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Urban Wildlife and Leopold's Land Ethic: "The squirrels on a college campus convey the same lesson as the redwoods. . . ."

Natalie Robiou
Fordham University, envstudies15@fordham.edu

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By Natalie Robiou

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Professor John Van Buren
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The United States has quickly become one of the most industrialized countries in the world. The Industrial Revolution of the 19th century brought Americans and immigrants alike employment opportunities in key locations throughout the country. This, in effect, translated into an influx of people living in close quarters; therefore, creating what is referred to today as urban centers. With the rapid growth of the American population and the greater demand for work, large urban areas developed throughout the U.S. landscape. This process, known as urbanization, is defined as the replacement of the rural areas with more urban ones. Urbanization has not only impacted human behavior, but also that of wildlife. Unfortunately, the continuous encroachment of humanity into wildlife habitats into the 21st century shows that urbanization is not coming to an end any time in the near future. It is for this reason that humans must study and understand the negative impacts that urbanization is having on the ecosystem around them. It is only through gaining an understanding of these environmental problems that they will be able to develop the tools and environmental policies to resolve these issues. However, once information is gathered one must apply certain environmental ethics theories to be use as a weighing mechanism in specific environmental crisis. Many of the negative effects of urbanization can be resolved by implementing the principles and values laid out by Aldo Leopold's "Land Ethic." This moral environmental theory places important emphasis on the interdependence and cooperation between humans and the surrounding natural environment. Surprisingly, urbanization is an excellent display of how human beings and the land community intertwine to create a unique, dynamic interconnected ecosystem.

Unfortunately, very few professionals within wildlife agencies have been trained to manage wildlife in urban settings and most traditional wildlife management strategies applied to rural areas are not always applicable to urban areas where the human population must be

factored in[1]. This is mainly due to the fact that many environmental social scientists and historians have overlooked the importance of studying the relationship between urban centers and the surrounding environment. In Andrew Light's article entitled, "The Urban Blind Spot of Environmental Ethics," he writes that "cities are considered sources of environmental disvalue: a landscape either to be mined for examples to be avoided or ignored all together as a product of human intentions – an artifact rather than part of nature and so outside of the appropriate boundaries of the discipline.[7]" For the remainder of his article Light goes on to argue why environmentalism must not overlook urban environmental issues and how studies aimed at urban areas can provide unique ecological insight that could never be obtained solely from rural landscapes. It is only recently, through the organization of movements such as environmental justice, that scientists have really began to closely examine the impact of urbanization not only on humans, but on the surrounding wildlife as well.

One aspect of ecosystems that urbanization greatly affects is the behavior of wildlife. Artificial food sources, such as birdseed, garbage, and pet food, in urban centers reduce the need for many animals to move around in search of something to eat. These urban populations tend to exhibit "clumped dispersion patterns", meaning that individuals in a population are in closer proximity to each other than would be expected at random. Experts believe that this is a direct result of clumped food sources in urban settings, which attract large groups of individuals to a single, common location. Urban heat islands, metropolitan areas which are significantly warmer than their surroundings, also induce behavioral changes in many wild species. The creation of these warmer environments lengthens breeding seasons and causes traditional migration activity to disappear from certain species lifestyles[1]. Urban wildlife is, in a sense, becoming more domesticated. Due to increased human interaction in

urban areas, some species are not even startled by the presence of humans anymore. Many animals simply go about their day completely undisturbed by human activity.

