Assessing Beaver Habitat on Federal Lands in New Mexico
Contract #13-667-5000-0007
WildEarth Guardians Final Report
July 31, 2013

Executive Summary

The absence of dam-building beaver (*Castor canadensis*) from significant portions of their historic habitat in New Mexico significantly undermines the resilience of aquatic ecosystems and therefore limits the aquatic ecosystems ability to adapt to climate change. The dam-building beaver's activities create a diversity of habitats. The dams trap sediment, create and maintain wetlands, and modify nutrient and decomposition cycles. The presence of dam-building beaver reduces high flows and downstream flooding that can result in destructive erosion, provides more constant summer flows, elevates the water tables and improves riparian habitat. All these activities provide an effective climate change adaptation tool.

Restoration of wetland and riparian ecosystems by beaver can be a simple, elegant and cost-effective way to restore riparian/wetland habitats and adapt to climate change.

Before dam-building beaver populations can be replenished in New Mexico, a systematic and thorough assessment of both potential and suitable habitat and an identification of possible impediments to population recovery are needed. This project's goal is to identify all potential, suitable, and occupied dam-building beaver habitats on federal, public lands in New Mexico. These outputs will facilitate efficacious relocation of nuisance beaver and restoration of habitat to re-establish and augment wetlands in the state of New Mexico. However, the field observations were only conducted in the Jemez River Watershed within the Santa Fe National Forest (SFNF), the adjoining San Pedro Parks Wilderness and the Valles Caldera National Preserve (VCNP).

Acknowledgements

Funding was provided by the New Mexico Environment Department Surface Water Quality Bureau (SWQB) for the project "Assessing Beaver Habitat on Federal Lands in New Mexico," U.S. EPA CWA Section 104(b)(3). We would also like to thank the members of the technical steering committee for their contributions to the review of the model. The contents of this document do not necessarily reflect the views and policies of the EPA, nor does the mention of trade names or commercial products constitute endorsement or recommendation for use.

Project Description

The project began August 1, 2012 and was completed July 31, 2013 as scheduled. It was conducted by:

Bryan Bird, the Wild Places program director for WildEarth Guardians in Santa Fe, NM. Bryan received his masters in conservation biology from New Mexico State University in 1995 and undergraduate degree in biology from the University of Colorado, Boulder in 1990. Bryan has undertaken conservation research and planning in Mexico, Central America and the Southwestern United States for nineteen years. Bryan has been researching the ecosystem services of beaver and recently published a comprehensive literature review and report titled *Beaver and Climate Change Adaptation in North America: A Simple, Cost-Effective Strategy*.[1]

Kurt Menke, a Certified GIS Professional (GISP) with 16 years of experience in the field. He received a Master's degree (MA) in Geography from the University of New Mexico in 2000. Kurt has extensive experience modeling potential wildlife habitat via both inductive and deductive approaches. Kurt has also facilitated numerous professional mapping workshops to gain consensus from experts on mapping protocols. Kurt has a unique skill in presenting complex information in a map format that is easily comprehended by laypersons and non-specialists.

Debra Budrow, an Environmental Scientist specializing in wetlands, streams, and ecological restoration. She has a M.S. in Environmental Sciences from Johns Hopkins University and an MBA from Duke University. This combination of training and experience allows her to contribute not only to the science of a project, but also to the procedural methodology, data collection and analysis, and production of multiple levels of reporting depending upon the audience. During this project, she led the team of interns by instructing the methodology, supervising the collection and input of data, and analyzing the effectiveness of the model.

Students interns **Drake Hebert** and **Andrew Nguyen** (graduate students at the UC Santa Barbara Bren School of Environmental Science) and **Janelle Roybal** collected field data to groundtruth the beaver habitat assessment model on federal lands in the Jemez Mountains and assisted with writing reports.

[1] http://www.wildearthguardians.org/site/DocServer/Beaver_and_Climate_Change_Final.pdf?docID=3482

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Project Tasks Completed/Highlights

Task A: Technical Steering Committee. A technical steering committee (TSC) was convened to inform the GIS model and identify threats and obstacles to beaver recovery/reintroduction. Experts in beaver and wetland ecology participated. The committee identified and ranked the habitat features most important for determining successful dam-building beaver habitat.

Task B: Develop Beaver Habitat Assessment Model. Spatial data representing the habitat factors identified at the expert workshop were obtained. These data were normalized in terms of projection, resolution and attributes, and were incorporated into a dichotomous tree analysis in ArcGIS 10. Output from the model was a vector dataset showing potential (See Appendix A) and suitable beaver habitat on federal land in New Mexico. (See Appendix B)

Task C: Apply the Model to Federal Lands. The model was applied and run for federal lands in New Mexico by overlaying a federal land spatial coverage dataset to the suitable, potential and occupied (see Appendix C) layers.

Task D: Ground Truth Model. Eighteen randomly selected sites within potential dam building beaver habitat were visited to assess the actual observable conditions in order to determine the model's accuracy. These observations identified four categories of habitat including: 1) occupied, 2) historically occupied but currently vacant, 3) suitable but unoccupied, and 4) potential habitats. Conducting the field surveys determined the effectiveness of the model in identifying the status and extent of occupied, suitable and potential beaver habitat and wetlands. The modeled variables that were observed and collected in the field were the existing vegetation type, the stream gradient, and the percent of canopy cover. (See Appendix C for location of selected sites)

Task E: One-Day Beaver Workshop. A statewide beaver and wetlands workshop was held May 9, 2013 bringing together the state's experts and potential partners in a beaver and wetlands climate adaptation strategy. Ongoing and potential obstacles or limitations to establishment, and expansion of functional beaver populations were evaluated at the workshop so that elimination or mitigation of such threats can be included in land management plans, state wildlife management plans and projects, all in the furtherance of wetland restoration and resilience.

