What New Mexico Meadow Jumping Mice Tell Us About Functional Riparian Ecosystems

CEAP Wildlife Component – Charlie Rewa
Northern Arizona University studies – Carol Chambers
Q&A
Conservation Effects Assessment Project (CEAP)
Wildlife Component

- Document F&W outcomes and inform delivery
- Collaborates across NRCS to identify assessment priorities
- Relies on cooperative partnerships with fish and wildlife science community
- NRCS and CEAP Wildlife focus on southwestern riparian systems
What New Mexico Meadow Jumping Mice Tell Us About Functional Riparian Ecosystems

Carol L. Chambers
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Carol.Chambers@nau.edu
1. How far can a jumping mouse travel in 25 minutes?
   A. 1640 feet
   B. 510 feet
   C. 5260 feet

2. How far could a human jump if we had the same ability as a jumping mouse?
   A. 9 feet
   B. 18 feet
   C. 27 feet
1. How far can a jumping mouse travel in 25 minutes?
   A. 1640 feet
   B. 510 feet
   C. 5260 feet

   A. 1640 feet. We tracked a female returning upstream to her nest. She moved 1640 feet in 25 minutes, about 66 feet per minute. Over half that distance she was moving upstream.
2. How far could I jump if I were a jumping mouse?

A. 52 feet
B. 6 feet
C. 15 feet
D. 27 feet

D. 27 feet. Given the NMMJM can jump a bit more than 3 feet (38 inches let’s say), and it averages about 8 inches long (it has a very long tail), the jumping mouse can leap about 4.5 to 5 times its body length. This is equivalent to me leaping, from a squatting position, about 27 feet.
3. True or False: Sedges and rushes are the main diet of New Mexico meadow jumping mice.

4. True or False: Introduced plant species have displaced most native species in New Mexico meadow jumping mouse habitat.
Funding and Support

• Funding: NRCS, AGFD, FS, FWS, NAU, NSF

• Collaborators
  • Dr. Faith Walker, Director of Genetics, Bat (and Jumping Mouse) Ecology & Genetics Lab
  • Judy Springer, Botanist, Ecological Restoration Institute, NAU
  • Jeff Jenness, Wildlife Biologist and GIS Analyst

• Graduate Students
  • Daniel Sanchez, Jennifer Zahratka, Charlotte Rozanski, José G. Martínez-Fonseca

• Genetics
  • Colin Sobek, Austin Dikeman, Samantha Hershauer, Jacque Lyman, Jordyn Upton

• Technicians
  • Alexandra Anderson, Garrett Billings, Garrett Davis, Ari Giller-Leinwohl, Garrett Gimbel, Jordyn Gladden, Sara Freimuth, Rachel Harrow, Mikenzie Hart, Jackie Holm, Darin Kopp, Samantha Langley, Paige Langle, Ryan Lima, Elizabeth Locke, Brianna Mann, Rosario Marroquin-Flores, José G. Martínez-Fonseca, Andrew Nemecek, Lauren Noble, Matt Parker, Jill Peiffer, Courtney Ray, Savannah Richard, Charlotte Rozanski, Matthew Voorhees, Erin Westeen, Sarah Wicks, Caitlin Winterbottom, Kei Yasuda, Emily Yurcich

• Photos
  • José G. Martínez-Fonseca, Charles Hood, Jennifer Zahratka
For perspective

• Handled ~7000 small mammals
• Developed 2 non-invasive approaches to surveying
• Collected hair samples, buccal samples, fecal samples, plant samples
• Surveyed 100s of sites for vegetation composition and structure, stream conditions
• Conducted lab work to determine diet, population structure, stable isotopes, fecal cortisol metabolites
• Created a database with >2000 jumping mouse locations
• Radio collared 100 jumping mice, tracked them every night for up to 50 days
Context in the Southwest
Riparian Ecosystems

Incredibly important
Especially in the arid southwestern US
<2% land area is riparian
Riparian Ecosystems

Functions
• Control water pollution
• Reduce erosion
• Mitigate floods
• Provide habitat
Riparian Ecosystems

Functions
• Provide habitat

80% of all vertebrates
70% of threatened or endangered species
Listed **Endangered** under the Endangered Species Act in 2014
Why care about a rodent?

