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Ecological Footprints in Monteverde, Costa Rica

Sarah Ory

Department of Biology, University of Puget Sound

ABSTRACT

In this study I calculated the Ecological Footprints of community members in three areas in the zone of Monteverde, Costa Rica. The three areas that I studied were San Luis/ Cañitas, Santa Elena/ Cerro Plano, and Monteverde. I presented a survey of 21 questions regarding a person's environmental impacts in rural communities and more urban communities. I assessed the difference in Ecological Footprints, Carbon Footprints, Food Footprints, Housing Footprints, and Goods and Services Footprints between the three communities and determined no statistically significant differences. The mean Ecological Footprint in San Luis/ Cañitas was 8.12, Santa Elena/ Cerro Plano was 8.44, and Monteverde was 7.04. Additionally, I compared the footprints in the three communities with the mean footprints in Costa Rica as a country. Costa Rica's mean Ecological Footprint (10.5) and Carbon Footprint (3.6) were significantly higher than those of the three communities I looked at in Monteverde. There were no significant differences between the Food Footprints and Goods and Services Footprints. I found that food consumption was the most influential factor in the Ecological Footprints in San Luis/ Cañitas, Santa Elena/ Cerro Plano, and Monteverde (48%, 52%, 49% respectively). The Housing Footprint was a higher percentage of the total Ecological Footprint in San Luis/ Cañitas (32%) in contrast to Santa Elena/ Cerro Plano (19%), and Monteverde (20%). The percentage of Goods and Services Footprint in the total Ecological Footprint was similar in San Luis/ Cañitas, Santa Elena/ Cerro Plano, and Monteverde (13%, 14%, and 14%, respectively). I also examined what percentage of people in each community finished primary school, high school, and university, as well as what percentage of people were from Monteverde, San Luis, other areas in Costa Rica, and areas outside of Costa Rica. Using the Ecological Footprint to determine the impact that a person has on the environment is extremely important in raising awareness through the knowledge of how each individual and their personal decisions can affect the environment. Through assessing different communities, understanding can be achieved as to how community dynamics and individual decisions can be utilized to improve human impact on the environment.

RESUMEN

En este estudio calculé la huella ecológica de los miembros de la comunidad en tres áreas diferentes de la zona de Monteverde, Costa Rica; San Luis/Cañitas, Santa Elena/Cerro Plano y Monteverde. Utilicé una encuesta de 21 preguntas sobre el impacto de las personas en las comunidades urbanas y rurales. Utilicé las diferentes huellas entre las comunidades y determine que no hay diferencias entre las comunidades. El promedio de la huella ecológica para San Luis/Cañitas fue de 8.12, Santa Elena/Cerro Plano 8,44 y Monteverde 7,04. Adicionalmente compare la huella ecológica en promedio de las tres comunidades con el promedio de Costa Rica como país. En este caso la huella ecológica para Costa Rica es mayor. Encontré que el consumo es el factor que ejerce mayor influencia en las tres comunidades estudiadas (48%, 52%, 49% respectivamente). El porcentaje de la huella por servicios en la huella ecológica total fue similar para las áreas estudiadas. Además examine el nivel educativo alcanzado por los habitantes de cada zona. Usando la huella ecológica para determinar el impacto de cada persona en el ambiente es muy importante para determinar el impacto que cada individuo y de las decisiones personales que pueden afectar el ambiente. A través del asesoramiento a diferentes comunidades, se puede entender como la dinámica de la comunidad y las decisiones individuales pueden ser utilizadas para mejorar el impacto humano en el ambiente.

INTRODUCTION

Throughout human history, people have exploited natural resources. Unsustainable use of resources leads to environmental degradation, which is a problem that must be addressed from ecological, social, economic and political perspectives (Lubchenco 1998). Considering the world population of approximately 6.7 billion, and the rapid depletion of resources, it is crucial to understand the causes and mitigation possibilities of environment degradation (Jorgenson 2003). In addition, it is of great importance to use this understanding to advance society toward a more sustainable, economically stable and socially fair culture (Lubchenco 1998). The Fourth Assessment Report of the Intergovernmental Panel on Climate Change has proclaimed that humans have significantly contributed to the considerable warming of the planet since 1750 (IPCC, 2007). Human generated carbon dioxide, methane, and nitrous oxide emissions have significantly increased since 1750, a likely correlation with the warming of the planet (IPCC 2007). Knowledge about how someone can alter his or her impact on the environment is imperative in creating a global culture of environmental stewardship (Lubchenco 1998). Many decisions that a person makes have implications that will either affect the environment in a positive or negative way (Jorgenson 2003). It is these decisions that are important to raise awareness about. We impact the environment through our daily habits like the decisions to drive, to eat imported food or meat, or to recycle. A person can simply make a conscious effort to minimize their impact on the environment by reducing the amount of resources they use and by modifying their daily practices (Rosenburg 1997).