The workshop was held at the New Mexico State Library in Santa Fe, where over 70 participants including officials from state and federal agencies. Keynote presentations and speakers included:

- *Beaver & Ecosystem Services* by Dr. Jennifer Frey, Dept. of Fish, Wildlife and Conservation Ecology, NM State University
- *Partnering with Beaver in Restoration - Examples from the Beaver Restoration Assessment Tool (Utah) & Bridge Creek (Oregon)* by Dr. Joe Wheaton, Dept. of Watershed Sciences, Utah State University
- *Utah Beaver Management Plan* presented by Justin Dolling, Utah Division of Wildlife Resources

A robust question and answer session followed each presentation with diverse viewpoints expressed through the variety of queries. Following the presentation on the Utah Beaver Management Plan several attendees expressed interest in developing a similar beaver management for the state of New Mexico. Suggestions were offered on possible methods for beginning the work whether by watershed or statewide.

Task F: Reports. Final maps were created along with a report documenting all procedures and results. All spatial data is available in ESRI's file geodatabase format including FGDC metadata.

Task G: Jemez Watershed Photo Documentation. WildEarth Guardians began photo documentation of the streams and rivers of the Jemez Mountains in 2004. Twenty six sites were revisited during June and July 2013, data for the model was collected and sites were documented with two photos at each site. (See Appendix E for locations, Appendix F for sample photos)

Project Chronology

Beaver Habitat Model

The initial process required collecting the existing peer-reviewed literature on dam-building beaver habitat requirements. An emphasis was placed on citations from the southwestern states and New Mexico. Initially a standard weighted overlay approach was proposed. However, it was determined by the Technical Steering Committee that traditional habitat suitability modeling approaches do not strongly predict beaver occupation. This is due to their nature as habitat generalists and a lack of local scale data.

There was a lack of data for many of the local habitat factors influencing dam-building beaver colonization. No statewide datasets representing bank height, bank slope, or stream sinuosity exist. Furthermore, all existing vegetation datasets do a poor job of identifying small patches of riparian willow and alder that are the beavers preferred food source. It was assumed that where a low gradient, low order stream passed through identified conifer vegetation types that there would be occasional stands of beaver preferred riparian vegetation. This assumption contributed to forest vegetation types being weighted higher than they otherwise would be.

The main habitat requirements for dam-building beaver are streams with low slope gradients, on lower order streams, and sufficient food. Given these requirements, it was decided that a dichotomous tree approach would be most appropriate. This approach splits the data into a progressive series of halves based on habitat variables First we identified **potential** dam-building beaver habitat and then used the rankings of stream order, stream gradient, existing vegetation type, canopy cover and road density to generate a qualitative measure of **suitable** dam-building beaver habitat. Identifying **potential** habitat involved running all streams through several filters. First we identified streams that are perennial, then those which have a slope gradient less than 15% (Allen 1983), of those which have lower order stream classifications and finally which are on federal lands. This remaining subset of streams was called **Potential** Dam Building Beaver Habitat.

Model Data

All the data used in the analysis are in the public domain.

- The NHDPlus version 2 dataset was used to represent streams. This dataset was provided by the NM Environment Department. The website for the NHDPlus program can be found here: http://www.horizon-systems.com/nhdplus/

- Slope was generated from a statewide digital elevation model (DEM). The data was obtained from NM-RGIS (http://rgis.unm.edu). A series of 30 meter resolution DEM's were mosaicked together to form a seamless DEM for the state.

- To represent existing vegetation type (EVT) and canopy cover (CC), data was obtained from the LANDFIRE program (http://www.LANDFIRE.gov/NationalProductDescriptions21.php). These data have a 30 meter resolution matching that of the slope dataset.

- Wildfire burn severity was obtained from both the Monitoring Trends in Burn Severity (MTBS) program and the Burned Area Reflectance Classification (BARAC) program; this gave coverage of wildfires over the last 5 years.

- The 2012 TIGER roads layer was used to generate a statewide roads dataset (http://www.census.gov/geo/maps-data/data/tiger-line.html). The roads were obtained by county and merged into a seamless statewide layer.

- Watershed boundaries were obtained from the Resource Geographic Information System Program (RGIS - http://rgis.unm.edu/).

- Landownership was obtained from the NM BLM office (http://www.blm.gov/nm/st/en/prog/more/geographic_sciences/spatial_data_metadata.html).

All data were normalized in terms of projection, cell alignment, resolution and attributes, for incorporation into the dichotomous tree analysis in ESRI's ArcGIS 10. The spatial reference used for the project was Universal Transverse Mercator (UTM), zone 13, NAD83.

Building the Model

Potential Dam Building Habitat: Perennial streams were selected from streams feature class and a field called perennial was populated with 1 for those streams. The most current stream order tabular dataset was downloaded from the NHD plus website and joined to the streams feature class and used to identify the beaver preferred stream orders. Dam-building beavers prefer stream orders 1-5 (Howard 1985 and Suzuki 1998). This is mainly due to the fact that larger streams can damage dams during floods or be too wide for dam construction. Stream order also serves as a surrogate for channel width and depth. Federal lands were selected from the land ownership layer and exported to a new feature class. An Identity operation was then run between the streams layer and federal lands to identify streams on federal lands. A field was added identifying stream reaches on federal lands.

To compute stream gradient the "to and from" nodes were then extracted from the perennial streams layer and intersected with the DEM. This provided the low and high elevation values for each stream segment. These values along with the segment length were used to calculate the percentage of slope gradient for each stream segment.