Because this endangered species tells us a lot about riparian function.
Primary threats
Overgrazing
Water use practices
Drought
Wildfire
Development
Highway projects
Recreation

USFWS 2014
Biology of the species poorly known
Questions in 2015

1. How can we detect jumping mice without harming them?
2. What type of habitat do they use?
3. How far do they move and what is their home range?
4. Where do they hibernate and for how long?
5. What do they eat?
6. How far do they disperse?
7. Do they move among watersheds?
8. Can they reproduce more than once a year?
9. What does a healthy stream look like?
10. Can degraded riparian areas be restored?
11. Can we translocate jumping mice successfully to newly restored riparian areas?
Answers (2015-2023)

- Non-invasive detection with track plates and eDNA
- Habitat models for individual sites and the geographic range
- Home range sizes and knowledge of movements
- Hibernacula at varied depths and varied locations
- Diet consists primarily of forbs and graminoids
- Dispersal capabilities through DNA
- Populations within watersheds with limited movement among them
- Reproductive capability study underway – maybe 2 litters per summer
- Streams with stable channels that maintain riparian habitat
- Restoration of streams and vegetation

11. Translocating prior to and post stream restoration
What should a “jumping mouse” stream look like?
### 5. PLANT FORM
Measure parallel to the stream and within the "overbank zone" (on the first flat surface) within the riparian zone.

<table>
<thead>
<tr>
<th>Value</th>
<th>Score</th>
<th>Bench</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. &gt;50% sedges with abundant forbs and grasses</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. 40-50% sedges with presence of forbs and grasses</td>
<td>0.7-0.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. &gt;30% sedge cover with some forbs</td>
<td>0.5-0.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Grasses dominate but some sedges present</td>
<td>0.2-0.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. No forbs or only grasses</td>
<td>0.0-0.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 6. GENERAL HYDROLOGY
Measure the presence of water and saturated soils.

<table>
<thead>
<tr>
<th>Value</th>
<th>Score</th>
<th>Bench</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Riparian with perennial flow</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Riparian with saturated soils during summer</td>
<td>0.7-0.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Intermittent stream that maintains saturated soils during summer</td>
<td>0.5-0.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Intermittent stream that dries out during warm, dry winters and summers</td>
<td>0.2-0.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. No stream flow, no moisture, dry, no dense riparian vegetation</td>
<td>0.0-0.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 7. CHANNEL EVOLUTION STAGE
Categorize the channel evolution stage of the stream described by Schumm et al. (1987).

<table>
<thead>
<tr>
<th>Value</th>
<th>Score</th>
<th>Bench</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. I, V</td>
<td>0.8-1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. IV</td>
<td>0.6-0.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. II, III</td>
<td>0-0.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 8. CHANNEL SINUOSITY
Using an aerial photo, measure the length of the stream compared to the valley length; measure outside Assessment Area if needed.

<table>
<thead>
<tr>
<th>Value</th>
<th>Score</th>
<th>Bench</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Stream length is ≥2 times length of the valley</td>
<td>0.9-1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Stream length is 1.3 to 1.9 times length of the valley</td>
<td>0.5-0.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Straight channel; stream length is ≤1.2 length of the valley</td>
<td>0-0.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Not a "mouse"
Family Zapodidae
“Mouse-like”
“Kangaroo-like”
Elongated hind limbs
Short forelimbs
Long tail
Leap 8 to 10 feet
Nocturnal
Solitary
Locomotion

• Creeping
• Climbing
• Leaping
• Hopping
• Swimming
• Diving

https://www.youtube.com/watch?v=rQXey4Q1Lew
Other unique aspects

• Hibernate 7 to 9 months
• Active 3 to 5 months
• Low reproductive rate
• 1 litter per year
Prior to hibernation (20 g)

Increase mass by 25 to 100% (6 to 20 g, mass of up to 39 g)
What does it take to survive?

