

Key points:

- Free-roaming populations of dogs and cats always return to fixed levels (carrying capacity)
- Intact females produce larger numbers of successful offspring if competing females are spayed
- Reducing constant population turnover through vaccination reduces preventable deaths over time
- Euthanasia of healthy animals in shelters within the United States has decreased due to cultural changes, not spay / neuter

What do Third World and Native American reservation veterinary medicine have to do with ecology?

Everything at the population level, because nothing exists in a vacuum. All animals are part of a larger ecosystem, and the status and size of the population at large depends on a myriad of small factors. Most small animal veterinarians work on individual animals (dogs and cats for the purposes of this discussion) that are attached to a household or individual owner. Given this, most vets make decisions based on the patient at hand or the needs of the client. Large animal vets that address herd health also deal with clients and sometimes individual animals, but are often more focused at the population at large, especially when dealing with reportable infectious disease at the state and federal level. But for any species, domesticated or otherwise, there is a much larger total population at the community level and beyond, and decisions we make as veterinarians can influence the larger picture. Spay / neuter can make

a difference in the individual household, but when these animals are viewed as part of the larger ecosystem, spay / neuter at levels less than 70+ percent of all breeding females within one to two heat cycles (and continued long term) has no effect on the total population number. This 70% is conservative, with most studies (see chapter 2) demonstrating a 75%-94% rate needed to achieve actual population reduction of free-roaming animals, and this free-roaming status applies to the vast, vast majority of dogs and cats on Earth. free-roaming includes owned animals that are not confined to a home or yard, and data from TNR studies should be considered to include these animals and not just the truly feral.

In the United States, most dogs and cats are either individually owned or in the shelter system, whether private shelter/rescue or government/animal control. There are the occasional stray cats, and less commonly dogs, but with the increasing urbanization of America, this is the norm. Most animals belong to a household, and in urban areas generally do not wander far from home, if at all. However, this is the exception worldwide, where a vastly different domestic animal landscape exists. In Latin America, Asia, Africa, and even within the US on Native American reservations, there is a much more fluid situation where animal ownership and responsibility can be vague. Some dogs and cats have clear owners, and these animals might live within a household or fenced yard. Other animals may not have a distinct human owner per se, but may live in a neighborhood and be fed by various people who consider the individual animal to be part of their community (24). Other animals may have even less of a communal ownership, and might roam between towns or neighborhoods, where people may recognize them and occasionally feed them but not consider them part of the community at large. Finally, there are the truly feral animals that seem to have no human attachment, might show up once then disappear to parts unknown. This is more common in cats, who are able to largely feed themselves, but many dogs live on the periphery of human communities where they exist as scavengers, eating food that may be placed out for "neighborhood dogs", eating from garbage, or living near community trash dumps.

The lack of clear ownership and division of dogs and cats is important, since each of these animals is part of an ecosystem at large. Domestic dogs are almost always food dependent on humans in some way, and their overall population status will depend on access to these food resources. Cats are less human dependent for food, but most exist in proximity to humans in some way and even the most feral cats that do not depend on human provided food resources are still limited by prey numbers. Given that human and wild resources are finite, all dogs and cats are thus limited in terms of populations, whether they live in a human household or are completely free-roaming.

Now, consider our goals as vets. Other than food animal production, government, industry, laboratory and biomedical research vets, most practicing vets work at some level dealing with the overall health care of animals. Within this context, the primary goal is to alleviate animal suffering in some way, whether through preventative care or treating the invariable issues that arise (disease, trauma, etc.). As vets, most of our focus is on the individual, by giving vaccines to puppies and kittens to prevent disease, offering food, heartworm preventative medication throughout adulthood, and ultimately treating end of life issues such as cancer.

At the population level, the goals are the same. Prevent disease with vaccination programs, provide food to prevent starvation, and provide homes to prevent succumbing to weather, attacks from other animals, being hit by cars in search of food or mating, etc. However, it is primarily this last goal of homes for all dogs and cats that proves the hardest. Most vets understand that there are more dogs/cats than there are available homes, and the ultimate result of this is animals left to fend for themselves, or animals euthanized for non-medical reasons. In our goal of reducing animal suffering, we often thus think of trying to reduce overpopulation and treat the remaining animals individually.