A query was then run to select stream reaches that were perennial, on federal lands, had slope gradients below 15% and stream orders 1-5. A field was added to identify those reaches selected as potential dam-building beaver reaches based on these four criteria. (See Appendix A potential New Mexico Beaver Habitat)

Suitable Dam Building Habitat: Suitable habitat is defined here as a qualitative ranking of potential dam-building beaver stream reaches. The ranking is based on the weights for stream order, stream gradient, existing vegetation type, canopy cover and road density. The Technical Steering Committee identified the weighting scheme shown in table 1. It is always very difficult to arrive at relative weights for model inputs. Literature doesn't often provide the detail necessary to assess exactly how high to weight a habitat factor within a GIS. That was the case here. There is research that indicates that stream gradient is one of the most significant factors for determining suitability of habitat (Slough and Sadler 1977). In narrowing the model to qualitatively identify dam building beaver habitat, it was also crucial to include stream order. There was a strong consensus that stream gradient and stream order should receive the heaviest weights. They were given equal weights of 30% each. The only other beaver habitat criteria that could be modeled statewide via GIS were existing vegetation type, canopy cover and road density. There was nothing to suggest that one of these should be weighted over the others. Therefore the remaining 40% was divided equally among those three. The resulting overall habitat factor weighting is shown in table 1.

GIS Habitat Factor	% Ranking
Stream Gradient	30.0
Stream Order	30.0
Existing Vegetation Type	13.3
Canopy Cover	13.3
Road Density	13.3
Total	**100.0**

Table 1: Beaver Habitat Model Input Weights

<u>Stream Gradient:</u> The stream gradient values were classified using the weighting scheme shown in table 2. These weights were placed in an attribute column in the stream feature class.

Stream Gradient (%)	Score
0 – 6	10
7 – 12	7
13 - 15	3
> 15	1

Table 2: Stream Gradient Weights

Stream Order: The stream order values were classified using the weighting scheme shown in table 3. These weights were placed in an attribute column in the stream feature class.

Stream Order	Score
1	8
2	10
3	9
4	7
5	5
6	3
7	2
8	1

Table 3: Stream Order Weights

Existing Vegetation Types (EVT): Existing vegetation types are incorporated to represent food availability and were given five different weights based on importance to beaver in the literature and according to the TSC. There was strong consensus on the TSC that riparian vegetation receive the highest weight of ten. Conifer, conifer-hardwood, exotic tree-shrub, and hardwood landcovers received the next highest weight of eight. The remaining vegetation types received one of three additional weights: five, three or one. Howard (1985) and McComb (1990) found that hardwood presence near streams led to colony longevity and increased likelihood of dam building. The weights for the remaining vegetation classes were set based on the quantity of food each would likely provide.

It was suggested by the TSC that the effect of recent large wildfires be incorporated. Wildfire data from the last 5 years was obtained. For 2008-2010 burn severity data from Monitoring Trends in Burn Severity (MTBS) was obtained. For 2011 and 2012 the provisional burn severity data from the Burned Area Reflectance Classification (BARC) program was obtained. The areas of high and moderate burn severity were classified as recently burned in the EVT dataset.

A new attribute column containing rankings (table 4) was created . For the analysis a model was generated in ArcGIS Model Builder to extract average pixel values per stream segment. This model was called summarize-raw-raster-by-stream-segment. This was done by conducting a Zonal Statistics operation by stream segment against the EVT layer. The mean value was then joined to the streams vector layer. The weighting scheme for EVT is shown in table 4.

Existing Vegetation Type	Score
Riparian	10
Conifer	8
Conifer-Hardwood	8
Exotic Tree-Shrub	8
Hardwood	8
Agricultural	5
Shrubland	5
Recently burned	5
Exotic Herbaceous	3
Grassland	3
Developed	1
No Data	1
Non-vegetated	1
Sparsely Vegetated	1

Table 4: Vegetation Type Weights

Canopy Cover (CC): It has been shown that canopy cover levels between 40-60% are optimum for beaver occupation (Leary 2012). Canopy covers greater than 60% begin to inhibit beaver food sources (Allen 1983) and lesser cover leads to a paucity of food. Therefore, canopy cover was weighted via a bell curve with the median cover classes being given the highest weights. The weighting scheme for canopy cover is shown below (Allen 1983, McComb 1990 and Leary 2012.).

A new attribute column containing the CC rankings was created. The summarize-raw-raster-by-stream-segment model was run against the CC ranking score and the average value per stream segment joined to the streams layer.

% Canopy Cover	Score
0	1
15	3
25	5
35	7
45	9
55	10
65	9
75	6
85	3
95	1

Table 5: Canopy Cover Weights

Road Density: Beaver can be highly tolerant of human activities, especially when all other habitat variables in a region support beaver occupation. However, roads can be a limiting factor for beaver (Leary 2012 and Slough 1977). Roads can also be a strong indicator of overall human impact to an area and were included for this reason. The specific densities were supported by findings in Leary (2012).

Road density was computed with 10 digit hydrographic unit code (HUC) watersheds and 2012 TIGER roads. An Identity operation was performed between the two datasets. This resulted in a roads layer cut at the HUC boundaries and with the HUC attributes attached. The road density per HUC was then calculated as miles of road per square mile. The road density was then classified via the weighting scheme shown in table 6 (Leary 2012 and Slough 1977). The road density data was then joined back to the HUC layer. The potential beaver stream segments were converted to vertices (points). Finally an identity operation was performed between the beaver stream points and the HUC layer. A summary table was created to generate the average road density score per stream ID. This was joined back to the stream line feature class by stream ID to create the road density score for each stream segment.

Road Density (Miles of road/sq. mile)	Score
≤ 1	10
1 - 1.5	7
1.5 – 2	5
2 - 2.5	3
> 2.5	1

Table 6: Road Density Weights

The final suitable habitat values were calculated for stream reaches defined as potential habitat. The formula was: (Stream Gradient score * 0.3) + (Stream Order score * 0.3) + (EVT Score * 0.1333) + (CC Score * 0.133) + (Road Density score * 0.1333) = Suitable Habitat Score (See Appendix B for suitable New Mexico Beaver habitat).