Knowledge of:
1. Species distribution
2. Habitat
3. Diet
4. Home range
5. Hibernation
6. Dispersal
7. Connectivity
8. Population structure and gene flow
9. Stream geomorphology
Species distribution
Species Distribution Model (SDM)

585 New Mexico meadow jumping mouse locations
1200 pseudo-absence locations
30x30 m pixel grain
Extent was the range for the jumping mouse
Variables modeled:
- Distance from stream
- National Vegetation Classification from Landfire
- 19 bioclimate variables from the World Climate dataset

Best variables:
- Distance from stream
- Bioclimate variables
  - Temperature (wettest quarter, coldest quarter, annual range, driest quarter)
  - Precipitation (driest quarter, driest month)
Riparian areas
Habitat modeling

- Occupancy modeling
- 2016
- 75 sites
- Arizona
- Trapping and track plating
Tools and Technology

Track Plates Detect the Endangered New Mexico Jumping Mouse

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CAROL L. CHAMBERS, School of Forestry, Northern Arizona University, Flagstaff, AZ 86011, USA

ABSTRACT The New Mexico jumping mouse (Zapus luteus luteus, formerly Z. hudsonius luteus), an endangered subspecies found in the southwestern United States, inhabits riparian areas with tall, dense herbaceous vegetation as habitat. To detect presence of this species for use in defining life history and habitat use, we developed and tested 4 noninvasive track-plate methods, and selected the best for field use. New Mexico jumping mice have unique feet and toes that are readily distinguishable from other small mammals within their geographic range. We created reference photos of rodent tracks that confirmed the unique footprints of the jumping mouse and tested this method against detection with live traps in the Apache–Sitgreaves, Arizona, and Santa Fe, New Mexico, USA, National Forests, 2016 and 2017. When comparing the 2 detection methods, in only 1 of 16 comparisons did results differ, where we captured jumping mice in live traps but did not detect them with track plates. Based on our results with this approach, track plates may be a cost-effective method to detect the endangered New Mexico jumping mouse.
New Mexico meadow jumping mouse

Deer mouse

Vole
Site selection

- Elevation
- Perennial and intermittent streams
- Riparian vegetation
- NAIP imagery to confirm vegetation structure
- 75 sites
Vegetation and habitat surveys

Canopy cover
Slope, aspect
Soil moisture
Daubenmire
Shrub count
Basal area
Vegetation height
Robel pole
Stream width
Stream gradient
## Occupancy modeling

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cumulative AIC weight</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean total vegetation height</td>
<td>0.995</td>
<td>positive</td>
</tr>
<tr>
<td>mean stream width</td>
<td>0.983</td>
<td>positive</td>
</tr>
<tr>
<td>% alder</td>
<td>0.972</td>
<td>positive</td>
</tr>
<tr>
<td>stream gradient</td>
<td>0.954</td>
<td>negative</td>
</tr>
<tr>
<td>% forb</td>
<td>0.877</td>
<td>positive</td>
</tr>
<tr>
<td>wild ungulate grazing</td>
<td>0.754</td>
<td>positive</td>
</tr>
<tr>
<td>mean soil moisture</td>
<td>0.643</td>
<td>positive</td>
</tr>
<tr>
<td>% sedge</td>
<td>0.426</td>
<td>positive</td>
</tr>
<tr>
<td>plant richness</td>
<td>0.203</td>
<td>positive</td>
</tr>
<tr>
<td>cattle grazing</td>
<td>0.169</td>
<td>negative</td>
</tr>
<tr>
<td>% grass</td>
<td>0.089</td>
<td>negative</td>
</tr>
<tr>
<td>distance to roads</td>
<td>0.019</td>
<td>positive</td>
</tr>
<tr>
<td>distance from recreational sites</td>
<td>0.022</td>
<td>positive</td>
</tr>
</tbody>
</table>
Mean total vegetation height

