Interim Core Map Documentation for Mead's Milkweed

December 17, 2024

Developed by US Environmental Protection Agency Office of Pesticide Programs and University of Georgia Extension Faculty

Species Summary

Mead's milkweed (*Asclepias meadii*; Entity ID #636) is a threatened plant (dicot). This species occurs primarily in tallgrass prairie with a late successional bunch-grass structure. This species also occurs in hay meadows and in thin soil glades or barrens. This species is not expected to use agricultural field as habitat. Mead's milkweed is pollinated by small bumblebees and miner bees. Additional information on the species is provided in **Appendix 1**. This species is currently included in the Vulnerable Species Action Plan.

Description of Core Map

The core map is based on biological information focused on suitable habitat within the range. This core map type was selected because (1) the species range is broad and contains contiguous areas that are not likely habitat for this species; (2) areas that can be included or excluded as habitat or non-habitat within the range is mappable; and (3) there is no designated critical habitat. This core map is based on habitat elements including prairie habitat, elevation, and slope data from the USGS. Cultivated land and unsuitable habitat were removed from the map based on the species habitat descriptions. EPA used available known location data to confirm that the habitat locations identified within the range are consistent with where this species is known to occur. **Figure 1** depicts the interim core map for Mead's milkweed. **Appendix 3** shows maps with close-ups of key areas by state. The size of this core map is approximately 29,600 acres. Landcover categories within the core map area are included in **Table 1**. Landcover within the core map is predominantly herbaceous/grassland.

The core map developed for Mead's milkweed is considered interim. This means that this core map will be used to develop pesticide use limitation areas (PULAs) that include Mead's milkweed, but it will not be considered 'final' until a FWS species expert reviews the core map. Therefore, this interim core map may be revised in the future to incorporate expert feedback from FWS. This interim core map has an "average" best professional classification to describe major uncertainties/limitations. EPA has confidence in the core map because there are strong connections between the species' life history and its biological needs and mappable GIS sources. However, there is uncertainty and error in all complex data sets such as those used to define the core map, specifically the assumptions made related to habitat. When FWS species experts reviews this interim core map, it may be possible to improve the confidence in this core map. This core map does not replace or revise any range developed by FWS for this species.
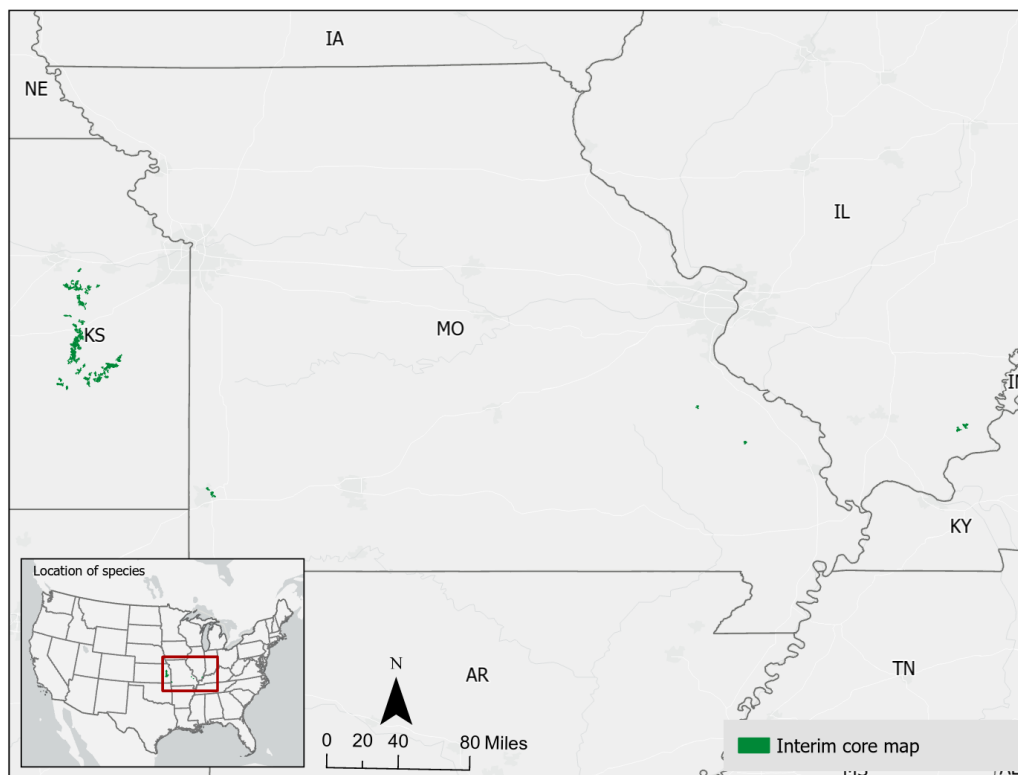
Figure 1. Interim core map for Mead's milkweed that accounts for habitat locations. Total acreage of the core map is approximately 29,600 acres.