Social and behavior adaptations have allowed urban wildlife to coexist with humans in these particular urbanized settings. Many wildlife species select certain structural features of urbanization that they use as alternative habitats which provide food, water, shelter, and protection from the external environment. The two categories are green spaces and gray spaces. The three subdivisions of urban green space are: remnant, successional and managed habitat patches[1]. Remnant habitat patches (RHPs) are sites that have not been cleared or heavily managed by humans and contain species that are typical to the geographic region. They can be found in urban areas because their particular habitat features can impede development. As a result, they become like islands embedded in the matrix of the urban/suburban landscape[1]. Successional habitat patches are sites that were previously cleared or managed by humans but have subsequently been abandoned. Managed habitat patches are sites under direct and intense management by humans[1]. In green space, such as this one, tree-trimming practices and natural senescence often result in the formation of cavities, which many types of birds and mammals will use for nesting, roosting, and/or shelter[1]. Even though these types of urban habitats may offer some benefits to urban wildlife species, they could never support the same level of biodiversity found in native biological ecosystems.

Urban habitats are known for containing specific kinds of wildlife. Raccoons, opossums, skunks, pigeons, geese, mice, and rats are just a handful of the most commonly found animals in urban settings[5]. Their everyday behavior can be monitored and studied to provide humans with a better understanding of exactly how their lifestyles have been effect by

urbanization. Since their size allows them to be seen easily, their habitats are readily observable, and they are found in abundance, squirrels are excellent test subjects in urban settings. In addition to this, they follow a daily cycle that coincides with human's, unlike raccoons or opossums that are typically nocturnal Given that squirrels adapt quickly, it is possible to study this group of mammals in order to relate to other types of mammals[3]. Even though squirrels are a large group of species, with many types of appearances and differing habits, they are easily identified by experts and novices alike. Although these are all good reasons why squirrels make such good study models, there is one particular drawback. It can sometimes be difficult to identify one individual squirrel from another. It is for this reason that environmental scientists must implement precise identification and monitoring systems when studying squirrels in urban centers.

Squirrels have actually been able to adapt fairly well in response to urbanization and are one of the most visible urban mammals in North America. There are approximately 55 species of tree squirrels[5]. These animals typically live in deciduous, coniferous, and tropical forests. Most squirrels make their nests, as known as dreys, above ground in the trees, which provide them with food and shelter. They tend to build their dreys, out of sticks and leaves, in the crevices of the tree itself, amongst the branches[6]. Just like their rural counterparts, urban squirrels store food, such as nuts and berries, underground for use during the winter season when food is scarce[2].

Squirrel density seems to be much higher in urban areas than in rural. Urban densities of five to six squirrels per acre are fairly common, whereas in rural areas, densities of one to two per acre are typically recorded[4]. These high densities are attributed to the supplemental feeding by people and many artificial nest boxes located in the parks and playgrounds of

urban settings. Many cities are taking steps to alleviate the large squirrel populations. Many times Animal Control is brought in to trap and remove squirrels when population levels start to become a nuisance to other surrounding populations, especially humans[1]. Other environmental studies have shown that there are other differences between rural and urban squirrels. Observations in one particular study showed that urban squirrels typically reach sexual maturity at a significantly older age than rural squirrels[2]. However, the exact mechanism resulting in this disparity is not fully clear. Although the breeding season and number of young born per litter were found to be equal between urban and rural squirrels, the survival of the young was higher among urban squirrels[3]. This may be a result of the fact that urban squirrels are just one of many species that have the opportunity to find den spaces for living and raising their young in abandoned houses and other buildings[1]. These locations provide protection and shelter from predators and other negative environmental factors.

As previously discussed, urbanization can lead to adaptations and behavioral changes within wildlife species. One specific example of this could be drey placement in an urbanization environment, such as a college campus. It is for this exact reason that our research group decided to see if squirrel populations on the Fordham University's Rose Hill campus have made certain behavioral changes to adapt to their surrounding urban environment. This study examined the correlation between drey placement and the following factors: tree height, tree density, and pedestrian traffic. Our hypotheses for the placement of dreys were as follows. Dreys would be located in taller trees; dreys would be located in areas of higher tree density; dreys would be in areas of lower pedestrian traffic. To test these hypotheses, the number of dreys, height of trees, density of trees, and pedestrian traffic were recorded on multiple locations on Fordham's campus: Eddie's Parade, Martyr's Lawn, the

Walsh Library, and O'Hare. Our results indicated that our hypothesis about tree height was supported, that there was no clear relationship between placement of dreys and density of trees, and that our data on pedestrian traffic data did not support our hypothesis.