Occupied Habitat: The data for currently occupied habitat was provided by Rick Winslow, Fur Bearer Biologist for the New Mexico Department of Game and Fish and based on firsthand knowledge. Beaver occupation can change from year to year solely based on changes in land management practices. This dataset cannot be considered complete and only represents a snapshot in time. An attribute column was created in the beaver habitat stream layer called Occupied that is populated with 1's for reaches considered occupied. It is important to note that while the potential and suitable data represents dam-building beaver only; this data also includes bank beaver populations (See Appendix C for beaver occupied New Mexico Rivers).

Ground-truthing the Model: The field observations for existing vegetation type, canopy cover and stream gradient were compared with the statewide model data. A team of interns was deployed in the field to gather data at 19 randomly selected points the model determined as suitable beaver habitat in the Jemez River watershed. Existing vegetation type was determined by observing the majority vegetation type at each point. Canopy cover was determined by using a spherical densitometer at each point. Stream gradient was determined by using a clinometer at each point. Data was recorded into an Open Data Kit Collect form on Google Nexus 10 tablets. Location was also recorded using a GPS device connected to the tablet. See Appendix G for sample data entry form. Deviance was measured via weighted model class. For example, if the field observation was riparian vegetation(weighted 10) and the model identified the area as conifer (weighted 8) that was considered a deviance of one model class. If the model identified that patch as Shrubland (5) that would be considered a deviance of 2. If the field and model observations differed, but both values received equal weight in the model the deviance score was 0.

Measures of Success: Despite restricted access to the Santa Fe National Forest, the WildEarth Guardians team was able to sample eighteen potential dam-building beaver points and locate twenty six photo points. The May 9, 2013 statewide-stakeholder meeting in Santa Fe was a success in that critical information was exchanged between presenters and participants and useful suggestions for next steps in developing an intentional and strategic beaver management plan for the state of New Mexico were discussed.

Obstacles: Due to extreme fire danger, access to randomly selected points was severely restricted. On Monday June 24, 2013 the Santa Fe National Forest was closed to all public access. After the national forest closure, WildEarth Guardians secured a special use permit from the Forest Service to access a limited number of locations. During closure of the Valles Caldera National Preserve (VCNP) WildEarth Guardians received permission to access the three beaver sample points within the VCNP. Due to this limited access sampling of additional sites to further test the model, resampling to test for accuracy, and locating all photo points did not occur.

Lessons Learned

Success and Difficulties: In order to ground-truth the model, 19 points were randomly selected in the Jemez Watershed for field data collection. The model was capable of identifying suitable beaver habitat to an acceptable degree of accuracy. Several scientists, including Joe Wheaton at the University of Utah, have stated that traditional habitat models for beaver are not generally successful due to the beaver's generalist nature. They are very adaptable and with sufficient water and food can establish in deserts as well as forests. Limiting the model to dam-building habitat reduces uncertainty, but predicting suitable beaver habitat is not a precise exercise.

WildEarth Guardians visited 18 of the 19 randomly selected beaver habitat sampling points. When comparing the model output with the field data, only 5 points (1, 3, 5, 9, and 17) were found where the model predictions and collected field data exactly matched on the three variables of vegetation type, stream gradient, and canopy cover. Eight points (2, 6, 7, 8, 10, 15, 18, and 19) had one incorrect prediction. Five points (4, 11, 13, 14, and 16) had more than one incorrect prediction. See the table 7 below for a summary of each point's predictions. Given the statewide scale of the model data the field observations were quite close.

Point	Prediction	Point	Prediction
1	Exact Match	11	The model predicted riparian vegetation, but exotic herbaceous was observed. The model predicted 35% canopy cover, while observed was between 0-25%.
2	The model predicted conifer vegetation, but riparian was observed	12	WildEarth Guardians was unable to visit this point
3	Exact Match	13	The model predicted riparian vegetation, but conifer was observed. The model predicted 75% canopy cover, while observed was between 0-25%.
4	The model predicted conifer vegetation, but riparian was observed. The model predicted 75% canopy cover, while observed was between 0-25%.	14	The model predicted 75% canopy cover, while 0-25% was observed. The model predicted a 7% slope, while between 0-6% was observed.
5	Exact Match	15	The model predicted 65% canopy cover, but between 0-25% was observed.
6	The model predicted shrubland vegetation, but riparian was observed.	16	The model predicted conifer vegetation, but riparian was observed. The model predicted 75% canopy cover, but between 0-25% was observed. The model predicted 5.8% stream gradient, while 7-12% was observed.
7	The model predicted conifer vegetation, but grassland was observed.	17	Exact Match
8	The model predicted conifer vegetation, but grassland was observed.	18	The model predicted riparian vegetation, but grassland was observed.
9	Exact Match	19	The model predicted conifer vegetation, but grassland was observed.
10	The stream was found to be dry. The model predicted conifer vegetation, but grassland was observed.		

Table 7: Comparison of Model Predictions and Field Data

We believe inconsistencies stem from two causes. One is the LANDFIRE dataset. While it is high quality data, the resolution prevents identification of the riparian vegetation that often occurs only several meters from the stream bank. The LANDFIRE website states that while the spatial resolution of the raster data sets is 30m, analysis should be done at a much higher spatial resolution for optimum success. This was addressed in the building of the model, as it was stated that riparian would be hidden within the large amount of conifer vegetation in the Jemez.