The carrying capacity of Earth can be defined as the maximum population that can be supported without depleting or permanently damaging the resources available or the surrounding ecosystem (Aina 1992). The human population has now surpassed the carrying capacity of Earth and we are damaging the functionality of our planet. It is nearly impossible to quantify the global carrying capacity accurately, but through understanding the stress we are placing on the environment it is easy to see how we are causing damage. It is estimated that humans use half of Earth's net terrestrial primary production (Abernathy 2001). This statistic illustrates just how much humans are exploiting Earth's limited resources. Other factors that influence the impact people have on the environment include culture, affluence and location. As a nation develops and affluence increases, there is a significant increase in consumption (Myers and Kent 2003). Furthermore, urbanization has a significant impact on the environment due to dense populations, consumerism, and the lack of urban planning (Foley et al. 2005). For example, China's meat consumption has increased 15% since 1961, which has far-reaching implications for deforestation in South America in order to produce enough soy to feed the livestock, which in turn cause increased carbon and methane emissions (Halweil and Nierenberg 2008). Through awareness and education of how our actions can impact the environment, perhaps we can still preserve the resources we have and protect the natural environment that is continuously being degraded.

In recent years, researchers have been trying to quantify human impacts on the environment. Reese 1992, William Reese first created the concept of the Ecological Footprint to measure how different actions and the uses of resources affect the environment (Rosenburg, 1997, Martine, 2009). The ecological measurements can be

conducted on an individual level, family level, community level, national level, and globally. The data used to calculate an Ecological Footprint estimate the effect that person, family, community, or country has on the environment. Furthermore, the results indicate whether the Earth can support the lifestyle of the respondent. These calculations are useful in determining how the human population is affecting the environment, while enabling people to understand their personal impact and make changes. Ecological Footprint calculations are valuable in making environmental assessments throughout the world and making positive decisions for the future about what can be done to improve the impact that the human population is having on the environment (Wackernagel et al. 1999).

In this study I examine the Ecological Footprints of communities around Monteverde, Costa Rica. The Monteverde area is comprised of several small towns and neighborhoods. These localities include Santa Elena, the most developed portion, Cerro Plano, another developed area, Monteverde, a group of small farms and hotels near the Monteverde Cloud Forest Preserve, and San Luis and Cañitas, two areas that are rural. Until the mid 1980's, the Monteverde area was primarily small family farms and rural communities, but has become a tourist hub, attracting more than 250,000 people annually (Rasmusson 2008). I investigated the Ecological Footprints of individuals in and around Monteverde. I compared the lifestyle and Ecological Footprints in these communities with people in Monteverde and Santa Elena and Cerro Plano, more developed, urban communities.

MATERIALS AND METHODS

I calculated individual Ecological Footprints using a survey designed by the Center for Sustainable Economy (<http://www.myfootprint.org>). The survey was translated from English to Spanish. It contains 21 questions that are divided into four subsections: Carbon Footprint, Food Footprint, Housing Footprint, and Goods and Services. The section on a person's Carbon Footprint assesses the impact that a person has on the environment through their transportation and energy usage. The Food Footprint analyzes how sustainable a person's eating habits are and how sustainable the food that they eat and its production is for the environment. The Housing Footprint evaluates how the amount of land that a person's house occupies affects the environment. In addition, this portion of the survey takes into account how sustainable the construction and upkeep of a person house is, as well as the amount of property that a person has. The last subsection, Goods and Services Footprint, looks at where a person obtains their consumer products, as well the sustainability of producing these goods.

