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*Development and Application
of a Habitat Suitability Ranking Model for
the New Mexico Meadow Jumping Mouse
(Zapus hudsonius luteus)*

Los Alamos
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by

James Biggs, Mary Mullen, and Kathryn Bennett

ABSTRACT

The New Mexico meadow jumping mouse (*Zapus hudsonius luteus*) is currently listed as a state threatened species in New Mexico and has been identified as potentially occurring within the Los Alamos National Laboratory (LANL) boundary. We describe the development of a model to identify and rank habitat at LANL that may be suitable for occupation by this species. The model calculates a habitat suitability ranking (HSR) based on total plant cover, plant species composition, total number of plant species, and plant height. Input data for the model is based on the measurement of these variables at known locations where this species has been found within the Jemez Mountains. Model development included the selection of habitat variables, developing a probability distribution for each variable, and applying weights to each variable based on their overall importance in defining the suitability of the habitat. The habitat variables (HV) include plant cover (HV1), grass/forb cover (HV2), plant height (HV3), number of forbs (HV4), number of grasses (HV5), and sedge/rush cover (HV6). Once the HVs were selected, probability values were calculated for each. Each variable was then assigned a "weighting factor" to reflect the variables' importance relative to one another with respect to contribution to quality of habitat. The least important variable, sedge/rush cover, was assigned a weight factor of "1" with increasing values assigned to each remaining variable as follows: number of forbs = 3, number of grasses = 3, plant height = 5, grass/forb cover = 6, and total plant cover = 7. Based on the probability values and weighting factors, a HSR is calculated as follows: $HSR = (P_{HV1}(7) + P_{HV2}(6) + P_{HV3}(5) + P_{HV4}(3) + P_{HV5}(3) + P_{HV6}(1))$. Once calculated, the HSR values are placed into one of four habitat categorical groupings by which management strategies are applied.

INTRODUCTION

The New Mexico meadow jumping mouse (*Zapus hudsonius luteus*) is currently listed as a state threatened species in New Mexico. This species has been identified as potentially occurring within the Los Alamos National Laboratory (LANL) boundary because LANL property has habitat that is similar to habitat at off-site locations that are known to be occupied by the New Mexico meadow jumping mouse. Known populations of meadow jumping mouse in New Mexico have been found close to permanent free-flowing water, in riparian zones along streams and ditches, and in wet meadows near cattail marshes

associated with major rivers (Morrison 1990, 1992). Dry, higher ground near waterways that provide locations for nesting and hibernation is also typical of habitat where jumping mice have been found. Soil is usually damp or moist, there is no standing water, and there is dense, tall vegetation (.5 m or greater) dominated by grasses and forbs that provide thick cover and food sources.

This document describes the following four-step process to identify and rank habitat at LANL, using a combination of the geographical information system (GIS) and field data, that may be suitable for occupation by the New Mexico meadow jumping mouse:

Step 4 describes model development and the application of the model to calculate a suitability ranking for the habitat. Once Step 4 has been completed and a suitability ranking calculated, management recommendations, as described in this document, can be applied.

PROCESS TO IDENTIFY AND RANK HABITAT

Step 1 – Use of GIS to Identify Wetlands

The first step utilizes the GIS as a screening tool to identify potentially suitable habitat on LANL property by delineating wetlands and/or riparian areas along stream channels and LANL outfalls. The GIS delineates wetlands/floodplains that have been surveyed and recorded by Ecology Group personnel and wetlands and floodplains identified in the US Fish and Wildlife Service wetlands inventory map.

Step 2 – Ground-truth Site

The second step is the use of a site investigation to conduct a preliminary evaluation of habitat identified by Step 1. By using the flow chart below, the evaluator determines if a formal data collection effort and

model application are necessary. Presence and size of the riparian area and vegetative composition and cover are recorded at the site.

If, based on Step 2, the site meets the minimum requirements for data collection and application of the habitat suitability ranking model, then Step 3 is performed.

Step 3 – Collection of Field Data for Model Input

Step 3 involves a thorough collection of data pertaining to total plant cover, plant species composition, total number of plant species, and plant height. Data measurements are taken on each side of the primary stream or drainage channel in the study site and analyzed separately. A suitability ranking is calculated for each side of the stream channel since habitat on one side of the stream channel could be sufficient to support meadow jumping mice. If the site is a marsh or meadow, use the primary drainage as the stream

channel. Each of these variables has been described in the literature as important factors in determining suitable habitat for meadow jumping mouse. The techniques used to collect data on these variables are provided below; all data are recorded on forms shown in the attachment to this document.

Total Plant Cover – The percent canopy cover for grasses, forbs, sedges, rushes, and shrubs are recorded using a Daubenmire plot (Daubenmire 1959). The plot is placed along a series of transects placed both parallel and perpendicular to the primary stream or drainage channel (Figure 1). Generally, the transects parallel to the stream channel are 100 m long, and those transects perpendicular to the channel are a minimum of 10 m long. However, modifications may be necessary depending on size and shape of site. Percent plant cover from each Daubenmire plot is pooled and averaged for the overall percent plant cover for each side of the site.