![Graph showing the relationship between mean vegetation height (in) and occupancy estimate (psi).]
Alder cover
Arizona
43 of 75 sites grazed

12 of 43 sites with ZAHU detections

31 of 43 without ZAHU detections
Based on our Arizona model, jumping mice select
• Sites with tall vegetation
• Wide streams with lower gradient
• Higher alder, forb, and sedge cover
• Moist soils
• Presence of elk and other wild ungulates
Habitat modeling

- Logistic regression
- 2016-2017
- 111 sites
- Arizona and New Mexico
- Trapping and track plating
Plant species composition
Logistic Regression

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>SE</th>
<th>$X^2$</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-15.95</td>
<td>3.44</td>
<td>21.54</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Plant species richness</td>
<td>+0.06</td>
<td>0.02</td>
<td>12.09</td>
<td>0.0005</td>
</tr>
<tr>
<td>% ground cover</td>
<td>+0.13</td>
<td>0.04</td>
<td>11.72</td>
<td>0.0006</td>
</tr>
<tr>
<td>Total vegetation height (cm)</td>
<td>+0.07</td>
<td>0.02</td>
<td>10.25</td>
<td>0.001</td>
</tr>
<tr>
<td>Average width of stream (m)</td>
<td>+0.45</td>
<td>0.20</td>
<td>5.27</td>
<td>0.02</td>
</tr>
<tr>
<td>% sedge cover</td>
<td>+0.04</td>
<td>0.02</td>
<td>4.36</td>
<td>0.04</td>
</tr>
<tr>
<td>% alder cover</td>
<td>+0.39</td>
<td>0.19</td>
<td>4.26</td>
<td>0.04</td>
</tr>
<tr>
<td>% water cover</td>
<td>+0.18</td>
<td>0.09</td>
<td>3.88</td>
<td>0.05</td>
</tr>
<tr>
<td>% forb cover</td>
<td>+0.27</td>
<td>0.15</td>
<td>3.25</td>
<td>0.07</td>
</tr>
</tbody>
</table>
Based on our regional model, jumping mice select:
- Sites with high plant species diversity
- Tall vegetation
- Wide streams
- Higher alder, forb, and sedge cover
Consistent predictors

Tall, dense vegetation
Wide streams
Alder, forb, and sedge cover

Plant species richness
Applications

WHEG
1. Herbaceous vegetation height
2. Herbaceous vegetation density
3. Native shrub cover
4. Plant species richness
5. Plant form
6. General hydrology
11. General site disturbance

Tool (SDM) for identifying potential habitat
Identify Diet

1. Gut contents
2. Field observations
3. Stable isotopes
4. Shotgun metagenomics
5. Metabarcoding
Jumping mice are \( \text{C}_3 \) herbivores.
<table>
<thead>
<tr>
<th>Family</th>
<th>Potential species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salicaceae</td>
<td>willow</td>
</tr>
<tr>
<td>Solanaceae</td>
<td>wild potato and variations</td>
</tr>
<tr>
<td>Poaceae</td>
<td>grass</td>
</tr>
<tr>
<td>Amaranthaceae</td>
<td>amaranth</td>
</tr>
<tr>
<td>Phrymaceae</td>
<td>monkeyflower</td>
</tr>
<tr>
<td>Fabaceae</td>
<td>clover, legume</td>
</tr>
<tr>
<td>Brassicaceae</td>
<td>mustards</td>
</tr>
<tr>
<td>Linaceae</td>
<td>blue flax</td>
</tr>
<tr>
<td>Asteraceae</td>
<td>wild oysterplant, sunflower</td>
</tr>
<tr>
<td>Geraniaceae</td>
<td>wild geranium</td>
</tr>
<tr>
<td>Amaryllidaceae</td>
<td>wild onion</td>
</tr>
<tr>
<td>Boraginaceae</td>
<td>bluebell, starflower, combseed</td>
</tr>
<tr>
<td>Rosaceae</td>
<td>wild rose</td>
</tr>
</tbody>
</table>
Diet

- 2016-2020
- June - October
- Arizona, Colorado, and New Mexico
- Live trapping

145 jumping mice
DNA Metabarcoding

Diet revealed (QIIME 1.9.1)
seqA = Carex sp.
seqB = Juncus sp.
seqC = Poa sp.