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 Land Cover (Value)	% of core map represented by landcover	% of core map represented by example pesticide use
Forestry	Deciduous Forest (41)	3	3
	Evergreen Forest (42)	0	
	Mixed Forest (43)	0	
Agriculture	Pasture/Hay (81)	3	6
	Cultivated Crops (82)	3	
Mosquito adulticide, residential	Open space, developed (21)	1	1
	Developed, Low intensity (22)	0	
	Developed, Medium intensity (23)	0	
	Developed, High intensity (24)	0	
Invasive species control	Woody Wetlands (90)	0	90

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

	Emergent Herbaceous Wetlands (95)	0	
	Open water (11)	1	
	Grassland/herbaceous (71)	83	
	Scrub/shrub (52)	3	
	Barren land (rock/sand/clay; 31)	3	
Total Acres	**Interim Core Map Acres**	**~ 29,600**	

Approach Used to Create the 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"[2] (referred to as "the process"). This core map was developed by EPA and University of Georgia extension faculty. This core map was developed 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 developer compiled available information for Mead's milkweed from FWS, as well as observational information available from various publicly available sources (including iNaturalist, GBIF and NatureServe). The information compiled for Mead's milkweed is included in **Appendix 1**. Influential information that impacted the development of the core map included:

- Species habitat descriptions including: glade/barren habitat, hay meadows, moderately dry-mesic upland tallgrass prairie, and late-successional prairie;
- Species' suitable habitat does not include cultivated lands;
- Elevation (800-1200 ft) and slope (<20%) parameters for suitable habitat;

For step 2, compiled information was used to identify the core map type. Information considered included the species range, known locations, and biological/habitat information. EPA did not select the species' range as the core map type because the range encompasses large areas that are not likely to include the species' habitat (for example, there are hundreds of thousands of acres of cultivated land within the range; however, this species does not live on tilled areas). Also, there is no designated critical habitat for this species. Description of the species' habitat in FWS recovery documents included elements that could be identified within its range. Therefore, the biological information core map type (focusing on mappable elements of species' habitat, elevation, and slope) was selected.

For step 3, the best available data sources were used to generate the core map. For this core map, EPA used habitat information, elevation data, and slope data. The cultivated data layer from EPA's cultivated UDL was also used to remove cultivated areas from the core map. The core map development process began with the 2023 ECOS range for the species, then:

- Selected for preferred species habitat (glade/barren habitat, hay meadows, moderately dry-mesic upland tallgrass prairie, and late-successional prairie) within the range;

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[2] Dated 2024, available online at: https://www.epa.gov/endangered-species/process-epa-uses-develop-core-maps-pesticide-use-limitation-areas

- Further refined the core map by only including areas with the appropriate elevation and slope for the species; and
- Removed cultivated areas from the core map.
- Visually compared the available known location data (iNaturalist, GBIF, NatureServe and FWS) to the interim core map.

Appendix 2 provides more details on the GIS analysis and data used to generate the core map.

Evaluation of Known Location Information

Four datasets with known location information were evaluated:
- Descriptions of locations provided by FWS;
- Occurrence locations in iNaturalist;
- Occurrence locations in GBIF; and
- Occurrence locations in NatureServe.

When examined, occurrences from all four sources were located within the ECOS range. EPA visually compared the descriptions of known locations from FWS documentation to the interim core map and found that there were no cases of the described sites clearly falling outside of the area given the precision of the data (details of the described sites are captured in **Appendix 1**). **Appendix 1** includes more information on the available known location information.

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

EPA considered whether or not to include areas in Illinois with habitat that could potentially help the species but have a low suitability ranking noted in FWS documents. Upon review of the 2003 FWS recovery plan, EPA decided that there was not clear enough justification to exclude the Illinois habitat from the core map. Table 1 of the 2003 FWS recovery plan outlined clear physiographic regions that are needed for successful recovery of the species, and some are in Illinois. The interim core map includes sites in Illinois because including these sites were aligned with FWS's recovery plan.

EPA also considered using the known location data to generate the core map; however, all known location information overlapped with the habitat location data. Therefore, the known locations (that were mappable and those that were not) were all used to confirm the appropriateness of the interim core map.

