Core Map Documentation for the Rabbitsfoot

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Developed by Center for Biological Diversity

EPA Reviewer Notes

The developers created this core map using EPA' process available at: https://www.epa.gov/endangered-species/process-epa-uses-develop-core-maps-pesticide-use-limitation-areas. EPA reviewed the draft interim map and documentation and evaluated if: (1) the map and documentation are consistent with EPA's process; (2) areas included or excluded from the interim core map are consistent with the biology, habitat, and/or recovery needs of the species; (3) data sources are documented and appropriate; and (4) the GIS data and mapping process are consistent with the stated intention of the developer. EPA finds that this map is a reasonable depiction of core areas for this species and was consistent with EPA's mapping process.

The core map developed for Rabbitsfoot is considered interim. This core map will be used to develop pesticide use limitation areas (PULAs) that include the Rabbitsfoot. This core map incorporates information developed by FWS and made available to the public; however, the core map has not been formally reviewed by FWS. This interim core map may be revised in the future to incorporate expert feedback from FWS. This interim core map has a "limited" best professional judgment classification because it consists of the species' critical habitat supplemented with occupied waterbodies named by FWS. This core map does not replace or revise any range or designated critical habitat developed by FWS for this species.

Species Summary

The rabbitsfoot (*Quadrula cylindrica cylindrica*; Entity ID #3645) is a threatened aquatic invertebrate, with designated critical habitat designated in 2020. The rabbitsfoot occurs in continuous flowing water such as rivers, streams, and creeks, which provide the resources it needs to survive and reproduce: suitable physical habitat and water quality conditions, food, and host fish species.

Description of Core Map

The core map for the rabbitsfoot is based on biological information. Specifically, it is based on the 2020 designated critical habitat and supplemented by named occupied waterbodies noted in the 2023 Recovery Plan within the range of the species. Catchments intersecting with occupied rivers were included in the core map as instructed by EPA's core map process document. We selected the narrower of the two catchment layers that EPA provided as the basis for including upstream and adjacent catchments.

Overlap and the map is presented below, where only 4 percent cultivated crops are overlapped by the core map.

Table 1. Percentage of Interim Core Map Represented by NLCD[1] Land Covers and Associated Example Pesticide Use Sites/Types.

Example pesticide use sites/types	NLCD Landcover (Value)	% of core map represented by landcover	% of core map represented by example pesticide use
Forestry	Deciduous Forest (41)	16	18.3
	Evergreen Forest (42)	.3	
	Mixed Forest (43)	2	
Agriculture	Pasture/Hay (81)	3	7
	Cultivated Crops (82)	4	
Mosquito adulticide, residential	Open space, developed (21)	1	2.7
	Developed, Low intensity (22)	1	
	Developed, Medium intensity (23)	.5	
	Developed, High intensity (24)	.2	
Invasive species control	Woody Wetlands (90)	16	72
	Emergent Herbaceous Wetlands (95)	3	
	Open water (11)	51	
	Grassland/herbaceous (71)	1	
	Scrub/shrub (52)	0	
	Barren land (rock/sand/clay; 31)	1	

1 Dewitz, J., 2023, National Land Cover Database (NLCD) 2021 Products: U.S. Geological Survey data release, https://doi.org/10.5066/P9JZ7AO3

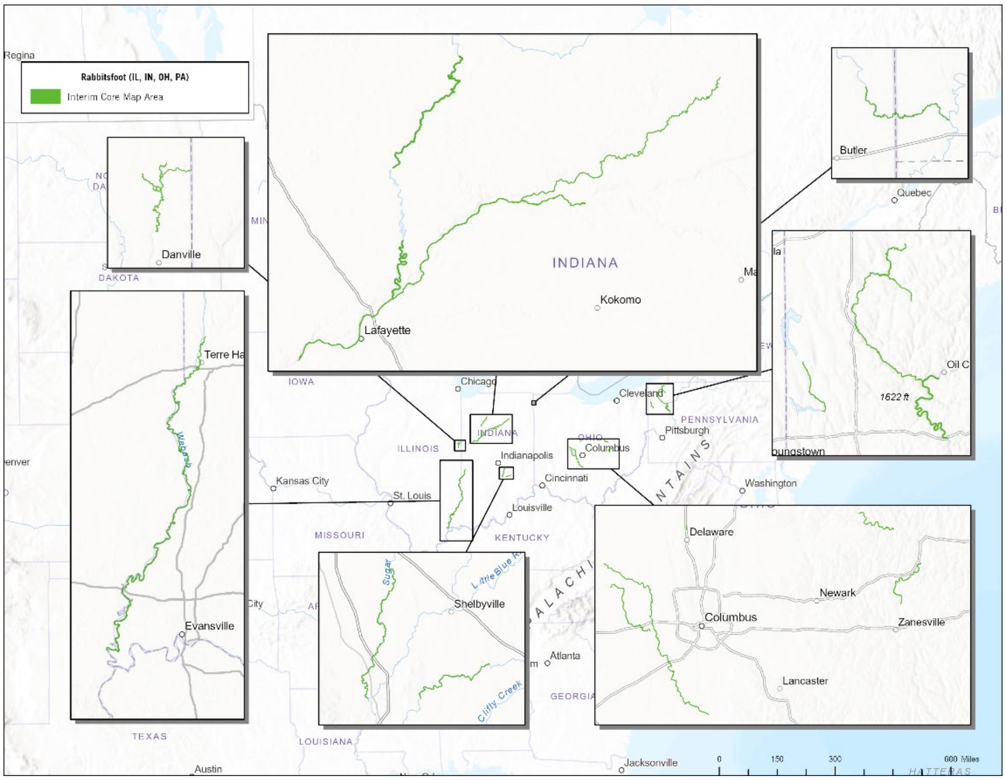


Figure 1. Rabbitsfoot mussel interim core map (IL, IN, OH, PA areas).

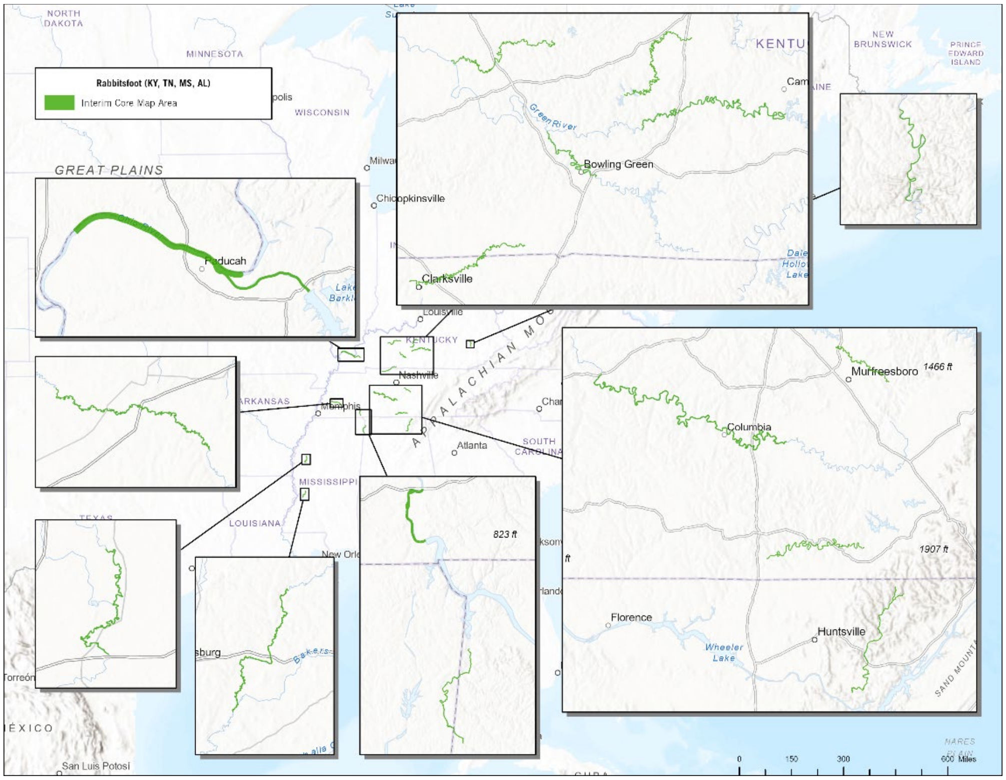


Figure 2. Rabbitsfoot mussel interim core map (KY, TN, NS, AL areas).

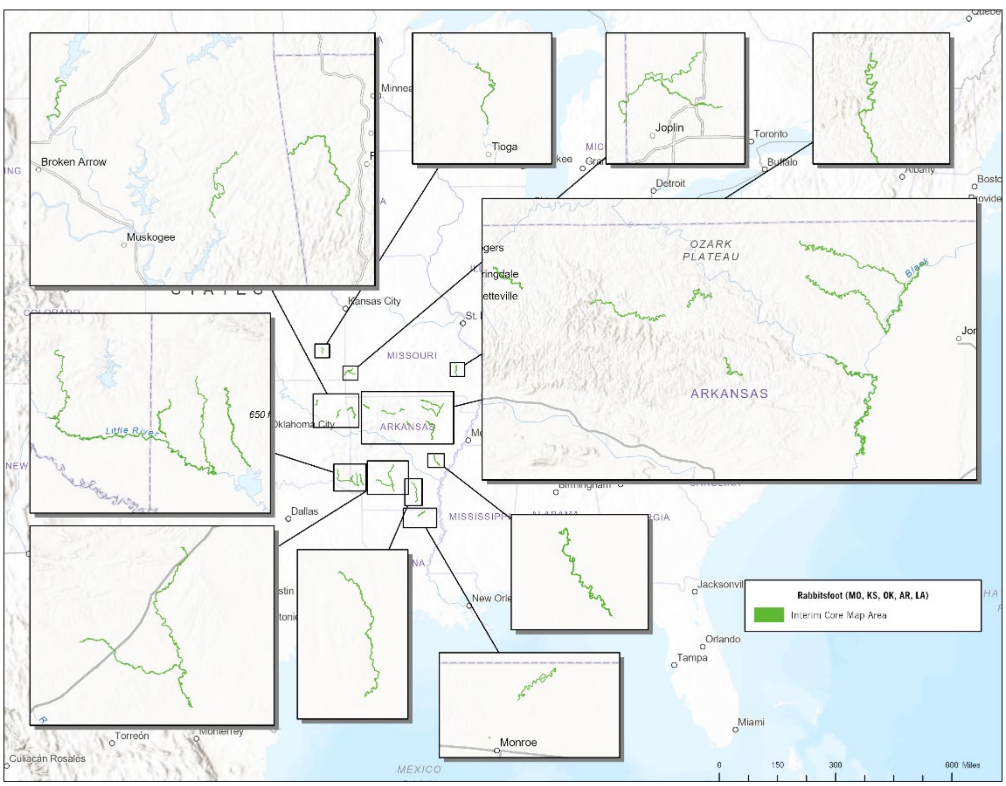


Figure 2. Rabbitsfoot mussel interim core map (MO, KS, OK, AR, LA areas).

Evaluation of Known Location Information

Known location information was only sourced from descriptions of locations and mapping provided by FWS in its Species Status Assessment (Appendix A) and 5 Year Review (Table 1). This information was cross-referenced with both designated critical habitat, range, and georeferenced mapping provided in the 2023 Recovery Plan. Designated critical habitat, supplemented by these named rivers, formed the basis of the core map. EPA finds that this information was robust enough to determine all known locations, therefore review of GBIF or iNaturalist data was unnecessary. See Appendix 1 for a more robust analysis of the extant and named locations from the SSA and 5 Year Review.

Approach Used to Create Core Map

The core map was developed using the "Process EPA Uses to Develop Core Maps for Draft Pesticide Use Limitation Areas for Species Listed by the U.S. Fish & Wildlife Service (FWS) and their Designated Critical Habitats" (referred to as "the process"). This core map was developed by EPA using the 4 steps described in the process document:

1. Compile available information for a species;

2. Identify core map type;

3. Develop the core map for the species; and

4. Document the core map

For step 1, the Center for Biological Diversity (CBD) compiled available information for the rabbitsfoot from FWS. Appendix 1 provides the compiled information for the mussel, and influential information includes:

- The 2015 designated critical habitat, which covers a majority of the occupied habitat at that time.
- In the 2021 SSA and 2020 5 Year Review, FWS provided a list of populations and corresponding waterbody names where the species is known to exist, which served to supplement the designated critical habitat where new populations were found.

For step 2, CBD used the compiled information to identify the core map type. The extant populations and corresponding waterbodies identified by FWS were located within the species range and could be mapped using the National Hydrography Dataset (NHD) Plus. Based on this information, CBD selected the designated critical habitat core map type supplemented by biological information, which consists of occupied waterbodies identified in the FWS 5-Year

Review and SSA. The designated critical habitat is a polygon, not a line. The range of the species was not selected as the core map because it contains currently unoccupied waterbodies, but it was used to confirm that extent of occupied river ranges that occurred outside of the designated critical habitat.

For step 3, CBD used the best available data sources to generate the core map. All GIS data sources used for the rabbitsfoot are discussed in process document, with the primary dataset being the designated critical habitat layer and NHDPlus version 2.1. For this core map, CBD used the designated critical habitat supplemented by known locations in the form of named rivers and streams for the rabbitsfoot as identified by FWS in the 2021 SSA and 2020 Five Year Review. The waterbodies used to represent the known locations were clipped to the species range in most cases, because nearly all extant populations are located within the species range based on the FWS 5-Year Review. A very small subsection of rivers outside the species range were included, as the latest SSA demonstrated known, recent occurrences and river viability. In most cases, even where the population was identified at a river confluence within the range, we clipped occupied rivers to the range. To deal with uncertainty regarding a small subset of river miles, additional upstream areas were considered as part of the core map. However, if the uncertainty already created a broader, county-level occupied river range, no additional river miles were included upstream.

EPA in its process document states to include "adjacent catchments upstream of habitat" as well as "identify the catchments flowing into habitat and locate catchments adjacent to the catchments encompassing habitat." EPA did not provide information on how to document catchments in its documentation for winged mapleleaf and scaleshell, but nonetheless we have used EPA provided resources to include the information EPA has requested. To identify and include catchments, we intersected occupied habitat that would be included as part of the core map with the narrower of two catchment layers provided by EPA and as recommended by the EPA core mapping process. We also included one catchment upstream of occupied habitat unless it intersected with a dam. Where the upstream catchments were under 2 acres, we considered it an anomaly and included an additional adjacent upstream catchment to represent the upstream area. Appendix 2 provides more details on the GIS data and analyses used to generate the interim core map.

Discussion of Approaches and Data that were Considered but not Included in Core Map

The Center for Biological Diversity considered including downstream buffers in consideration of the rabbitsfoots movement and increased upstream buffers in consideration of host-fish. Some river miles were already uncertain in their range, and adding additional buffers would not likely result in an additional conservation benefit to the species. EPA provided two layers it considers "catchments," one of which is based on a larger Hydrologic Unit Code. Considering that the purpose of this exercise is to create a map consisting only of this species' occupied aquatic habitat, we opted to use the narrower catchment layer, which is based on smaller hydrologic unit codes.

Appendix 1. Information compiled for species during Step 1

1) Recent FWS documents

2023 Recovery Plan, 2021 SSA, 2020 Five-Year Review, 2015 Critical Habitat

2) Background information

Status: Listed as threatened since 2013

Resiliency, redundancy, and representation (the 3Rs):

Resiliency – Because of the substantial reduction in its historical range, number of watersheds classified as low condition, and isolation of watersheds classified as high and medium condition from each other, resilience, redundancy, and representation for the Rabbitsfoot i.e., current condition, is low. (Recovery Plan)

Redundancy – see above

Representation – see above

Habitat, Life History, and Ecology

Habitat:

Rabbitsfoot is primarily an inhabitant of small to medium sized streams and some larger rivers. It usually occurs in shallow water areas along the bank and adjacent runs and shoals with reduced water velocity. Specimens also may occupy deep water runs, having been reported in 2.7 to 3.7 m (9 to 12 feet) of water. Bottom substrates generally include gravel and sand. This species seldom burrows but lies on its side.

Life History:

Rabbitsfoot populations west of the Mississippi River reach sexual maturity between the ages of 4 to 6 years (Fobian 2007). Rabbitsfoot exhibit seasonal movement towards shallower water during brooding periods, a strategy to increase host fish exposure but one that also leaves them more vulnerable to predation and fluctuating water levels, especially downstream of dams

It is a short-term brooder, with females brooding between May and late August. Similar to other species of Quadrula, the rabbitsfoot uses all four gills as a marsupium (pouch) for its glochidia. Female rabbitsfoot release glochidia as conglutinates (matrices holding numerous glochidia together and embryos and undeveloped ova), which mimic flatworms or similar fish prey. Fecundity (capacity of abundant production) in river basins west of the Mississippi River ranged from 46,000 to 169,000 larvae per female. Suitable fish hosts for rabbitsfoot populations west of the Mississippi River include blacktail shiner (Cyprinella venusta) from the Black and Little River and cardinal shiner (Luxilus cardinalis), red shiner (C. lutrensis), spotfin shiner (C. spiloptera), and bluntface shiner (C. camura) from the Spring River, but host suitability information is lacking for the eastern range (Fobian 2007). In addition, rosyface shiner (Notropis rubellus), striped shiner (L. chrysocephalus), and emerald shiner (N. atherinoides) served as hosts for rabbitsfoot, but not in all stream populations tested (Fobian 2007).

Diet: adult rabbitsfoot feed by filtering food particles from the water. Juveniles are pedal feeders meaning they bring food that adheres to their foot into the shell because structures for filter feeding are not fully developed. Specific food habits of the Rabbitsfoot are unknown, but likely it consumes detritus, diatoms, phytoplankton, and zooplankton like other freshwater mussels. (5YR)

Taxonomy:

Aquatic invertebrate, mussel. FWS currently recognizes the following taxonomy for rabbitsfoot:

Phylum: Mollusca
Class: Bivalvia
Order: Unionoida
Family: Unionidae
Genus: Quadrula
Species: Quadrula cylindrica
Subspecies: Quadrula cylindrica cylindrica

Relevant Pesticide Use Sites: Chemical contaminants are ubiquitous in the environment and a major threat in the decline of mussel species. Specifically, agricultural runoff pesticide concentrations into the aquatic environment. Elevated concentrations of pesticide frequently occur in streams due to residential or commercial pesticide runoff, overspray application to row crops, and lack of adequate riparian buffers. Agricultural pesticide applications often coincide with the reproductive and early life stages of mussels, and these effects may increase during critical times. (Recovery Plan 2023) SSA specifically mentions increased toxicity to glochidia from pesticide formulations as well as active ingredients (SSA 2021)

Relevant Recover Criteria and Actions:

Objective:

The fundamental objective in developing a recovery strategy for a rabbitsfoot is to maximize its viability by maximizing the probability of persistence and geographic extent for a specific number of watersheds.

Criteria:

The recovery criteria to water quality and pesticide use, under which Rabbitsfoot will be considered for delisting, are as follows:

1. Watersheds identified support the resource needs necessary for each life history stage of the Rabbitsfoot, such as appropriate water quality, food availability, and sufficient abundance.
2. Chemical pollution identified in the recovery plan as a threat requiring mitigation or abatement to the extent necessary to maintain resiliency
3. Through protection and/or improvement of habitat in extant watersheds, successful establishment of reintroductions in watersheds currently classified as extirpated or unknown condition or the discovery of additional extant watersheds, seven of nine representation units contain 95 to 103 watersheds that maximize the probability of persistence.

Recovery Actions:

The Recovery Plan notes that FWS will develop and implement a standardized monitoring program for collecting data to assess population trends and habitat quality, estimate abundance and recruitment, and evaluate recovery efforts. FWS will also develop a database that will be used to prioritize watersheds, threats, and needed recovery actions as well as track recovery efforts and document when threats to each watershed have been eliminated or abated.