Black and Eastern Grey squirrels inhabit the Rose Hill Campus at Fordham University in the Bronx. Native to deciduous woodlands, squirrels are tree-dwelling rodents, who build nests, or dreys, in trees where they reside year round, occasionally leaving the nests to forage. Ecologists have studied what factors affect the placement of these nests[6]. Some site characteristics shown to be relevant in nest-site selection are the height of the tree, tree-density of the surrounding area, and the types of trees at the site[4]. Our study aimed to test these three factors on drey placement at the Rose Hill Campus, as well as examine the relationship of the frequency of pedestrians on the location of dreys.

Knowledge of the optimal conditions for squirrel dreys would allow the University to effectively control the squirrel population by limiting the number of trees of a certain species or height. Similarly, knowing the optimal tree density for drey-site selection would allow for the control of the campus squirrel population by adjusting the tree density at Rose Hill. One might want to limit the squirrel population because of its inclination to strip the bark from trees, causing fungal infection[1]. It is important to note that hawks and raccoons also inhabit the campus and prey on squirrels, thus any decline in the squirrel population would result in the decline of the populations of predators as well[5]. We hypothesized that there was a positive correlation between the distribution of squirrel dreys at Rose Hill and the height of the tree, the tree-density of the surrounding area, and the frequency of pedestrians in the area. Our research group tested this hypothesis though the observation and analysis of each of these four factors and the number and placement of dreys.

Our experimental design involved the classification of each tree by height, species, and number of dreys. Tree height was determined using the angle of elevation method, where the height of the tree was a trigonometric function of the distance away from the tree and the angle of elevation from the top. In addition to classifying each tree in this manner, we divided the campus into different sections which contained a large number of trees as well as pedestrian footpaths. We used this approach to determine the frequency of pedestrians per area. Counting the pedestrians moving in both directions at different times during the day and at different days of the week gave an accurate estimation of the overall traffic in a given area. If the data indicated a correlation between the number of squirrel dreys and the height of the tree, the tree density, or traffic frequency of the surrounding area, this would support our hypothesis that drey placement is dependant on these three factors.

Number of Dreys per Tree: Each tree on the Rose Hill campus was examined for squirrel dreys. This was accomplished by visual inspection alone. *Tree Height Estimation:* The angle of elevation method was used to determine the height of each tree on the Rose Hill campus. At a measured distance (x) away from the tree, the angle of elevation (θ), the angle from the ground that is needed to see the treetop, could be measured with an inclinometer. The tree's height was obtained by the following calculation: $h = (x)\tan(\theta)$. *Drey Density Determination:* An estimation of the tree density was determined by measuring the number of trees within a 10 m radius around the trunk of each tree sampled. *Pedestrian Traffic Determination:* To estimate the traffic levels of pedestrians on the Rose Hill campus, our study examined several different areas of the campus at several different times during the day. Pedestrians walking in either direction were counted, each counting session lasting thirty minutes. The campus areas, chosen at random, included: the Walsh Library, Eddies Parade,

Martyrs Lawn, McGinley Center, O'Hare Lawn, and Duane Library. The time intervals (9 am, 3 pm, and 6 pm, on Tuesday, Thursday, and Saturday) were chosen to reflect different times of day and different days of the week. A sum of our collected values gave a reliable estimate of the overall traffic patterns at Rose Hill.

The average recorded tree height was 13.69m, with a standard deviation of 4.89 meters. The average height of drey-containing trees was higher, at 16.51 m, while the average height of a tree with no drey was lower at 13.13 m. In terms of density, the average number of trees within a 10 m radius of the trunk of each tree was 1.13 trees with a standard deviation of 0.83. The average tree density of trees containing dreys was 1.05 trees while the average density for trees without dreys was 1.14. Table 1 demonstrates the relation of pedestrian traffic to percentage of trees with dreys. Data showed that Eddie's Parade had the highest pedestrian count and highest percentage of trees with dreys.