Appendix 1. Information Compiled for the Mead's Milkweed During Step 1

1. **Recent FWS documents**
   - 5-year review (2022): https://ecosphere-documents-production-public.s3.amazonaws.com/sams/public_docs/species_nonpublish/3695.pdf

- 5-year review (2012): https://ecosphere-documents-production-public.s3.amazonaws.com/sams/public_docs/species_nonpublish/2158.pdf
- Recovery plan (2003): https://ecos.fws.gov/docs/recovery_plan/030922b.pdf

2. **Background information**
   - **Status**: Federally listed as threatened in 1988
   - **Resiliency, redundancy, and representation (the 3Rs).**
     Resiliency/Redundancy/Representation are inferred low (Final Malathion BiOp Appendix C) and are described in more detail below.

     Resiliency: "Although several populations have been discovered since 2012, many of these are small, located within the Osage Plains, and have a limited contribution to the range wide recovery criteria for the species (USFWS 2012, p. 18). The disappearance of previously known populations is possible as 56% of sites have not had observations in at least 10 years and 23% have not been observed in the last 30 years. Additionally, approximately 29% (106 sites) of all known populations have been surveyed since 2010." (5 Year Review 2022).

     Redundancy: "Mead's milkweed is threatened by the destruction and alteration of tallgrass prairie due to intense agricultural use, urban growth, and urban residential, industrial, and commercial development, recreational use of sites, and hay mowing that disrupts the species' sexual reproductive cycle. Predation, pathogens, intrinsic biological factors, such as sexual incompatibility, and unpredicted catastrophes also may threaten small populations that have been isolated by fragmentation and are incapable of sexual reproduction and population recovery." (Recovery Plan 2003)

     Representation: "no reintroduced populations are considered highly viable, 16 are considered moderately viable, and 13 of low viability (Table 2 of 5 Year Review 2022). Viability of these is likely overoptimistic. Initial establishment and later declines are evidence of both heterosis (improved or increased function of any biological quality in a hybrid offspring) and outbreeding depression (crosses between highly genetically differentiated individuals results in reduced fitness) (Bowles et al. 2015). Recent research suggests that flowering in reintroduced Mead's milkweed may be influenced by proximity to large natural populations. Initial survivorship of planted seeds and juvenile plants is low, and recruitment of individuals in reintroduced populations has not been recorded. After individuals become established, they are more likely to persist despite slow growth and maturation rates (Roels 2013, Bowles et al. 2015).

   - Habitat, Life History, and Ecology
     - "Mead's milkweed requires moderately wet-mesic to moderately dry-mesic upland tallgrass prairie or glade/barren habitat characterized by vegetation adapted to drought and fire. It persists in stable late-successional prairie; however, due to the suppression of fire and conversion of suitable habitat to agriculture throughout much of its range, remaining patches of habitat are highly fragmented." (5 Year Review 2022)

     - "Mead's milkweed occurs primarily in tallgrass prairie with a late successional bunch-grass structure, but also occurs in hay meadows and in thin soil glades or barrens. This plant is essentially restricted to sites that have never been plowed and only lightly grazed, and hay meadows that are cropped annually for hay." (Recovery Plan 2003)

- "Over 220 of all known sites are hayed annually or periodically, 46 sites are managed with fire, and 10 sites are regularly grazed. It should be noted that land use descriptions have not been updated since 2003 and it's likely some have changed." (5 Year Review 2022)

- Mead's milkweed requires "moderately dry-mesic upland tallgrass prairie or glade/barren habitat characterized by vegetation adapted to drought and fire. It persists in stable late-successional prairie" (U.S. FWS Mead's milkweed (*Asclepias meadii*) Recovery Plan, pg. 9). Mead's milkweed populations are "generally restricted to full sun in late-successional or virgin grassland; however, plants may also persist vegetatively in partial shade, such as the edges of glades or barrens that are being encroached upon by woody vegetation" (U.S. FWS Mead's milkweed (*Asclepias meadii*) Recovery Plan, pg. 9).

- Mead's milkweed "usually occurs between 800-1200 feet above sea level on middle and upper portions of slopes less than 20 percent" (U.S. FWS Mead's milkweed (*Asclepias meadii*) Recovery Plan, pg. 10).

- **Relevant Pesticide Use Sites**
  - Herbicides and other pesticide applications are noted as a threat to some populations of this species (Eulinger and Skinner 2007; Delisle 2010; 5 Year Review 2012) presumably on prairies or adjacent agricultural use sites.

- **Relevant Recovery Criteria and Actions**
  - **Recovery Criteria**: "Twenty-one populations are distributed across plant communities and physiographic regions within the historic range of the species (See Table 7 in Recovery Plan for distribution of these populations)." (Recovery Plan 2003)

  "Each of these 21 populations is highly viable. A highly viable population contains: more than 50 mature plants; seed production is occurring and the population is increasing in size and maturity; the population is genetically diverse with more than 50 genotypes; the available habitat size is at least 125 acres (50 hectares); the habitat is in a late successional stage; the site is protected through long-term conservation easements, legal dedication as nature preserves, or other means; and the site is managed by fire in order to maintain a late successional graminoid vegetation structure that is free of woody vegetation (Bowles and Bell 1998)." (Recovery Plan 2003)

  "Monitoring data indicates that these populations have had a stable or increasing trend for 15 years." (Recovery Plan 2003)

  - **Recovery Actions** (All information below taken from 2003 Recovery Plan)

  Recovery actions include: protect habitat, manage habitat, increase size and number of populations, conduct field surveys for new population occurrences or potential habitat for introduction, maintain conservation populations.

