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Red fox (Vulpes vulpes) distribution in relation to two prey species: eastern fox squirrel (Sciurus niger) and eastern gray squirrel (Sciurus carolinensis)

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Introduction

Red Fox Distribution

The European red fox (*Vulpes vulpes crucigera*) was introduced to North America for fox hunting (Schwartz et al., 2016). As result of vegetation changes due to the agricultural revolution in the United States, the native red fox (*Vulpes vulpes*) migrated south to take advantage of the new abundance of prey in the landscape, mixing with the introduced subspecies (Schwartz et al., 2016). Thus, the red fox's range shifted and expanded (Kamler & Ballard, 2002; Fig. 1). The species' current range extends throughout most of the US and Canada (Schwartz et al., 2016).

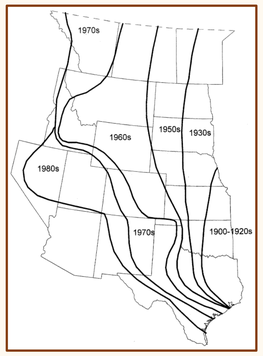

Figure 1. Range expansion of the red fox (*Vulpes vulpes*) over past decades. Bold lines indicate a shift westward throughout North America. Map and data from Kamler & Ballard 2002 *Wildlife Society Bulletin.*

Prey Species Interaction

Changing land uses led to fragmented, scattered habitats and increases in crop cover (Schwartz et al., 2016). This change attracted prey species, such as squirrels and other foraging mammals, which the red fox includes in its diet (Sidorovich et al., 2006). Eastern fox squirrels (*Sciurus niger*) and eastern gray squirrels (*Sciurus carolinensis*) occupy similar habitats (Brown & Batzli, 1984). Habitat preferences are similar to the red fox; therefore, all three species can have similar distributions and overlap in their ranges.

Study Objective

Our goal was to determine if the distribution of red foxes was affected by either the presence or absence of eastern fox and eastern gray squirrels.

Methods

We analyzed data collected by Snapshot USA (Cove et al. 2021) for our study.

Snapshot USA

- A nationwide passive camera trap survey was conducted synchronously from Aug to Nov in 2019.
- 1,509 camera traps were deployed across 110 camera arrays.
- Sampling locations covered 12 ecoregions and four different developmental zones (i.e., urban, suburban, rural, wild).
- Cameras were required to be 200 meters apart and not baited.
- We downloaded data from Cove et al. (2021) and Brown (2022). Cove et al. (2021) considered species detections at the same camera independent only when > 1 min apart.

Data Analysis

- We used data from each Snapshot USA camera to determine the presence or absence of each species.
- We used frequency histograms to create choropleth maps based on an equal interval method in ArcGIS.

Results

Survey Detections

- 52,024 cumulative trap nights were sampled for Snapshot USA in 2019.
- Eastern gray squirrels (EGS) were detected at a greater rate and at more locations than fox squirrels (EFS; Table 1).

Table 1. Red fox, eastern fox squirrel (EFS), and eastern gray squirrel (EGS) recorded across all study locations, with the number of detections per species. The most abundant mammal was eastern gray squirrel.

Species	Detections	Locations
Red Fox	1,569	175
EFS	5,826	175
EGS	19,009	542

Distribution Observations

- Red fox overlapped the greatest with EGS (Fig. 2 & 3).
- Minimal overlap occurred between red fox and EFS (Fig. 2 & 3).

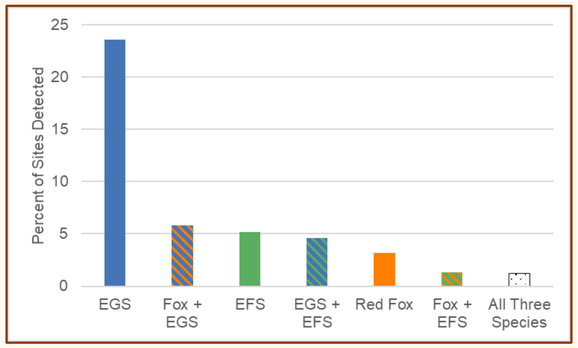

Figure 2. Percent of sites where the three focal species (i.e., eastern gray squirrel, EGS; eastern fox squirrel, EFS; red fox, "Fox") were detected. EGS were detected at the most sites, while few sites detected all three species together.

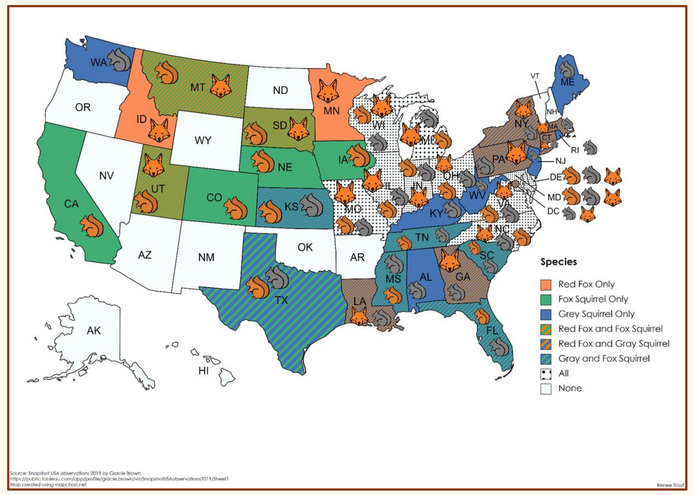

Figure 3. Red fox, eastern fox squirrel, and eastern gray squirrel detections by state. All states were sampled, but sampling effort was uneven (Cove et al., 2021). Icons represent species and colors represent where species' distributions overlapped.

Conclusions

Distribution and Range Overlap

- EGS and red fox ranges overlapped extensively. There was a weak overlap in the distributions of red fox and EFS, and all three species.
- Patterns may exist due to species' similar adaptability and habitat preferences (Creley & Muchlinski, 2017; Gil-Fernández et al., 2020).
- Range overlap can lead to species competition, as both squirrel species and foxes may compete for similar resources.
- Increasing distributions may also lead to unwanted competition between squirrels or fox predation on other rodent species.

Constraints

- Constraints with camera surveys include inclement weather, faulty equipment, human disturbance, and limitations of site locations.
- Sampling effort was uneven across surveyed states. For example, Vermont and New Hampshire only had a single camera array.

Distribution Surveys

- Surveys that evaluate predator distribution in relation to prey species are effective in providing data on both spatial and temporal patterns.
- Long-term studies, like Snapshot USA, are important to determine species' responses to land use shifts and climate change.

Future Research

- Snapshot USA has surveyed mammals nationwide in 2019–2023.
- This project serves as a baseline for observing predator-prey dynamics. Future efforts can explore the extrinsic and intrinsic factors which contribute to similarity in predator-prey distributions.

Figure 4. Camera trap photographs from Snapshot USA. Photographs include a red fox with a mouthful of eastern gray squirrel (left), an eastern gray squirrel (middle), and an eastern fox squirrel (right). Photos were cropped to focus on the individual.

Acknowledgements & References

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