The second cause of discrepancy stems from the weights of the vegetation relative to the other factors, specifically the stream gradient and stream order. All 19 of these points were predicted to be suitable beaver habitat, even those that were designated grassland vegetation type with a low weight. This is actually an acceptable outcome. Beaver, being the generalists they are, will inhabit grassland and agricultural areas given suitable stream gradient, reliable water levels and adequate food nearby. The nature of the weighting scheme will often cause problems if the weights, which are extremely hard to determine, are not precise. For instance, point 9 was predicted as suitable beaver habitat. The point is located in the middle of a large valley bottom in the Valles Caldera National Preserve, with no riparian vegetation or trees nearby. This point however is a very good match for stream order and stream gradient, which are given a larger value in the model weighting scheme. The high scores for these two factors obscured the low score for the existing vegetation type. This is not to say the model is invalid, but only that there are always problems identifying habitat and the weighting of the factors can be difficult, if impossible, to get exactly right. It is recommended that anyone using this model ground truth results in order to ensure accuracy.

Effectiveness: Modifying the values of the weighting factors of the variables provide valuable insights into the sensitivity of the model. Multiple maps of suitable habitat can be generated and field verified to test which weighting factors provide the best prediction of actual suitable habitat conditions.

Predicted conifer habitat in the sampled sites did not provide suitable beaver habitat. The conifers have encroached upon the riparian areas to the degree that there is very limited riparian vegetation present. Conifer is not a vegetation type that beavers prefer or utilize to any great extent, except perhaps under extenuating circumstances.

Several of the predicted suitable habitats were observed as those with grassland vegetation. Though beavers will utilize grasses and forbs as a food source, they cannot be used for dam building. Therefore ground-truthing grassland sites demonstrated that the

LANDFIRE dataset had the correct vegetation type, but that the model could not always predict suitable habitat that dam-building beaver would utilize.

Technical Transfer

At present, the model is intended for landscape level assessment, resulting in limitations when applied to smaller target areas. For the model to be useful for land and wildlife management planners, on-the-ground assessments will be necessary. Potential transfers of technology include:

- The model can be applied to any land ownership.
- The New Mexico Environment Department can incorporate the Beaver Assessment Model in its efforts to develop their own Rapid Assessment Method of montane riverine systems.
- The model can be revised and expanded to incorporate private lands. Private landowners likely do not have access to the GIS technology and could find the detailed maps of use in searching for suitable beaver habitat on their property.
- Before significant funding is directed to habitat restoration projects at any scale, field observations are highly recommended. The model generated here is a coarse first-step in identifying good potential areas for dam-building beaver reestablishment and finer-scale analysis should be requisite for funding.
- The NMED Surface Water Quality Bureau will provide access to the model and GIS shape files from its website.

Citations

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Suzuki, N. and William C. McComb. 1998. *Habitat Classification Models for Beaver (Castor canadensis) in the Streams of the Central Oregon Coast Range.* Northwest Science. 72: 102-110.