3. Description of Species Range (2023)
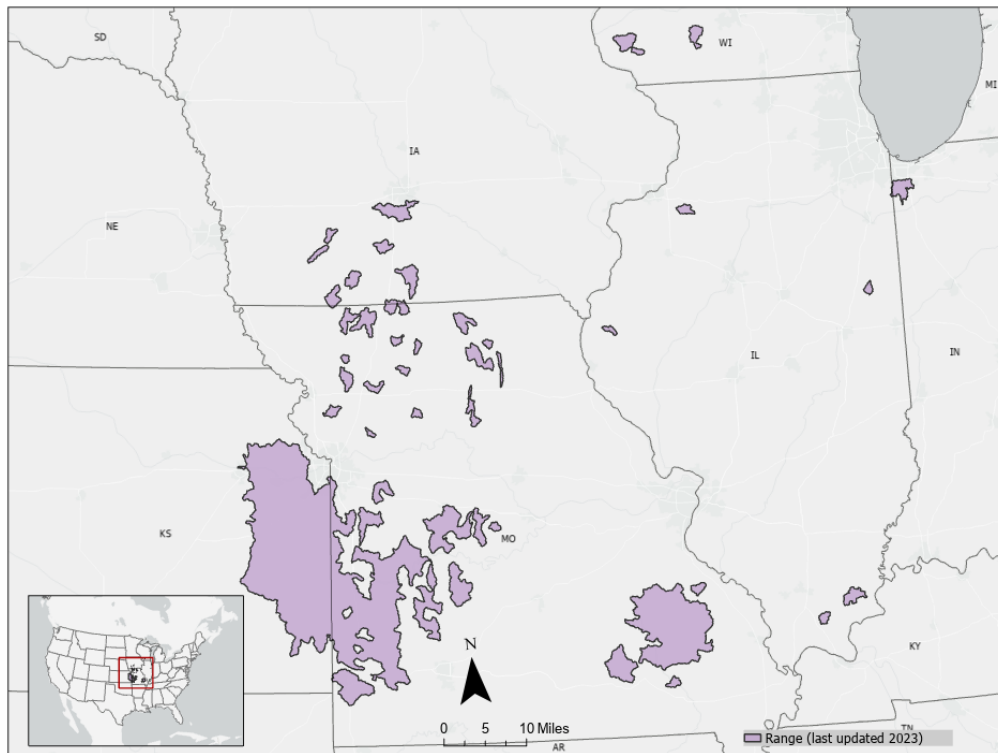
Figure A1-1. Current ECOS range for Mead's milkweed, last updated 03/14/2023. The range is 9,973,509 acres.

4. Description of Critical Habitat
This species does not have a designated critical habitat.

5. Known Locations
"Mead's milkweed historically occurred in 46 counties throughout Kansas, Missouri, Illinois, Iowa, Indiana, and Wisconsin (**Figure A1-1**; USFWS 2003). At the time of listing, it was considered extirpated from Wisconsin and Indiana, and from 7 counties in Illinois. The previous 2012 status review reported 330 populations of Mead's milkweed throughout the range in Kansas (258), Missouri (60), wi (8), and Illinois (4). Before 2012, nineteen reintroductions occurred in Illinois (7), Indiana (1), and Wisconsin (11). Since then, additional plantings have occurred in Missouri and Illinois, resulting in a total of 375 recorded populations across 15 physiographic regions and two plant community types (Table 1 of 5 Year Review 2022). Although several populations have been discovered since 2012, many of these are small, located within the Osage Plains, and have a limited contribution to the range wide recovery criteria for the species (USFWS 2012, p. 18)" (5-Year Review 2022).

Species also occurs in Marais des Cygnes National Wildlife Refuge.