Enrich plant targets only

Parallel sequencing (Illumina)

Gene target: ITS2
- 98% plants to Genus
- 65% to species
Forbs and graminoids are most common in diet
Plants

- Up to 9 genera per jumping mouse
- Forbs and graminoids
- Reflect native vegetation at capture sites
- 41% of plant diet items identified to species
- 74% native
- 81% perennial
Flower and seed predators
Application

WHEG

3. Native shrub cover
4. Plant species richness
10. Adjacent upland condition

Seed mix for restoration
Only 1 published study on home range

Major rivers

Current distribution

Home range

- 2017-2020
- June - October
- Arizona, Colorado, and New Mexico
- Live trapping and radio collaring
Day nests

Above ground bolus nests
Day nests

Above ground bolus nests
Home ranges

2017-2020

70 home ranges

11 in CO, 4 sites
23 in NM, 6 sites
36 in AZ, 9 sites
Minimum Convex Polygon
95% Kernel Density
Home range and movements ($\bar{x} \pm SE$)

<table>
<thead>
<tr>
<th>Metric</th>
<th>This study</th>
<th>Wright and Frey (2015)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% MCP (ha)</td>
<td>3.0 ± 0.5</td>
<td>1.4</td>
</tr>
<tr>
<td>95% KD (ha)</td>
<td>2.8 ± 0.6</td>
<td>NA</td>
</tr>
<tr>
<td>Max distance last location (m)</td>
<td>273 ± 27</td>
<td></td>
</tr>
<tr>
<td>Distance from stream (m)</td>
<td>11 ± 2</td>
<td></td>
</tr>
</tbody>
</table>

Maximum distance moved by an individual from its last location = 1155 m
Landscape connectivity

• Facilitation or disruption of gene flow
• Connectivity and barriers
• Do disconnected watersheds structure populations?
Population structure

- Gene flow
- 3 watersheds
- Arizona
- Trapping and fecal DNA
- nuDNA, mtDNA

Do disconnected watersheds structure populations?

- Black (BR), Little Colorado (LCR), San Francisco (SF) Rivers
- Headwaters 2 to 6 km apart
- Monsoon rains (Jul-Sep)
  - No gene flow
  - Low to moderate gene flow but discernable structure
  - Moderate to high gene flow, no discernable structure
Intermediate

Low to moderate but discernable genetic structure, occasional gene flow

Populations in watersheds were distinct
Over-land dispersal & fragmentation

Assuming 3 populations

Migration rate

Non-natal disperser

Assuming 2 populations

Human development

East Fork LCR – SF
Do disconnected watersheds predict genetic isolation in New Mexico meadow jumping mice?

Yes

Disconnected watersheds impede movement and genetically isolate jumping mice.
Application

WHEG

6. General hydrology
10. Adjacent upland condition
11. Site disturbance
12. Water depletions

Information for captive breeding program
Fluvial geomorphology

- 2020
- 58 sites
- Arizona
- Level III – Stream state and condition
- Rosgen’s Classification of Natural Rivers

How does local fluvial geomorphology affect the presence of the jumping mouse?

NRCS conducted 20 stream surveys and identified a geomorphic reference site

Current stable analog, which indicates the most desirable physical condition for a natural stable system, with excellent floodplain connectivity
Historically occupied site (Lincoln National Forest)

Degraded stream, loss of floodplain connectivity
**Surveys**

**Stream Metrics:**

1. Bank-height ratio
2. Meander-width ratio
3. Entrenchment ratio
4. Width flood prone area
5. Width-depth ratio
6. Sinuosity
7. Bed material size (D50)
8. Slope (%)
9. Stream type
10. Channel Evolution Stage

**Survey Methods:**

- Stream Cross-section
- Longitudinal Profile
- Water Surface Profile
- Pebble Count
What predicted use by jumping mice?