Figure 1. Transect Placement for Measuring Vegetation and Riparian Area Characteristics for Application to Meadow Jumping Mouse Model.

Plant Species Composition – The relative percent composition of five different cover types is recorded in each of the Daubenmire plots: grass, sedge/rush, forb, shrubs, and bare ground. All data are pooled from the plots and averaged for the overall relative percent species composition for each side of the stream channel.

Total Number of Plant Species – The total number of individual forb and grass species is calculated from the Daubenmire plots for each side of the site.

Plant Height – The grass and forb plant height is averaged for each of the Daubenmire plots, then the plots are pooled and averaged for each side of the channel. The average plant height is classified as <0.05 m, 0.5 to 1.0 m, and greater than 1.0 m. Once the data have been collected, the data are input into the habitat suitability ranking model (Step 4).

Step 4 – Application of Habitat Suitability Ranking Model

This section describes the development and application of a model that provides a habitat suitability ranking. The ranking will fall within one of several categories that are used in determining the need for actual meadow jumping mouse surveys and for use in future LANL project planning. The intent of the model is to delineate and rank habitat on LANL property that could potentially support the existence of the meadow jumping mouse. The model development is based on the measurement of habitat variables, as described in Step 3, at known locations where this species has been found during surveys within the Jemez Mountains. The measurement of variables is based on previously published literature (Morrison 1990, 1992) and measurements taken in 1998 at an off-site location of known meadow jumping mouse occupancy.

MODEL DEVELOPMENT

The model development included the selection of variables, developing a probability distribution for each variable, and applying weights to each variable based on their overall importance in defining the suitability of the habitat.

Selection of Variables

The variables used in the model development were based on Morrison (1990) and a review of the BISON-M database (NMDGF 1988). These variables were selected based on their importance in determining suitable habitat. The variables (model acronyms are given in parenthesis), given in order of importance, include plant cover (HV1), grass/forb cover (HV2), plant height (HV3), number of forbs (HV4), number of grasses (HV5), and sedge/rush cover (HV6). The variables are measured at each site identified by the GIS/site checklist screening tool as potentially containing habitat suitable for occupancy by meadow jumping mice (Step 2).

Calculation of Variable Probability Values

The probability distribution development for each variable was based on Morrison (1990), and weights were qualitatively assigned by the authors based on a review of the literature. Site vegetation values are entered into the model to obtain an overall score for the site. The overall score is a weighted composite of individual variables; each variable was assumed to have a unique probability distribution.

Development of individual distribution curves and assignment of probability values (designated as “p”) for each variable are described below in descending order of variable weight.

Plant Cover (HV1) – The p-value is equivalent to the percent total plant cover (as shown in the example below) based on a scale of 0 – 100.

Grass/Forb Cover (HV2) – The p-value is calculated from a bivariate normal distribution (Neter et al. 1989) where the two variables are percent grass cover and percent forb cover (as shown in the figure below). The optimum percent cover values are based on Morrison (1990) as follows: percent grass cover = 39% (se = 3), percent forb cover = 37.85% (se = 2.8).

The formula is

$$p = \frac{e^{-\frac{1}{2} \left(\frac{\% \text{ grass} - 0.3785}{28} \right)^2 + \left(\frac{\% \text{ forb} - 0.39}{30} \right)^2}}{(2\pi)(28)(30)}$$

Plant Height (HV3) – The p-value is calculated from the following logistic regression:

$$p = \frac{1}{1 + e^{[5.6643 - (7.86365 \times \text{plant height})]}}$$

The logistic regression function was selected because the curve is an increasing sigmoidal shape (as shown in the figure below) that begins increasing sharply at 0.5 m and levels off at 1.0 m (based on Morrison 1990).

Number of Forbs (HV4) – The p-value is derived from a distribution that has a linear increase until it reaches 50 species and then remains level after that (based on Morrison 1990) (see figure below). For

study sites with greater than or equal to 50 forb species, $P_{HV4} = 1$; for sites with less than 50 species of forbs, $P_{HV4} = \text{total \# of forbs}/50$.

Number of Grasses (HV5) – The p-value is derived from a distribution that has a linear increase until it reaches 12 species and then remains level after that (based on Morrison 1990) (see figure below). For study sites with greater than or equal to 12 grass species, $P_{HV5} = 1$; for study sites with less than 12 grass species, $P_{HV5} = \text{total \# grasses}/12$.

Sedge/Rush Cover (HV6) – The p-value is derived from a logistic regression function that begins decreasing rapidly when sedge/rush cover = 11% and levels off when sedge/rush cover = 44% (based on Morrison 1990) (see figure below).