Recommendations for Future Actions:

Protect and improve habitat to maintain and increase resiliency (Recovery Plan 2023)

3) Description of Species Range:

The rabbitsfoot's range was last updated on 6-28-2024. The species historical range included 434 watersheds locations throughout nine representation units. Range has been reduced between 63% and 70% from its historical range. Rabbitsfoot is presently extant in 63 out of 149 streams of historical occurrence in Alabama, Arkansas, Illinois, Indiana, Kansas, Kentucky, Louisiana, Mississippi, Missouri, Ohio, Oklahoma, Pennsylvania, and Tennessee. (SSA 2021) The FWS-defined range is large (>5 million acres) and appears to be based on Hydrologic Unit Codes watershed boundaries. The species range is depicted below:

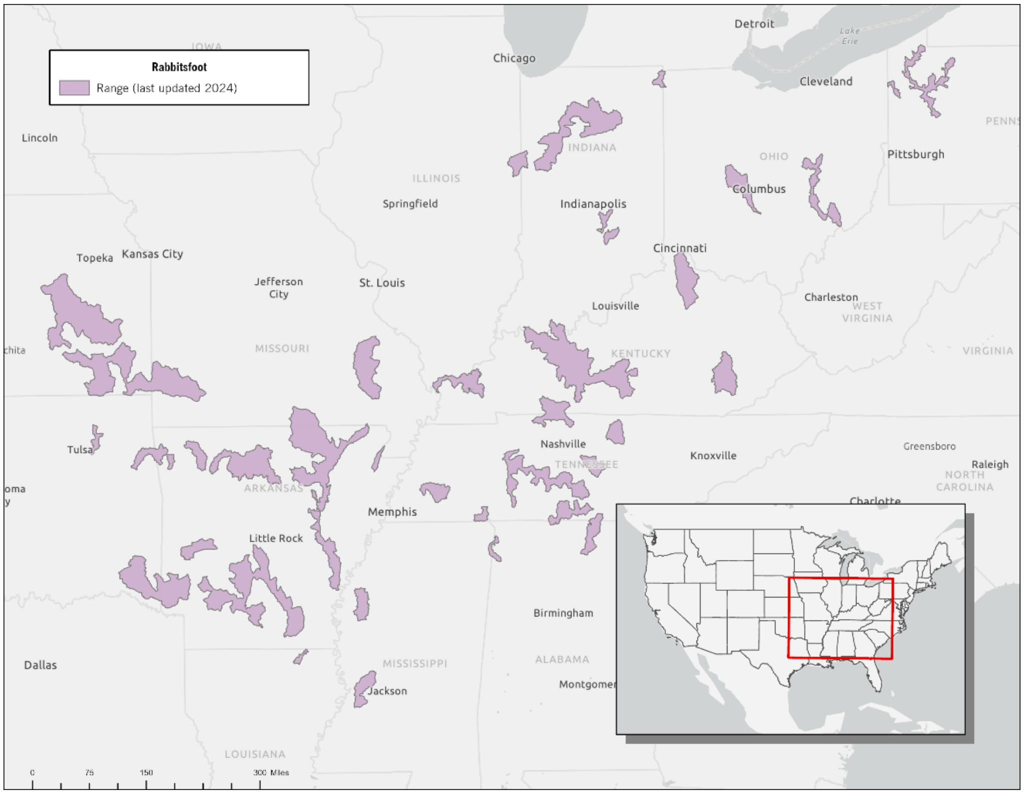


Figure A1-1. FWS range from ECOS last updated on 06/28/2024.
(https://ecos.fws.gov/ecp/species/5165)

4) Critical Habitat:

The designated critical habitat was finalized in 2015. In total, the Service designated 2,312 river kilometers (1,437 river miles) for a total of 34 units in Alabama, Arkansas, Illinois, Indiana, Kansas, Kentucky, Mississippi, Missouri, Ohio, Oklahoma, Pennsylvania, and Tennessee. The Service did not designate any unoccupied stream reaches, as defined in the proposed critical habitat rule, as critical habitat. The Service defined occupied habitat as those stream reaches that contain sizeable and small populations. The designated critical habitat is depicted below:

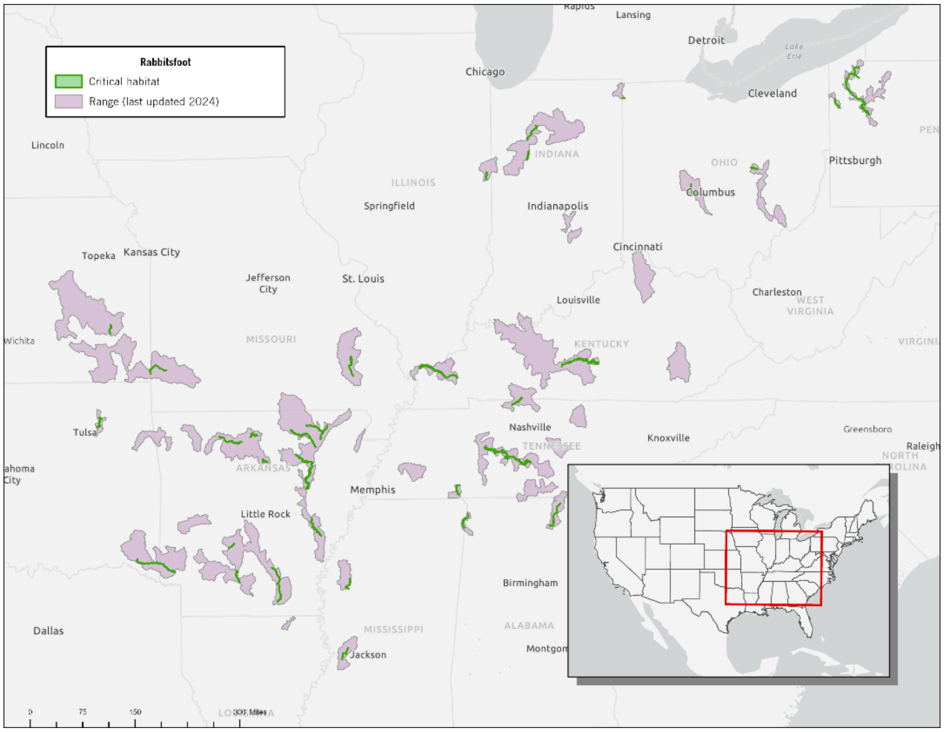


Figure A1-2. FWS Designated Critical Habitat of Rabbitsfoot. Range also included for reference.

5) Known Locations

As of the latest SSA, 63 of the 149 rivers where rabbitsfoot were historically identified are considered extant, some of which are not covered by the designated critical habitat. 434 total watersheds are considered in the historical range – of which 123 are considered extant. Additional populations have been discovered after the promulgation of critical habitat, which should be considered in drafting a core map

Since publication of the proposed listing rule in 2012 and critical habitat designation in 2015, biologists have reported records of occurrence for the Rabbitsfoot from 10 additional rivers or creeks, some of which pre-date listing. As of the latest 5-Year Review, 63 of 148 rivers are considered extant, some of which are not covered by the designated critical habitat. **APPENDIX A of the SSA and TABLE 1 of the 5YR contains descriptions of each unit which were used as the primary basis for this review.**

The 10 additional populations reported in the latest SSA are not considered in the designated critical habitat map, but are considered under the range (i.e. Hatchie River), which include:

- The Hatchie River, where mussels were reported in 2008, which occurs in the Lower Mississippi River Sub-basin. Biologists located a fresh dead specimen at the Highway 70 crossing, southwest of Brownsville, Haywood County, Tennessee. This is the first record of occurrence for the Rabbitsfoot from a direct tributary of the Mississippi River in west Tennessee.

- In the Ohio River Basin, 1 live specimen was found in Jordan Creek, Vermilion County, in Illinois. Jordan Creek is a tributary of the Middle Branch North Fork Vermilion River. (Confluence included on CH)
- In 2012, biologists also reported 1 live specimen from Sugar Creek, a tributary of the East Fork White River, Shelby County, Indiana, and an unknown number of weathered shells from the creek in Shelby and Johnson counties, Indiana. Areas within the range of this new location were included.
- Recent records of occurrence from both Big Monon Creek, White County, Indiana, and Pipe Creek, Madison County, Indiana, respectively. Big Monon Creek is a tributary of the Tippecanoe River and Pipe Creek a tributary of the West Fork White River. SSA produced after the 5YR claims these populations are extirpated and thus were not included.
- Weathered dead specimens have been reported from the Salamonie River, Huntington and Wells counties, Ohio. The Salamonie River is a tributary of the Wabash River. The SSA claims extirpation, and since it was outside the range it was not included.
- Live specimens reported from Bayou D'Arbonne upstream of Louisiana Highway 143 at the boundary of D'Arbonne NWR, Ouachita Parish, Louisiana
- They surveyed 34 sites along Rolling Fork Little River in Little River and Sevier counties, Arkansas, and reported 3 live specimens from 2 sites in Sevier County for a relative abundance of 0.20%.
- They also surveyed 45 sites along the Saline River in Howard and Sevier counties, Arkansas, and reported 6 live specimens from 5 sites in Sevier County, Arkansas, for a relative abundance of 0.40%.
- Live specimens have been reported from the North Fork Spring River, near Neck City, Jasper County, Missouri. The North Fork Spring River is a tributary of the Spring River and occurs in the Arkansas River Basin

Assuming that TABLE 1 and APPENDIX A represent the most current, best available information, 5 populations were upgraded from extirpated to unknown or decreasing based on new occurrences. These include:

- The Mohican River (OH): reported 1 live specimen downstream of the TR-715 bridge approximately 200 meters upstream of the confluence with the Kokosing River
- Olentangy River (OH): In 2016, biologists conducting a survey in Delaware County, Ohio, located 1 live and 1 weathered specimen and 2 sets of subfossil valves
- Nolin River (KY): In 2013, biologists reported an unknown number of specimens from Hardin and Grayson counties, Kentucky
- Flatrock River (IN): In 2012, biologists located 3 live specimens from Shelby County, Indiana
- Buffalo River (TN): No information on river miles in latest 5-Year review, so we assumed Buffalo River within the range.

No populations in Table 1 or Appendix A moved from unknown to extirpated, and therefore, this Table is presumed as representative of the known locations for Rabbitsfoot.

The 2023 Recovery Plan also includes mapping that was used to confirm whether populations are still extant and whether they are to be considered in the PULA.

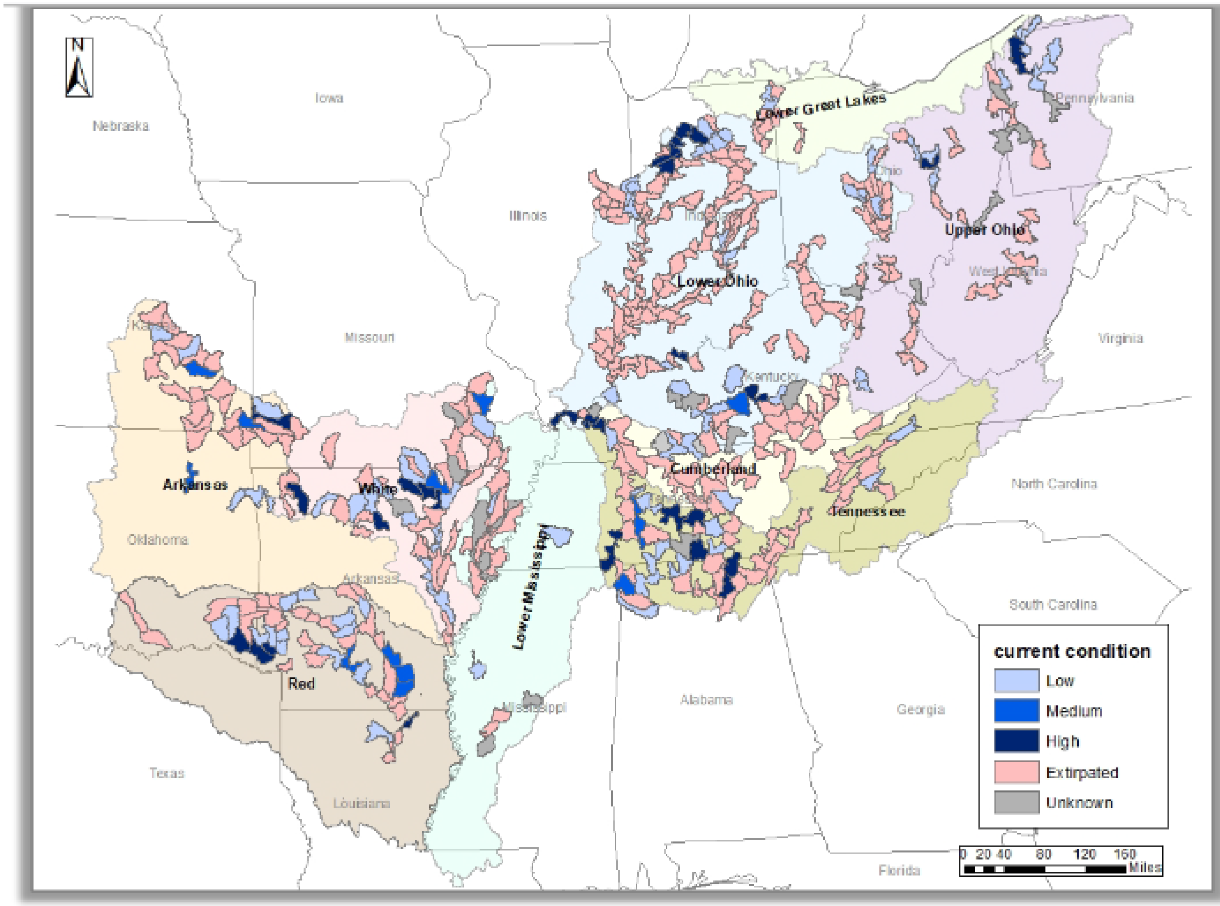


Figure 1. Current condition of the Rabbitsfoot by watershed distributed across the nine representation units.

The FWS 2020 5-Year review figure 2 shows the historical range and populations considered extant at the time of listing.

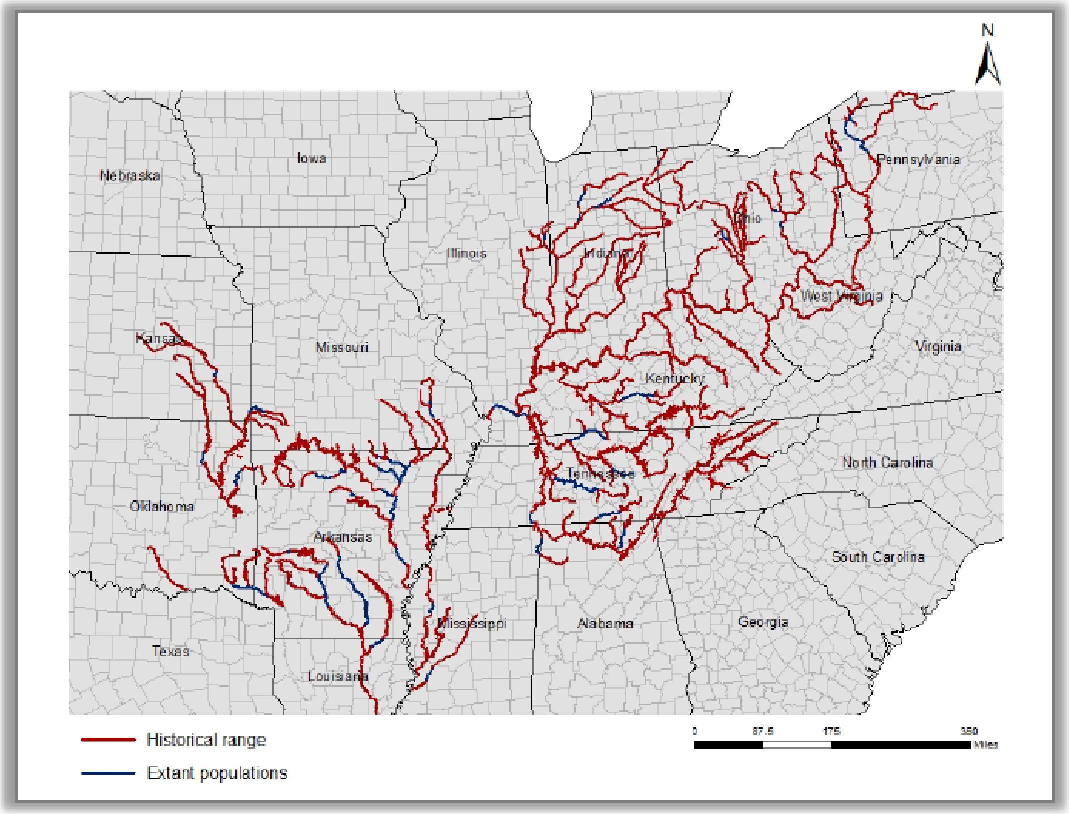


Figure 2. Historical range and populations considered extant at the time of listing.

Appendix 2. GIS Data Review and Method to Develop Core Map (Step 3)

The core map type for this species is based on biological information, including known locations (named, occupied rivers/streams) reported in the 2023 Recovery Plan, 2020 5-year review and 2015 Critical Habitat identified as suitable habitat. This section details the data and steps used to create the core map for the Rabbitsfoot based on this biological information

1) **References and Software**

- Range: https://ecos.fws.gov/ecp/species/5165

- Critical Habitat: https://ecos.fws.gov/docs/crithab/zip/FCH_QUADRULA_CYLINDRICA_SSP_CYLINDRICA_20150430.zip
- Esri Living Atlas "National Hydrography Dataset Plus High Resolution": https://www.arcgis.com/home/item.html?id=f1f45a3ba37a4f03a5f48d7454e4b654
- Census 2024 TIGER/Line Shapefiles downloaded 1/14/2025: https://www.census.gov/geographies/mapping-files/time-series/geo/tiger-line-file.html
- National Geospatial data Asset (NGDA) data form the U.S. Army Corps of Engineers (USACE)National Inventory of Dams: https://resilience.climate.gov/datasets/fedmaps::national-inventory-of-dams-1/about
- NHDPlus High Resolution EPA Snapshot 2022 Data (Esri File Geodatabase download): https://www.epa.gov/waterdata/get-nhdplus-national-hydrography-dataset-plus-data#NHDPlusV2Map.
- USA NLCD Land Cover https://www.arcgis.com/home/item.html?id=3ccf118ed80748909eb85c6d262b426f https://landscape10.arcgis.com/arcgis/rest/services/USA_NLCD_Land_Cover/ImageServer
- USGS PAD-US Data Download (National Geodatabase) Version 4.0: https://www.usgs.gov/programs/gap-analysis-project/science/pad-us-data-download
- World UTM Grid: https://services.arcgis.com/P3ePLMYs2RVChkJx/arcgis/rest/services/World_UTM_Grid/FeatureServer
- Software used: ArcGIS Pro version 3.2

1) Datasets Used in Core Map Development

1.1. Range

The range was last updated on 06/28/2024. The file was downloaded from the FWS ECOS web page on 9/30/2024. Layer used was "usfws_F03X_I01_Quadrula_cylindrica_cylindrica_current_range". It was added to a map in ArcGIS pro, and the original name was kept

1.2. Critical Habitat

The designated critical habitat has a published date of 04/30/2015 and has an effective date of 06/01/2015. The file was downloaded from the FWS ECOS webpage on 9/30/2024. It was added to a map in ArcGIS Pro, and the layer's name was renamed to "Rabbitsfoot critical habitat".

1.3. Esri Living Atlas "National Hydrography Dataset Plus High Resolution"

Layers used include Line Features and Area Features.

1.4. Census 2024 TIGER/Line Shapefiles

Layers used is named “tl_2024_us_county”. The file was downloaded on 01/14/2025. It was added to a map in ArcGIS Pro and the original name was kept.

1.5. USGS PAD-US Data Download (National Geodatabase) Version 4.0

Layers used is named “PADUS 4.0 Combined Proclamation, Marine, Fee, Designation, Easement”. The file was downloaded on 01/16/2025. It was added to a map in ArcGIS Pro and the original name was kept.

1.6. National Geospatial data Asset (NGDA) data form the U.S. Army Corps of Engineers (USACE) National Inventory of Dams

Layers used is named “Dams”. The file was downloaded on 07/03/2024. It was added to a map in ArcGIS Pro and the original name was kept.

1.7. NHDPlus High Resolution EPA Snapshot 2022 Data (Esri File Geodatabase download)

Layers used is named “CatchmentFabric”. The file was downloaded on 01/16/2025. It was added to a map in ArcGIS Pro and the original name was kept.

1.8. NHDPlus World_UTM_Grid

Layer used is named “World_UTM_Grid. The file was added to ArcGIS Pro as an URL. The original name was kept.

1.9. Locations Identified by FWS

According to the 2023 Recovery Plan, 2020 5-year review and 2015 Critical Habitat, this species has been found in the following river basins: Lower Great Lakes, Ohio River, Cumberland River, Tennessee River, Lower Mississippi River, White River, Arkansas River, and Red River. Table 2 provides a summary of the river basins with year of last observation, status at the time of listing, and current status (summarized from Table 1 in the 2020 5-Year Review).

The Center for Biological Diversity extracted the FWS 2020 5-year table 1 as an excel table. Then the excel table was filtered to remove any records that had a “Current Status” equal to “Extirpated.” See modified Table 1 below.

Table 2. Modified version of 2020 FWS 5-Year Review. Occurrence, status at time of listing, year of last observation of live and/or fresh dead specimen(s), and current status for the Rabbitsfoot within 8 river basins.

River Basin	River/Creek	States	Status at time of listing	Year of last observation	Current Status (modified)
Lower Great Lakes					
	Fish Creek	IN, OH	Declining	2012	Declining
Ohio River					
	Ohio River	IL, IN, KY, OH, PA, WV	Stable	2018	Stable
	Allegheny River	PA	Declining	2007	Unknown
	French Creek	PA	Stable	2017	Stable
	Conneautee Creek[6]	PA	Unknown	2006	Unknown
	Le Boeuf Creek[6]	PA	Unknown	2006	Unknown
	Muddy Creek	PA	Declining	2003	Unknown
	Shenango River	PA	Unknown	2009	Unknown
	Muskingum River	OH	Declining	2007	Unknown
	Walhonding River	OH	Declining	2019	Improving
	Mohican River[4]	OH	Extirpated	2019	Unknown
	Olentangy River	OH	Extirpated	2016	Unknown
	Big Darby Creek	OH	Declining	2001	Unknown
	Little Darby Creek	OH	Declining	2006	Unknown
	South Fork Kentucky River	KY	Declining	2009	Unknown
	Green River	KY	Improving	2015	Stable
	Nolin River	KY	Extirpated	2013	Unknown
	Barren River[2 and 3]	KY	Declining	2008	Unknown
	Rough River	KY	Declining	2012	Unknown
	Wabash River	IL, IN	Declining	1988	Unknown
	Eel River	IN	Declining	2017	Declining
	Tippecanoe River	IN	Stable	2017	Stable
	N Fork Vermilion River	IN	Declining	2011	Unknown
	Middle Branch N Fork Vermilion River	IL	Declining	2014	Declining
	Jordan Creek	IL	Unknown	2010	Unknown
	Flatrock River[3]	IL	Extirpated	2012	Unknown
	Sugar Creek (East Fork White River)[3]	IN	Unknown	2012	Unknown
Cumberland River					
	East Fork Stones River[2]	TN	Declining	2002	Unknown
	Red River[3]	KY, TN	Declining	1992	Unknown
Tennessee River					
	Tennessee River[1]	AL, KY, MS, TN	Stable	2018	Stable
	Paint Rock River	AL	Improving	2018	Improving
	Elk River	TN	Declining	2018	Stable
	Bear Creek	AL, MS	Declining	2019	Improving
	Duck River[1]	TN	Improving	2015	Improving
	Buffalo River	TN	Extirpated	2013	Unknown
Lower Mississippi River					
	St. Francis River	AR, MO	Declining	2016	2016
	Big Sunflower River	MS	Declining	2017	2017
	Big Black River	MS	Declining	2000	2000
	Hatchie River3	TN	Unknown	2008	2008
White River					
	White River	AR	Stable	1999	Unknown
	Rolling Fork Little River	AR	Unknown	2013	Unknown
	Black River	AR, MO	Declining	2014	Declining
	Current River[5]	AR	Declining	1984	Unknown
	Spring River	AR	Declining	2018	Declining
	South Fork Spring River	AR	Declining	2006	Unknown
	Strawberry River	AR	Unknown	2018	Improving
	Middle Fork Little Red River	AR	Stable	2016	Declining

Table 1. Modified version of 2020 FWS 5-Year Review continuation.