I presented this survey to a sample of 52 people in the communities of Monteverde, San Luis, Cañitas, Santa Elena, and Cerro Plano in Monteverde, Costa Rica. I combined the communities of San Luis and Cañitas and the communities of Santa Elena and Cerro Plano due to their close proximities and the similarity in the demographics. I visited local shops, restaurants, people's homes, and approached people on the street to request their participation in my project. The majority of the respondents were local Costa Ricans that had not emigrated from other countries. The survey was completed by 20 people from the Santa Elena and Cerro Plano, 19 people from San Luis and Cañitas, and 13 people from Monteverde. I then entered the responses of these 52 surveys into the

online calculator at <http://www.myfootprint.org>. In addition to the Ecological Footprint, the calculation provided the number of earths required to sustain the population as if everyone lived the same way as the respondent. In addition to the questions, I added supplemental questions to take into account a person's age, level of education, and where they are from (See Appendix). The level of education was described as completing primary school, high school, or university. A person's geographical background was determined as either from Monteverde, San Luis, other areas in Costa Rica, or outside of Costa Rica.

RESULTS

Communities in the Monteverde area do not differ in their average Ecological Footprint (San Luis/ Cañitas: mean= 8.12, stdev= 13.69, Santa Elena/ Cerro Plano: mean= 8.44, stdev= 6.55, Monteverde: mean= 7.04, stdev= 1.86, $f = 0.995932781$ and p -value 0.376731455). Further, they do not differ in their Carbon Footprints, Food Footprints, Housing Footprints or Goods and Services Footprints (Carbon Footprint: San Luis/ Cañitas mean= .55, stdev= 0.24, Santa Elena/ Cerro Plano mean= 1.25, stdev= 7.03, Monteverde mean= 1.17, stdev= 0.64. $f = 0.916156111$ and p -value 0.406796556) (Food Footprint: San Luis/ Cañitas mean= 3.90 stdev= 1.10, Santa Elena/ Cerro Plano mean= 4.13, stdev= 1.24, Monteverde mean=3.48, stdev= 1.01. $f = 2.427044031$ and p -value 0.098843108) (Housing Footprint: San Luis/ Cañitas mean= 2.64, stdev= 12.11, Santa Elena/ Cerro Plano mean= 1.64, stdev= 0.76, Monteverde mean= 1.4, stdev= 0.19. $f = 1.546415115$ and p -value 0.223225652) (Goods and Services Footprint: San Luis/ Cañitas mean= 1.04, stdev= 0.15, Santa Elena/ Cerro Plano mean= 1.21, stdev= 0.18, Monteverde mean= 1, stdev= 0.15. $f = 1.324589596$ and p -value 0.275264414). These areas vary little in the impact that they have on the environment in relation to one another.

Where a person grows up is not independent of the where that person lives in the Monteverde zone ($\chi^2 = 23.87$, $P = 0.0005$). In my sample of 19 people from San Luis/ Cañitas, the majority grew up in San Luis (57.89%). In my sample of 20 people in Santa Elena/ Cerro Plano the majority of residents were from locations outside of the Monteverde zone (65%). Likewise, the majority of the 13 people I surveyed in Monteverde are from other regions outside of Monteverde (53.85%) (Figure5). A person's level of education was independent from where a person lives ($\chi^2 = 10.29487922$, $P = 0.112770762$). Monteverde had the highest proportion of people that attended university (45.45%), in contrast to San Luis/ Cañitas and Santa Elena/ Cerro Plano (15.79% and 15% respectively). In San Luis/ Cañitas the majority of the respondents only completed primary school (57.89%), where as a considerable portion of people in Santa Elena/ Cerro Plano only completed primary school (40%). Very few people in Monteverde only finished primary school (18.18%). A small percentage of people from San Luis/ Cañitas only completed high school (21.05%), while nearly half of the respondents from Santa Elena/ Cerro Plano and Monteverde had completed high school, not including those who attended university (45% and 54.54% respectively).

The mean Ecological Footprints from San Luis/Cañitas (8.12), Santa Elena/Cerro Plano (8.44), and Monteverde (7.04) were each significantly lower than the mean Ecological Footprint in Costa Rica (10.5) (t -stat= -6.258, p -value= 0.025). The mean

Carbon Footprints from San Luis/Cañitas (0.55), Santa Elena/Cerro Plano (1.25), and Monteverde (1.16) were each significantly lower than the mean Carbon Footprint in Costa Rica (3.6) (t-stat= -11.886, p-value <0.01). The mean Food Footprints from San Luis/Cañitas (3.90), Santa Elena/Cerro Plano (4.31), and Monteverde (3.48) were not significantly different from the mean Food Footprint in Costa Rica (3.6) (t-stat= 1.258, p-value 0.335). Similarly, the mean Housing Footprints from San Luis/Cañitas (2.63), Santa Elena/Cerro Plano (1.64), and Monteverde (1.4) were not significantly different from the mean Housing Footprint in Costa Rica (1.8) (t-stat= 1.476, p-value 0.278). Furthermore, The mean Goods and Services Footprints from San Luis/Cañitas (1.04), Santa Elena/Cerro Plano (1.21), and Monteverde (1) were not significantly different from the mean Goods and Services Footprint in Costa Rica (1.5) (t-stat= - 2.734, p-value 0.112; Figure 1).

