Microplastics are Nuts! Examining the Interplay between Squirrel Foraging Dynamics and Plastic Pollution

Faith James, Olivia Vergin, Dr. Joseph Whittaker, Dr. Jennifer Sweatman

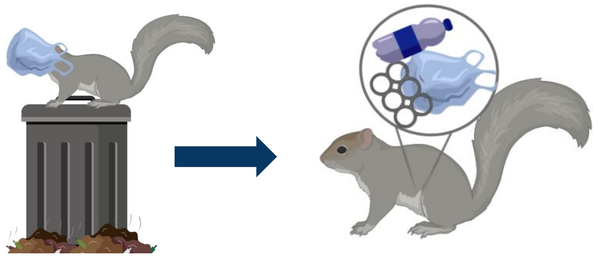
Introduction

Almost 348 million metric tons of plastic are produced globally each year (Lappé 2021). Plastic waste breaks down into microplastics (MPs, <5mm) (Huerta-Lwanga et al. 2016, Xu et al. 2020) that pollute the ecosystem. Eastern gray squirrels (*Sciurus carolinensis*) and American red squirrels (*Tamiasciurus hudsonicus*) have adapted new feeding behaviors to increase fitness in urban habitats (Dupras et al. 2016). They rely on both anthropogenic and natural food sources and have been observed consuming plastic on Concordia College's campus (personal observation).

Our goal: Characterize baseline plastic content of anthropogenic food sources for squirrels and understand the pervasiveness of microplastics in squirrels in urban and rural ecosystems in northwestern Minnesota.

Hypotheses:

- Over half of squirrel foraging material (by mass) from trash cans will be plastic
- Urban squirrels will contain more MPs than rural squirrels



Methods

Waste Audit

- Surveyed four trash cans outside on campus
- Collected all contents each night for one week
- Weighed and categorized items

Behavioral Observations

- Trapped and equipped squirrels with radio collar
- Used radio telemetry to track and identify individuals
- Characterized observed behaviors via an ethogram

Microplastic Analysis

- Extracted gastrointestinal tracts from urban and rural squirrels
- Digested organs in KOH and filtered to extract microplastics
- Counted and characterized microplastics in each sample

Results

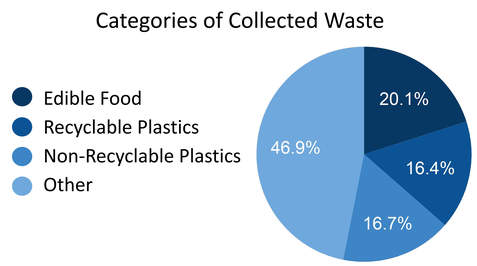


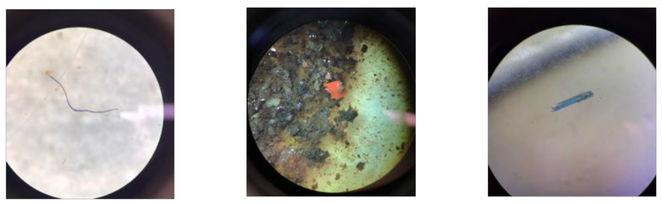
Figure 1. Pie chart showing the proportion of each type of trash found in trash cans outside on Concordia College's campus.

(a) Chew marks on garbage can

(b) Squirrel nest with plastic

(c) Dining Services containers

Figure 2. Observations of squirrels consuming and using plastic on campus.



(a) Fiber

(b) Foam

(c) Granule

Figure 3. Three categories of MPs found in squirrel gut samples: (a) Fiber, (b) Foam, (c) Granule.

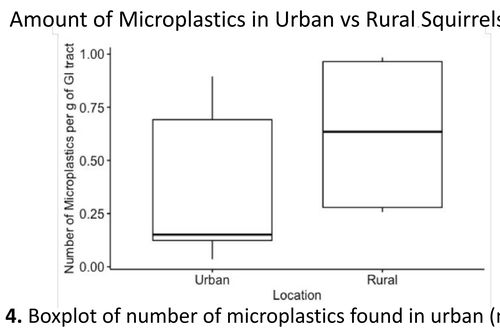


Figure 4. Boxplot of number of microplastics found in urban (n = 7, $\bar{X}$ = 0.38743 ± 0.13663) versus rural (n = 5, $\bar{X}$ = 0.62408 ± 0.15819) squirrels after standardization by GI tract mass (p = 0.123).