River Basin	River/Creek	States	Status at time of listing	Year of last observation	Current Status (modified)
Arkansas River					
	Verdigris River	KS, OK	Unknown	2018	Unknown
	Neosho River	KS, OK	Declining	1999	Unknown
	Spring River	KS, MO	Declining	2017	Declining
	North Fork Spring River	MO	Unknown	1995	Unknown
	Saline River (Little River)[3]	AR	Unknown	2013	Unknown
Red River					
	Little River	AR, OK	Stable	2018	Stable
	Glover River	OK	Declining	1996	Unknown
	War Eagle Creek	AR	Unknown	2013	Improving
	Cossatot River	AR	Declining	2013	Declining
	Ouachita River	AR, LA	Stable	2013	Stable
	Little Missouri River	AR	Declining	1996	Unknown
	Saline River (Ouachita River)	AR	Declining	2015	Stable
	Bayou Bartholomew[3]	LA	Declining	2017	Improving
	Bayou D'Arbonne	LA	Unknown	2017	Unknown
	Illinois River[3]	AR, OK	Declining	2017	Declining

[1]The GIS data source for this river/creek came from the 2015 FWS Critical Habitat layer. Because review of the imagery in dam upstream areas show minimal volume increase and that the FWS designated critical habitat choose not to remove upstream river segment, the polygon was left as is.

[2] Because review of imagery in dam upstream areas show minimal volume increase, the upstream segment was not removed.

[3]Rivers/Creeks where the 2020 FWS 5-Year Review individual water description or GIS Hydrography area fell outside the range and were clipped.

[4]Rivers/Creeks based on the 2020 FWS 5-Year Review individual water geographic descriptions and fall outside the range were included in the core map.

[5]2021 Rabbitsfoot SSA Appendix A table notes river as "Extirpated." River/Creek not included in core map.

[6]2020 FWS 5-Year Review individual water description notes that in both LeBoeuf and Conneautee Creeks that the survey observations were near the confluences with French Creek rather than upstream. Additionally, they primarily reside outside of the range. The decision was not to include them in the core map.

This Table 2 information is duplicated by 34 records in the 2015 Critical Habitat and was used first to create polygons in core map polygon layer. Any rivers/creeks not in the 2015 FWS Critical Habitat layer but described geographically in the 2020 FWS 5-Year Review by which county or counties the species is located within or with other geographic markers, the Line and Area features from the Hydrography dataset were used to create the initial polygons and lines and clipped by County boundaries. Rivers/creeks mentioned in Table 2 that are not shown in the Critical Habitat GIS layer or are described geographically by which county or counties the species is located within or with other geographic markers, the FWS 2020 5-year figure 2 was geo-referenced and used to identify the start and end locations of river segment(s). The same Line and Area features from the Hydrography data were used to create the initial polygons and lines.

1.10. Used FWS Critical Habitat Layer as the basis to create records.

To develop a core map, the Center for Biological Diversity instituted a hierarchical process to create GIS data based on the source's accuracy. Rabbitsfoot's FWS 2015 Critical Habit GIS layer is the best source of GIS data and was used as the basis to create as many rivers/creeks polygons as possible first.

1) First, the layers listed above under 2.1., 2.2., 2.3., 2.4., 2.5., 2.6., 2.7., and 2.8. were add to an ArcGIS Pro map. A copy of the Line Features from the Hydrography dataset was made and symbolized to show the rivers/creeks flow , renamed to “Line_Feature_Direction”, (**Figure A2-1**) and (**Figure A2-2**).

Figure A2-1. Screenshot of partial ArcGIS Pro map layer contents

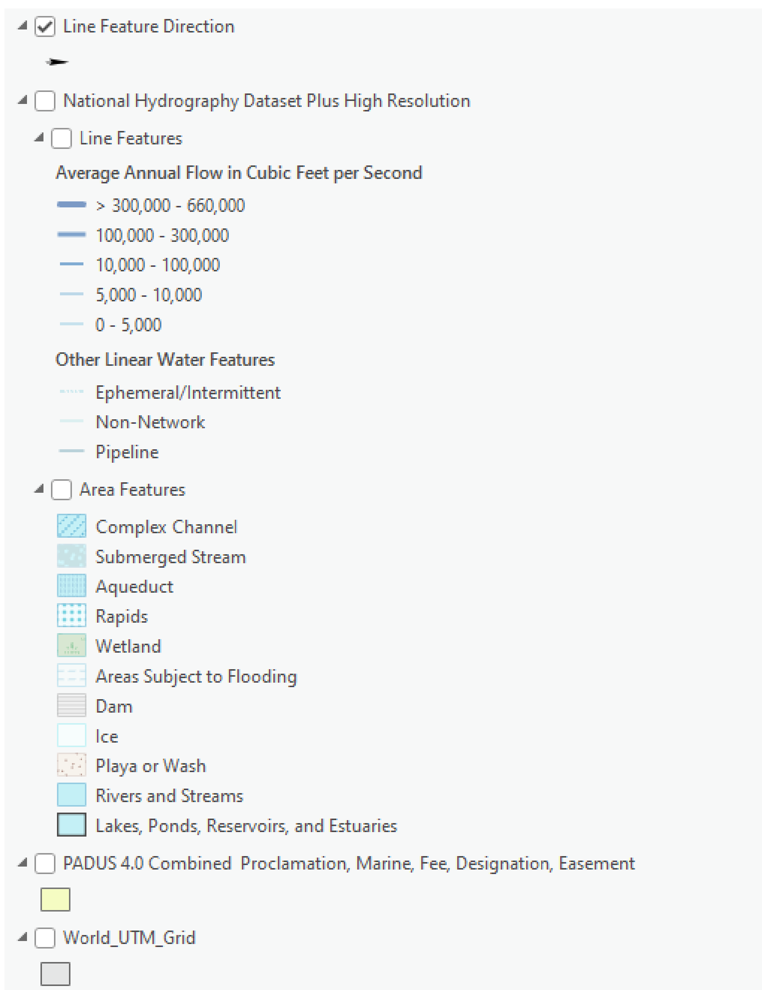


Figure A2-2. Screenshot of partial ArcGIS Pro map layer contents

2) One line and two polygons template shapefiles that hold the created results were added. (**Figure A2-3**)

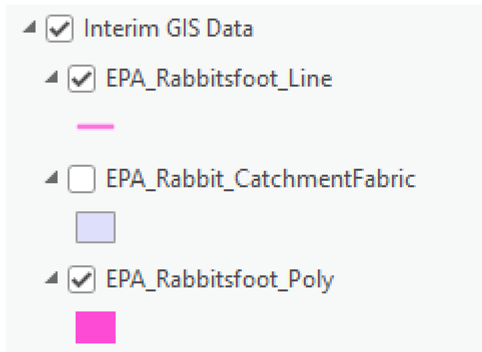


Figure A2-3. Screenshot of partial ArcGIS Pro map layer contents

3) Added a new text field the “Rabbitsfoot critical habitat layer named, “Descriptio”. This was used to compose a brief description of the polygon source and location. Manually selected 28 records in the “SUBUNITNAME” field where it equals null. “Calculate Field” (**Figure A2-4**) was used to populate the “Descriptio” field. Manually selected 6 records in the “SUBUNITNAME” field where it is not null. “Calculate Field” (**Figure A2-5**) was used to populate the “Descriptio” field.

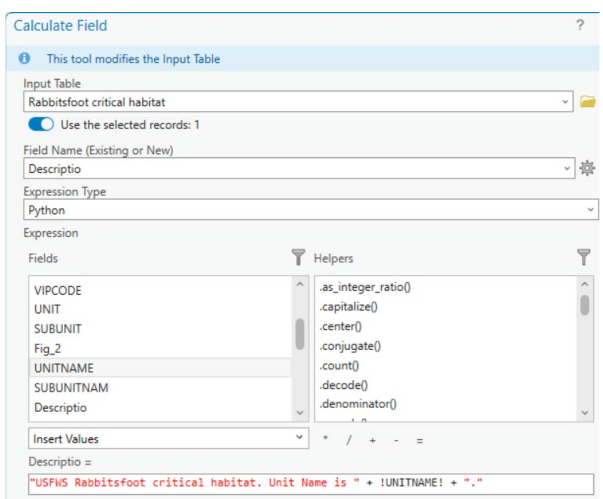


Figure A2-4. Field Calculate formula for “Descriptio” field

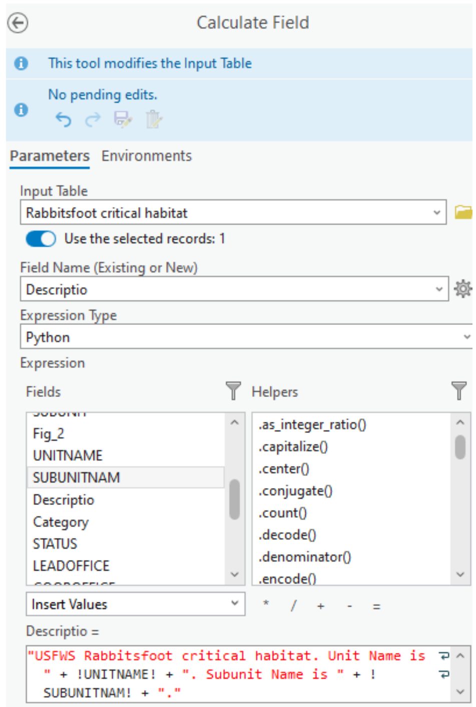


Figure A2-5. Field Calculate formula for "Descriptio" field

4) Checked that the "Map Properties" coordinate system matches the Interim shapefiles, which is "USA Contiguous Albers Equal Area Conic USGS". Glochidia, fertilized mussel eggs, attach to suitable host fish and travel upstream and drop off the fish's gills and settle on the stream bottom. To protect the Glochidia, when available, this process creates a five-mile upstream buffer. For each FWS Critical Habitat record, the extent was zoomed to and the area reviewed. Further zoomed into the furthest upstream portion and turned on the "Line Feature Direction" layer to confirm that this area is upstream. Started editing mode → select Create feature →select the trace mode of the "EPA_Rabbitsfoot_Line→ "Limit trace length" to 5 miles→click OK. (**Figure A2-6**)

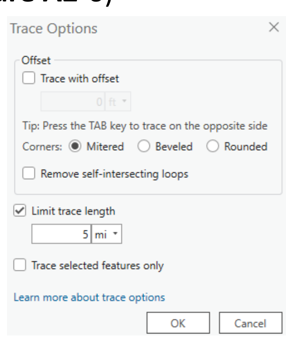


Figure A2-6. Limit trace length to 5 miles settings

5) Used the trace method to create a five-mile upstream line segment. Used the "Measure Distance" tool to determine the width at the end of the Critical Habitat polygon. (**Figure A2-7**). Used the "Buffer" mode in edit mode to create a new polygon in "EPA_Rabbitsfoot_Poly". Buffered the five-mile segment by half of the measured width. Copied the Critical Habitat to the "EPA_Rabbitsfoot_Poly". Selected both recently created polygons (Upstream and Critical Habitat) and merged them. Added the following text to the end of the "Descriptio" field. "Plus five miles upstream." (**Figure A2-8**). When the Critical Habitat record upstream area doesn't exist because of headwaters or confluence with another river/creek or another designated critical habitat area, the process to create and upstream buffer is not done.

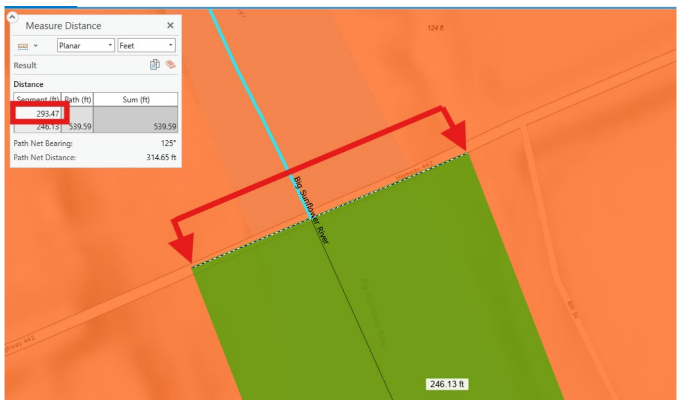


Figure A2-7. Critical Habitat polygon width is 293.47 ft

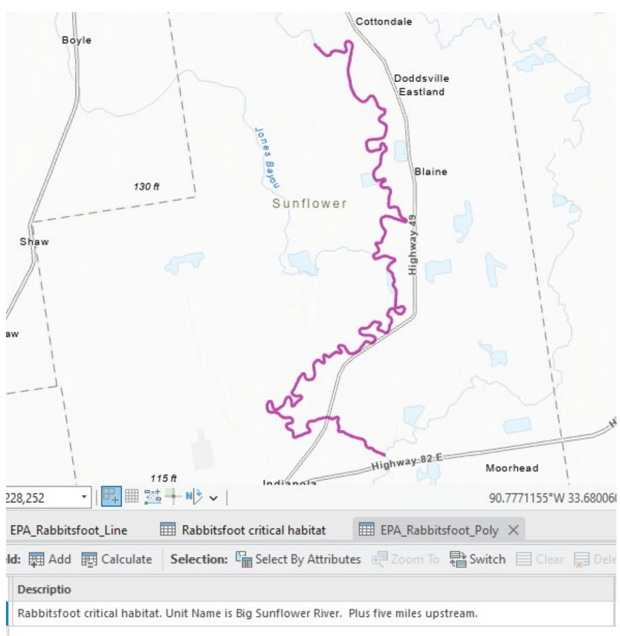


Figure A2-8. Finished buffered and merged polygon

6) All line segments used as the basis for the buffering and creation of the five-mile upstream polygons are no longer needed and were deleted.

Please note in Table 2's superscript, ([1]The GIS data source for this river/creek came from the 2015 FWS Critical Habitat layer. Because review of the imagery in dam upstream areas show minimal volume increase and that FWS designated critical habitat choose not to remove upstream river segment, the polygon was left as is.)

1.11. Used FWS 2020 5-Year Descriptive Text and Hydrography Area layer as basis to create records.

To develop a core map, the Center for Biological Diversity instituted a hierarchical process to create GIS data based on the source's accuracy. The second-best source of GIS data is the FWS 2020 5-YR individual water feature descriptions mentioning county limits or geographic markers that can be readily determined used and utilized by records in the Esri Living Atlas "National Hydrography Dataset Plus High Resolution" Area Layer.

1) For each river segment created with this process, certain considerations where made.

- **a.** FWS 2020 5-Yr individual water descriptions equal to the year 2000 and later were taken into consideration. Any before year 2000 are not.
- **b.** Removal of the river/creek upstream area of a dam was done, except in two cases. The dam located along Barren was noted both as a lock and a dam in the GIS dam layer attributes and did not significantly increase the volume of water upstream. The river segment upstream of the dam located along East Fork Stones River did not create significant enough volume to decrease the possible concentration of pesticide.
- **c.** No five-mile upstream segments were created. Descriptions are broad enough and covered the areas host fish would normally travel upstream.
- **d.** When hydrography water areas available, they were used first over line areas even if there were gaps in the water areas. A polygon with the with the average width between the gaps was created from a buffered line segment and merged. Please note that a following section, 2.12., will describe the process used on the Hydrography Line feature layer, as the process is different.

2) For each river segment created where the individual water feature description mentioned county limits, steps 3-10, were completed. For each river segment created where the individual water feature used geographic markers, steps 11-20 were completed.

3) A definition query was created in the Hydrography Line feature layer. Selected the field "Name from Geographic Names Information" that "is equal to" the actual name of the river creek. (**Figure A2-9**)

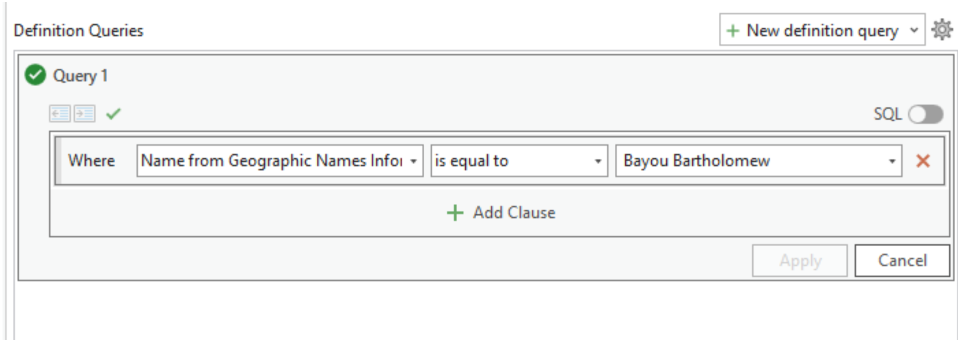


Figure A2-9. Line Area Definition Query Example

4) Created a definition query in the County layer. Selected the "STATEFP" code or codes that the county resides in "And" the "NAME" of the County or Counties. (**Figure A2-10**)

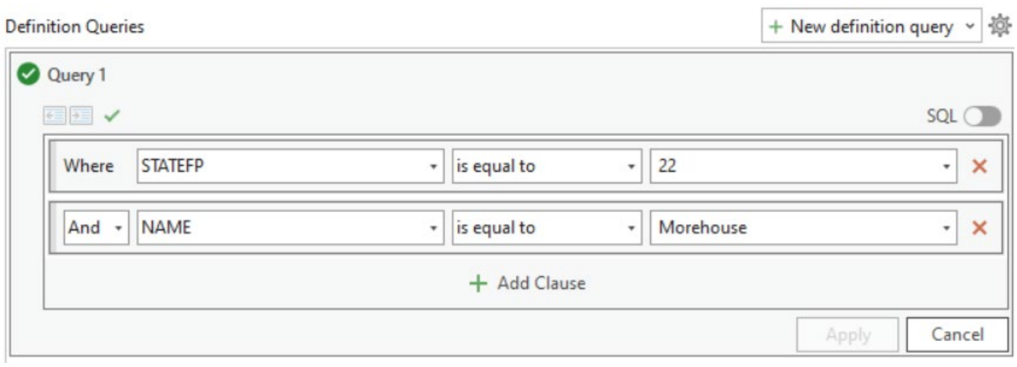


Figure A2-10. County Definition Query Example

5) With the "Select by Polygon" tool the Hydrography Area records were selected. (**Figure A2-10**)

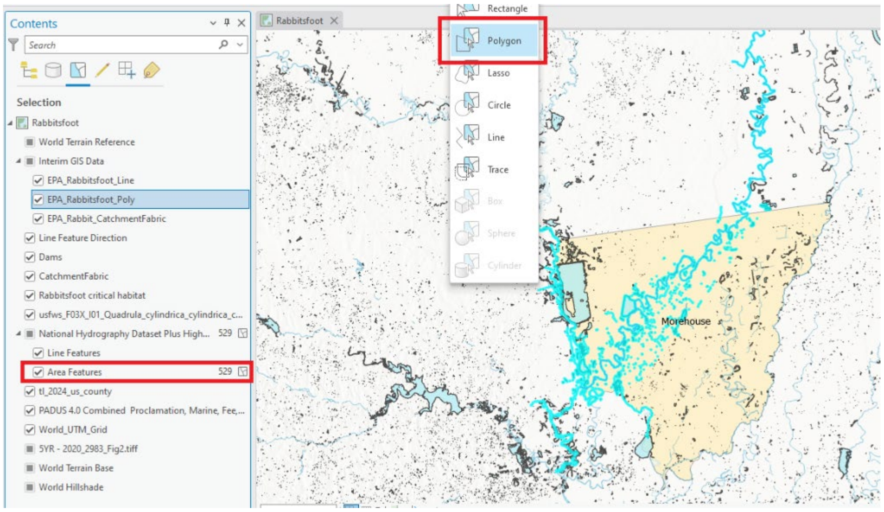


Figure A2-11. Screenshot of selected Hydrography Areas

6) Used the “Select by Location” tool with a “Select subset from the current selection” Selection Type. (**Figure A2-12**) From the Hydrography Area attribute table with the “Show Selected Records”, determine if any records can be unselected or selected to reduce the number of records to those that are necessary. (**Figure A2-13**) In this example OBJECTID 111404 was removed.