I calculated the proportions that the Carbon Footprint, Food Footprint, Housing Footprint, and the Goods and Services Footprint comprised of the total Ecological Footprint for San Luis and Cañitas, Santa Elena and Cerro Plano, and Monteverde (figure 2 and 3). These results indicate the Carbon Footprint percentage in Monteverde (17%), compared to the Carbon Footprint percentages in the other two communities (San Luis/ Cañitas: 7%, Santa Elena/ Cerro Plano: 15%), had a greater percentage of the total Ecological Footprint. The Food Footprint comprised the greatest portion on the Ecological Footprint in Santa Elena/ Cerro Plano (52%). The Housing Footprint was greatest in San Luis/ Cañitas (32%) in comparison to the other two community Housing Footprint percentages (Santa Elena/ Cerro Plano = 19%, Monteverde = 20%). The Goods and Services portion of the Ecological footprint had relatively equal proportions of the Ecological Footprint in San Luis/ Cañitas Santa, Elena/ Cerro Plano and Monteverde (13%, 14%, and 14% respectively).

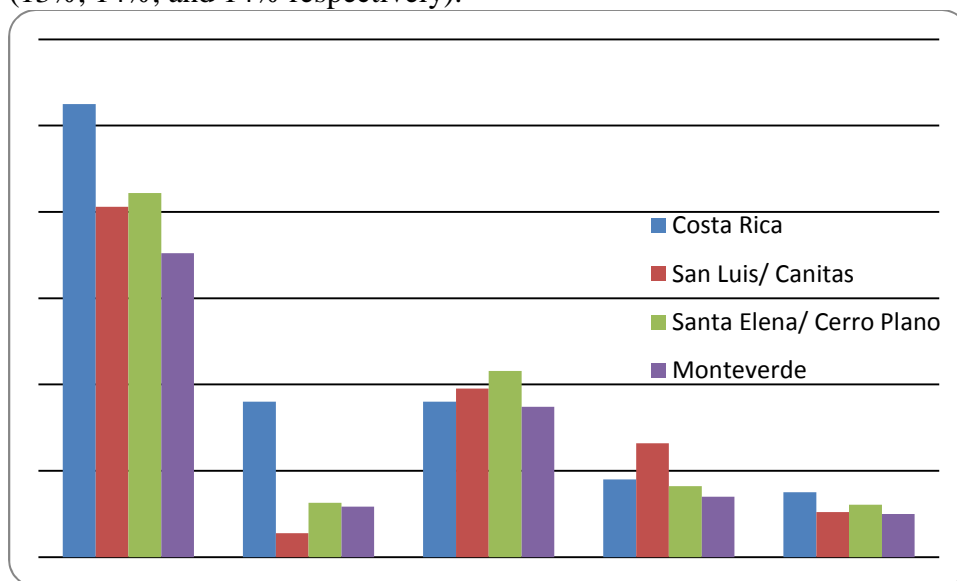


Figure1. Comparison of the mean Ecological Footprint, Carbon Footprint, Food Footprint, Housing Footprint, and Goods and Services Footprint in Costa Rica, San Luis/ Cañitas, Santa Elena/ Cerro Plano, and Monteverde.