Considering this, many small animal vets advocate for spay / neuter programs as the solution to overpopulation. Spay / neuter is presented as a preventative measure at the population level, effectively a preventative measure for pre-emptively treating the

medical and housing needs of countless as-yet-to-be born individual animals. Shelter medicine programs actively promote this, frequently using the concept of exponential population growth as justification. One breeding pair has a litter of 8 offspring, that themselves procreate and each produce another 8, and so on until in a short time there are hundreds of thousands of unwanted dogs and cats that could have been prevented by a simple surgery in the first generation.

Yet, if population growth operated this way, shouldn't there be millions of dogs and cats taking over the landscape? In places like Latin America, where a tiny percent of dogs and cats are ever surgically neutered, why aren't there absurdly large populations on every street corner? Dogs have been part of Native American communities for centuries, and if exponential population growth were a reality, shouldn't there be millions of dogs there as well? On the converse, spay / neuter programs have existed in these areas for several decades, so why are there not decreasing numbers of free-roaming dogs and cats?

The wildlife ecology perspective

Think about it from the perspective of wildlife ecology, an imaginary population of rabbits. Given the conventional wisdom that rabbits "breed like rabbits", why are there not millions of wild rabbits decimating the landscape? Given the stereotypical upside down pyramid of exponential population growth that spay/neuter programs reference, there should be rabbits in massive numbers, combing the landscape. Yet there is not. This is because the total number of rabbits is ultimately determined by food availability. Increase the number of rabbits born into a community with fixed food resources, and pretty soon the food available will be exhausted, the population will starve and succumb to disease and predation, and the total numbers will decrease (25).

Another way to look at it is from the perspective of large game species such as deer and elk. Governmental game and fish agencies in the United States have successfully managed deer populations for over a

century, with the understanding that populations not only remain stable barring environmental change but allow for a percentage of deer to be removed by hunters every year. There is a percentage that can be removed annually without changing the long term population levels. The balance between food resources and death from predation (including hunting) ends up with a stable population in any given area. This is referred to as the "carrying capacity", and is fundamentally dependent on food resources and not birth rates. Increasing food resources will increase the total population, as has occurred with high deer populations in areas of the USA where forests have been replaced by farmland, effectively changing the carrying capacity.

Spay / neuter advocates might argue with this game agency approach, implying that although current deer population levels are actually held reduced by hunting in the same way that advocates perceive spay / neuter to limit free-roaming dog and cat populations. Given that game agencies want to maximize long term game species populations, removing the hunters should by this analogy increase deer populations, right?

This ecologic system is tightly controlled, however, and tweaking it in attempts to alter carrying capacity can have unanticipated consequences. Game and fish agencies discovered this in the early 1900's, when they decided to increase deer populations available for human hunters by killing off mountain lions that fed on deer. The deer population temporarily increased, then plummeted as food resources were exhausted and deer starved to death. Ultimately, the deer populations returned to their normal (carrying capacity) levels, with a mixture of human and mountain lion predation.

Domestic animal ecology

What does this have to do with dogs and cats? Population levels for free-roaming animals are fixed, and playing with birth or death rates will not change the total carrying capacity. If a large percentage of white tailed deer (a species that only has one offspring per year) can

be removed annually without any decrease in the average population number, what of dogs and cats that can have multiple litters per year?

Free-roaming dogs and cats effectively act as a population subject to normal pressures the same as any other mammalian species. The total number of animals is a balance between factors that increase the numbers of animals (food, fecundity, survival to adulthood, etc.) and factors that decrease the numbers of animals (predation, starvation, disease, etc.). For any species, including dogs and cats, there is a finite limit to the number of animals that can exist in the long term, and the limit is determined by available food resources. I.e. "Dogs with unrestricted access to resources will produce larger litters, with pups that are more likely to survive to reproductive age" (26). Dogs are largely dependent on humans for food resources, but cats can freely survive without human intervention and their population numbers coincide with local small wildlife availability. In Australia, for example, an estimated 2.8 million feral cats freely roam in any given year, but this number can double to 5.6 million in years with significant precipitation (27). With the return of normal dry years, the cat number decreases dramatically in response to food limitations.