The data indicated a correlation between tree height and placement of squirrel drey. Larger trees were more likely to contain a squirrel drey whereas the smaller trees sampled in this study contained no dreys. The benefits of selecting a taller tree include protection from predators as the drey is further from the ground. Predators include cats, dogs, hawks, owls, and people, each of whom would be limited by making the drey inaccessible in trees of larger height. Larger trees, as they contain a larger network of branches, also allow for a more stable structure on which to build the dreys.

Though the data does not indicate a strong correlation between the density of trees and drey placement, reasons exist to support the claim that higher tree densities support more squirrel dreys than do areas of lower tree density. Interconnected branch networks would lessen the risk from land-predators by reducing the amount of time spent on the ground.

Dense woods would also help to protect flying predators, as well as land animals, as it would provide camouflage and better hiding spots for squirrels. Dense woods also facilitate the access to food sources by having the nut-producing trees grouped together. That no strong correlation was found experimentally suggests the need for a change in the experimental parameters of determining tree density. Since the benefits of tree density are linked to the networks of branches created by trees, future studies should measure branch overlap instead of merely measuring the proximity of the tree-trunks to other tree-trunks.

The data concerning the frequency of pedestrians did not support the hypothesis that areas of higher traffic would contain fewer percentages of trees with dreys. Eddie's Parade, the area with the largest amount of pedestrian traffic, likewise contained the largest percentage of trees with dreys, while the other areas of lesser traffic contained proportionately fewer trees with dreys. While the data did not make it possible to determine any causal conclusion as to why this is the case, the presence of other variables may explain why fewer squirrel dreys were found in trees near Martyr's Lawn. Recently, several red-tailed hawks, predators of squirrels, have built a nest near Collins Auditorium, near Martyrs'. The placement of this nest may skew the data, as the presence of hawks may act as a selective force in determining where squirrels build nests. It was also not surprising that more dreys were found on Eddie's Parade since this location had a much higher abundance of trees than all other areas. The other locations, the Walsh Library, Martyr's, and Collins, contained 29, 22 and 15 trees, respectively. With a total of 62 trees on Eddie's to choose from, squirrels may be more likely to build more dreys in locations such as these because they can select from a much wider variety of tree heights and densities. Also, other research has shown that squirrels are becoming more adaptive to urban settings, especially college campuses[3].

Therefore, pedestrian traffic many not be as strong a factor for determining drey location as squirrel adaptation increases their social interactions with pedestrians. This research project, conducted in a college setting as well as in an urban environment such as the Bronx, was an excellent way to observe exactly how squirrels have adapted to the dynamics of urbanization.

Other squirrel studies conducted on college campuses have turned their focus to the other effects on urban squirrel populations, as well as the problems they may present for the human population. Although most people may perceive squirrels as cute and harmless, since the growth of urbanization it has become clear that they can often become a nuisance. Often they can chew on buildings and wires and can cause major electrical damage[2]. Many researchers have cited that the begging behavior of squirrels as one example of adaptation. As previously stated, squirrels have been quick to learn that people are an abundant source of food. Urban areas, especially college campuses, can many times provide urban squirrels with a greater sense of security as well. Studies have also shown that squirrels typically occupy a limited home range on college campus[12]. For example, a squirrel found one day in the vicinity of one academic building is likely to be found in that same area later in the week. There are, however, rare occasions when the squirrels may move to a wider range of occupancy. Some experts have attributed this squirrel movement to territorial disputes[2]. Although squirrels forage together and occupy overlapping ranges, they also appear to demonstrate a social hierarchy in which the bigger squirrel is allocated more territory[12]. Younger squirrels have been known to be pushed out of more ideal locations to areas with fewer resources. Crossing the busy streets in and around urban settings is a risky proposition for the squirrels as well. A major source of mortality among urban squirrels is running out into traffic. With the squirrel populations being so large in some urban areas, it is not

uncommon to have high rates of squirrel mortality due to the frequent trafficking in these areas.