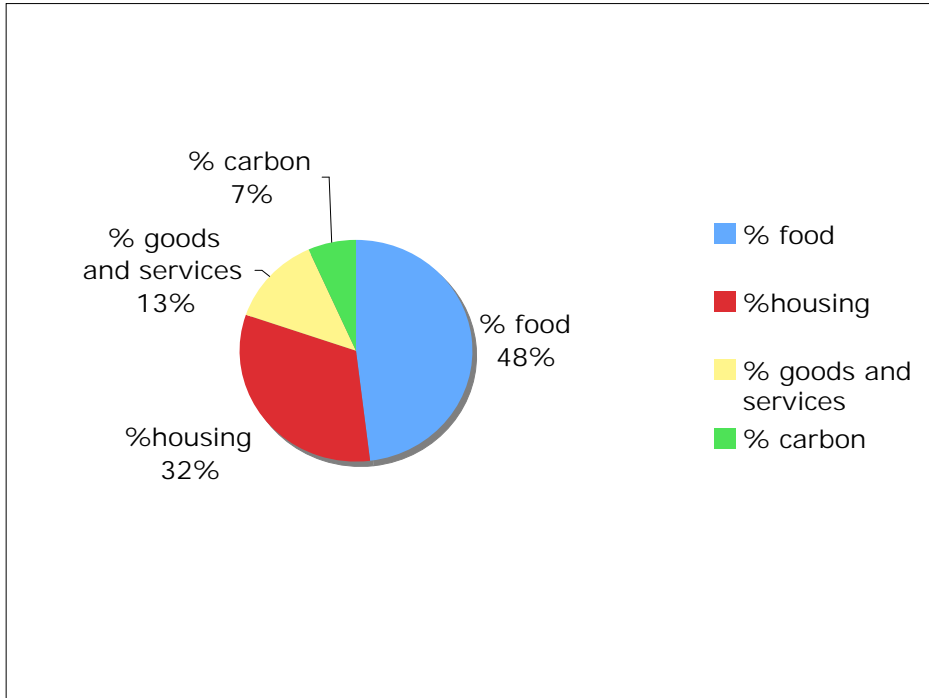


Figure2. Proportions of the mean Carbon Footprint, Food Footprint, Housing Footprint, and Goods and Services Footprint within the total mean Ecological Footprint of San Luis and Cañitas.

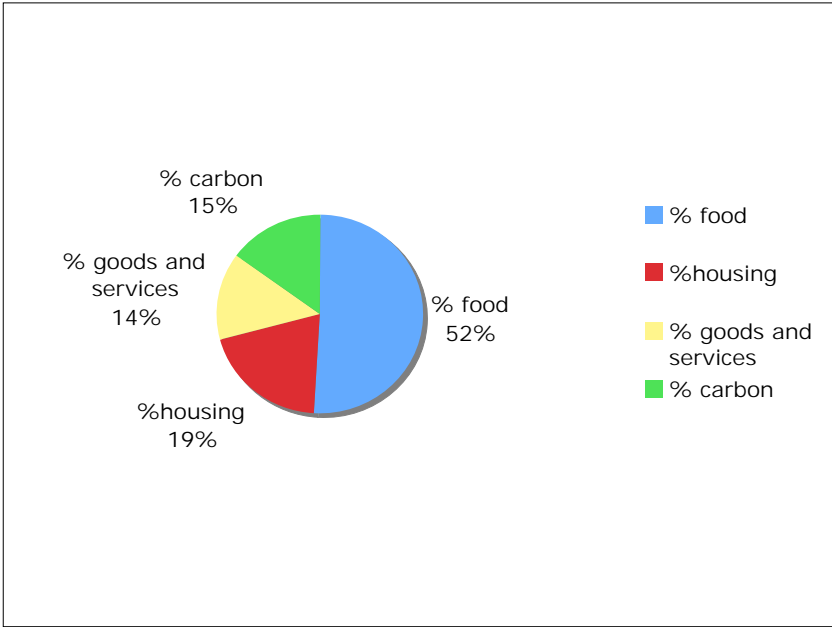
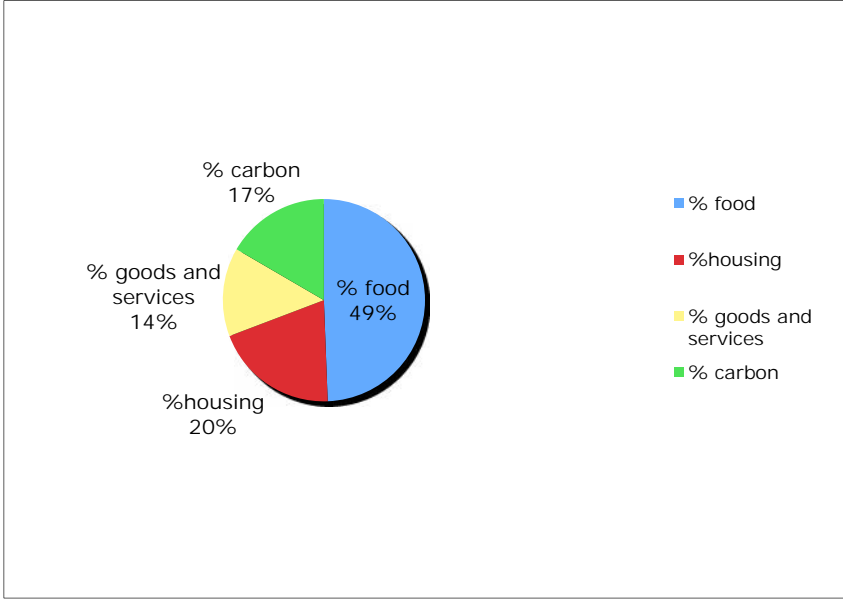