Discussion

Waste Audit

- Although the total proportion of plastic in anthropogenic sources was less than half (33%), there was evidence of squirrels chewing on plastic containers
- Many DS containers were chewed on

Behavioral Observations

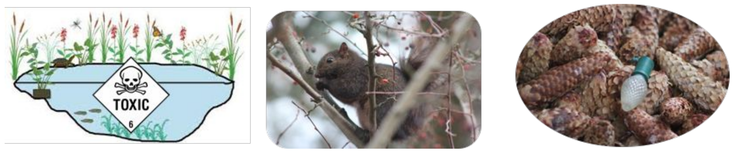
- Squirrels have been observed foraging through garbages and eating food scraps from plastic waste in person and on trail cams
- Behavioral analysis will be spatially analyzed using GIS

Microplastic Analysis

- Urban squirrels had a greater number of MPs than rural squirrels
  - Trend data indicates MP pollution in both rural and urban ecosystems
  - Could indicate the pervasiveness of human activities: researchers have found MPs in soil and water samples (Huerta-Lwanga et al. 2016); there is potential for all animals and ecosystems to be exposed to MPs
- Small sample sizes can lead to high levels of variability

Future Directions

Microplastic analysis will continue in order to increase sample size. We plan on conducting more trash can audits, continuing behavioral observations, and spatially analyzing food sources with nesting locations and individual sightings.



Acknowledgements

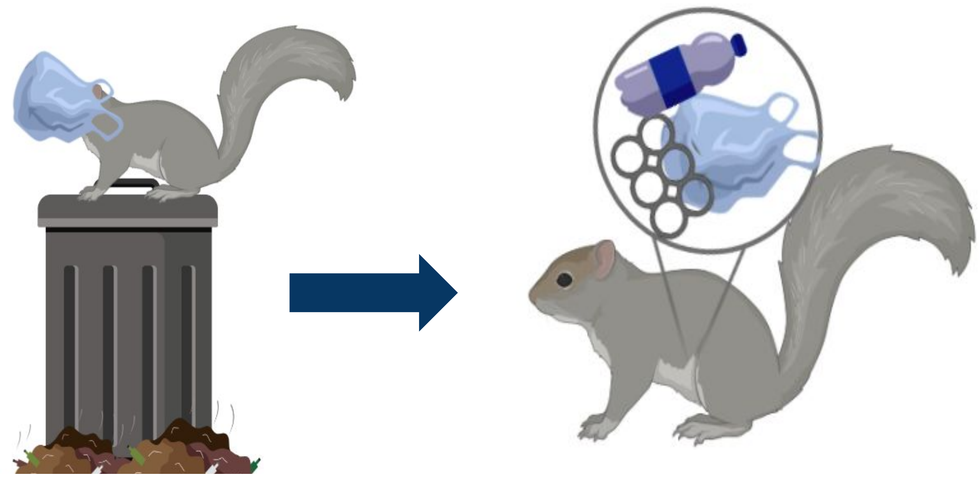
We would like to acknowledge URSCA internship program for funding, and we would like to thank Concordia College for use of their facilities and equipment and Dr. Whittaker and Dr. Sweatman for their guidance.

Literature Cited

Graphics created with BioRender.com.
Dupras, J., J. Marull, L. Parcerisas, F. Coll, A. Gonzalez, M. Girard, and E. Tello. 2016. The impacts of urban sprawl on ecological connectivity in the Montreal Metropolitan Region. *Environmental Science and Policy* **58**:61-73.
Huerta Lwanga, E., H. Gertsen, H. Gooren, P. Peters, T. Salanki, M. van der Ploeg, E. Besseling, A. Koelmans, and V. Geissen. 2016. Microplastics in the Terrestrial Ecosystem: Implications for *Lumbricus terrestris* (Oligochaeta, Lumbricidae). *Environmental Science and Technology* **50**:2685-2691.
Lappé, A. 2021. The problem with plastics. *Consumer Reports on Health* **33**:2.
Xu, C., B. Zhang, C. Gu, C. Shen, S. Yin, M. Aamir, and F. Li. 2020. Are we understanding the sources of microplastic pollution in terrestrial environment? *Journal of Hazardous Materials* **400**:1-12.