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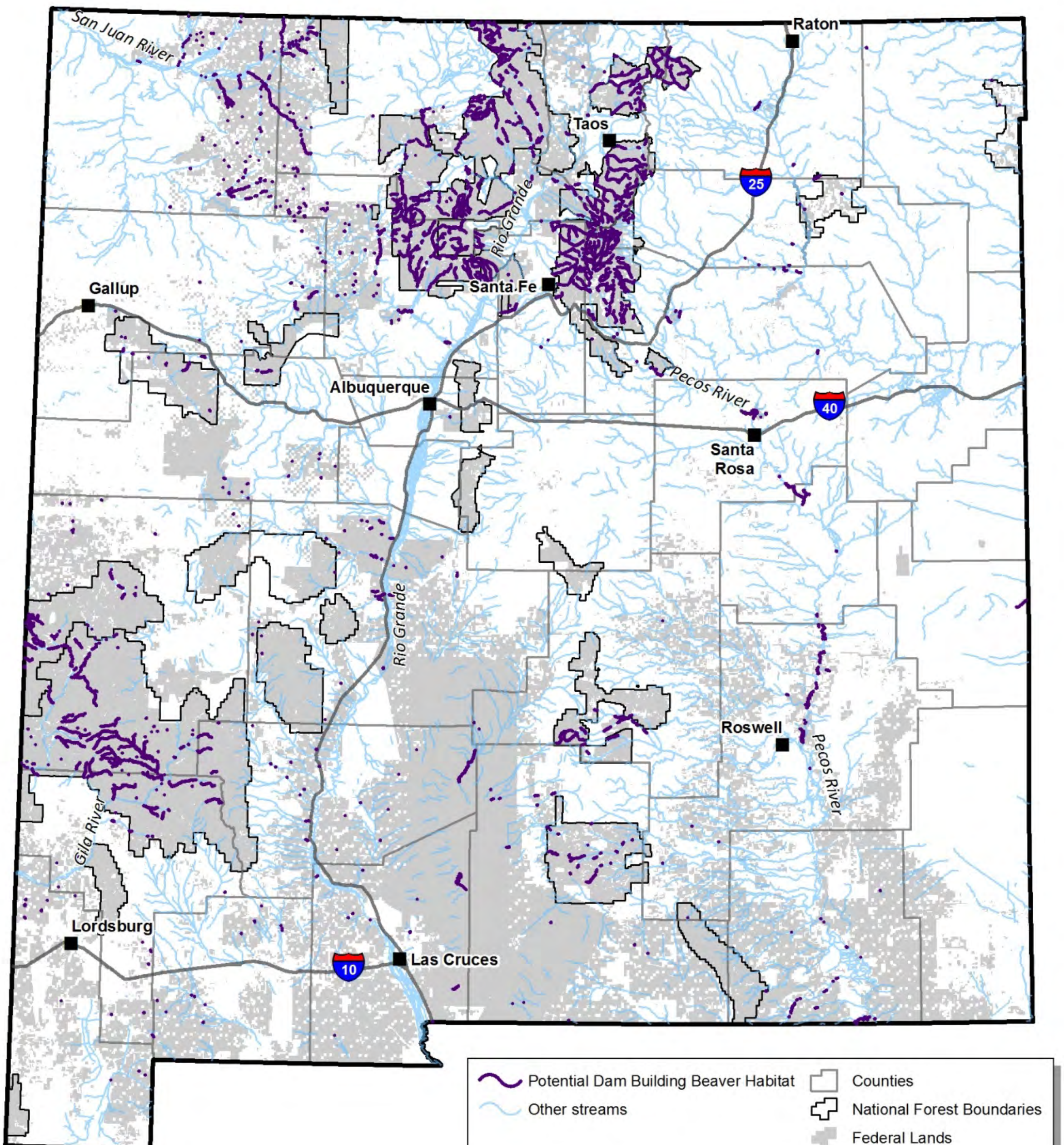
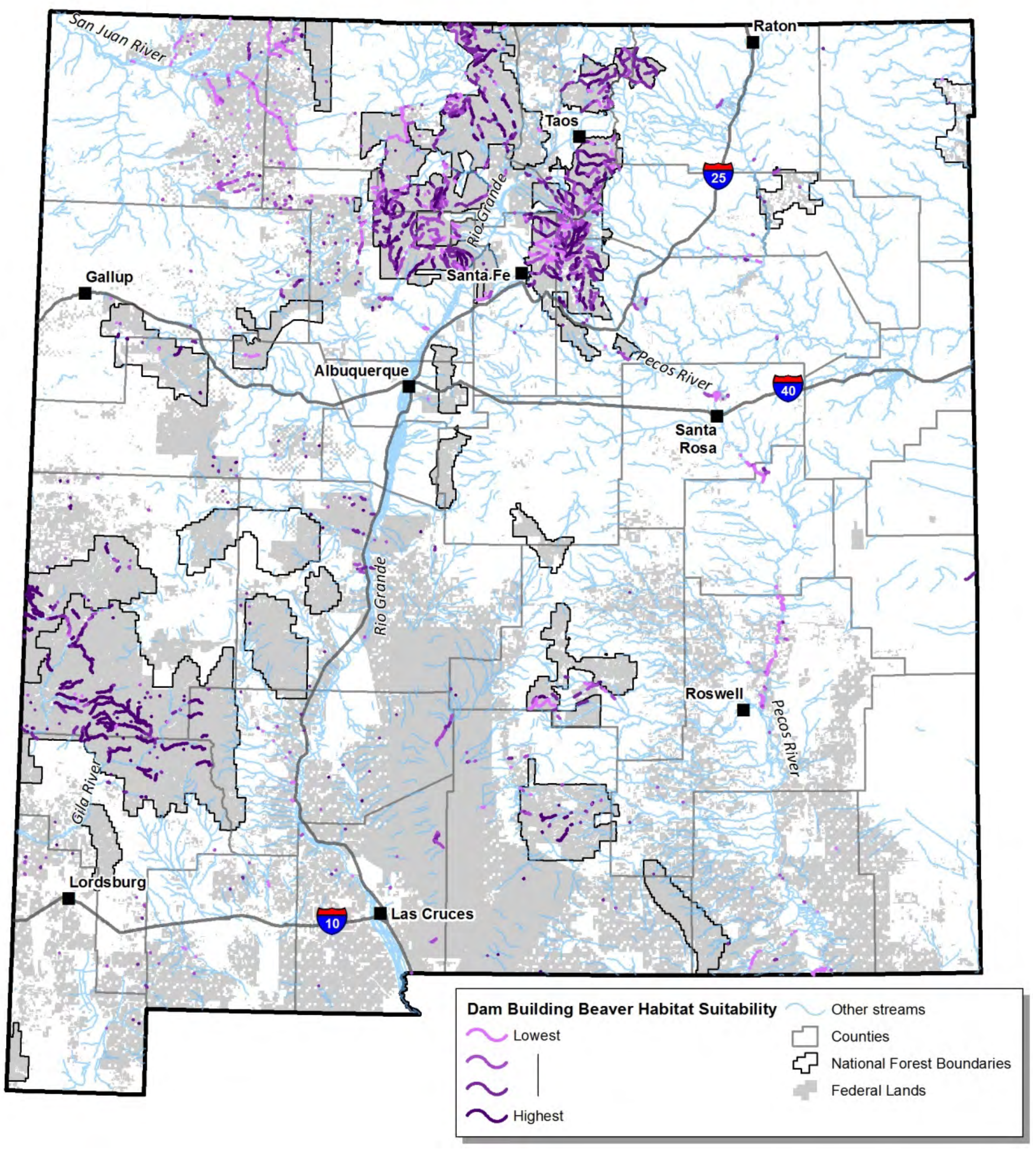
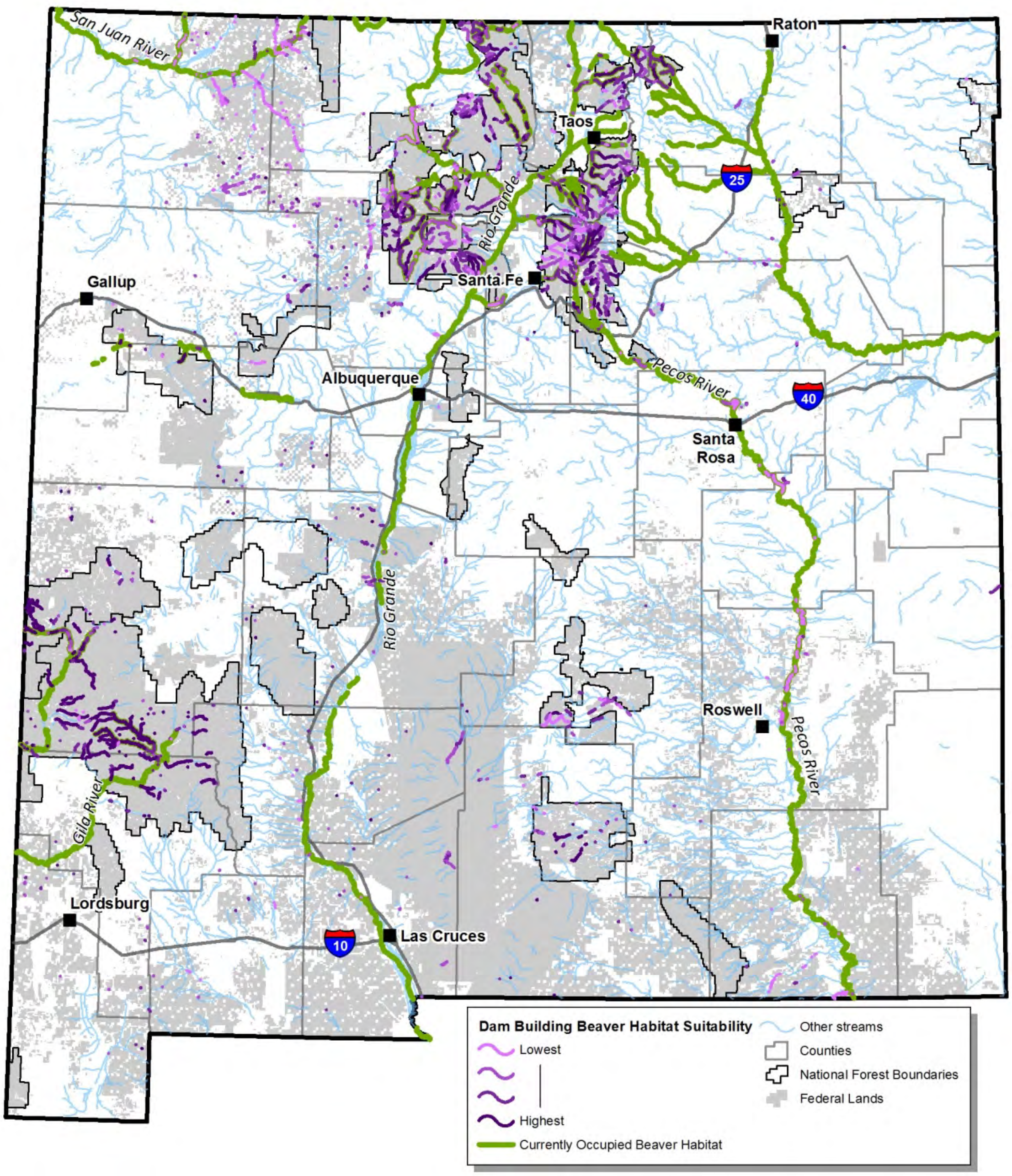
Appendix A – Potential New Mexico Beaver Habitat