Figure3. Proportions of the mean Carbon Footprint, Food Footprint, Housing Footprint, and Goods and Services Footprint within the total mean Ecological Footprint of Santa Elena/ Cerro Plano (top) and Monteverde (bottom).

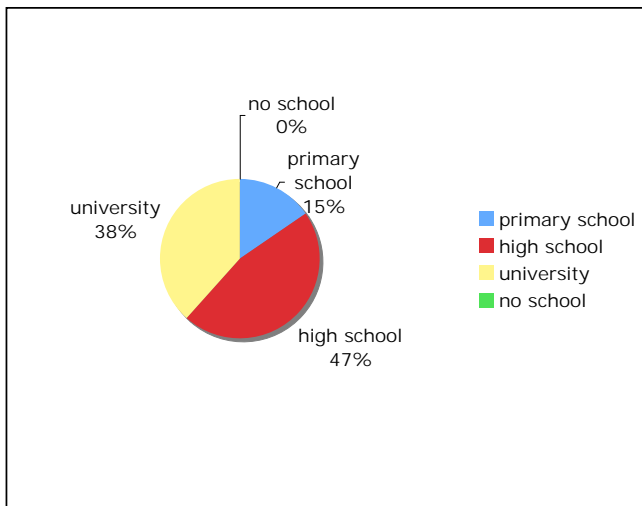
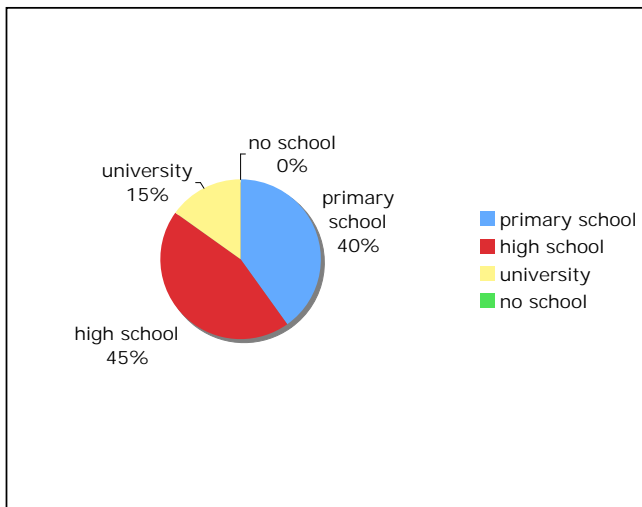
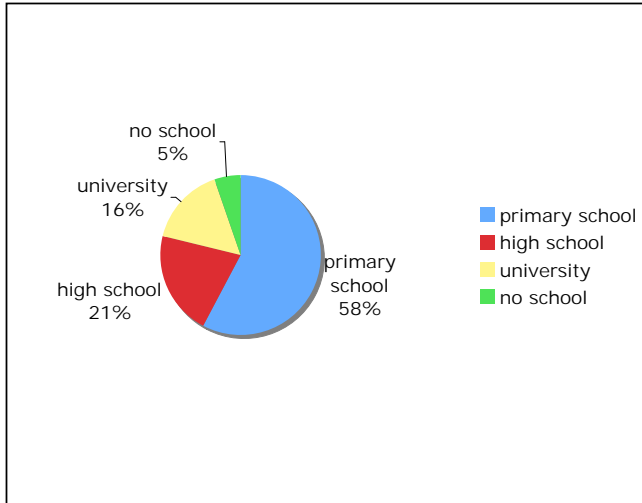


Figure4. Proportion of completed education levels in San Luis/ Cañitas (top), Santa Elena/ Cerro Plano (middle) and Monteverde (bottom).