Introduction

Almost 348 million metric tons of plastic are produced globally each year (Lappé 2021). Plastic waste breaks down into microplastics (MPs, <5mm) (Huerta-Lwanga et al. 2016, Xu et al. 2020) that pollute the ecosystem. Eastern gray squirrels (*Sciurus carolinensis*) and American red squirrels (*Tamiasciurus hudsonicus*) have adapted new feeding behaviors to increase fitness in urban habitats (Dupras et al. 2016). They rely on both anthropogenic and natural food sources and have been observed consuming plastic on Concordia College's campus (personal observation).



Our goal: Characterize baseline plastic content of anthropogenic food sources for squirrels and understand the pervasiveness of microplastics in squirrels in urban and rural ecosystems in northwestern Minnesota.

Hypotheses:

- Over half of squirrel foraging material (by mass) from trash cans will be plastic
- Urban squirrels will contain more MPs than rural squirrels

Methods

Waste Audit

- Surveyed four trash cans outside on campus
- Collected all contents each night for one week
- Weighed and categorized items

Behavioral Observations

- Trapped and equipped squirrels with radio collar
- Used radio telemetry to track and identify individuals
- Characterized observed behaviors via an ethogram

Microplastic Analysis

- Extracted gastrointestinal tracts from urban and rural squirrels
- Digested organs in KOH and filtered to extract microplastics
- Counted and characterized microplastics in each sample

Results

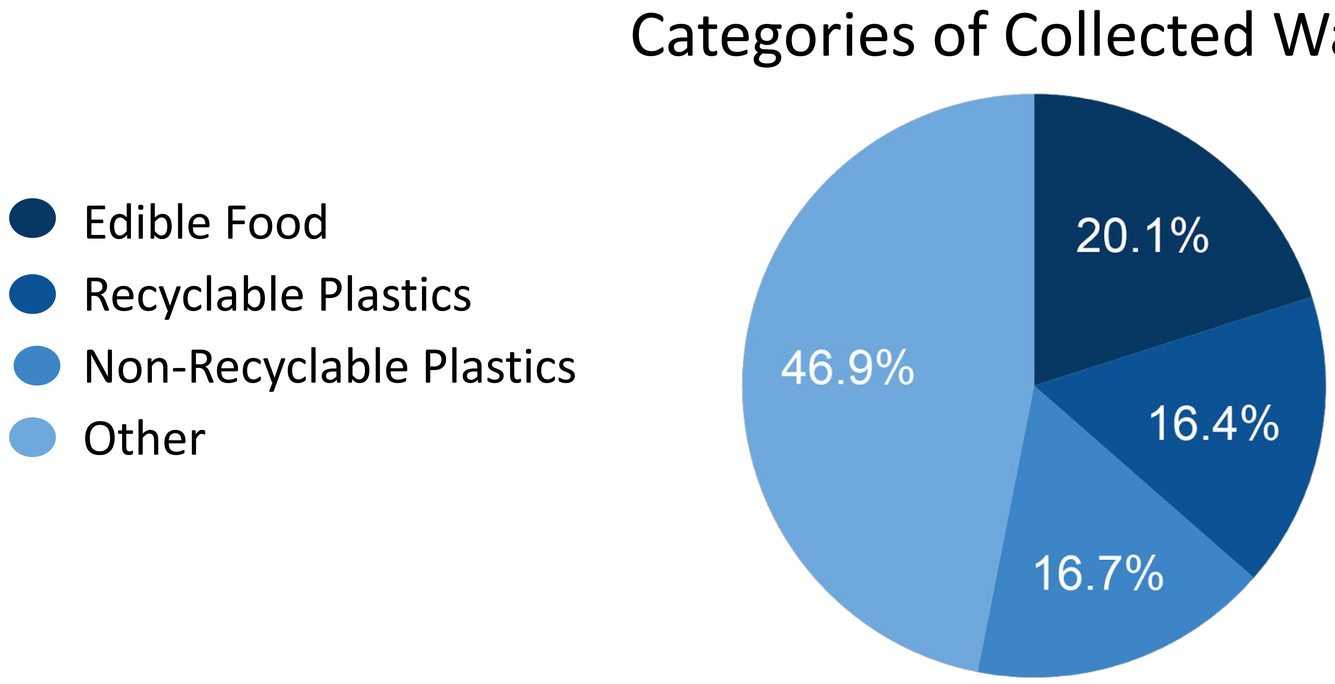


Figure 1. Pie chart showing the proportion of each type of trash found in trash cans outside on Concordia College's campus.