Most unowned animals in the world exist in a state of semi-starvation, competing for food, sometimes fighting for access to food, and in the process become injured, spread disease, etc. Anybody who has traveled to Third World countries is familiar with the typical street dog, ribs prominent, looking for food but scared to approach humans given a lifetime of bad experiences. Remaining in a state of semi starvation makes reproduction a luxury, and only a female with enough food will come into heat and successfully deliver a litter of puppies. The more access to food a female has, the more likely it is that she will come into heat, the larger the number of offspring delivered will be, the healthier the offspring will be, and in the end the number of successful offspring that make it to weaning will increase.

The idea of semi starvation limiting what is termed "fecundity" no longer applied in the modern western world where dog and cat food are regularly provided, and in which most pets are actually overweight. But in free-roaming, feral populations that act the same as wildlife

populations, biology plays a huge role, and it is only past a certain threshold of resources in which a female will arbitrarily deliver large litters on a regular basis and where extra food no longer plays a factor in fecundity.

This idea is critical when one considers that feral animals compete for limited food resources, whether this food is garbage dumps for feral dogs, or rodents and small wildlife for cats. There is only so much food out there, and this will inherently limit population growth to whatever its current levels are.

The limitation that food places on female fecundity is the fundamental reason why spaying will not reduce population levels of free-roaming animals until a critical threshold is reached (70+% of all intact females in two heat cycles and repeated annually every year thereafter). If 10 females in an imaginary closed population at carrying capacity (births = deaths) are in competition for the same resources, spaying half of them results in a decreased influx to the population. This results in more food for everybody, and the remaining intact females increase their body weight, come into heat more readily, deliver larger litters, and are able to nurse the litters until weaned. This increases the population to fill in the gap, until carrying capacity is again reached. In this way, spaying one female directly results in another female increasing her collective output of healthy offspring. Once again, males are of no value since the presence of even a handful of intact males means everybody gets pregnant.

If spay / neuter has no effect on total population at carrying capacity, what of vaccines?

Vaccination programs reduce morbidity and mortality, but do not change overall food resources and thus have no net effect on carrying capacity and therefore the total population over time. However, reducing the death rate does reduce the total number of animals that live and die over a given time period.

This factor is very important and not commonly discussed, and that is the total number of animals that exist not just at one moment in time, but over a period of time. To simplify things, imagine a theoretical population of 1000 free-roaming dogs on an island inhabited by humans. This could be a literal island, or could be an isolated town in Baja or on the Navajo Nation, somewhere with no dog migration in or out to complicate matters or introduce new diseases. With a carrying capacity of 1000, this means that about 1000 dogs have enough food and resources to exist at any given time. But, over a ten year span, this could be the same 1000 dogs that actually live long enough to make it to their genetic lifespan, or could be 10,000 different dogs that each live one year before dying from parvovirus, distemper, trauma, and all of the other common causes of death for free-roaming dogs without veterinary care. If we know that most dogs in these communities will not be humanely euthanized but will die on their own, and if our goal is to reduce as much suffering as we can, then the time factor (lifespan) becomes tremendously important. In the face of carrying capacity that puts a finite limit on our dog population, how many dogs live and die in a time period becomes as or more important than the total carrying capacity itself.

Why euthanasia rates have decreased in the USA

Within the small animal community, the overarching goal is to reduce the number of unwanted (i.e. healthy) dog and cat euthanasias, which historically occurs within the shelter system. Total euthanasia numbers in the United States have in fact decreased over the past few decades, but the reasons for this have been largely, and incorrectly, accredited to spay / neuter instead of a large cultural shift in the United States. The traditional rural household with multiple pets that free roam has steadily been replaced with urban households that have less pets and do not allow them to free roam. The US population over the past 100 years has shifted from >50% rural to largely urban, as has also occurred in the Third World nations (28). Culturally, more people are choosing to find pets through shelters as rescue organizations than through breeders (29). A much higher adoption

rate from shelters nationally accounts for the decrease in shelter euthanasias, and the fact that these animals are being surgically altered is ancillary.