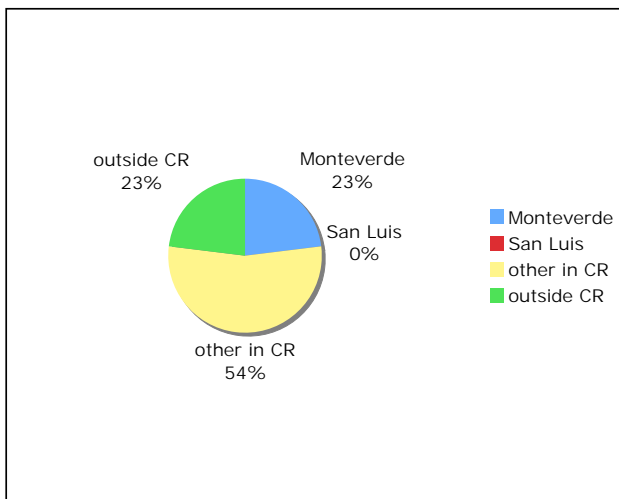
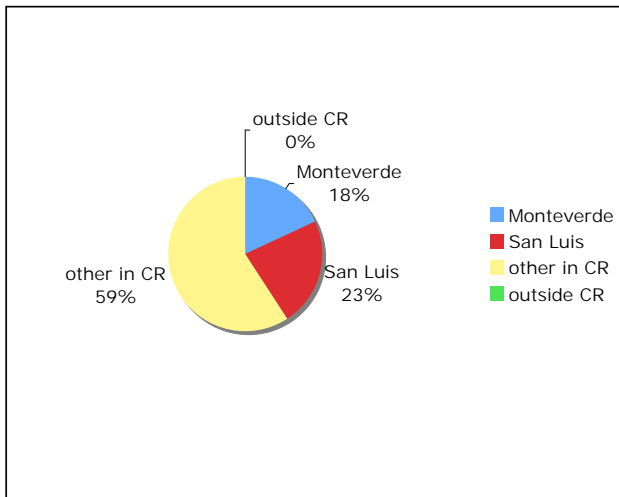
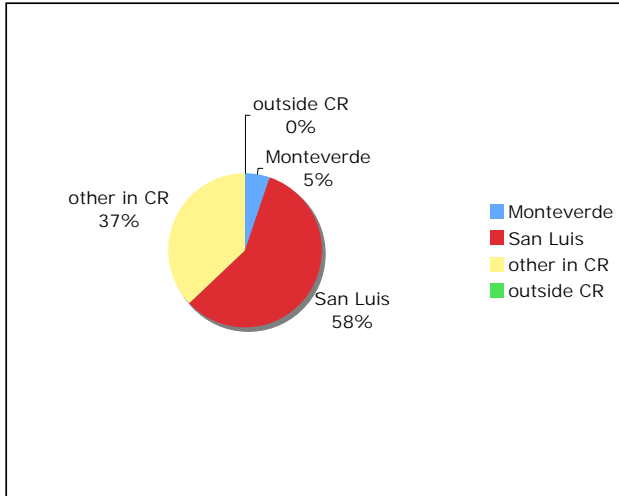


Figure5. Proportion of community members from San Luis/ Cañitas (top), Santa Elena/Cerro Plano (middle), and Monteverde (bottom) that grew up in Monteverde, San Luis, other places in Costa Rica, and outside Costa Rica.

DISCUSSION

My results indicate that there were not significant differences between the Ecological Footprint, Carbon Footprint, Food Footprint, Housing Footprint, and Goods and Services Footprint in San Luis/ Cañitas, Santa Elena/Cerro Plano, and Monteverde. This shows that according to the calculations, people in these three communities have nearly equal on the environment. In all cases, the Food Footprint is nearly 50% of the total Ecological Footprint. This is likely, attributed to the fact that the majority of people who live in these three communities eat meat for every meal. This significantly impacts a person's Food Footprint due to the high impact that meat production has on the environment (Marlow, H. et al. 2009). Although some of the meat that people consume in the more rural areas in these communities is literally from their backyard, raising livestock and the resources that cattle consumption requires still affect the environment negatively. The Goods and Services Footprint distribution in the Ecological Footprint was also very similar in all three communities. This is most likely the case because of the rarity of purchasing unnecessary consumer goods in this area. The majority of people observed in this study would describe themselves as frugal and would only buy things when it was truly necessary. Through these comparisons, one can see how daily decisions and habits can influence a person's impact on the environment