Figure 2. Observations of squirrels consuming and using plastic on campus.

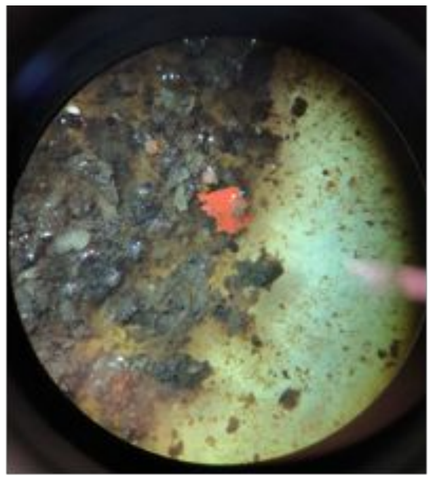
(a) Chew marks on garbage can

(b) Squirrel nest with plastic

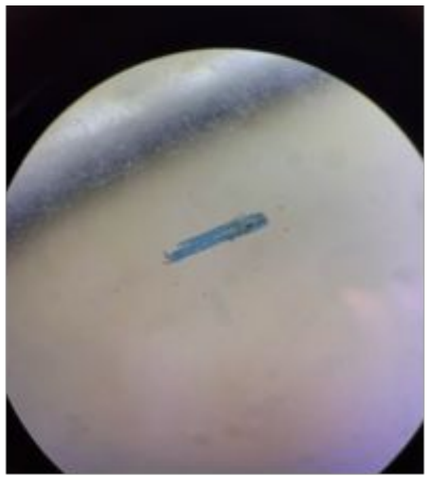
(c) Dining Services containers

Results

(a) Fiber



(b) Foam



(c) Granule

Figure 3. Three categories of MPs found in squirrel gut samples: (a) Fiber, (b) Foam, (c) Granule.

Figure 4. Boxplot of number of microplastics found in urban (n = 7, $\bar{x}$ = 0.38743 ± 0.13663) versus rural (n = 5, $\bar{x}$ = 0.62408 ± 0.15819) squirrels after standardization by GI tract mass (p = 0.123).

Discussion

Waste Audit

- Although the total proportion of plastic in anthropogenic sources was less than half (33%), there was evidence of squirrels chewing on plastic containers
- Many DS containers were chewed on

Behavioral Observations

- Squirrels have been observed foraging through garbages and eating food scraps from plastic waste in person and on trail cams
- Behavioral analysis will be spatially analyzed using GIS

Microplastic Analysis

- Urban squirrels had a greater number of MPs than rural squirrels
  - Trend data indicates MP pollution in both rural and urban ecosystems
  - Could indicate the pervasiveness of human activities: researchers have found MPs in soil and water samples (Huerta-Lwanga et al. 2016); there is potential for all animals and ecosystems to be exposed to MPs
- Small sample sizes can lead to high levels of variability

Future Directions

Microplastic analysis will continue in order to increase sample size. We plan on conducting more trash can audits, continuing behavioral observations, and spatially analyzing food sources with nesting locations and individual sightings.

Acknowledgements

We would like to acknowledge URSCA internship program for funding, and we would like to thank Concordia College for use of their facilities and equipment and Dr. Whittaker and Dr. Sweatman for their guidance.

Literature Cited

Graphics created with BioRender.com.

Dupras, J., J. Marull, L. Parcerisas, F. Coll, A. Gonzalez, M. Girard, and E. Tello. 2016. The impacts of urban sprawl on ecological connectivity in the Montreal Metropolitan Region. *Environmental Science and Policy* **58:**61-73.

Huerta Lwanga, E., H. Gertsen, H. Gooren, P. Peters, T. Salanki, M. van der Ploeg, E. Besseling, A. Koelmans, and V. Geissen. 2016. Microplastics in the Terrestrial Ecosystem: Implications for *Lumbricus terrestris* (Oligochaeta, Lumbricidae). *Environmental Science and Technology* **50:**2685-2691.

Lappé, A. 2021. The problem with plastics. *Consumer Reports on Health* **33**:2.

Xu, C., B. Zhang, C. Gu, C. Shen, S. Yin, M. Aamir, and F. Li. 2020. Are we understanding the sources of microplastic pollution in terrestrial environment? *Journal of Hazardous Materials* **400:**1-12.