The formula is as follows:

$$p = \frac{1}{1 + e^{[-3.50783 + (0.11915 \times \% \text{ sedge/rush cover})]}}$$

Applying Weights to Variables

Each variable was assigned a “weighting factor” to reflect the variables’ importance relative to one another with respect to contribution to quality of habitat. The level of importance was qualitatively assigned based on a review of the literature. Total plant cover was selected as the most important variable, and percent sedge/rush cover was selected as the least important variable. The placement of the remaining variables on to the scale was based on the perceived importance of those variables relative to the most and least important variables. The least important variable, sedge/rush cover, was assigned a

weight factor of “1” with increasing values assigned to each remaining variable as follows: number of forbs = 3, number of grasses = 3, plant height = 5, grass/forb cover = 6, and total plant cover = 7.

Calculation of Habitat Suitability Ranking

Once all variables are measured and probability values calculated, the results are multiplied by their weights and then summed in the following formula:

$HSR = (P_{HV1}(7) + P_{HV2}(6) + P_{HV3}(5) + P_{HV4}(3) + P_{HV5}(3) + P_{HV6}(1))$ where:

HSR = Habitat Suitability Ranking,

$P_{HV1}(7)$ = probability value for percent plant cover multiplied by a weight of 7,

$P_{HV2}(6)$ = probability value for percent grass/forb cover multiplied by a weight of 6,

$P_{HV3}(5)$ = probability value for plant height multiplied by a weight of 5,

$P_{HV4}(3)$ = probability value for number of forb species multiplied by a weight of 3,

$P_{HV5}(3)$ = probability value for number of grass species multiplied by a weight of 3, and

$P_{HV6}(1)$ = probability value for percent sedge/rush cover multiplied by a weight of 1.

APPLICATION OF MANAGEMENT RECOMMENDATIONS

Once the HSR values have been calculated, they are placed into one of four habitat categorical groupings by which management strategies are applied. These were developed based on data collected at four riparian sites at LANL (selected based on their representation of riparian areas at LANL) and at one off-site location where meadow jumping mice presence was confirmed. The calculated HSRs from these sites were used to aid in delineating the upper limit, lower limit, or midpoint for each categorical grouping HSR value range. An HSR calculated for each site is given in Table 1 along with the categorical grouping and range of HSRs that fall within that category. The maximum HSR value that could be calculated by the model is 24.96; the minimum value is approximately 2.72.

Table 1. The calculated HSR for each site and the categorical grouping and range of HSRs.

Habitat Categorical Grouping	HSR Value Range	LANL, Off-Site HSR Values used to Define Range*
VERY GOOD	≥ 14	14.18
GOOD	12 – 13.99	12.13, 12.33, 12.43, 12.63, 12.8
FAIR	10 – 11.99	10.2, 11.11
POOR	7 – 9.99	7.13, 9.35
VERY POOR	< 7	No sites measured within this HSR range

* Data were collected from each side of the stream channel at five sites for a total of ten HSR values

APPLICATION OF HABITAT CATEGORICAL GROUPING TO MANAGEMENT

RECOMMENDATIONS

Once the habitat categorical grouping has been designated for the site, management recommendations will be implemented based on Table 2 below. The recommendations are based on a review of the literature and the biological opinion of LANL subject matter experts.

Table 2. Management recommendations for performing meadow jumping mouse surveys based on habitat categorical grouping.

Habitat Categorical Grouping	Management Recommendations
GOOD/VERY GOOD	Perform two years of species surveys prior to impact to confirm presence or absence. If present, area will be protected from impact and measures evaluated to maintain quality of habitat; if absent, further recommendations for site protection will be evaluated on a project-by-project basis.
FAIR	Perform two years of species surveys prior to impact to confirm presence or absence. If present, area will be protected from impact and measures evaluated to enhance and/or maintain quality of habitat; if absent, further recommendations for site protection will be evaluated on a project-by-project basis.
POOR	If riparian area will not be altered or if only partially altered, then no further action will be necessary. If riparian area is to be completely altered (removal of riparian vegetation), then perform two years of species surveys prior to impact to confirm presence/absence. If present, area will be protected from impact and measures evaluated to enhance or maintain quality of habitat; if absent, no further action necessary.
VERY POOR	If riparian area will not be altered or if only partially altered, then no further action necessary. If riparian area is to be completely altered (removal of riparian vegetation), then further recommendations will be made on a project-by-project basis.

REFERENCES

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New Mexico Department of Game and Fish (Santa Fe, NM 87503) Handbook of Species Endangered in New Mexico, G-217:1-2, (1988).

Neter, J., W. Wasserman, M.H. Kutner. 1989. *Applied linear regression models*. Irwin, Boston, MA.

Attachment: Plant Data Collection Forms

LOCATION: _____ DATE: _____

INDICATE STREAMSIDE TRANSECT: **NORTH TRANSECT** **SOUTH TRANSECT**

READER/RECORDER: _____

[illegible]

LOCATION: _____ **DATE:** _____

TRANSECT NUMBER:	1	2	3	STREAMSIDE LOCATION:	NORTH	SOUTH
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Average width of riparian area: _____

READER/RECORDER: _____

[illegible]