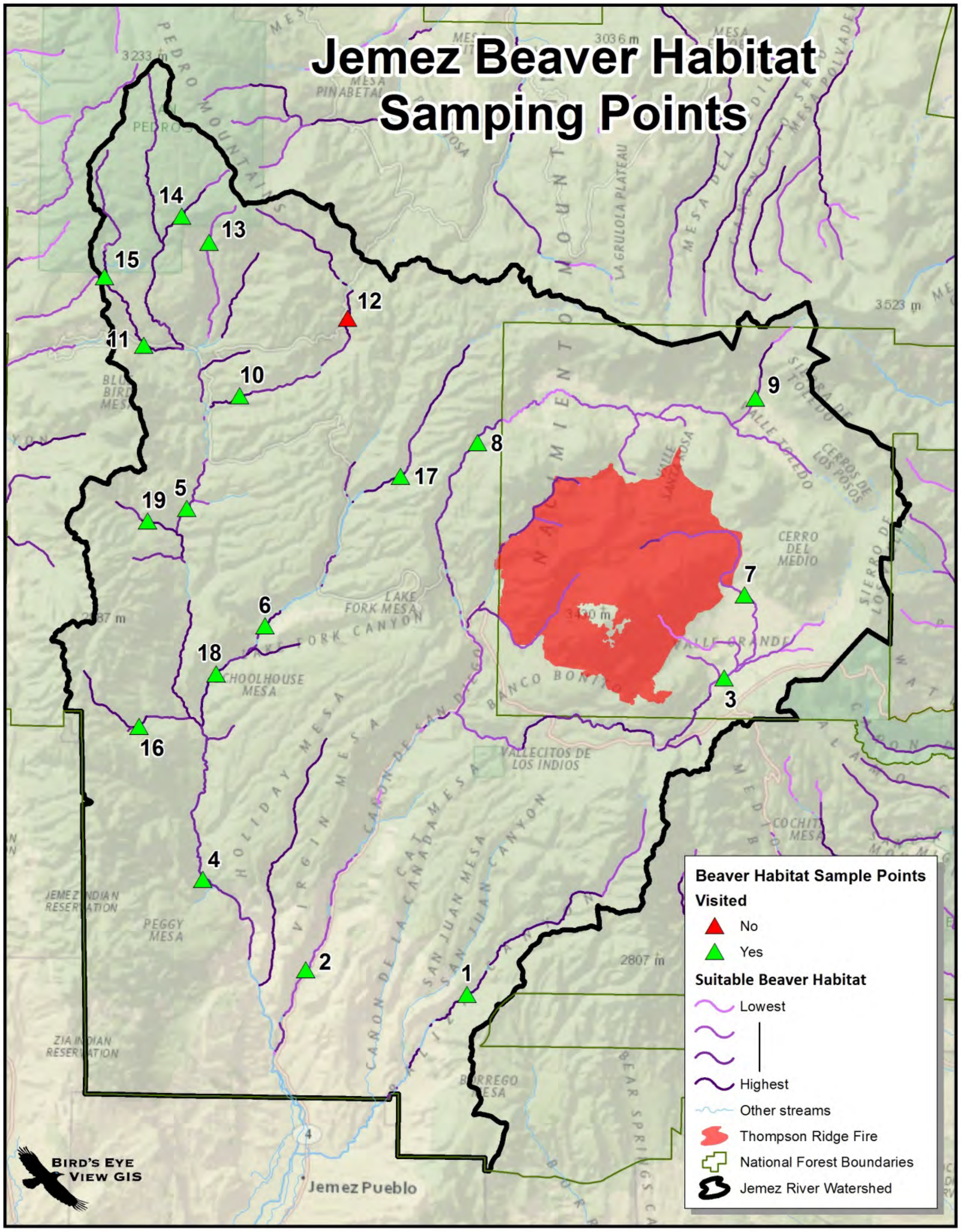
Appendix B – Suitable New Mexico Beaver Habitat