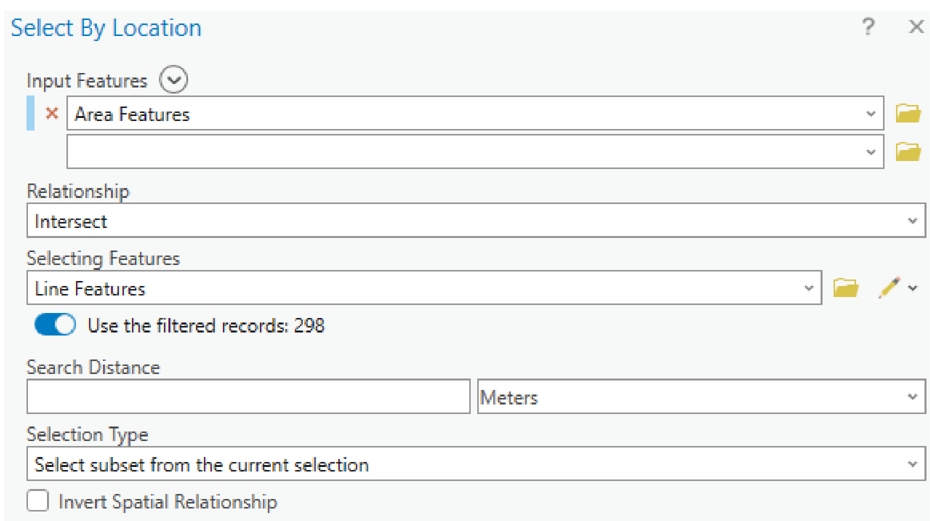


Figure A2-12. Screenshot of “Select by Location”

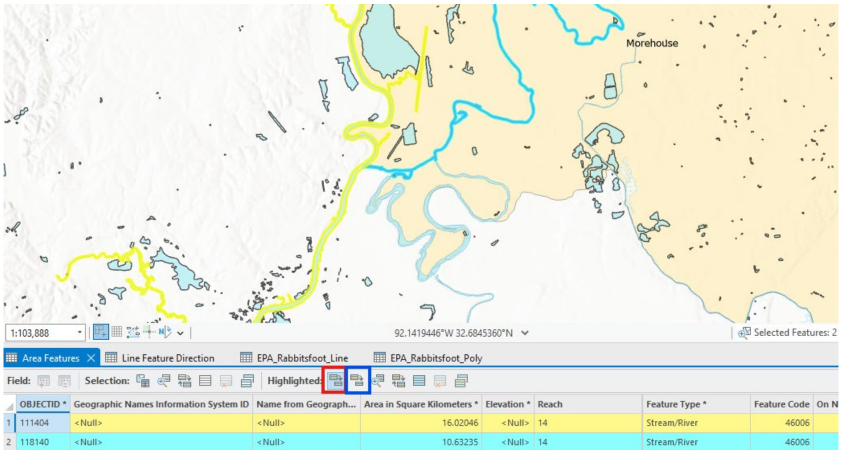


Figure A2-13. Screenshot of selected records. The "Unselect Highlighted" will be used to unselect unnecessary record.

7) Copied and pasted record(s) into the "EPA_Rabbitsfoot_Poly" shapefile. If more than one record was copied and pasted, merge them together. Review the newly merged polygon and make sure there are not any gaps. If there are, trace short segments of the Line Feature layer → Buffer the line with half the average width of the polygons on either side and merge them. Saved edits. While in edit mode, select "Modify" → Select "Clip" from the Modify Feature tools→ Move the selected river/creek record to target features→ Select all County records and ensure it is an input feature→Under "When clipping features", select "Preserve". Click "Clip" in the bottom right. (**Figure A2-14**) The resulting polygon will appear. Please note that although the polygon is clipped to intersect with a county or counties, due to a headwater or confluence starting or ending inside the same county of counties the polygon will naturally fall far inside. (**Figure A2-15**)

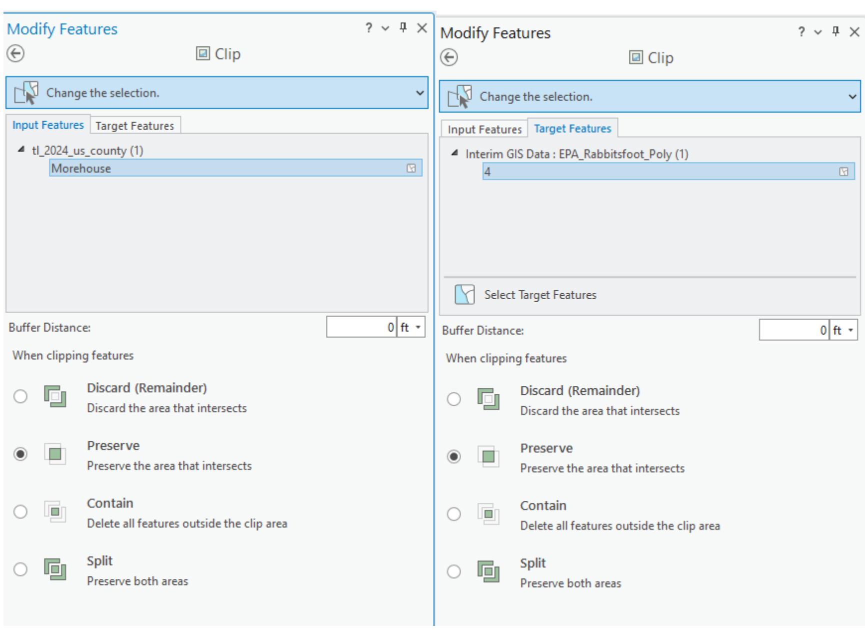


Figure A2-14. Screenshot of Modify Features Clip Tool

Figure A2-15. Screenshot of Clipped River/Creek Segment

8) While the record is still selected, review the result by zoom in and confirmed that there are not any polygon “offshoots” that are part of another river/creek and should not be included because this is part of a tributary etc. If necessary, turned on the “Line Feature Direction” layer on and zoomed in and around the length of the river/creek segment. If an area was found where this scenario exists, used the “Split” or “Edit Vertices” tools to remove that segment that belonged to a tributary. (**Figure A2-16**)

Figure A2-16. Screenshot of Example “offshoot” Tributary that is Split

9) Turned on the “Dams” layer zoomed to the records extent. Visually reviewed if there are any dams along the length of the records. If there is, zoomed in and switched the base map to “Imagery”. Used the “identify” tool to view the attributes of the dam and looked upstream to see the increase in volume of water. The EPA_Rabbitsfoot_Poly record was modified with the Modify Features “Split” tool. (**Figure A2-17**) Removed portion upstream. There are two instances, noted earlier where this was not done.

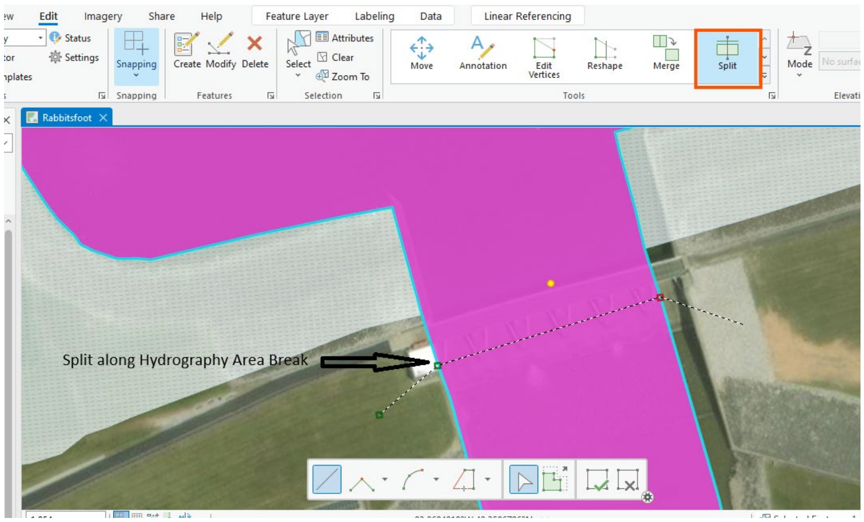


Figure A2-17. Screenshot of Example Split Upstream of Dam

10) Updated the “Descriptio” field with information about the source and location of the river segment. In the scenarios where the headwater or a confluence exists and the clipped intersection falls far inside the polygon, the headwater and confluence is noted as either the starting or ending point in the text. (**Figure A2-18**) Saved edits

USGS NHD area layer, Olentangy River starts at Delaware dam and continues downstream and is clipped at the southern border of Delaware County, OH.
USGS NHD area layer of Barren River within Warren County.

Figure A2-18. Screenshot of Example “Descriptio” field text

11) Used the geographical marker location text to discern the start and end locations of the river/creek segment. Examples of geographical marker location texts are:

- **a.** Live specimens reported from Bayou D’Arbonne upstream of Louisiana Highway 143 at the boundary of D’Arbonne NWR, Ouachita Parish, Louisiana
- **b.** Christian and Harris (2004) surveyed 131 sites starting at Arkansas Highway 195 bridge, Pike County, Arkansas, and ending downstream of Arkansas Highway 53 bridge, Clark County, Arkansas, but did not locate any specimens. At the time of listing, biologists considered this population a metapopulation with the population in the Ouachita River and determined the status of the population as declining (Table 2). We did not receive any new information about surveys conducted in this river since publication of the proposed listing rule. The current status of this population is unknown (Table 2).

12) Turned on the “Dams” layer zoomed to where the start and end locations are visible. Visually reviewed if there are any dams along the length of the river/creek. If there is, zoomed in and switched the base map to “Imagery”. Used the “identify” tool to view the attributes of the dam and looked upstream to see the increase in volume of water. If there are no dams, proceed to step 13. If there is, then determined the new start and end locations based on the dam, then proceed to step 13.

13) A definition query was created in the Hydrography Line feature layer. Selected the field “Name from Geographic Names Information” that “is equal to” the name of the river creek. (**Figure A2-19**)

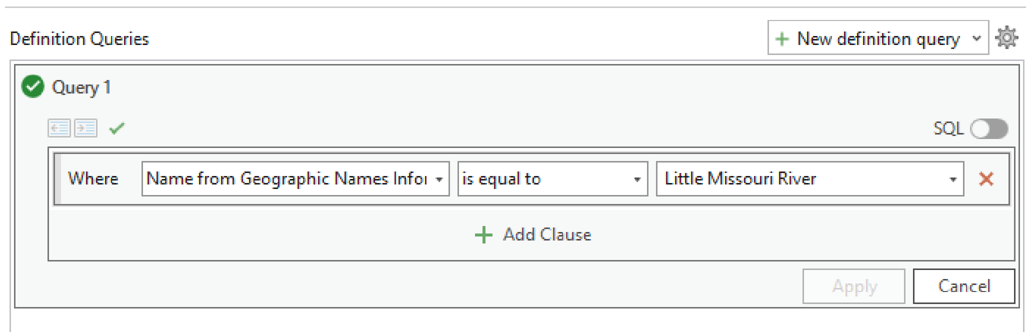


Figure A2-19. Screenshot of Example Definition Query

14) Used the “Select by Polygon” tool to select the Hydrography Area records that are within the determined start and end locations. (**Figure A2-20**)

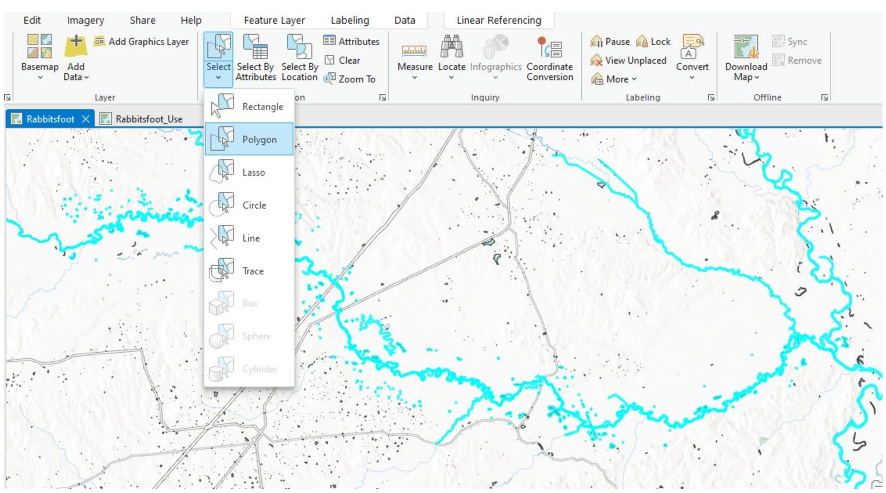


Figure A2-19. Screenshot of Example Selected Hydrography Records

15) Used the “Select by Location” tool with a “Select subset from the current selection” Selection Type. (**Figure A2-21**)

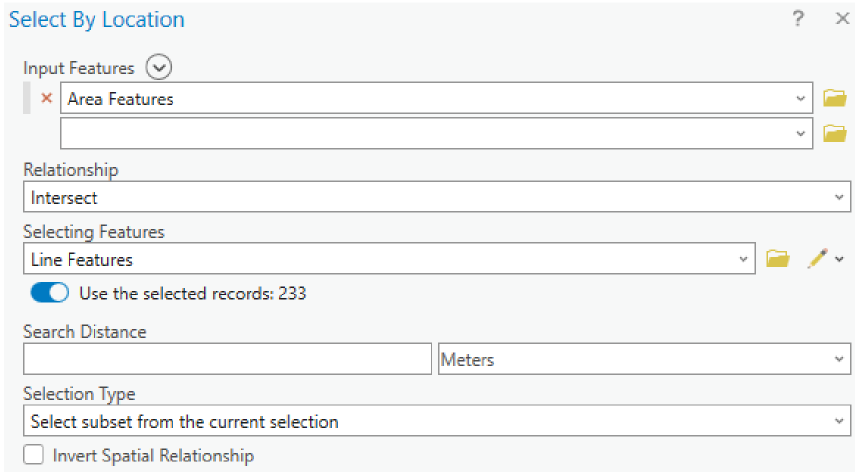


Figure A2-21. Screenshot of Example Selected Hydrography Records

16) From the Hydrography Area attribute table with the "Show Selected Records", determined if any records can be unselected or selected to reduce the number of records to those that are necessary. (**Figure A2-22**) In this example OBJECTIDs 120188,1168304,4119066, 6916719 were removed.

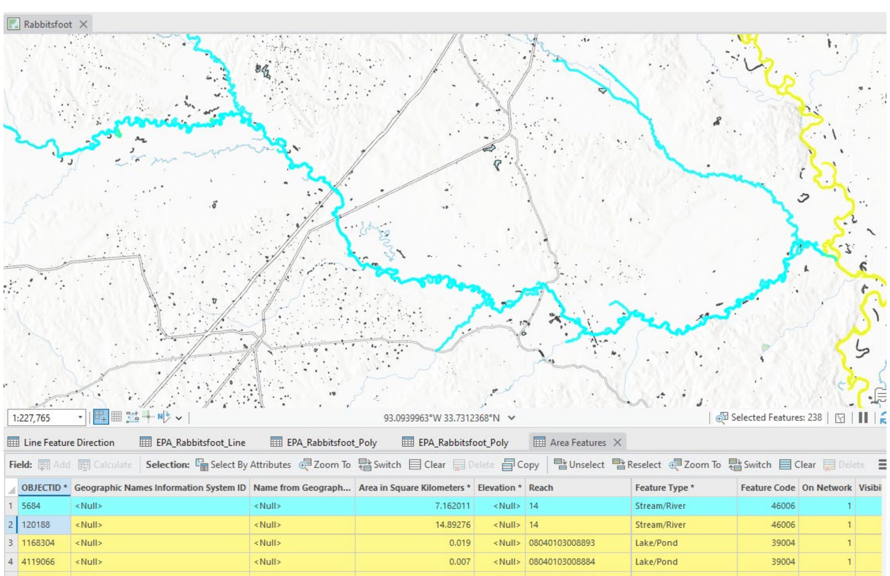


Figure A2-22. Screenshot of Selected Records to be Unselected.

17) Copied and pasted record(s) into the "EPA_Rabbitsfoot_Poly" shapefile. If more than one record was copied and pasted, merged them together. Saved edits.

18) Zoomed to the start and end locations and splitted the polygon. Delete any unneeded sections. (**Figure A2-23**)

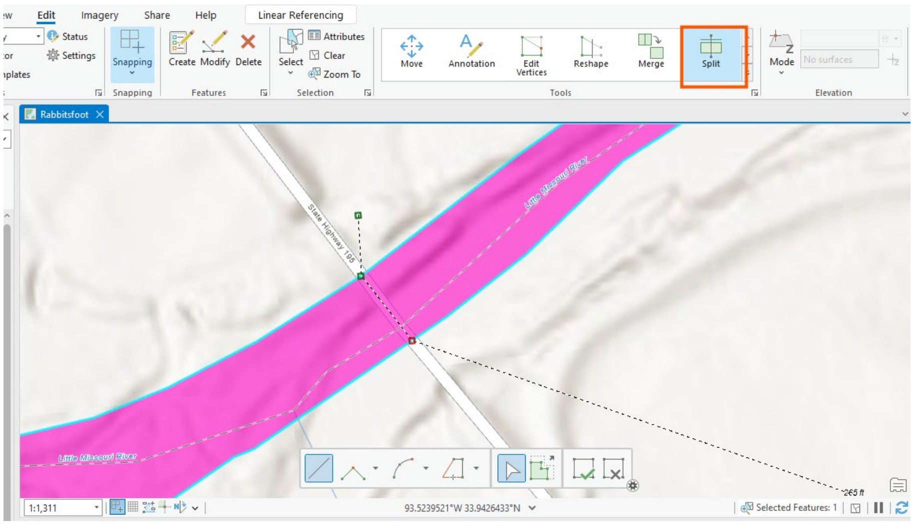


Figure A2-22. Screenshot of Example of Splitting Polygon

19) While the record is still selected, review the result by zoomming in and confirmed that there are not any polygon "offshoots" that are part of another river/creek and should not be included because this is part of a tributary etc. If necessary, turned on the "Line Feature Direction" layer on and zoomed in and around the length of the river/creek segment. If an area was found where this scenario exists, used the "Split" or "Edit Vertices" tools to remove all segments that belong to a tributary. (**Figure A2-23**)

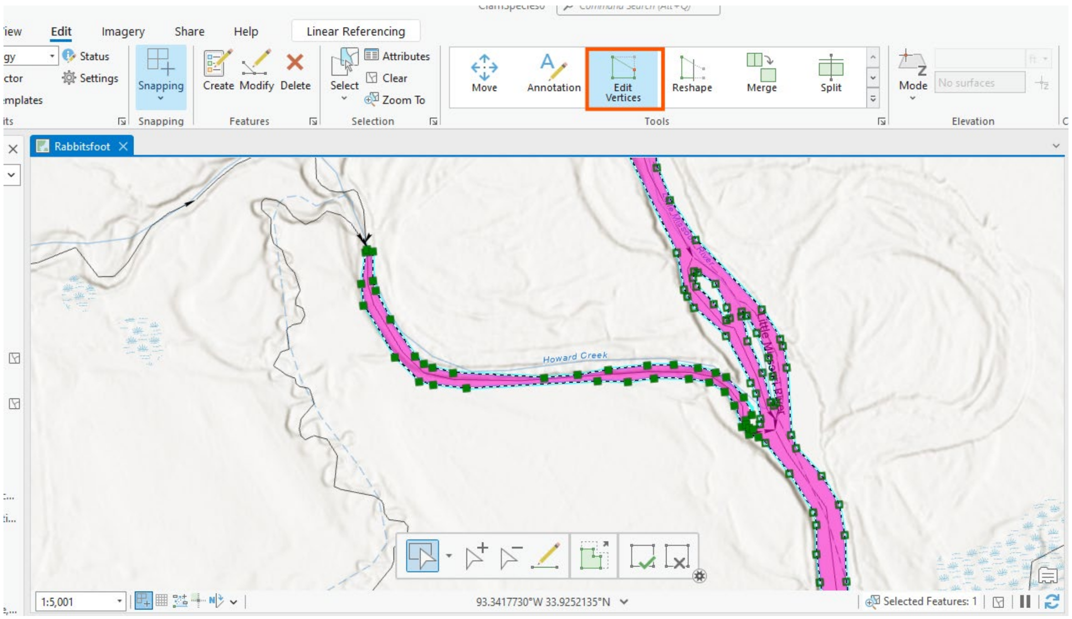


Figure A2-23. Screenshot of Example Editing Vertices

20) Updated the "Descriptio" field with information about the source and location of the river segment. Saved edits. (**Figure A2-24**)

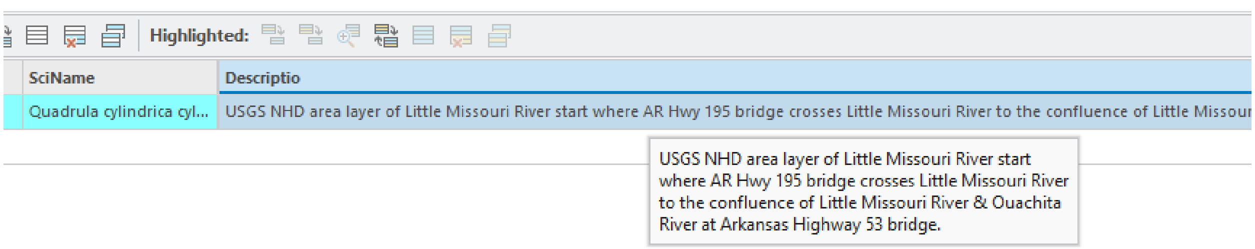


Figure A2-24. Screenshot Example Location Text

1.12. Used FWS 2020 5-Year Descriptive Text and Hydrography Line Layer as the Basis to Create Records

To develop a core map, the Center for Biological Diversity instituted a hierarchical process to create GIS data based on the source's accuracy. The second-best source of GIS data is the FWS 2020 5-YR individual water feature descriptions mentioning county limits or geographic markers that can be readily determined used and utilized by records in the Esri Living Atlas "National Hydrography Dataset Plus High Resolution" Area Layer. However, if an Area Layer record is not available, the "National Hydrography Dataset Plus High Resolution" Line Layer was used, and this section describes this process.