- **Known locations described in FWS' 2022 5-Year Review**

The following figures (**Figures A1-2, A1-3, A1-4, A1-5, A1-6**) were taken from FWS documents that illustrate occurrence data described in those documents.
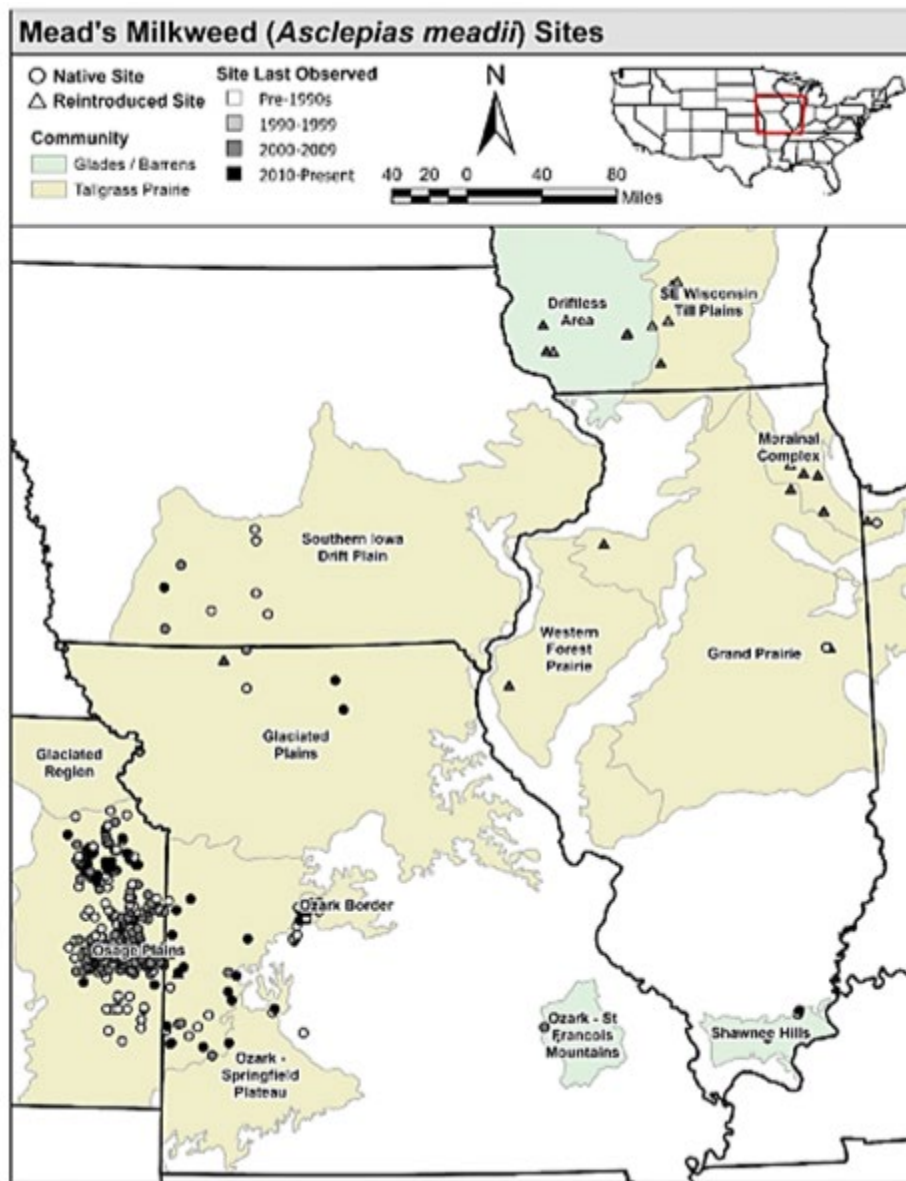
Figure A1-2. Distribution of Mead's milkweed sites and habitat communities across its range. Triangles indicate sites where plantings (i.e., seeds, juveniles, tubers) have been reintroduced. Circles indicate remnant native sites. Opacity indicates the recency of observations where darker shapes have been most recently observed and white shapes have not been observed in over 30 years.

Table 1: Summary of recovery progress for Mead's milkweed. The number of Mead's milkweed populations per the recovery criteria, past and current number of extant populations in the United States. Viability of extant populations is preliminary. Modified from (USFWS 2003, 2012). * Indicates physiographic regions that were not included in the 2003 Recovery plan, - indicates no data for this time period. These values are for extant populations in 2021 and does not include reintroduced populations.