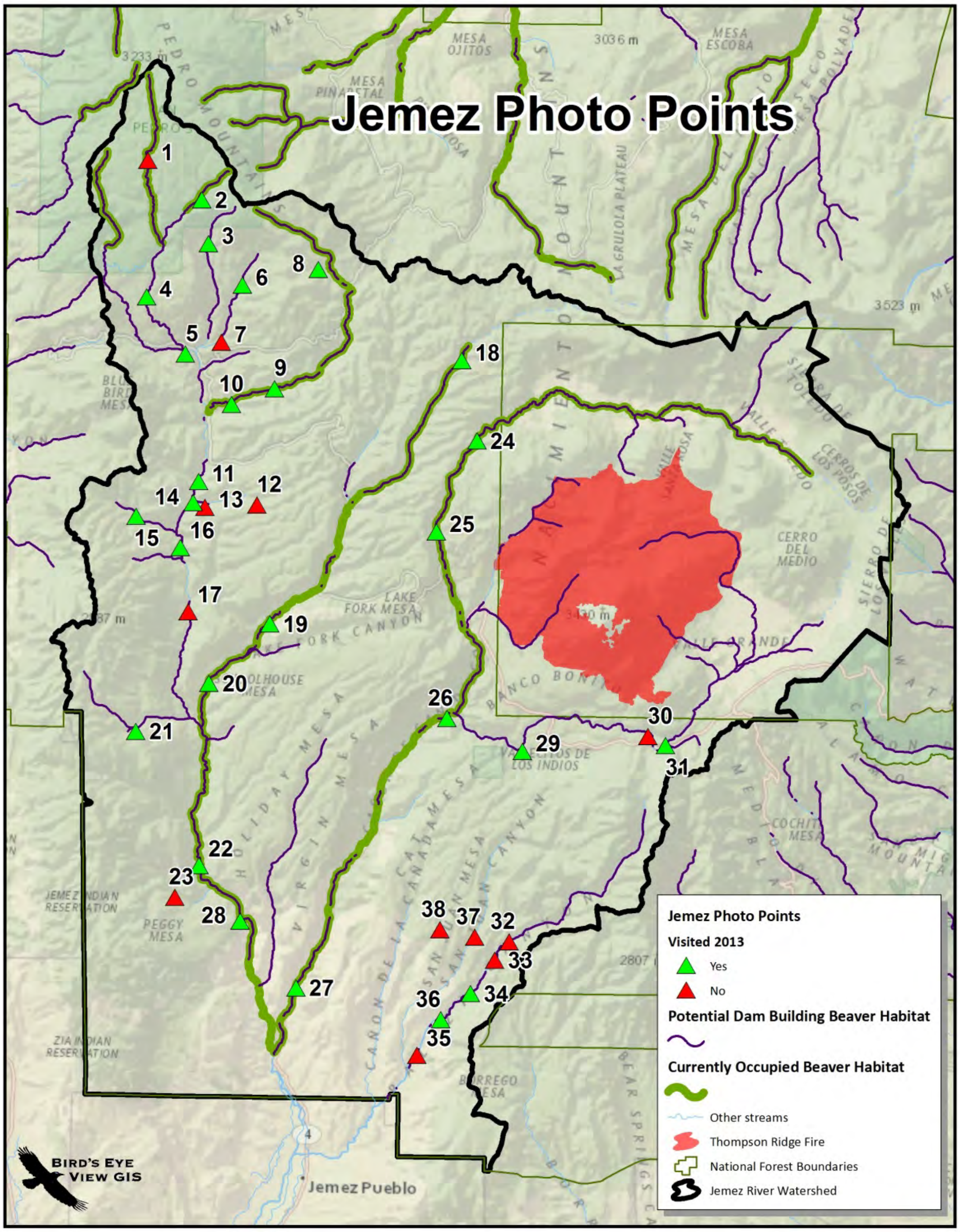
Appendix C – Occupied New Mexico Beaver Habitat



Appendix D – Jemez Beaver Sampling Points



Appendix E – Jemez Photo Point Locations



Appendix F – Photo Point 26

Appendix G: Sample Data Entry Form

Sample Point ID	Vegetation Type	Canopy Cover	Stream Gradient	Notes	Lat/Long
	Observed field vegetation type	Observed canopy cover using densiometer	Observed stream gradient using clinometer	Any important notes on the site	Recorded location using a GPS

You may wish to also include fields for current beaver occupation and signs of past beaver occupation, but these are not necessary for the ground truthing of the model.