1) For each river segment created with this process, certain considerations where made.

a. FWS 2020 5-Yr individual water descriptions equal to the year 2000 and later were taken into consideration. Any before year 2000 are not.
b. Removal of the river/creek upstream area of a dam was done.
c. No five-mile upstream segments were created. Descriptions are broad enough and covered the areas host fish would normally travel upstream.
d. When hydrography water areas available, they were used first over line areas even if there were gaps in the water areas. A polygon with the with the average width between the gaps was created from a buffered line segment and merged. Please note that a following section, 2.12., will describe the process used on the Hydrography Line feature layer, as the process is different.

2) For each river segment created where the individual water feature description mentioned county limits, steps 3-8, were completed. For each river segment created where the individual water feature used geographic markers, steps 9-16 were completed.
3) A definition query was created in the Hydrography Line feature layer. Selected the field "Name from Geographic Names Information" that "is equal to" the actual name of the river/creek. (**Figure A2-25**)

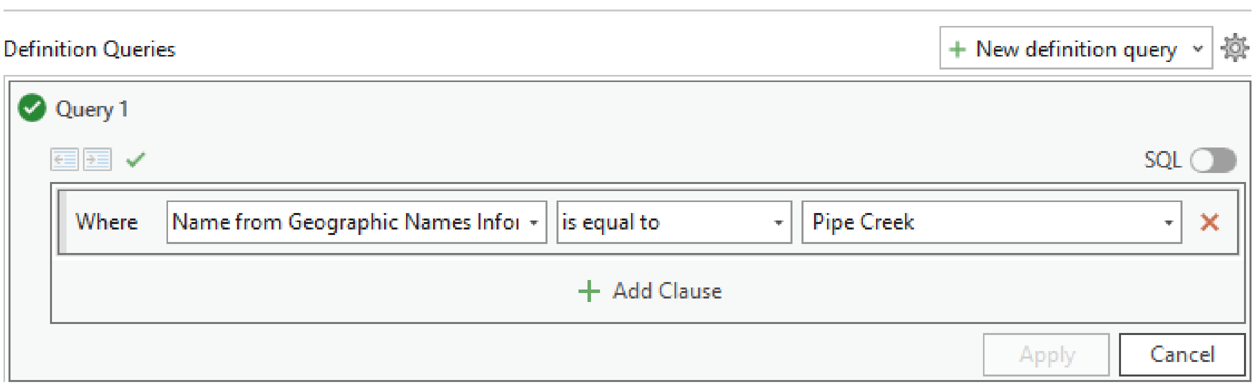


Figure A2-25. Line Area Definition Query Example

4) Created a definition query in the County layer. Selected the "STATEFP" code or codes that the county resides in "And" the "NAME" of the County or Counties. (**Figure A2-26**)

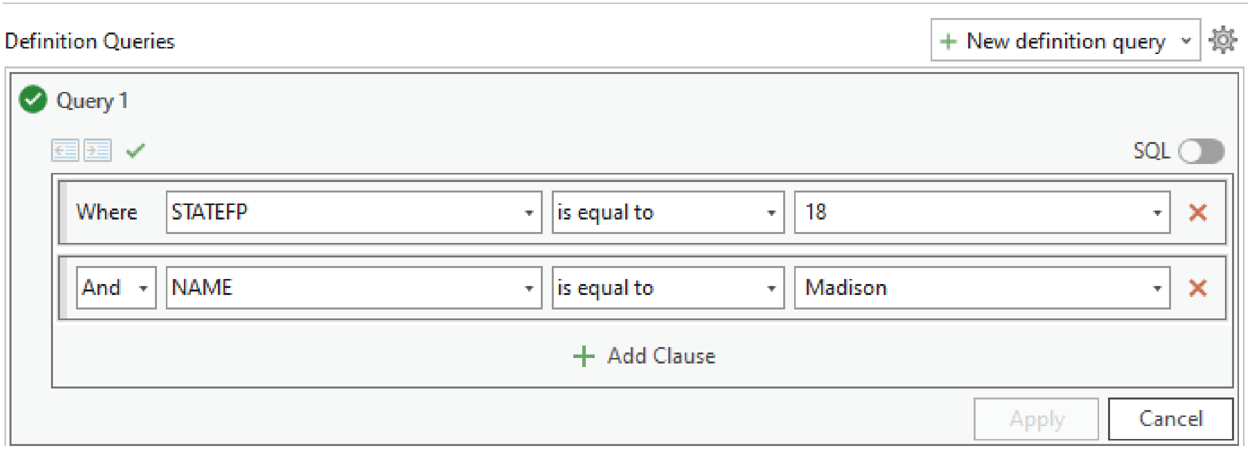


Figure A2-26. County Definition Query Example

5) Used the “Select by Polygon” tool, to select Hydrography Area records. (**Figure A2-27**)

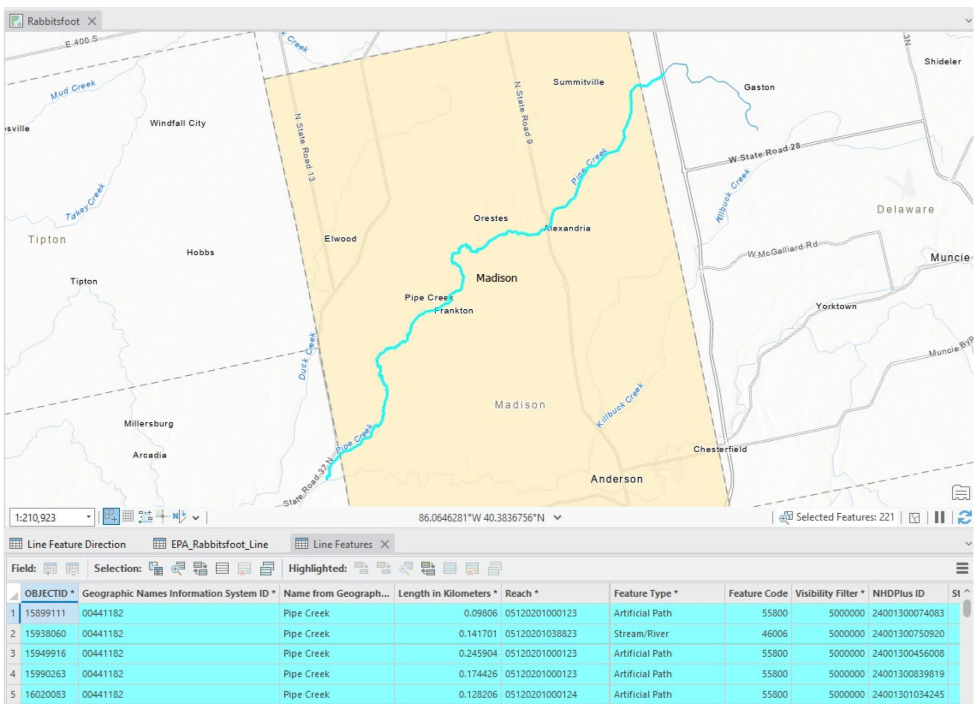


Figure A2-27. Screenshot of selected Hydrography Lines

6) Copied and pasted record(s) into the “EPA_Rabbitsfoot_Line” shapefile. If more than one record was copied and pasted, merged them together. Reviewed the line and made sure there were not any gaps. (In this process there were no river/creek lines that had gaps) Saved edits. While in edit mode, selected “Modify” → Select “Clip” from the Modify Feature tools→ Move the selected river/creek record to target features→ Select all County records and ensured it is an input feature→Under “When clipping features”, selected “Preserve”. Click “Clip” in the bottom right. (**Figure A2-28**) The resulting line will

appear. Please note that although the line is clipped to intersect with a county or counties, due to a possible headwater or confluence starting or ending inside the same county of counties, some lines will naturally fall far inside. (**Figure A2-29**)

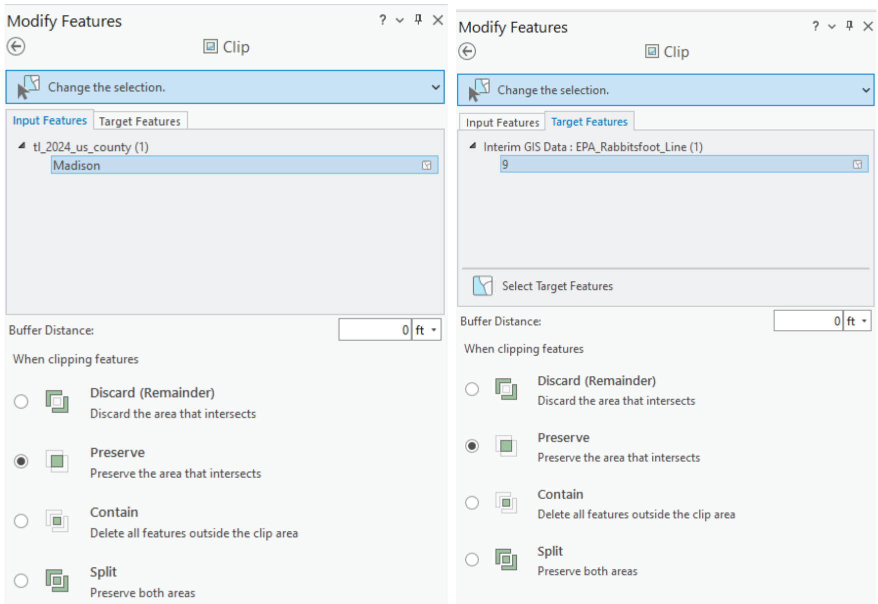


Figure A2-28. Screenshot of Modify Features Clip Tool

Figure A2-29. Screenshot of Clipped River/Creek Segment

7) Turned on the "Dams" layer zoomed to the record's extent. Visually reviewed if there are any dams along the length of the record. If there is, zoomed in and switched the base map to “Imagery”. Used the “identify” tool to view the attributes of the dam and looked upstream to see the increase in volume of water. The EPA_Rabbitsfoot_Line record was modified with the Modify Features “Split” tool. (**Figure A2-30**) Removed portion upstream.

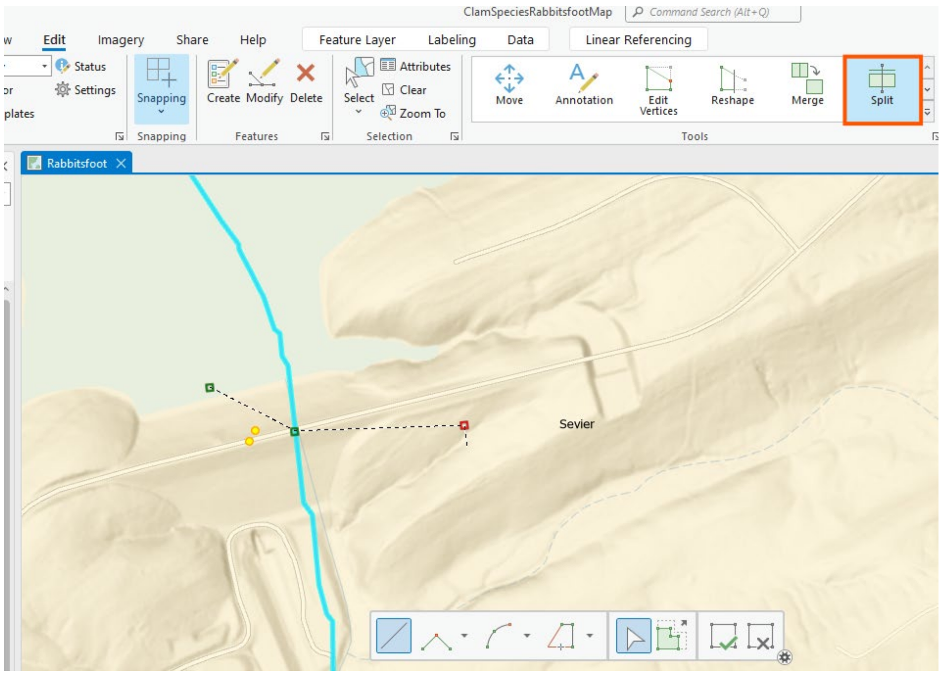


Figure A2-30 Screenshot of Example Split Upstream of Dam

8) Updated the “Descriptio” field with information about the source and location of the river segment. In the scenarios where the headwater or a confluence exists and the clipped intersection falls far inside the polygon, the headwater and confluence is noted as either the starting or ending point in the text. Also, if the line was split at a dam this is used in the text as well. (**Figure A2-31)** Saved edits

USGS NHD line layer of Rolling Fork from Dequeen dam to southern border of Sevier County.

Figure A2-31. Screenshot of Example “Descriptio” field text

9) Used the geographical marker location text to discern the start and end locations of the river/creek segment. Example of geographical markers locations text is:

a) Data collected since listing suggest this population may be improving. Bouldin et al. (2013a) surveyed 17 sites along 42.2 RMs from Arkansas Highway 23 at Withrow Springs State Park, Madison County, Arkansas, downstream to Benton County Road 9 at War Eagle Mill, Benton County, Arkansas,

10) Turned on the "Dams" layer zoomed to where the start and end locations are visible. Visually reviewed if there are any dams along the length of the river/creek. If there is, zoomed in and switched the base map to "Imagery". Used the "identify" tool to view the attributes of the dam and looked upstream to see the increase in volume of water. If there are no dams, proceed to step 13. If there is then determine the new start and end locations based on the dam, then proceed to step 13.

11) A definition query was created in the Hydrography Line feature layer. Selected the field "Name from Geographic Names Information" that "is equal to" the actual name of the river/creek. (**Figure A2-32**)

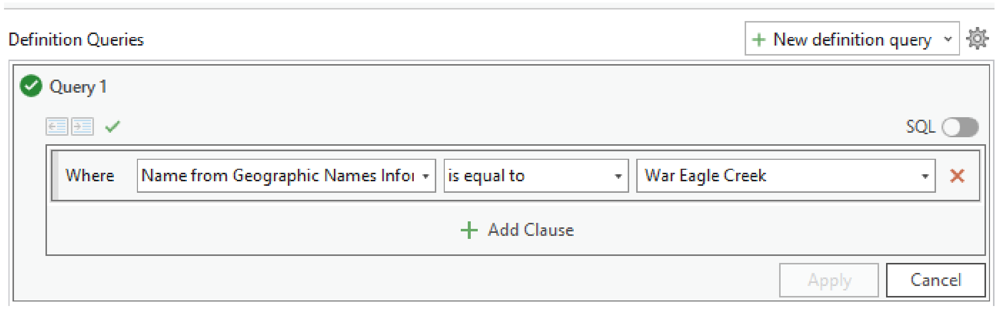


Figure A2-32. Screenshot of Definition Query Example

12) Used the "Select by Polygon" tool, the Hydrography Area records were selected. (**Figure A2-33**)

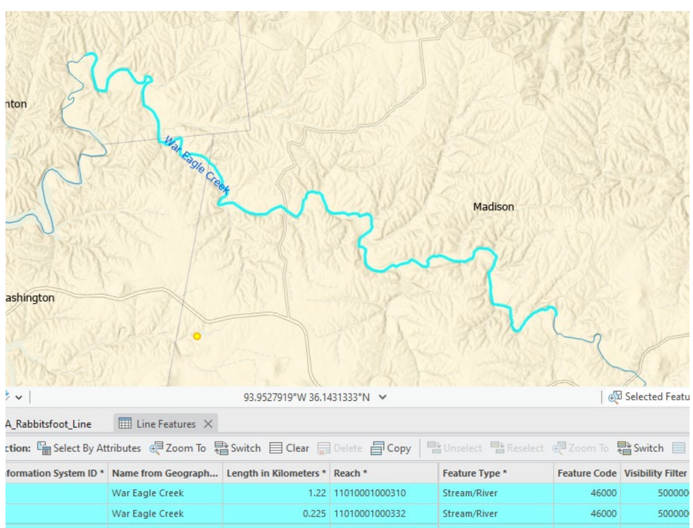


Figure A2-33. Screenshot of Selected Lines

13) Copied and pasted record(s) into the "EPA_Rabbitsfoot_Line" shapefile. If more than one record was copied and pasted, merged them together. Reviewed the line and made sure there were not any gaps. (In this process there were no river/creek lines that had gaps) Saved edits.

14) Zoomed to the start and end location of each line. The EPA_Rabbitsfoot_Line record was modified with the Modify Features "Split" tool. The unneeded part was deleted. Save edits. (**Figure A2-34**)

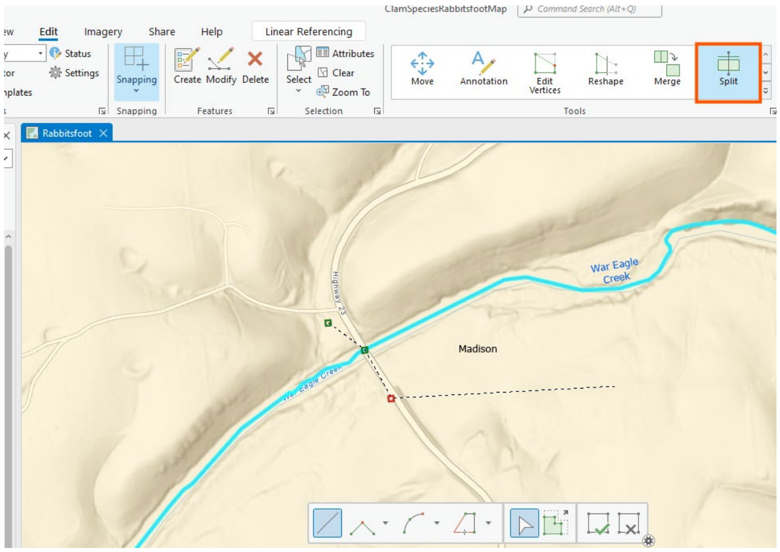


Figure A2-34. Screenshot of Split Process

15) Updated the "Descriptio" field with information about the source and location of the river segment. If the line was split at a dam this is used in the text. (**Figure A2-35)** Saved edits

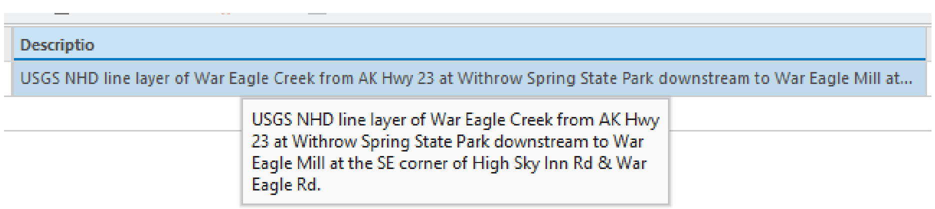


Figure A2-35. Screenshot of Example "Descriptio" field text

1.13. Used FWS 2020 5-Year Figure 2 image (Geo-referenced in ArcGIS Pro) and Hydrography Area Layer as the Basis to Create Records

To develop a core map, the Center for Biological Diversity instituted a hierarchical process to create GIS data based on the source's accuracy. The third-best source of GIS data is the FWS 2020 5-YR figure 2 on page 5. Once geo-referenced, the start and end points can be determined. In all cases, either the start and/or end touches a Critical Habitat polygon.

Because of this, it was determined to match the width of the adjacent Critical Habitat polygon by buffering the Esri Living Atlas "National Hydrography Dataset Plus High Resolution" line layer to match.

1) There were four rivers/creeks that used this process to create GIS data: Ouachita River /
   a) Ouachita River – Although there is geographical text the describes the two Critical habitats and the river between the two Critical habitats, there is no mention of a river segment upstream that is shown as an extant population if figure 2. Per figure 2, this river segment begins at the confluence of Ouachita River and Black Branch then upstream on Ouachita River to State Hwy 30 bridge. Plus, five miles upstream.
   b) Red River – There are no geographical text of surveys equal to or greater than the year 2000. However, in Table 2, the "Current Status" is unknown. In figure 2 of the FWS 2020 5-Year Review, there exists an extant population upstream and downstream of the FWS Critical Habitat, where Unit Name equals Red River. Per figure 2, the river segment is a section starting at the confluence of Red River and South Fork Red River, upstream to the headwaters of the Red River. Additionally, there is a river segment starting at the confluence of Red River and Cumberland River, upstream to where it meets the Red River Critical Habitat.
   c) Spring River – There is geographical text of surveys equal to or greater than the year 2000 that has Rabbitsfoot in Sharp County. Additionally, in figure 2 of the FWS 2020 5-Year Review, there exists an extant population upstream of the FWS Critical Habitat, where "Unit Name" equals "Spring River (AR)". This segment starts at the confluence of Spring River & Ott Creek, then upstream to confluence of Spring River & South Fork Spring River, then continues upstream on South Fork Spring River to 1/2 mi N of end Miller Creek Lane. Plus, 5 miles upstream.
   d) Black River – There is a Critical Habitat polygon in Lawrence County, Arkansas. The geographical text does not include the river downstream. However, in figure 2 of the FWS 2020 5-Year Review, there is an extant population visible. This segment starts at southern end of Rabbitsfoot's critical habit of Black River unit and continues downstream to the confluence with Strawberry River.

2) For each of the four river/creek a .tif was created from page 44 of FWS 2020 5-Year Review. The files were renamed with each river/creek's name at the end.

3) A .tif was added to the ArcGIS Pro map and "yes" was selected to "Calculate statistics". While the .tif is highlighted in the map "table of contents", click on "Imagery" context tab in the ribbon →clicked on "Georerence" in the "Alignment" group→unclicked the "Auto Apply" in the "Adjust" group. Zoomed to the general area of the river→clicked on "Fit to Display in the "Prepare" group. Used the "Prepare" group tools: "Move", "Scale", and “Rotate” to best size, move and rotate the .tif to match as close possible to the target datasets.

4) In the “Georeference” context tab, under the “Adjust” group, click on “Add Control Points”. Zoomed to four corners around the area in question and created “Control Points”. Under the “Adjust” group, clicked on “Apply”. Visually reviewed the georeferencing to confirm the applied changes worked. If not, redo. If it worked, proceed with step 5. (**Figure A2-36)** In figure A2-36 below, the white lines are the county boundaries, The pink polygons are the core areas, the green polygons are the Critical Habitats and the medium blue lines are hydrography areas that are filtered to show the larger rivers/creeks.