- Lower Bank-height ratio
- Higher Sinuosity
- Channel evolution stages I, IV, and V
Stage 1 - Stable

Stage 2 – Incising and degrading

Stage 3 – Widening, deepening, degrading

Stage 4 – Widening and aggrading

Stage 5 – Functionally recovered or quasi-equilibrium

Schumm et al. 1984; Hawley et al. 2020
WHEG

6. General hydrology
7. Channel evolution stage
8. Channel sinuosity
9. Adjacent upland condition
12. Water depletions

Recommendations for restoration
Restoration

Process-based watershed restoration

1. Restore streams with jumping mouse populations that are showing signs of degradation.

2. Identify degraded stream reaches that have resulted in the fragmentation of riparian habitat corridors.
   • 200 m of low-quality riparian habitat could be a barrier to dispersal.
   • Grazing exclosures around designated critical habitat should be monitored and extended when possible.
   • Low-cost restoration actions include Beaver Dam Analogs, one-rock dams, rock weirs.
Beaver Dam Analogs (BDAs)
Restored stream section
What should a “jumping mouse” stream look like?
Current and Future Work

Fecal Cortisol Metabolites
eDNA
Translocation
Mammalian eDNA on herbaceous vegetation? Validating a qPCR assay for detection of an endangered rodent

<table>
<thead>
<tr>
<th>Journal:</th>
<th>Environmental DNA</th>
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</thead>
<tbody>
<tr>
<td>Manuscript ID</td>
<td>EDN3-2021-0079.R1</td>
</tr>
<tr>
<td>Wiley - Manuscript type:</td>
<td>Original Article</td>
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<tr>
<td>Search Terms:</td>
<td>eDNA, endangered species, noninvasive survey, conservation</td>
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</tbody>
</table>

Vegetation is an underutilized medium for environmental DNA (eDNA) sampling. eDNA methods leveraging water as a substrate exclude application to many terrestrial species. The use of eDNA to detect small mammals can complement current survey approaches (live capturing, track plating, camera trapping) while reducing risks to the animals. We demonstrated feasibility of using eDNA isolated from vegetation to detect an endangered rodent. The New Mexico meadow jumping mouse (Zapus humulis俭ustus) is specialized to herbaceous riparian zones, making it an ideal candidate for terrestrial eDNA monitoring.
<table>
<thead>
<tr>
<th>Plant Species Richness</th>
<th>Plant Form</th>
<th>General Hydrology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbaceous Vegetation Height</td>
<td>Herbaceous Vegetation Density</td>
<td>Native Shrub Cover</td>
</tr>
<tr>
<td>Channel Evolution Stage</td>
<td>Channel Sinuosity</td>
<td>Channel Condition</td>
</tr>
<tr>
<td>Adjacent Upland Condition</td>
<td>Site Disturbance</td>
<td>Water Depletions</td>
</tr>
</tbody>
</table>
3. True or False: Sedges and rushes are the main diet of New Mexico meadow jumping mice.

4. True or False: Introduced plant species have displaced most native species in New Mexico meadow jumping mouse habitat.
3. True or False: Sedges and rushes are the main diet items of jumping mice.

False: Forbs and grasses are the main diet items of jumping mice.
4. True or False: Introduced plant species have displaced most native species in NMMJM habitat.

**False**: On average, <12% of plants are introduced species in NMMJM habitat.
Summary

- Healthy riparian areas are key for this species
- Tall, diverse vegetation
- Diverse diet
- Small home ranges, close to streams, day nests and hibernacula outside flood zone
- Genetic isolation likely exists among watersheds
- Excellent potential for riparian improvement and restoration
- Connecting suitable habitat is critical (private lands contribution)
Questions?
Thank You

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