For individual shelters, the situation becomes more complex and can be artificially manipulated to make one shelter look better than another. Shelter euthanasia rates can vary widely depending on the intake numbers (the denominator). Shelter euthanasia numbers (the numerator) can be artificially adjusted by selective intake, especially in the face of limited shelter space (effectively "carrying capacity" in free range situations). By selecting only those individuals that a shelter knows will be easily adopted, and refusing to accept other animals that will be difficult to place in homes, the individual shelter can prop up their adoption "success rates" at the expense of animals left out on the street. This is a common occurrence, especially in the world of "no kill" shelters that ultimately try and get as many donations as they can, leaving undesirable animals to the city and county shelters to deal with.

Regardless of competition between shelters in the United States, the overall euthanasia rate of otherwise healthy animals has decreased, not due to spay and neuter, but as the public has embraced adoption and rejected purchasing intentionally bred animals, effectively decreasing the death rate and the birth rates of the population at large but without altering the total carrying capacity of dogs and cats in the US. When one considers that there is limited shelter space and ultimately a limited number of homes in the US for adopted or purchased animals, it becomes clear that whether an animal is in a home, a shelter, at a breeding facility, or anywhere else, they are using what are limited resources, and are thus part of the total population ecology.

Does spay / neuter explain lower euthanasia rates?
What is the consequence of this assumption?

The European model is likely the best real world evidence that feral animals, semi-feral community animals, and owned animals are all

part of the same total population for which spaying and neutering and use of large financial resources towards such does not account for the low euthanasia rates of healthy animals nor the absence of large free-roaming populations, but instead cultural issues regarding pet ownership and free-roaming status account for the differences. In Europe, stray dog populations are rare and yet spaying / neutering of dogs is uncommon and in fact illegal for nonmedical purposes in some countries (30). In Sweden, by some estimates only 7% of the total dog population is neutered (31). Sweden has no feral domestic animal problem and does not spay, and yet Arctic Inuit communities in the same general climate have large feral dog populations. Considering the above, cultural practices appear far more important than surgical alteration.

This is in agreement with the actual history of shelter euthanasia in the US, in which rates of shelter euthanasia started to decline significantly in the 1970's prior to the overall widespread use of spay / neuter (29) . More likely, the urbanization of the human population and the move away from free-roaming but owned rural animals, and the cultural shift towards adoption and away from purchase of bred animals accounts for the success in reducing euthanasia rates, cultural processes that had started long before veterinarians began to promote spay and neuter as standard procedures. Correlation does not imply causation, especially when the supposed prime mover came onto the scene years later.

Whether or not spay / neuter efforts are the primary cause for the reduction in euthanasia rates may seem to be of less consequence given that things have improved for owned and shelter animals in the western world, but that assumption prevents efforts to find a real solution that can be applied to the much larger percentage of the world's dogs and cats that live in the Third World without regular veterinary care. Further, 75% of the dogs on Earth are estimated to be free-roaming (32), and the percentage of cats that are feral is likely even higher. For these animals, there are not enough vets, money, human resources, or even enough human interest to surgically alter enough to reduce populations. Thus, there is much more at stake when spay / neuter advocates use this correlation between reduced

euthanasia rates and a cultural shift towards spay / neuter, while ignoring the move away from neighborhood dogs and cats, as "proof" that surgical spay / neuter is the answer.

Considering that 75% or more of the world's dogs and cats are free-roaming and/or feral, this becomes the realm of Trap-Neuter-Release (TNR), or Trap-Vasectomize-Neuter-Release (TVNR). It is in this critical area that virtually all university level, peer reviewed studies have repeatedly demonstrated that such large percentages of spays are required that is impractical for real world use at large, leaving the development of an injectable or oral spay medication as "the Holy Grail" of small animal medicine. Yet, despite the clear, hard evidence as to the failure of conventional spay / neuter programs, the billion dollar animal welfare industry, with literally millions of dollars in board member salaries, continues to push for spay / neuter of free-roaming populations. Additionally, this industry has taken a further step in the past half decade of pushing epidemiologically flawed pseudo-science in non-peer reviewed journals in order to confuse driven donors and offset the actual science demonstrating the futility of the current approach using spay/neuter. This direct attempt to take from the finite pool of limited public donation money available overall for animal welfare and direct it towards the large organizations and away from the development of a non-surgical method of spay likely ends up costing hundreds of millions of feral canine and feline lives with every passing year that a real solution is not brought to the table.