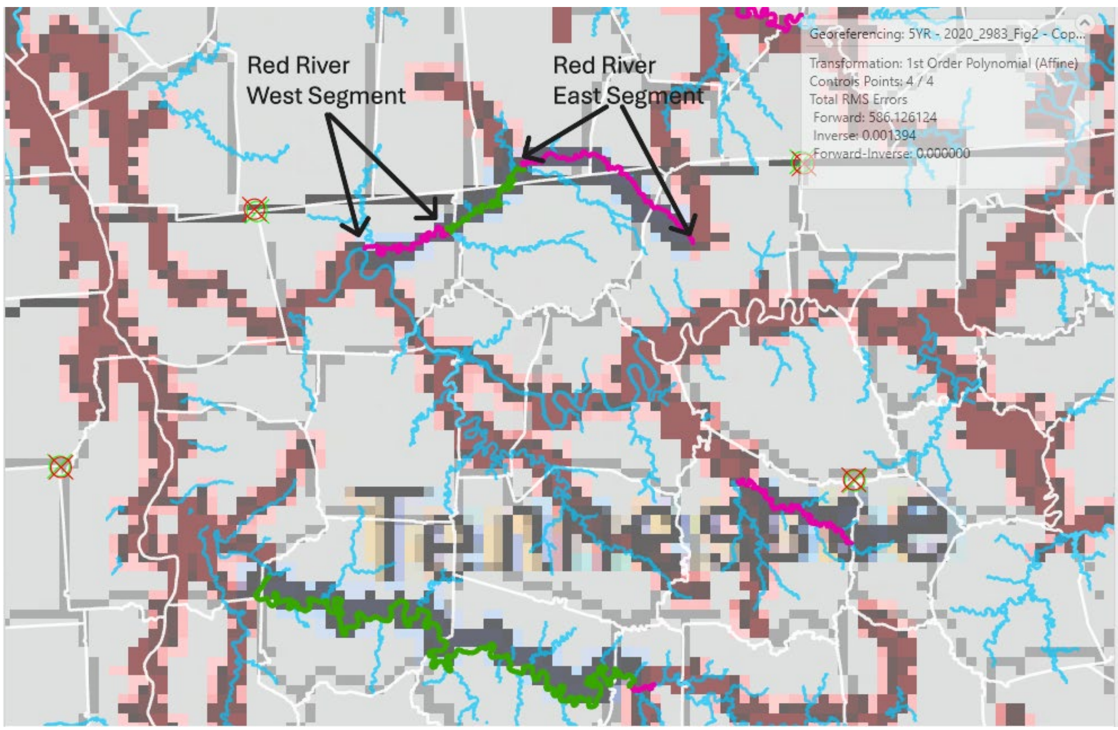


Figure A2-36. Screenshot of Red River Area Georeferencing

5) Turned on the “Dams” layer to see if there is a dam along the river segment length or not. If so, determine the new start and end point. Zoomed into the start and end points of the river/creek in question to determine a better-defined start and end point. Based on previous experience, beginning and end points trend to happen at river confluences, sources or headwaters. If there is a major confluence, headwater or source in the zoomed in area, this was used.

6) Check that the “Map Properties” coordinate system the Interim shapefiles, which is “USA Contiguous Albers Equal Area Conic USGS”. Ensure that the Hydrography Line layer is on. Start edit mode→Click “Create” in “Features” Group”→Under Templates, Click on “EPA_Rabbitsoot_Line “Trace” option. Create a line record, tracing from the start to the end. For only the Ouachita and Spring River segments, a five-mile segment line is created by tracing upstream for host fish traveling upstream. Set the tracing “Limit trace length” option to five miles. See Figure A2-6 for screenshot.

7) Used the “Measure Distance” tool to determine the width at the end adjacent Critical Habitat polygons. See figure A2-7 for example screenshot. Used the “Buffer” tool in edit mode to create a new polygon record in “EPA_Rabbitsfoot_Poly”. Buffered each segment based on the adjacent Critical Habitat width. Merged the “five-mile segments” with the other neighboring polygons.

8) Updated the “Descriptio” field with information about the source and location of the river segment. Remove all line feature records created as the basis for the buffered polygons as they are no longer needed. Save edits. (**Figure A2-37)**

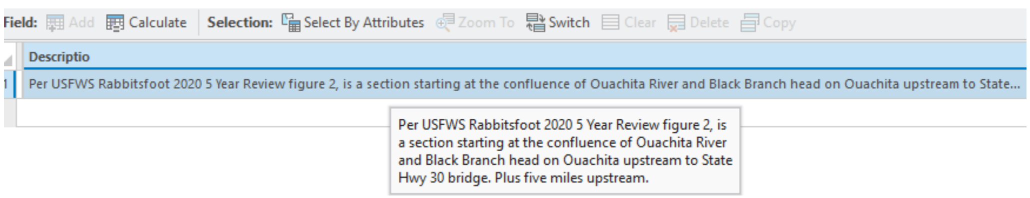


Figure A2-37. Screenshot Example Location Text

9) The following rivers/creeks were clipped by the range.

a) Red River

b) Barren River

c) Bayou Bartholomew

d) Flatrock River

e) Illinois River

f) Sugar Creek (East Fork White River)

g) Saline River (Little River)

h) Hatchie River

10) The following river was not included because in the 2021 FWS Rabbitsfoot SSA, Appendix A, Current River’s current condition is “Extirpated.”

11) Both LeBoeuf Creek and Conneautee Creek river lengths were not included because the written individual description in the 2020 FWS 5-YR Review says past surveys show occupation is the confluence of the French River. The inclusion of French River itself covers this survey area.

12) Rivers/Creeks that fall outside of the range and were included because of the 2020 FWS 5-YR Review written description or are a Critical Habitat are:

a) Mohican River (2020 FWS 5-Year Review written description)

b) Nolin (2020 FWS 5-Year Review written description)

c) Bayou D'Arbonne (2020 FWS 5-Year Review written description)

d) Wabash River (2020 FWS 5-Year Review written description)

e) Olentangy (2020 FWS 5-Year Review written description)

f) Muddy Creek (Critical Habitat)

1.14. Updated the "CommName", "SciName", "Category", "EPA_Code", "FWS_Code", and CBD_Code field with Field Calculator. Calculate Geometry acres of Polygon Layer.

1) Updated the "CommName" with Field Calculator. This process is the same for both the EPA_Rabbitsfoot_Line and EPA_Rabbitsfoot_Poly. Right clicked on "CommName"→ Select "Calculate Field" → Entered "Rabbitsfoot" below the field name **(1)** → Set "Enable Undo" **(2)** →Click "Apply" **(3)** **(Figure A2-38)**

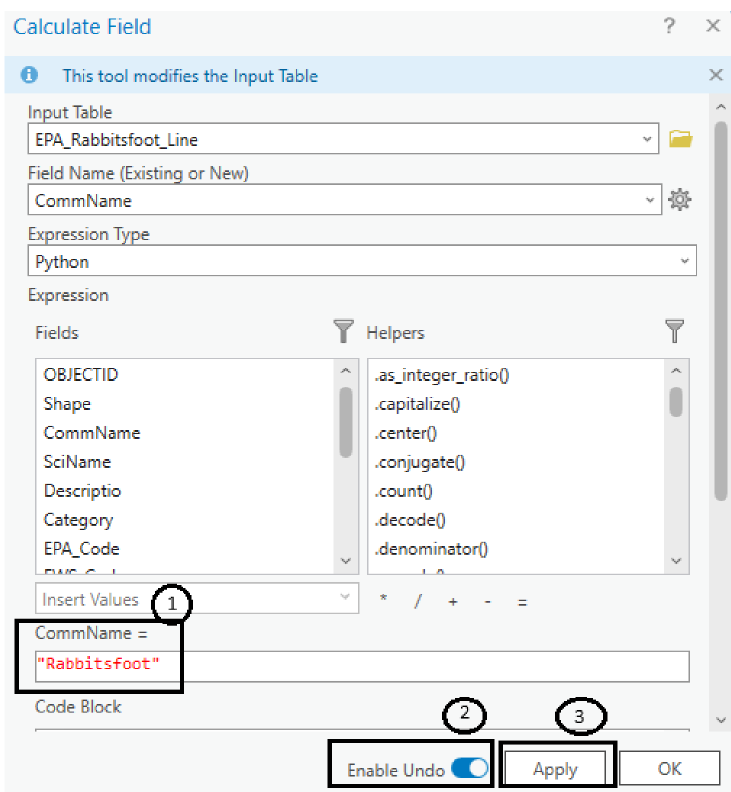


Figure A2-38. Screenshot Example Field Calculator

2) Updated the “SciName” with Field Calculator. This process is the same for both the EPA_Rabbitsfoot_Line and EPA_Rabbitsfoot_Poly. Right clicked on “SciName”→ Select “Calculate Field” → Entered " Quadrula cylindrica cylindrica" below the field name **(1)** → Set “Enable Undo” **(2)** →Click “Apply” **(3)** (**Figure A2-39)**

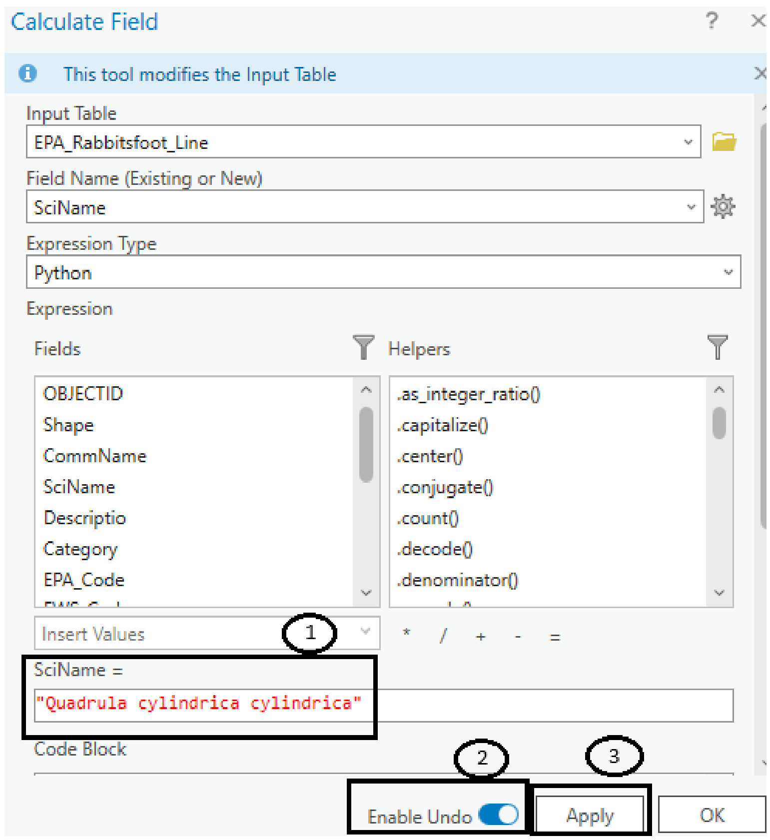


Figure A2-39. Screenshot Example Field Calculator

3) Updated the “Category” with Field Calculator. This process is the same for both the EPA_Rabbitsfoot_Line and EPA_Rabbitsfoot_Poly. Right clicked on “Category”→ Select “Calculate Field” → Entered " Area of occupancy " below the field name **(1)** → Set “Enable Undo” **(2)** →Click “Apply” **(3)** (**Figure A2-40)**

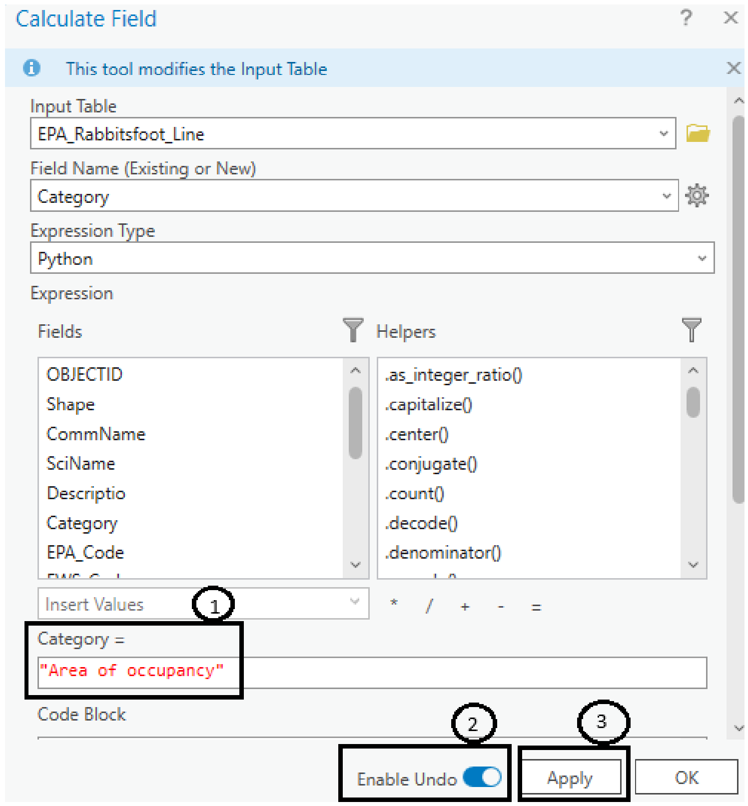


Figure A2-40. Screenshot Example Field Calculator

4) Updated the "EPA_Code" with Field Calculator. This process is the same for both the EPA_Rabbitsfoot_Line and EPA_Rabbitsfoot_Poly. Right clicked on "EPA_Code"→ Select "Calculate Field" → Entered "3645" below the field name **(1)** → Set "Enable Undo" **(2)** →Click "Apply" **(3)** **(Figure A2-41)**

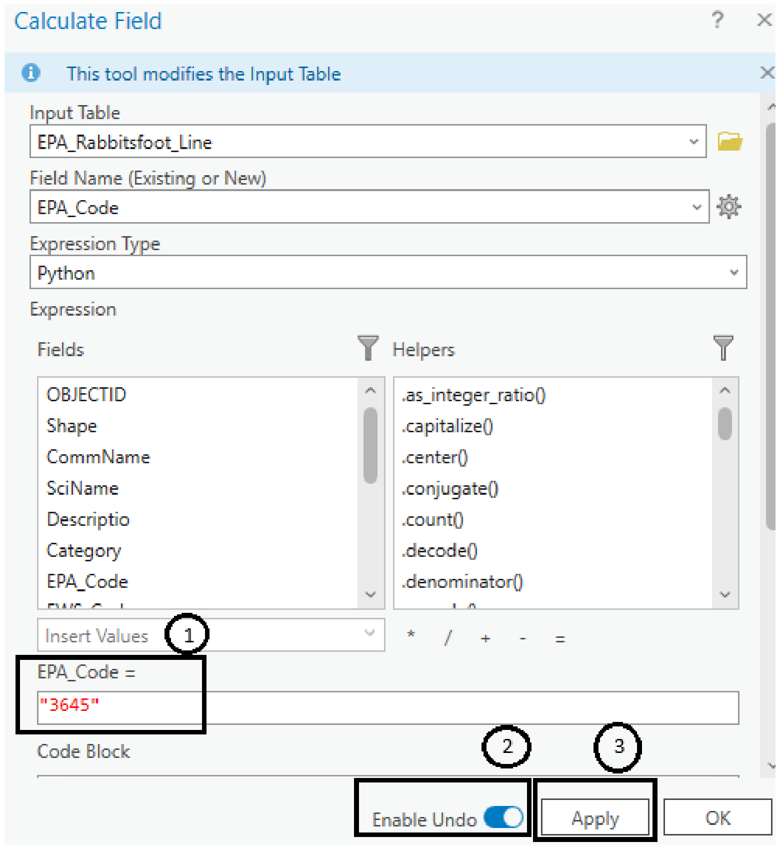


Figure A2-41. Screenshot Example Field Calculator

5) Updated the "FWS_Code" with Field Calculator. This process is the same for both the EPA_Rabbitsfoot_Line and EPA_Rabbitsfoot_Poly. Right clicked on "FWS_Code"→ Select "Calculate Field" → Entered "F03X" below the field name **(1)** →Click "Apply" **(2)** (**Figure A2-42)**

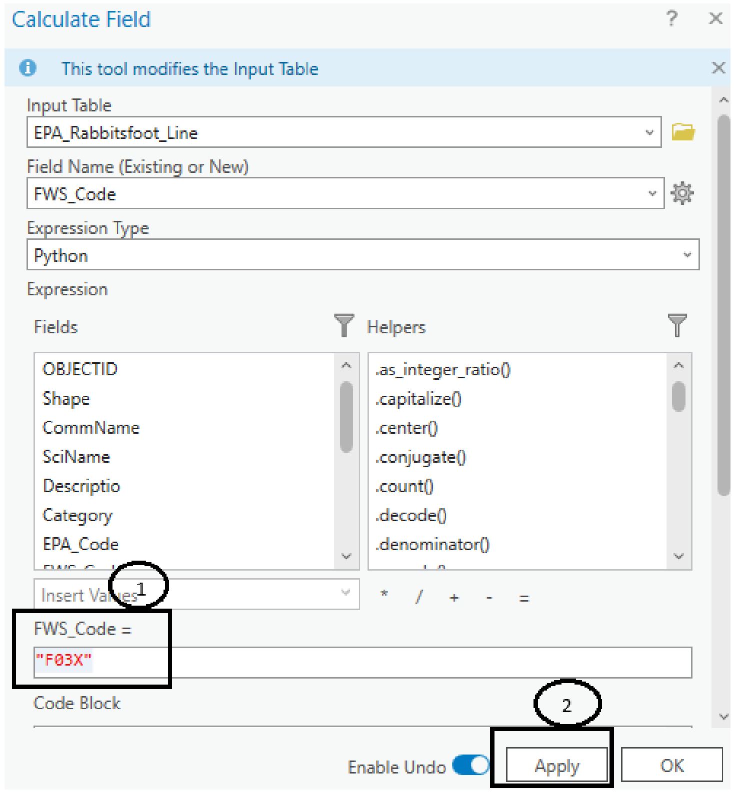


Figure A2-42. Screenshot Example Field Calculator

6) Updated the “CBD_Code” with Field Calculator. This process is the same for both the EPA_Rabbitsfoot_Line and EPA_Rabbitsfoot_Poly. Right clicked on “CBD_Code”→ Select “Calculate Field” → Entered "796043" below the field name **(1)** →Click “Apply” **(2)** (**Figure A2-43)**

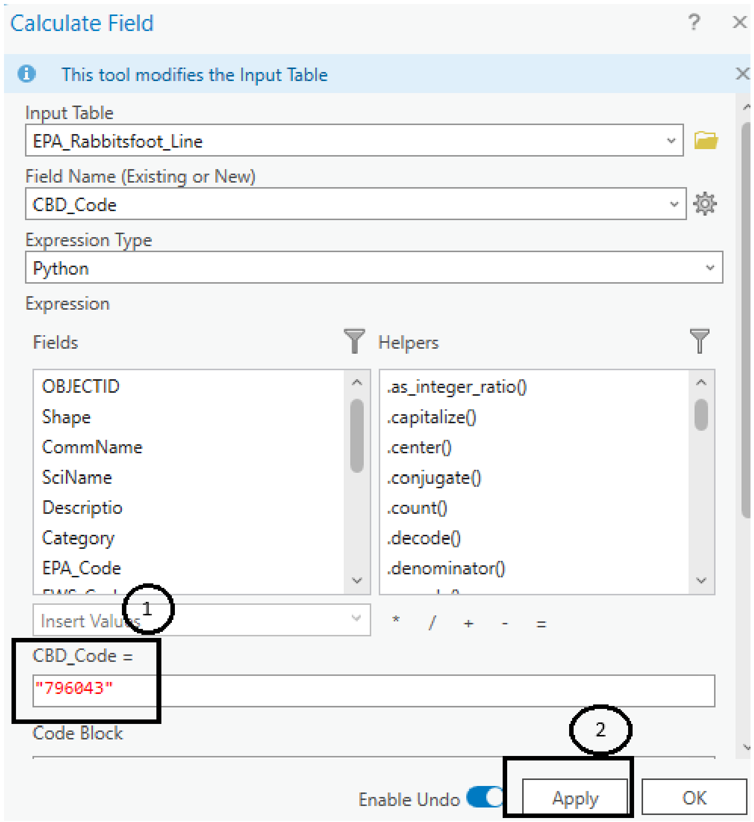


Figure A2-43. Screenshot Example Field Calculator

7) Updated the "ECOS_WebPg" with Field Calculator. This process is the same for both the EPA_Rabbitsfoot_Line and EPA_Rabbitsfoot_Poly. Right clicked on "ECOS_WebPg"→ Select "Calculate Field" → Entered "https://ecos.fws.gov/ecp/species/5165" below the field name **(1)** →Click "Apply" **(2)** Review all the updates in steps 2-7. If everything is correct, click "Save". (**Figure A2-44)**