Physiographic Region	State	Community	Recovery Criteria	Known Natural Populations			Viability of All Populations (PVI)		
				2003	2012	2021	High	Moderate	Low
Coastal Plain*	Illinois	Tallgrass Prairie	-	-	-	0	0	0	0
Middle Mississippi River Border*	Illinois	Tallgrass Prairie	-	-	-	0	0	0	0
Northeastern Morainal*	Illinois	Tallgrass Prairie	-	-	-	0	0	0	0
Shawnee Hills	Illinois	Glades / Barrens	1	4	4	4	0	0	4
Grand Prairie	Illinois / Indiana	Tallgrass Prairie	3	0	0	1	0	0	1
Northwestern Morainal*	Indiana	Tallgrass Prairie	-	-	-	0	0	0	0
Western Forest-Prairie	Iowa / Illinois	Tallgrass Prairie	2	0	0	0	0	0	0
Southern Iowa Drift Plain	Iowa	Tallgrass Prairie	2	7	8	8	0	2	6
Glaciated Region	Kansas	Tallgrass Prairie	2	8	18	18	1	0	17
Osage Plains	Kansas / Missouri	Tallgrass Prairie	4	129	277	291	1	85	205
Glaciated Plains	Missouri	Tallgrass Prairie	2	3	3	4	0	2	2
Ozark Border	Missouri	Tallgrass Prairie	1	3	3	3	0	0	3
Ozark-Springfield Plateau	Missouri	Tallgrass Prairie	2	10	9	9	1	1	7
Ozark-St. Francis Mountains	Missouri	Glades / Barrens	1	7	8	8	0	7	1
Driftless	Wisconsin	Glades / Barrens	1	0	0	0	0	0	0
SE Wisconsin Till Plains*	Wisconsin	Tallgrass Prairie	-	-	-	0	0	0	0
Totals			21	171	330	346	3	97	246

Figure A1-3. Table from FWS 5-Year review describing select recovery elements for some Mead's Milkwood populations (FWS 5-year review)

- **Known locations described in FWS' 2003 Recovery Plan**
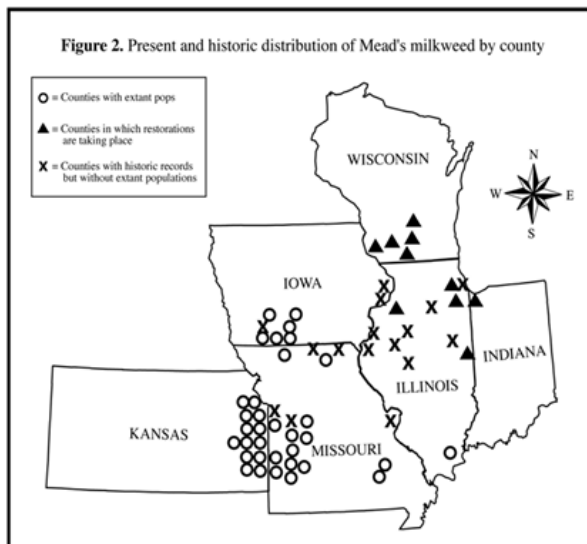
Figure A1-4. Figure of known locations presented in species Recovery Plan (2003)

Table 7. Number of Mead's milkweed populations needed to meet recovery criteria and number of extant populations in the United States by State, physiographic region, and plant community. Viability of extant populations has not been determined.

Physiographic Region	State	Community	Recovery Criteria	Extant Populations
Grand Prairie	Illinois/ Indiana	Tallgrass Prairie	3 highly viable	0
Shawnee Hills	Illinois	Glades/Barrens	1 highly viable	4
Western Forest-prairie	Illinois/Iowa	Tallgrass Prairie	2 highly viable	0
Southern Iowa Drift Plain	Iowa	Tallgrass Prairie	2 highly viable	7
Glaciated Region	Kansas	Tallgrass Prairie	2 highly viable	8
Osage Plains	Kansas/ Missouri	Tallgrass Prairie	4 highly viable	129
Glaciated Plains	Missouri	Tallgrass Prairie	2 highly viable	3
Ozark Border	Missouri	Tallgrass Prairie	1 highly viable	3
Ozark-Springfield Plateau	Missouri	Tallgrass Prairie	2 highly viable	10
Ozark-St. Francois Mountains	Missouri	Glades/Barrens	1 highly viable	7
Driftless	Wisconsin	Glades/Barrens	1 highly viable	0
TOTALS			21 highly viable	171

Figure A1-5. Site names of Mead's milkweed Known Locations from FWS (2003)

Figure A1-6 was taken from FWS' 2003 recovery plan and includes information on known occurrences by state. The table was separated into segments from a larger table that was in FWS' recovery plan to reduce the potential for transcription errors.

APPENDIX 2.
ELEMENT OCCURRENCE RANKING (EOR) OF MEAD'S MILKWEED POPULATIONS (OBSERVED 1970-2001)

State	County	Site Name	Ownership	Protection Status [1]	EOR [2]	Number of Ramets	Date of Last Observation
IA	Adair	Woodside Prairie	Private	2	C	3	2001
IA	Clarke	Flaherty Prairie	Private	2	D	2	1989
IA	Decatur	Garden Grove Prairie	Private	2	D	4	1992
IA	Ringold	Tingley Prairie	Private	1	D	4	1992
IA	Taylor	Powell Prairie	Private	1	D	30	6-12-2002
IA	Warren	Great Western Trail, Churchville Prairie	Warren County Conservation Board	1	D	4	1988
IA	Warren	Great Western Trail, Cumming	Warren County Conservation Board	8	D	5	1990
IL	Saline	Saline #1	U.S. Forest Service	1	D	<5	1998
IL	Saline	Saline #2	U.S. Forest Service	1	D	<5	1998
IL	Saline	Saline #3	U.S. Forest Service	1	D	<5	1998
IL	Saline	Saline #4	U.S. Forest Service	1	D	17	1998
KS	Allen	Allen #1	Private	0	D	17	06-16-1986

