. Rarely are most suitable sites occupied or all available food eaten. Out of 342 sites identified as available goose habitat, geese were observed on only 232 of them. Flocks were frequently concentrated on a relative handful of sites. Sometimes geese were clustered on one site, but avoided a nearly identical site nearby, for no apparent reason. With an abundance of vacant potential habitat, it is unlikely that we are nearing a regional carrying capacity. Similarly, despite known problems with Canada Geese and a harvest surplus in excess of 20%, Puget Sound was declared to be well below carrying capacity (USDA 1999).

And, if carrying capacity were linked to estuarine ecosystems, the poor condition of the marshes should be suppressing carrying capacity, yet there is some evidence to the contrary, i.e., decreasing numbers of nests at the LQRE which is rehabilitating, and increasing numbers at the ERE where restoration is sorely needed. (Keep in mind that numbers of nesting birds at the LQRE are probably dropping due to the effect of addling, more than the condition of the estuary.)

To determine whether the condition of estuarine marshes is limiting or even influencing carrying capacity, we would need to track geese 24/7 using telemetry, calculate how much time they spend in each habitat, and analyze and compare the composition and nutritive quality of the vegetative resources in each habitat.

Additionally, the notion that reducing populations below a specific number will solve our problems, is ripe with complexity. If the 'too many geese' problem is related to 'too much goose habitat', then we may in fact need to significantly reduce the carrying capacity of non-estuarine habitats to revive estuarine ecosystems - by modifying grassy and ponded areas, altering farm practices, and implementing other control techniques. Yet there is a risk that reducing habitat elsewhere may inadvertently increase use of the estuaries.

Price (1999) noted, "carrying capacity is supposed to be a natural limit that regulates the growth of populations, but its existence is hard to document apart from its presumed effect (p. 18). Less complex, but not uncomplicated, is the concept of social carrying capacity.

13.2 Social Carrying Capacity

Canada Goose in Parksville Community Park

In most Canada Goose management strategies and plans, population targets are based on social carrying capacity, not biological carrying capacity. This is sometimes called 'wildlife acceptance capacity' or 'cultural carrying capacity', and is the maximum population that is acceptable to people (USDA 2004). Here, it is clear that Canada Geese have adversely impacted our communities in many ways, affecting the tourism and agricultural sectors, sports and recreation, and the overall quality of life of community members. With tourists saying they'll never return because of the prevalence of goose feces; locals refusing to swim, walk and golf in favourite areas; and potential risks to the health of children and the elderly, it is clear that local goose populations have reached intolerable levels. Some of the more vociferous community members have stated that the geese are invasive and populations should be reduced to zero. We have likely exceeded our social carrying capacity for Canada Geese.

13.3 Alternatives to Carrying Capacity

Disagreement over the concept of carrying capacity engendered the Limits of Acceptable Change (LAC) and other measures that may be useful in assessing environmental conditions and the socioeconomic tolerance for Canada Geese. Developed by the U.S. Forest Service in 1985 (Cole & Stankey 1997), the LAC assessment was founded on the notion that capacity is a relative concept rather than an absolute number (Ashor 1985). LAC were designed as compromises, to balance conflicting recreation and wilderness protection mandates (Brunson 1997). As such, the assessment involved determining which conflicting goal would ultimately constrain another, identifying standards - absolute limits defining minimally acceptable conditions (not desired conditions or unacceptable conditions), monitoring to determine whether the standards have been met, and developing appropriate management prescriptions for when the standards are not met (Cole & Stankey 1997).

Using LAC, Canada Geese would be managed in accordance with limits set for the region's estuaries, farms, community parks, school grounds, golf courses, and so on. The extent of Lyngbye's Sedge - Herbaceous Vegetation community, diversity and abundance of dabbling ducks, and the duration juvenile salmonids are in the estuary are some indicators that may be considered for mid-island estuaries. In wilderness situations, 'acceptable' future conditions are typically those within the natural historic or pre-settlement range of variability, whereas non-wilderness situations tend to require a new kind of sustainable condition (Brunson 1997). Ideally, LAC for sedge communities would reflect vegetative conditions known to exist in the 1970s (Dawe & Lang 1980; Kennedy 1982; Dawe & White 1982, 1986), prior to the first records of breeding geese. However, it may be necessary to contemplate a new sustainable condition, considering losses to marsh platform, climate change, and other conditions that are irreversible in the short-term.