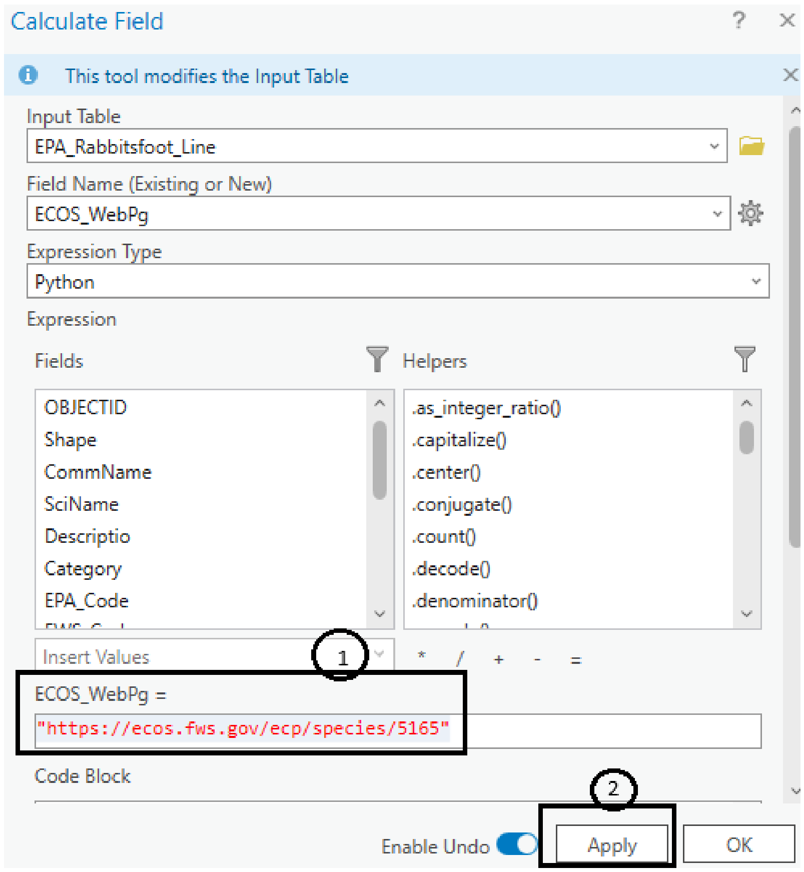


Figure A2-44. Screenshot Example Field Calculator

8) To “Calculate Geometry” acres, the “World_UTM_Grid” layer was used. The records in “EPA_Rabbitsfoot_Poly intersect World UTM Zones 15, 16, and 17. (**Figure A2-45)** Select UTM Grid(s) for each zone and used the “Select by Location” to select “EPA_Rabbitsfoot_Poly” records that intersect the selected UTM zone. Click “OK” (**Figure A2-46)**

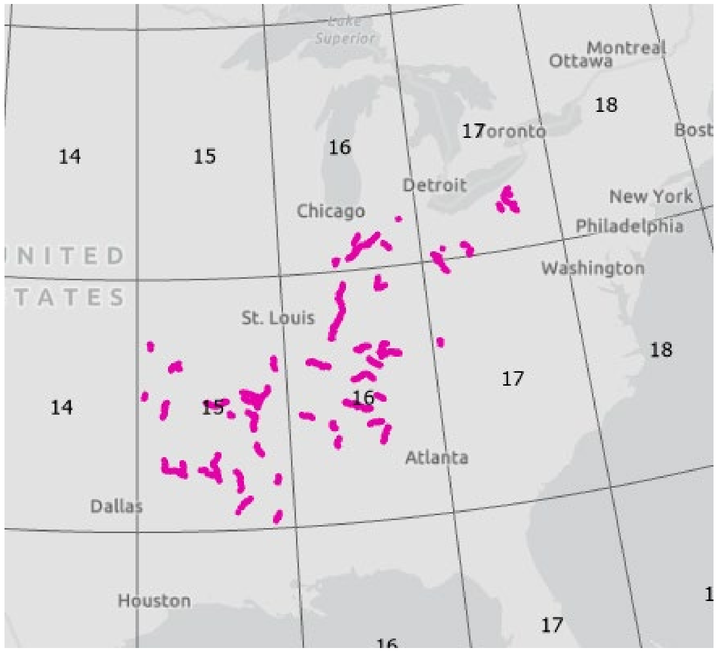


Figure A2-45. Screenshot EPA_Rabbitsfoot_Poly within UTM Zones

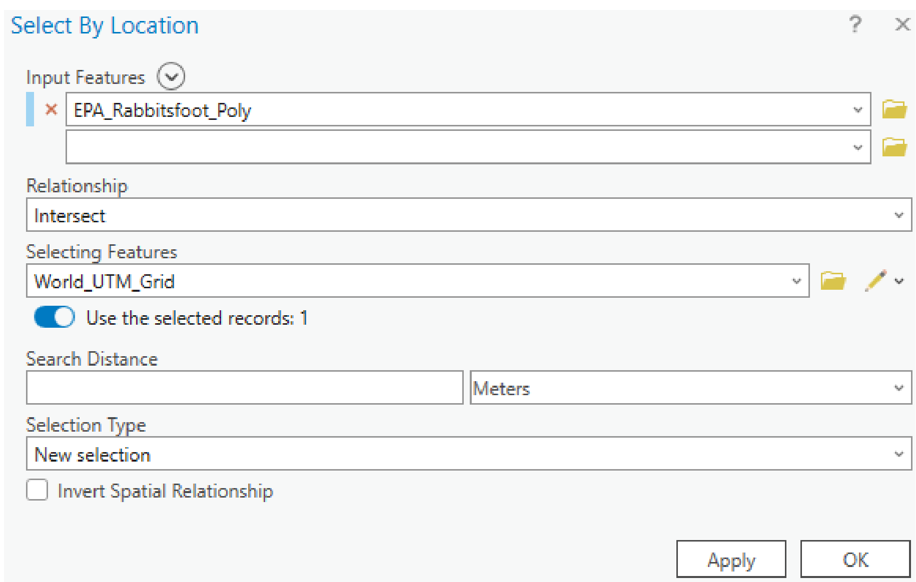


Figure A2-46. Screenshot "Select by Location"

9) For each UTM zones, updated the "Acres" field with "Calculate Geometry. This process is done only for EPA_Rabbitsfoot_Poly. Right clicked on "Acres"→ Select "Calculate Gemetry" → Select "Area" under "Property" **(1)** →Select "US Survey Acres" under "Area Unit" **(2)** Select the NAD_1983_UTM_Zone_XX" that was used in Step *. Click "OK". (**Figure A2-47)**

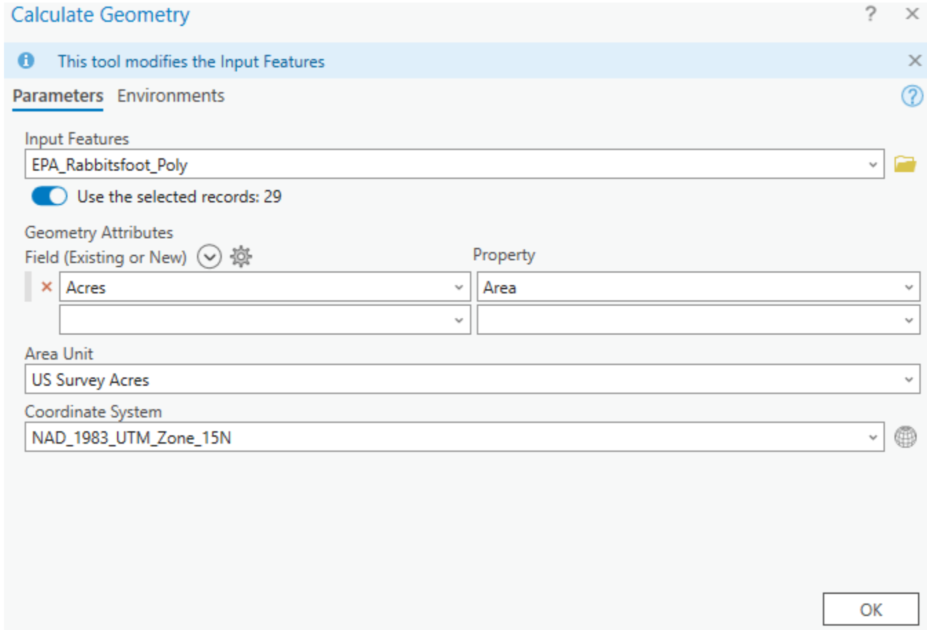


Figure A2-47. Screenshot "Calculate Geometry"

1.15. Created Catchment Areas that Intersect Core Map Areas Layer

1) The NHDPlus High Resolution EPA Snapshot 2022 Data downloaded file geodatabase was used as the source for "Catchment". The layer used is named "CatchmentFabric". Selected all the "EPA_Rabbitsfoot_Poly" records. Used the "Select by Location" tool to create a "New selection" of "Catchment" that intersected "EPA_Rabbitsfoot_Poly" records. (**Figure A2-48)** Exported selected "CatchmentFabric" records to a temporary polygon layer.

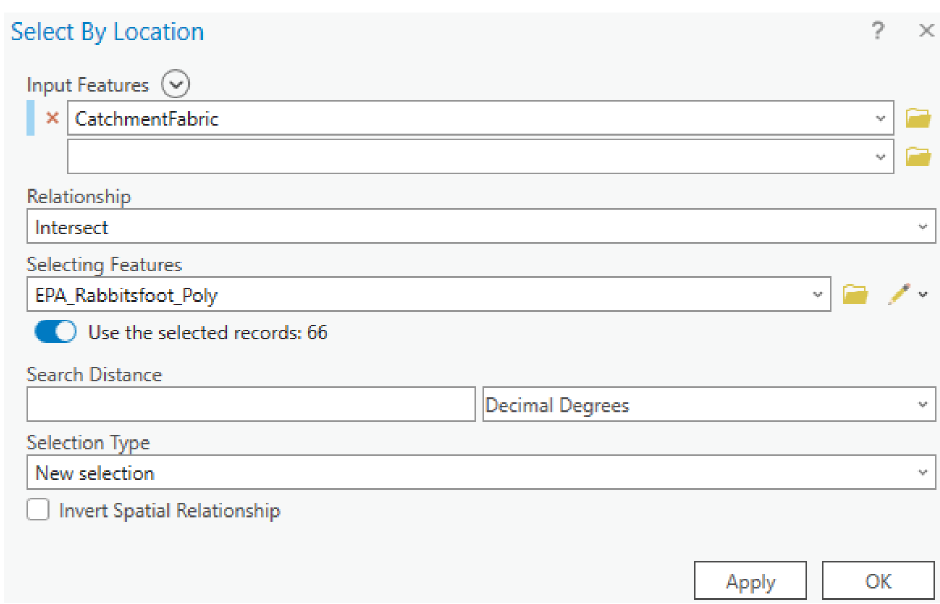


Figure A2-48. Screenshot "Select by Location"

2) Selected all the "EPA_Rabbitsfoot_Line" records. Used the "Select by Location" tool to create a "New selection" of "Catchment" that intersected "EPA_Rabbitsfoot_Line" records. (**Figure A2-49)** Exported selected "CatchmentFabric" records to a temporary polygon layer.

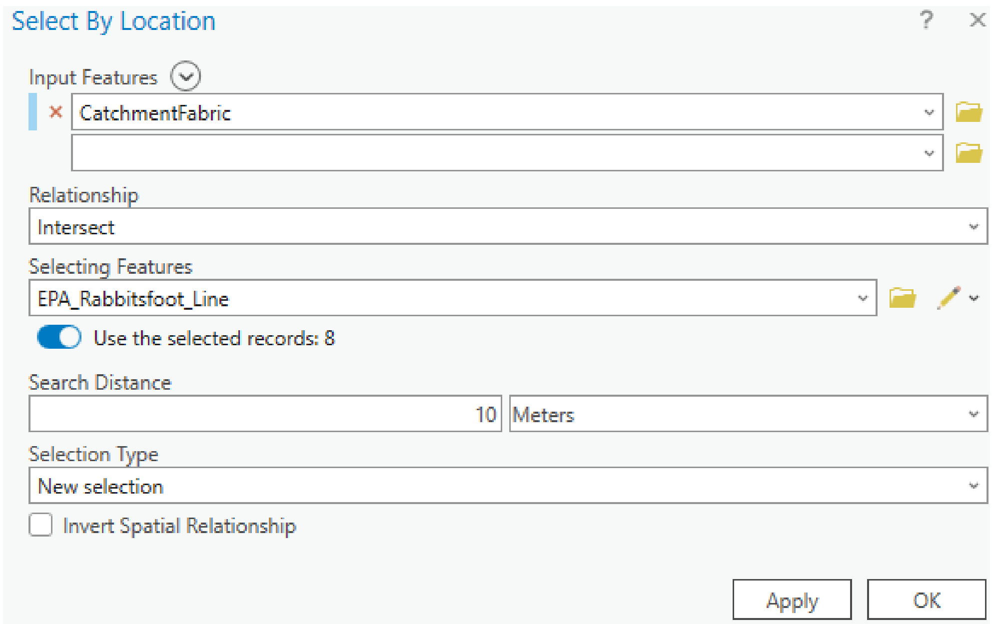


Figure A2-49. Screenshot "Select by Location"

3) Used from the "Data Management" tools, the "Merge" tool to combine the export records from Steps 1 and 2 to a polygon feature class named, "EPA_Rabbitsfoot_Catchment. (**Figure A2-50)**

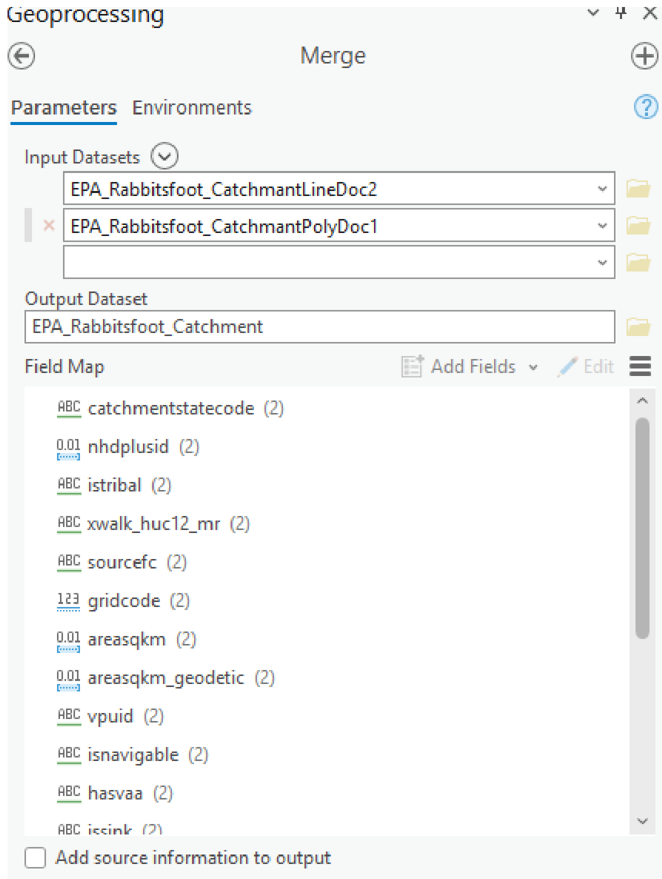
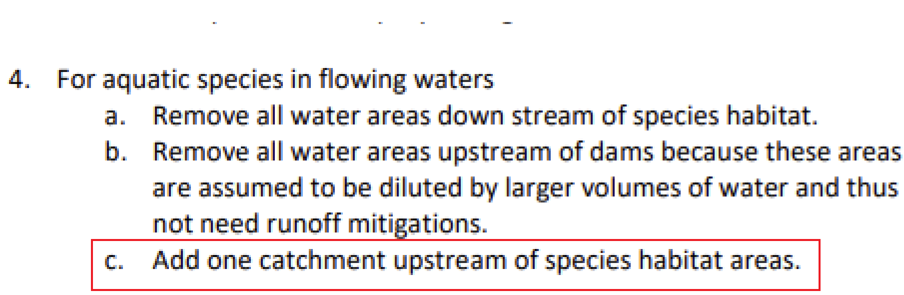


Figure A2-50. Screenshot Merge Catchment Polygons

3) In the "Core Map Process Document" on page 28, it says for aquatic species in flowing waters, to "Add one catchment upstream of species habitat areas." (**Figure A2-51)**



4. For aquatic species in flowing waters
   a. Remove all water areas down stream of species habitat.
   b. Remove all water areas upstream of dams because these areas are assumed to be diluted by larger volumes of water and thus not need runoff mitigations.
   c. Add one catchment upstream of species habitat areas.

Figure A2-51. Screenshot from the "Core Map Process Document"

4) The process to add one catchment upstream of each river segment was a manual one. Zoomed to each polygon and line record→turned on the "Line Feature Direction" layer to determine what is upstream→Selected the "CatchmentFabric" polygon that is upstream→Copied and pasted the selected polygon from the “CatchmentFabric” layer to the EPA_Rabbitsfoot_Catchment→Saved Edits. Repeated this process until all records have been reviewed and catchments added.

5) There are a few scenarios where there are exceptions to the process in Step 4.
   a) If the river/creek segment ends at its headwaters. (**Figure A2-52)**

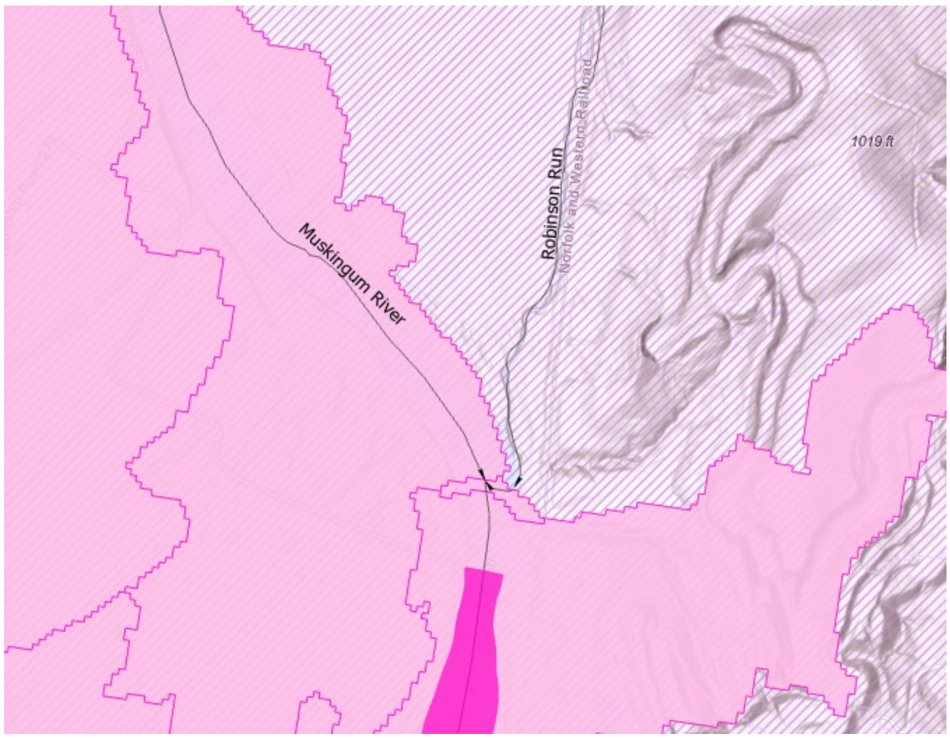


Figure A2-52. Screenshot of Muskingum River with Catchments

   b) If the river/creek segment ends at a dam. (**Figure A2-53)**

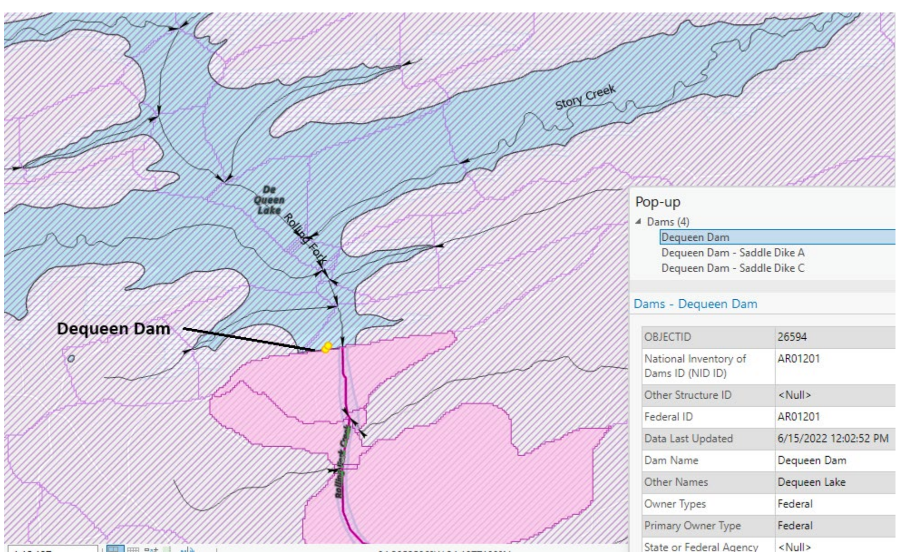


Figure A2-53. Screenshot of Rolling Fork Creek and Dequeen Dam

c) If the length of the river/creek that is passing through the upstream catchment is so short that it is unlikely to account for an adequate pesticide use limitation area, then another catchment area was included. (**Figure A2-54)**

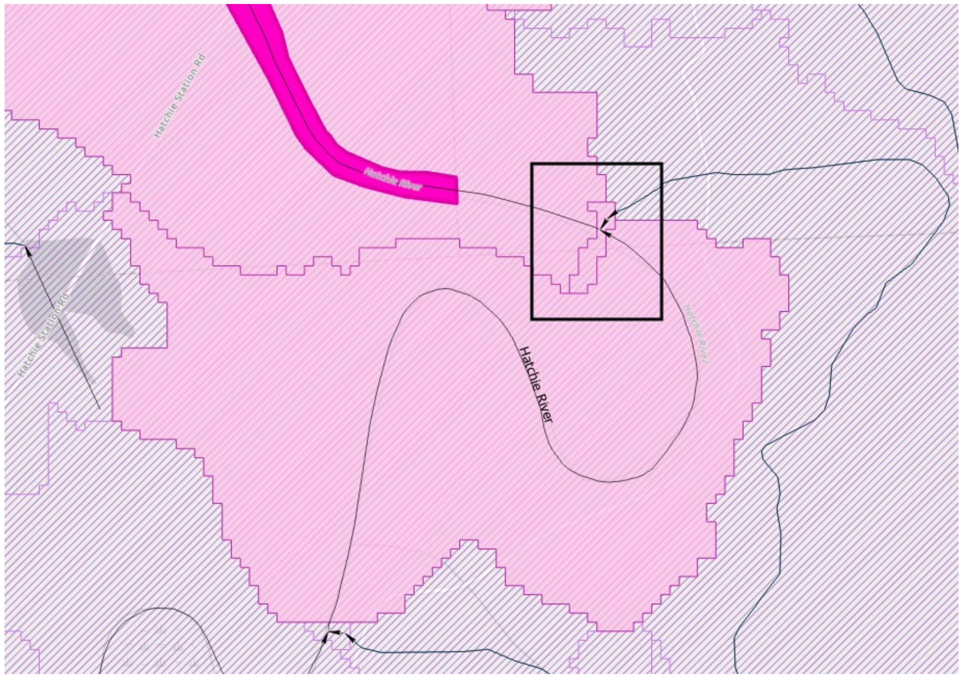


Figure A2-54. Screenshot of Small Upstream Catchment

d) There were three river/creek segments where the scenario is that they are next to the range but not inside the range. (Mohican River, Muddy Creek and Wabash River). The only catchment include was one catchment both outside and upstream.