State	County	Site Name	Ownership	Protection Status [1]	EOR [2]	Number of Ramets	Date of Last Observation
KS	Allen	Allen #2	Private	0	?	Unknown	06-02-1988
KS	Allen	Paint Brush Prairie	Private	0	C	28	05-13-1989
KS	Allen	Wolfpen Creek Prairie	Private	0	D	17	05-13-1989
KS	Anderson	Anderson #1	Private	0	?	100	07-02-2001
KS	Anderson	Anderson #2	Private	0	?	Unknown	05-27-1987
KS	Anderson	Anderson #3	Private	0	?	Unknown	05-19-1987
KS	Anderson	Anderson #4	Private	0	?	Unknown	1987
KS	Anderson	Anderson #5	Private	0	D	Unknown	1987
KS	Anderson	Deer Creek Prairie	Private	0	?	Unknown	05-31-1987
KS	Anderson	Dumped-On Prairie	Private	1	D	3	10-01-1990
KS	Anderson	Garnet Prairie	Private	0	B	122	08-04-1988
KS	Anderson	Lone Elm Prairie	Private	0	?	Unknown	05-26-1987
KS	Anderson	Lone Elm Prairie Southwest	Private	0	?	Unknown	05-25-1987
KS	Anderson	Mont Ida Cemetery Prairie	Private	1	D	4	09-26-1990
KS	Anderson	Mount Zion Cemetery North	Private	0	?	Unknown	05-11-1987

State	County	Site Name	Ownership	Protection Status [1]	EOR[2]	Number of Ramets	Date of Last Observation
KS	Anderson	Mount Zion Cemetery South	Private	0	D	5	05-07-1987
KS	Anderson	North Rich Prairie	Private	0	?	Unknown	05-30-1987
KS	Anderson	Northeast Garnett Prairie	Private	0	D	4	06-02-1993
KS	Anderson	Pipeline Prairie	Private	1	D	2	09-11-1990
KS	Anderson	Pott Creek Prairie	Private	1	C	18	07-10-1988
KS	Anderson/Linn	Puppy Dog Prairie	Private	0	D	6	10-04-1990
KS	Anderson	Selma Prairie	Private	1	B	>100	09-08-1987
KS	Anderson	Southfork Pott Creek Prairie	Private	0	?	Several	06-08-1986
KS	Anderson	Sunset Prairie	Private	0	A	>150	05-26-1988
KS	Anderson	Two Rocks Prairie	Private	1	C	>48	09-08-1987
KS	Anderson	Welda Prairie	Private				
KS	Anderson	Welda Prairie North	Private				
KS	Anderson	Westphalia Prairie	Private	0	C	73	06-15-1989
KS	Bourbon	Bourbon #1	Private	0	?	Rare	1971
KS	Bourbon	Bronson Prairie	Private	1	D	5	06-17-1986
KS	Bourbon	Hinton Creek	Private	0	A	439	05-13-1989

State	County	Site Name	Ownership	Protection Status [1]	EOR[2]	Number of Ramets	Date of Last Observation
MO	Benton	Windmill Prairie	Private	0	D	10	06-28-1988
MO	Cass	South Fork Prairie	Private	2	D	16	06-02-2001
MO	Cass	West Dolan Prairie	Private	1	D	6	05-26-1988
MO	Cedar	Mo-Ko Prairie	The Nature Conservancy/Private	8	D	1	06-06-1989
MO	Cedar	Thorsen Prairie	Private	0	C	14	06-06-1989
MO	Dade	Niawathe Prairie	The Nature Conservancy/Missouri Department of Conservation	8	B	20	06-12-1993
MO	Harrison	Helton Prairie Natural Area	Missouri Department of Conservation	8	D	2	06-17-1994
MO	Harrison	Old Catholic Church	Private	2	D	3	06-09-2001
MO	Henry	Grand River Bottoms	Missouri Department of Conservation	8	D	12	06-06-1990
MO	Iron	Bell Mountain - West	U.S. Forest Service	6	D	24	05-24-2001
MO	Iron	St. Francois Mountains Natural Area	Missouri Department of Natural Resources	8	D	6	05