Communities differ in their Housing and Carbon Footprints. In San Luis/ Cañitas the proportion of the Housing Footprint is considerably larger than the percentages in Santa Elena/Cerro Plano and Monteverde. This is most likely a result of the large land use in the more rural communities. Many of the people that live in San Luis/ Cañitas have farms and substantial gardens. Having property significantly alters a person's Housing Footprint. In contrast, people in Santa Elena/ Cerro Plano and Monteverde live in more traditional, urban neighborhoods, in small family homes with little property. Another important difference in these proportions is the increase in Carbon Footprint percentage in Santa Elena/ Cerro Plano and Monteverde (15% and 17% respectively) in contrast to the lower Carbon Footprint proportion in San Luis/ Cañitas (7%). This is most likely due to the increase in driving and an increase in traveling in the more urban areas, whether it was solely by car, or more extensive travel, it was considerably higher in the more urban areas. This is supported by fact that of the participants, nearly 58% of the people that live in San Luis/ Cañitas grew up in San Luis. In addition, 65% of people from Santa Elena/ Cerro Plano and nearly 54% of people from Monteverde were from other places in Costa Rica outside of the studied regions. This implies more traveling and use of transportation, in contrast to the people who do not leave the community that they grew up in.

When looking closely at the distribution of each level of completed education, there are considerable differences between the three studied communities. While in Monteverde nearly 45% of people went to college or university, only about 15% of people in San Luis/ Cañitas and Santa Elena/ Cerro Plano attended university. There is clearly a large difference between the communities in the number of people that have a higher education (Jorgensen 2003). People who have higher education typically are more affluent. This supports the greater percentage of the Carbon Footprint in Monteverde's Ecological Footprint where people that are educated and affluent are able to own cars and travel more frequently (Jorgensen 2003).

This quiz attempts to take into account variables that are uncontrollable on an individual level, such as the types of resources that are available like energy sources. For example, it is designed based upon the country the respondent is from. However, not all factors can be accounted for, including the resources that are available to a person and other things that a person cannot control in their impact on the environment. For instance, people cannot really control the average transport of goods and the way that energy is generated.

For future studies it would be interesting to look at the populations of non- native residents in Monteverde. Incorporating this population into my study would have considerable effects on the total Ecological Footprints from each community. Additionally, it would be of significance to obtain a more random sample through visiting random homes in the communities. Because I frequently went to businesses to speak with people, I did not obtain a substantial sample of people who do not work or of people that are above the age of 60. Also, a larger sample size would create a more accurate depiction of the community structure. It would be of interest to repeat this study after 10-20 years to see how the values of the Ecological Footprints have changed. It would be relevant to look at this in relation to the change in tourism and development in Monteverde.

Specifically looking at how community dynamics in Monteverde affect the environment is important in understanding how living in a rural area versus more developed regions can affect the environment. Moreover, this sheds light on how developing countries are having a big impact on global environmental change through changes in consumption patterns. As a region becomes more developed and urban, certain actions affect the environment in a more influential ways. For example, as urbanization occurs, such as Monteverde in contrast to San Luis/ Cañitas, more people are driving and contributing to the increase in carbon dioxide emissions but also living in small houses on small lots. This study shows how it is not so much where a person lives, but how they live. Individual decisions made with sustainability in mind are vital to protecting the environment. This study illustrates how although people in Monteverde are living sustainably, as compared with the rest of the world, their impact can still be broken down into negative and positive impacts. Based upon my study, it takes approximately 0.53 Earth's to support a typical person in Monteverde, meaning that a typical person in Monteverde is living sustainably and if everyone lived as they did, we would not be exceeding the global carrying capacity. This shows that even if people are living in sustainable ways, they can still make improvements in their daily lives to further minimize their impact on the environment.

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Appendix

Additional Survey Questions:

- 1.) ¿Cuántos hijos tiene?
- 2.) ¿Cuántos hijos tiene sus padres?
- 3.) ¿Cuántos hijos tiene sus abuelos?
- 4.) ¿Donde trabaja?
- 5.) ¿Cuál fue su ultimo nivel de educación?
- 6.) ¿Donde creció?
- 7.) ¿Dónde vive?
- 8.) ¿Cuántos años tiene?