1.16. Calculated Percentage of Interim Core Map Represented by NLCD Land Covers and Associated Example Pesticide Use Sites/Types Process

1) Because the Center for Biological Diversity is submitting both line and polygon shapefiles for the core map, it was determined for the line shapefile, that it would be best to buffer it by the same average width of the polygons in the Critical Habitat. The Critical Habitat is a FWS verified representation of known locations are area.

a) To calculate the average width of the Critical Habitat polygons, first all the polygons were copied and pasted into a line feature class named "EPA_Rabbitsfoot_Transact"→Used the "Generate Transects Along Lines" tool to create a series of perpendicular line segments .5 survey miles apart and 750 feet in length (**Figure A2-55)**→These perpendicular lines with clipped by the Critical Habitat polygon creating "EPA_Rabbitsfoot_TransactClip1"→Opened the "EPA_Rabbitsfoot_TransactClip1" attribute table →Right Clicked on

"Shape_Length"→Left Clicked "Explore Statistics"→ The mean length equals 76.923 meters. (**Figure A2-56)**

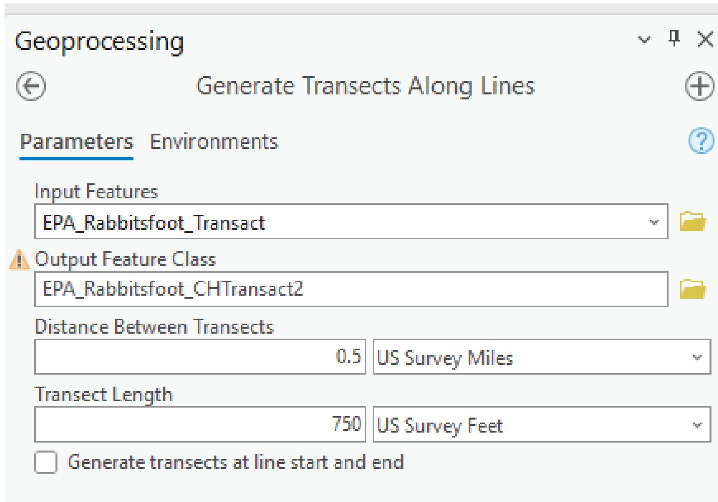


Figure A2-55. Screenshot Generate Transects Along Lines tool

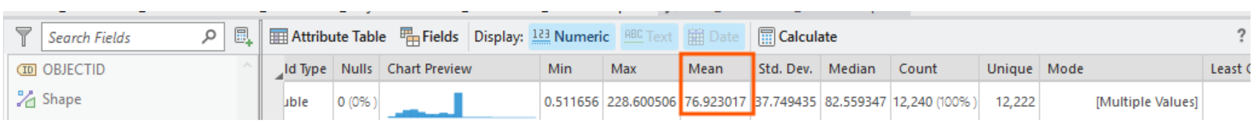


Figure A2-56. Mean Shape_Length of Clipped Transect Lines

b) The "Buffer" tool was used on the "EPA_Rabbitsfoot_Line" and created "EPA_Rabbitsfoot_Line_Buffer1" with a buffer distance of 38.5 meters. (**Figure A2-57)**

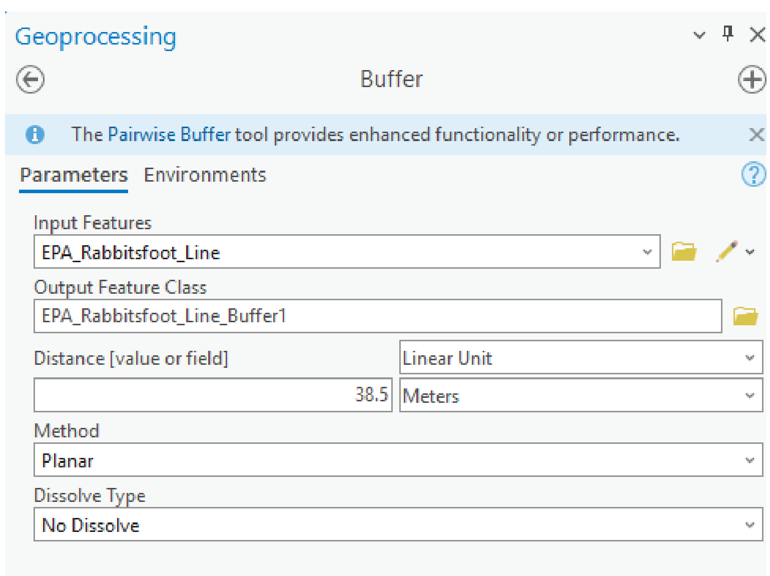


Figure A2-57. Screenshot of Buffer Tool

c) Merged “EPA_Rabbitsfoot_Line_Buffer1” with “EPA_Rabbitsfoot_Poly” and created “EPA_Rabbitsfoot_Merge”. (**Figure A2-58)**

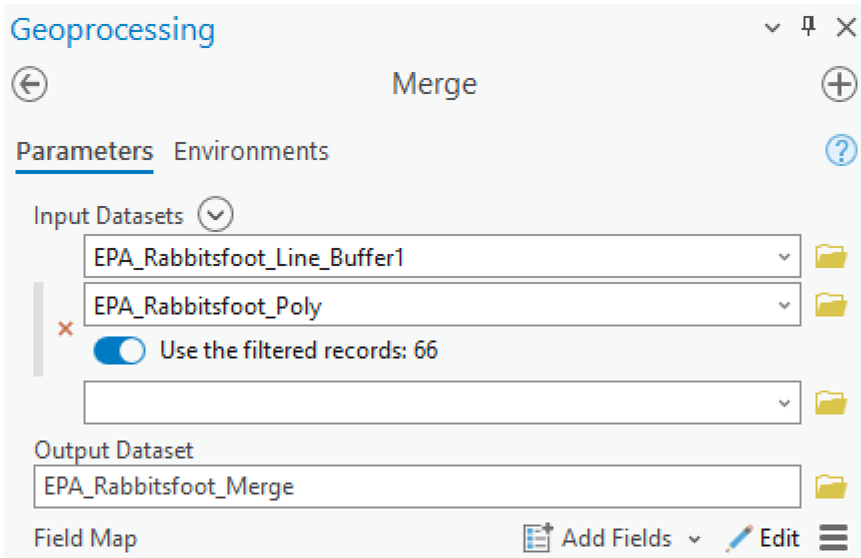


Figure A2-58. Screenshot of Merge Tool

2) Attempted to use the entire USA NLCD Land Cover raster and the feature class created from step 1C named, “EPA_Rabbitsfoot_Merge” with the “Extract Mask” tool. However, the tool had a message. “Cannot process above the size limits of the image service ‘USA NLCD Land Cover’”. (**Figure A2-59) Decided** to go online to the MRLC viewer (https://www.mrlc.gov/viewer/) and upload six shapefiles of smaller areas to use to download the NLCD that cover all the “EPA_Rabbitsfoot_Merge” reocrds. (**Figure A2-60)**

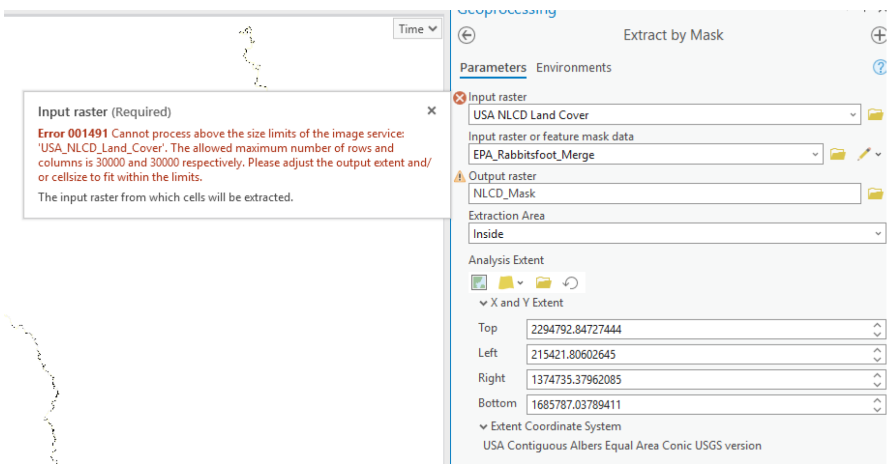


Figure A2-59. Screenshot of Extract by Mask Error Message

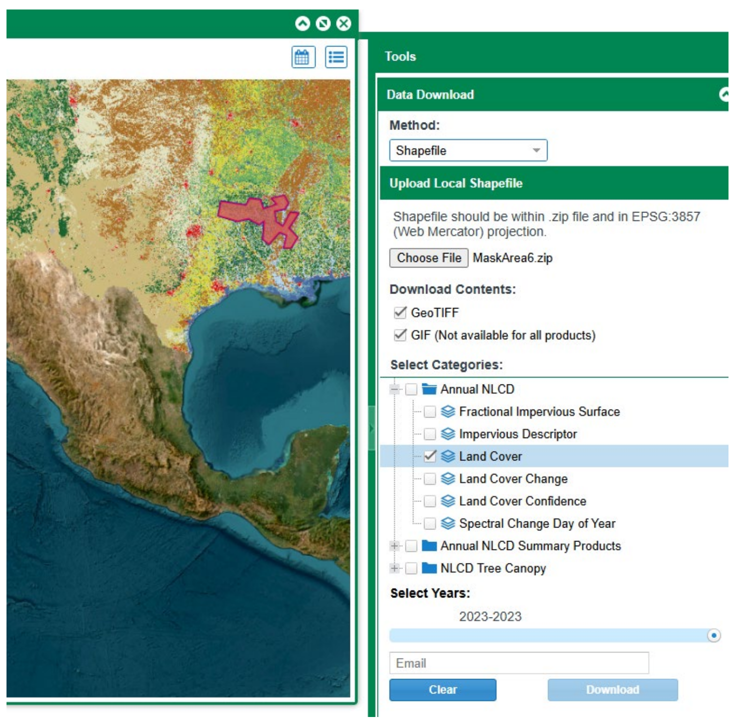


Figure A2-60. Screenshot of MLRC download by shapefile extent

3) For each of the six areas the “Extract by Mask” tool was used with “EPA_Rabbitsfoot_Merge” filtered by the same area within “EPA_Rabbitsfoot_Merge” as the extent. (**Figure A2-61)** In the “Environments” tab, changed the output coordinate system to match "EPA_Rabbitsfoot_Merge", which in this case is "USA_Contiguous_Albers_Equals_Area_Conic_USGS_version". (**Figure A2-62)** They were named, "NLCD_MaskArea1", NLCD_MaskArea2", etc.

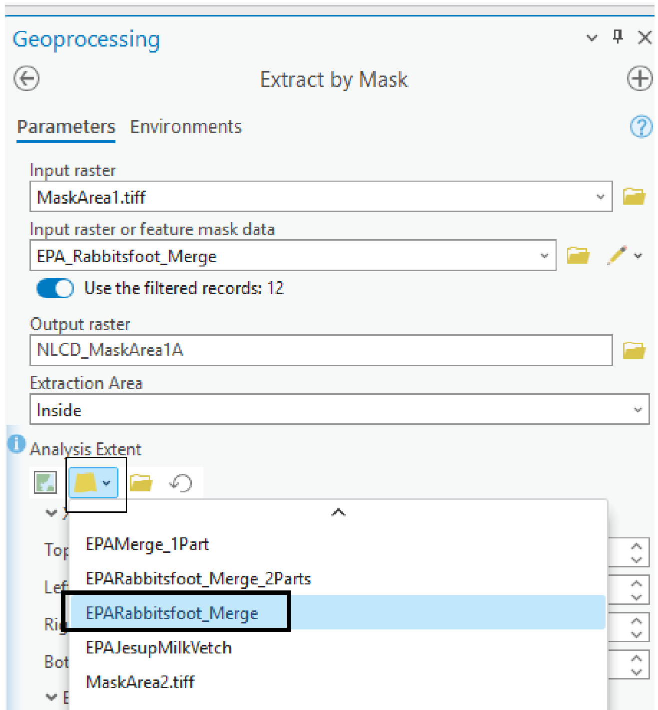


Figure A2-61. Screenshot "Extract by Mask" Parameters Tab

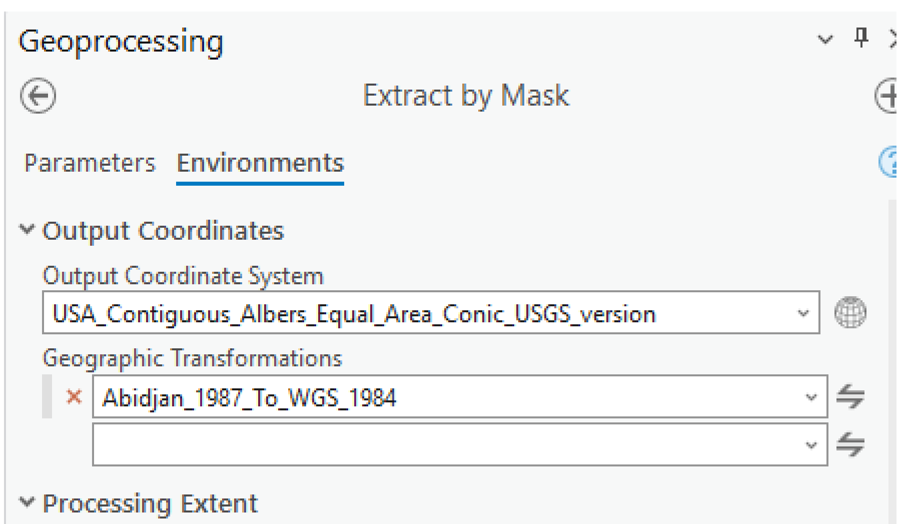


Figure A2-62. Screenshot "Extract by Mask" Environments Tab

4) Used the “Mosaic To New Raster” tool to gather all six into one output. (**Figure A2-63)**

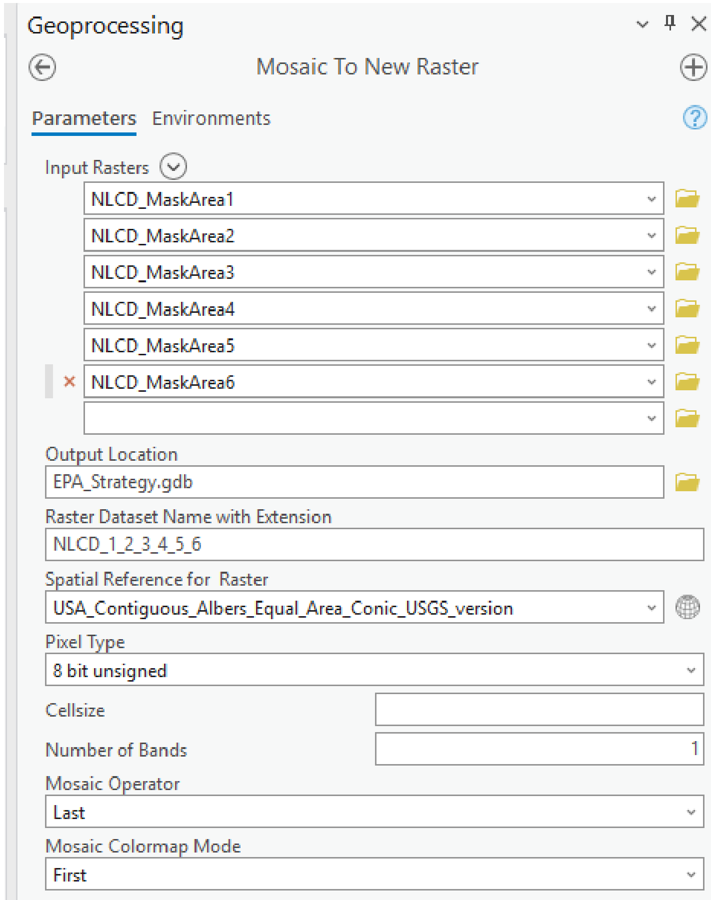


Figure A2-63. Screenshot “Mosaic To New Raster” Parameters Tab

5) Used the “Tabulate Area” tool to determine the count of area for each NLCD code. (**Figure A2-64)**

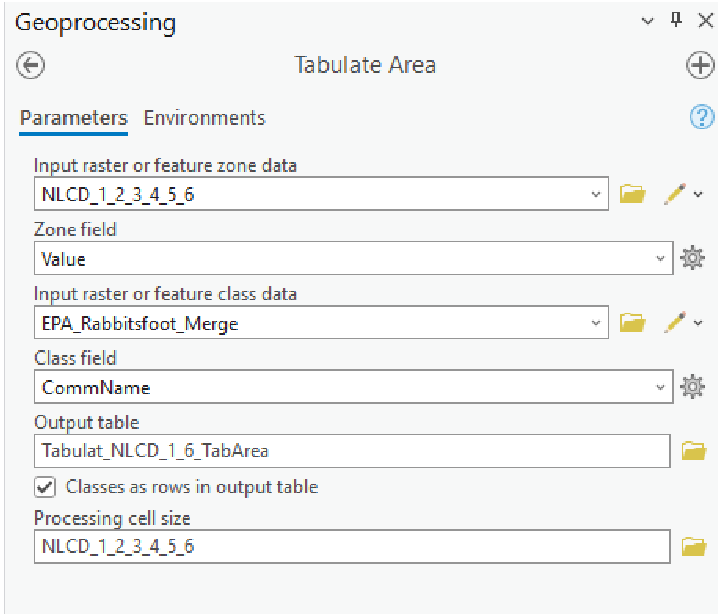


Figure A2-64. Screenshot "Tabulate Area" Tool

Added a double field named, "Per". Right clicked on field and selected "Calculate Field". Entered the formula "(!Count!/697429)*100". This calculated the percentage of NLCD within the core map area. (**Figure A2-65)** Review Results and input into (Table 1. Percentage of Interim Core Map Represented by NLCD Land Covers and Associated Example Pesticide Use Sites/Types.) (**Figure A2-66)**

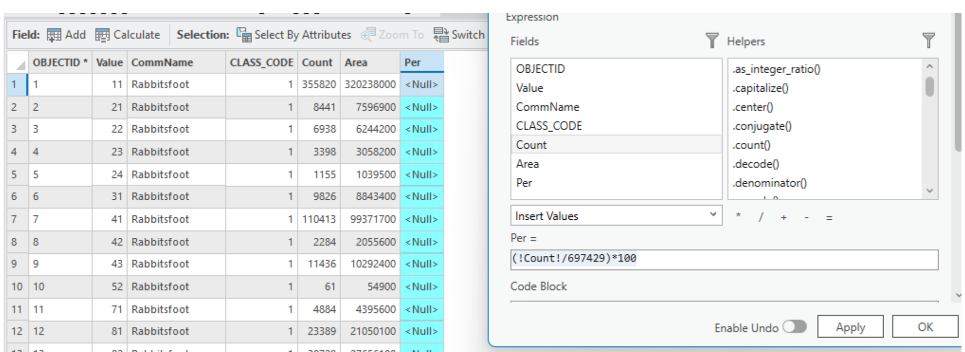


Figure A2-65. Screenshot "Field Calculate"

Field: Add Calculate Selection: Select By Attributes Zoom To Sw

	OBJECTID *	Value	CommName	CLASS_CODE	Count	Area	Per
1	1	11	Rabbitsfoot	1	355820	320238000	51.018813
2	2	21	Rabbitsfoot	1	8441	7596900	1.210302
3	3	22	Rabbitsfoot	1	6938	6244200	0.994797
4	4	23	Rabbitsfoot	1	3398	3058200	0.487218
5	5	24	Rabbitsfoot	1	1155	1039500	0.165608
6	6	31	Rabbitsfoot	1	9826	8843400	1.408889
7	7	41	Rabbitsfoot	1	110413	99371700	15.831432
8	8	42	Rabbitsfoot	1	2284	2055600	0.327489
9	9	43	Rabbitsfoot	1	11436	10292400	1.639737
10	10	52	Rabbitsfoot	1	61	54900	0.008746
11	11	71	Rabbitsfoot	1	4884	4395600	0.700286
12	12	81	Rabbitsfoot	1	23389	21050100	3.353603
13	13	82	Rabbitsfoot	1	30729	27656100	4.40604
14	14	90	Rabbitsfoot	1	109341	98406900	15.677725
15	15	95	Rabbitsfoot	1	18231	16407900	2.61403
16	16	255	Rabbitsfoot	1	1083	974700	0.155285

Figure A2-66. Screenshot "Field Calculate" Results