In 2012, LAC were redefined for Ramsar-designated wetlands as 'Limits for Defining Change in Ecological Character' (LDCEC). Article 3.2 of the Ramsar Convention requires countries to monitor and report if the ecological character of a Ramsar wetland has changed; LAC/LDCEC have been used by several countries for notification and to trigger additional higher-level management (Ramsar 2012; Rogers et al. 2013). An Australian example is available at http://www.environment.gov.au/system/files/resources/0c0185c8-8e0b-4194-a6ca-d0f795bef410/files/21-ecd-ch-4-5.pdf. (See also Table 13-1)

Table 13-1. Examples of Limits of Acceptable Change for Gippsland Lakes Ramsar Site, Australia (Australian Department of Sustainability, Environment, Water, Population and Communities 2010).

Indicator for critical component/ process/service for the LAC	Relevant timescale	Limits of acceptable change	Spatial scale/ temporal scale of measurements	Underpinning baseline data
Abundance and diversity of waterbirds	Medium Term	The absence of any of the following species in five successive years will represent a change in character: [list of species]. (one of several criteria)	Sampling to be undertaken at least twice a year (during summer) at stations containing favourable habitat.	Records for these species are reliable. Birds Australia and Department of Sustainability data can be used to assess this qualitative LAC.
Marine sub-tidal aquatic beds	Long Term	Total seagrass extent will not decline by greater than 50% of the baseline value of Roob and Ball 1997 (i.e., 50% of 4,330 ha) in two successive decades at a whole of site scale. (one of several criteria)	Sampling to occur at least twice within the decade under consideration. Baseline mapping against which this LAC can be tested is within Roob and Ball 1997.	Recent quantitative data describes seagrass condition at various sites but over a limited timeframe. There is no available seagrass condition data prior to listing.

A similar assessment, ‘Thresholds of Potential Concern’ (TPC) was used in a South African national park to manage invasive plants (Southwestlearning.org n.d.). TPC are based on the premise that ecosystems are in perpetual flux, and that the eradication of all invasive or problem species is neither feasible or practical. TPC define the envelope of conditions within which desirable ecosystem states may fluctuate (Southwestlearning.org n.d.). Rates of movement towards or away from thresholds indicate how the ecosystem is tracking, and provides a measure of its resilience (Rogers et al. 2013). TPC for Kruger National Park in South Africa are shown at http://www.southwestlearning.org/download_product/812/0 (See Table 13-2 for an example).

Table 13-2. An example of Limits of Acceptable Change for Kruger National Park, South Africa (Whyte et al. 1999 in Southwestlearning.org n.d.).

Criterion	Measure	Within-zone TPC	Whole-park TPC
Erosion/piosphere	Bare ground index	When affected area > unaffected area (i.e., index > 50%) or when affected area < 5% (latter to guarantee some eroded habitat in any zone)	When aggregated whole-park bare ground index less than 2.5% or > 25%.

More recently, LAC were used in concert with TPC to assess wetland condition and vulnerability in Australia. (Rogers et al. 2013). Compared to LAC, TPC trigger management intervention at a finer scale. Roger et al. (2013) identified 4 ecological values with which to set LAC: vital habitat, representativeness, distinctiveness, and diversity (See Table 13-3 for an example). Indicators included integral vegetative communities, certain threatened and endangered species, species representing different guilds of waterbirds, and specialist fish species, among others. TPC were derived from the status of the asset under management and known threats to the condition of the asset (See Table 13-4 for an example). A 'red-amber-green' choropleth map was produced and scored to show the status of each indicator - red meaning the threshold had been crossed (Rogers et al. 2013).

Table 13-3. An example of Limits of Acceptable Change for Lowbidgee wetlands, Australia (Rogers et al. 2013).

Value	Component or process	Limit of acceptable change
Diversity	Supports extensive area and diversity of wetland habitat including Black Box woodland, lignum shrubland and spike rush	Reduction in extent of Black Box woodland and lignum shrubland by 20% each, reduction in extent of spike rush by 20% (measured post-flood against previous post-flood benchmarks)

Table 13-4. An example of thresholds of potential concern for Lowbidgee wetlands, Australia (Rogers et al. 2013).

Selected value/ component	Threat/condition indicator	Threshold of potential concern	Goal
Diversity/Black Box woodland, lignum shrubland and tall spike rush	Clearance of Black Box woodland, lignum shrubland and spike rush	Any loss to clearance of Black Box woodland, lignum shrubland, and spike rush	Restoration of Black Box woodland, lignum shrubland and spike rush