Specific environmental theories can be applied to the cases such as the urbanization of squirrels and be used as tool to resolve the environmental conflict within the ecosystem. Applying an environmental theory, such as Aldo Leopold's "Land Ethic" could be used as a "weighing mechanism" to solve the problems caused by urbanization. Formulated from the basic principle of sciences, such as evolutionary biology and ecology, Leopold designed something he refers to as the "land pyramid." This "land pyramid" is a representation of concepts put forth from the idea of what it means to be an "ecosystem" or "biotic community.[11]" It contains elements of interdependence and cooperation, which are exhibited by the food chains and transfer of energy that flows through every type of ecosystem. The interpendent relationship between nature and humans is another large part of "land pyramid." The theory is based on several fundamental moral principles as well. First, humans must do their best to preserve the greatest integrity and stability of the biotic, land community. In order to maintain constant respect for the entire land community, humans need not forget the direct duties they hold towards individual members of the land community[11]. Developing a sense of ecological citizenship can also help humans become members of the land community themselves instead of seeing themselves as separate entities. It is important for humans to hold a certain degree of admiration and appreciation for the esthetic value of nature. A love of nature would serve as a visible reminder of the importance of preserving the land community. Leopold's "land ethic" does, however, allow room for the use of nature for human economic self-interest, as long as it is in agreement with the other moral principles.

These moral principles can, in turn, be used to derive specific values for which humans can live by. Cooperation with nature, maintaining the health of global and regional ecosystems, and appreciation and admiration for the esthetic beauty of nature are just some examples of values that can be drawn from the previous moral principles[11]. It is also important that human beings become better ecological citizens by increasing their knowledge and education about the environment. Humbleness and non-aggression towards the land community are attitudes they must posses in order to understand and respect the biotic land community. It is through these central values that humans will be able to use and develop nature in such a way that they produce and ecologically sustainable economy through the mutual sharing of ecosystem with its other members.

Once Leopold's theory is used to develop certain values and guidelines which one can extend into their personal lifestyle, humans can begin collaborating with one another to design specific environmental policies that better the entire "land community." In order to increase awareness and knowledge about the global community, educational reforms could be made in schools that would require students to engage in dialogue about current environmental issues and the ways they may be able to resolve them. State legislature could enact laws that preserve the nature land agriculture and force park management to establish ecologically sustainable practices. Decreasing consumer practices that have negative impacts on the ecosystem is just another way the government and consumers could alleviate environmental problems, such as pollution, deforestation, and industrialization of landscape.

The basic "criterion of moral standing" for Leopold's "Land Ethic" is simply being a member of the land community. Basically, this encompasses every integral part of the earth's biotic ecosystem. What sets Leopold's theory apart from many other moral environmental

theories is the fact that he extended his "criteria of moral standing" to things not previously included in others. The "moral community" he refers to is every living and non-living member/thing in the earth's ecosystem. According to his theory, humans have "direct duties to" all members of the moral community.

Although this research project on the Fordham University's squirrel population does not show a large degree of harmful effects of urbanization, the minor environmental issues could be solve by implementing an environmental ethics theory like Leopold's. Applying his "Land Ethic" to the squirrel population in urban areas would not only benefit the squirrels but humans as well. As stated by the theory itself, there in a fundamental interdependence that exists between humans and squirrels. According to Leopold, if humans admired and valued their surrounding environment they would not disrespect it by throwing uneaten food and other garbage on the ground. As explained earlier, this creates artificial food sources which squirrels can feed off of. Leaving trash around only serves to attract large populations of squirrels to a common area which can become a nuisance to human beings. By respecting the urban ecosystem and disposing of trash properly, humans would eliminate large influxes of squirrels to certain areas and maintain a balance between themselves and the squirrel population. Minimizing trafficking in urban settings is another policy which would be indorsed by Leopold. Unfortunately, humans can some times be careless when driving or simply not have the reflexes to react in time to avoid running over a squirrel, or any urban wildlife for that matter. In addition to decreasing wildlife mortality, decreasing traffic and highway/street construction would result in a decline in air pollution.

Leopold's "Land Ethic" can be applied to the much broader issue of urbanization itself, not just squirrel populations. With the increase in the human population and

industrialization, the needs of the natural environment are overlooked. Too often the "land community" is abused by humans who use it for their own economic benefits. Many times they destroy ecosystems to establish housing developments, industrial buildings, and recreational outlets, without ever even understanding the environmental ramifications. Leopold's theory could resolve this through his idea that the use of nature is only permitted if it is in agreement with other moral principles. This being said one would not be able to destroy a particle ecosystem to build a shopping mall somewhere if it comprised the stability of that ecosystem. However, Leopold's theory may allow for the construction of some sort of building if it was constructed in such a way that it did not jeopardize the natural balance of that particular ecosystem. Although it would be rather difficult to figure out exactly how to go about the construction, the development of that particular structure would need to maintain the integrity of the "land community" surrounding it. Leopold's theory is also an excellent "weighing mechanism" for the growing issue of suburban sprawl, a direct product of urbanization, which in recent years has spiraled out of control as American lifestyle becomes more and more extravagant.

The moral reasoning of Leopold's "Land Ethic" theory is one of the most defensible all of the other environmental theories. Leopold lays out a clear theory, which if properly applied, would yield the most beneficial results. The concerns of the entire land community are given weight and are taken into consideration when making decisions about particular environmental issues. Complete respect for and maintenance of the greatest integrity and stability of the land community are main principles from which humans can establish a firm foundation on which to base their moral values. Most importantly, it recognizes the interdependent relationship that exists between humans and nature, which is an important

aspect of urban environments. It is through this acknowledgement that humans are better able to serve the needs of the land community, as well as themselves. As compared to the other environmental theories presented before, Leopold's is one that encompasses every possible environment issue and those that it concerns, both human and nonhuman. It is not just limited to humans or to nonhumans. He presents a true metaphysical theory to base his moral principles and proves a clear weighing mechanism to decide moral conflicts regarding the environment.

While Leopold's theory is an excellent tool for combating the negative effects, there are numerous ways one can go about making positive change in their urban areas. Thankfully, action is being taken in urban communities across the country in response to the increasing knowledge of the environmental issues associated with urbanization. Nature Network, a collaboration of various organizations, is dedicated to nurturing a healthy natural environment in the NJ-NY-CT Metropolitan region. "[It] inspires ecological citizenship by creating and disseminating knowledge and fostering dialogue on critical environmental issues. It is structured in a way so that organizations can collaborate through research, education, and public information to implement public policies.[8]" In addition, the NYC major's PlaNYC is designed to make the city "the most ecological city in America" by 2030, which includes creating green/park space and protecting urban wildlife[9].

This research project has shown that there are negative and positive effects of urbanization on both sides of the fence, humans and squirrels. Not only can Leopold's environmental theory be applied to the issue of urbanization, but in particular it can be put into practice in the case of the squirrels in this study. The most important thing to take away from this all is that a balance needs to be achieved between the needs of humans and the

needs of the rest of the land community. Through the development of ecological citizenship, humans will be better equipped to deal with the environmental problems associated with urbanization. Once humans acknowledge the unbreakable connection that exists between them and the rest of the land community, they will understand why it is so important that they resolve any crisis that might threaten the balance and integrity of the entire biotic community.

Appendix.

TABLES

Table 1: Pedestrian Traffic and Frequency of Dreys

Location	Pedestrian Count	% Trees w/ dreys
Eddies	1632	18.3
Martyr's	970	17.4
Library	878	0.9
O'Hare	877	13.3

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