State	County	Site Name	Ownership	Protection Status [1]	EOR[2]	Number of Ramets	Date of Last Observation
MO	Iron	Taum Sauk Mountain State Park #1	Missouri Department of Natural Resources	8	C	41	06-24-1991
MO	Iron	Taum Sauk Mountain State Park #2	Missouri Department of Natural Resources	8	D	9	05-28-1998
MO	Iron	Taum Sauk Mtn State Park - Mina Sauk Falls	Missouri Department of Natural Resources	8	D	11	05-28-2001
MO	Pettis	Bahner Branch Prairie	Private	0	D	3	07-16-1989
MO	Pettis	Bahner vicinity	Private	0	D	2	07-11-1989
MO	Pettis	Cordes Prairie	Private	0	D	16	06-14-1988
MO	Pettis	Friendly Prairie	Missouri Prairie Foundation	8	D	7	05-31-1989
MO	Pettis	Grandfather Prairie Conservation Area	The Nature Conservancy	8	D	12	06-01-1989
MO	Pettis	Highway W Prairie	Private	0	D	1	06-26-1989
MO	Pettis	Paint Brush Prairie Natural Area	Missouri Department of Conservation	8	C	86	2002-06-06
MO	Pettis	Paint Brush Prairie Vicinity South	Private	0	D	22	06-14-1989

State	County	Site Name	Ownership	Protection Status [1]	EOR[2]	Number of Ramets	Date of Last Observation
MO	Vernon	KCSI Prairie	Missouri Prairie Foundation	8	D	18	06-04-1994
MO	Vernon	Little Osage Prairie	The Nature Conservancy	8	D	11	1978
MO	Vernon	McGennis Prairie	Private	0	D	3	06-27-1989
MO	Vernon	Osage Prairie Natural Area	Missouri Department of Conservation	8	C	12	05-20-1981
MO	Vernon	West Twin Lakes Prairie	Private	0	C	25	06-02-1993

Figure A1-6. Description of occurrences by state presented in FWS' 2003 recovery plan

- **Occurrence data from NatureServe:** https://explorer.natureserve.org/pro/?page=Welcome/
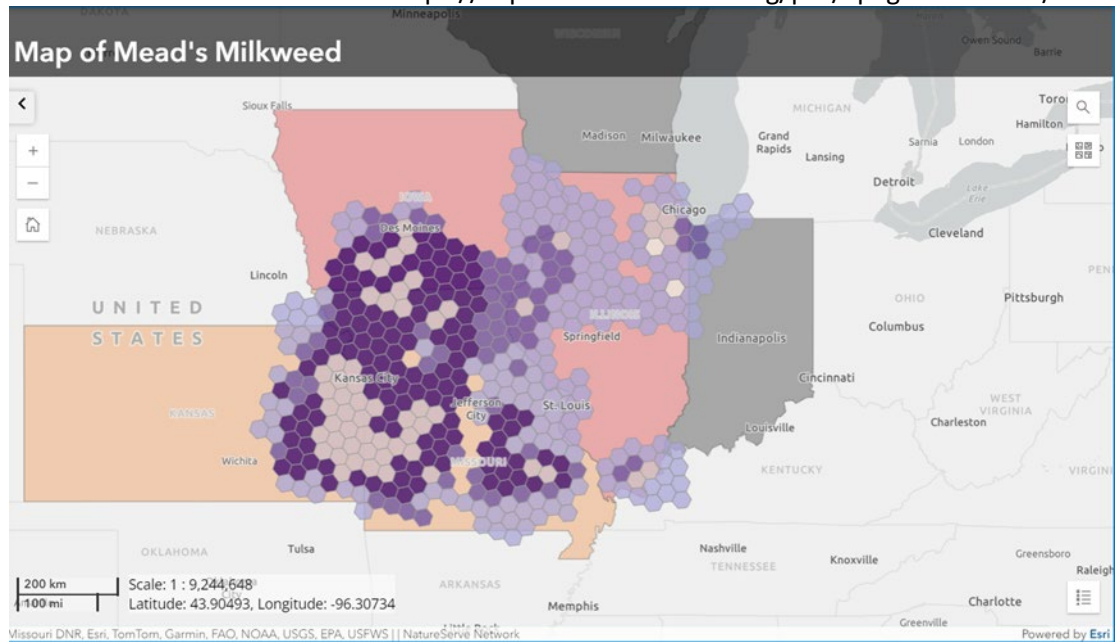
Figure A1-7. NatureServe Known Location Information

- **Occurrence data from GBIF**: https://www.gbif.org/species/3170259
  706 occurrences, uncertain reliability (193 of the records are georeferenced)

Figure A1-8. GBIF Known Location Information

- **Occurrence data from iNaturalist** (117 observations; 113 research grade observations):
  https://www.inaturalist.org/observations?place_id=any&subview=map&taxon_id=158749
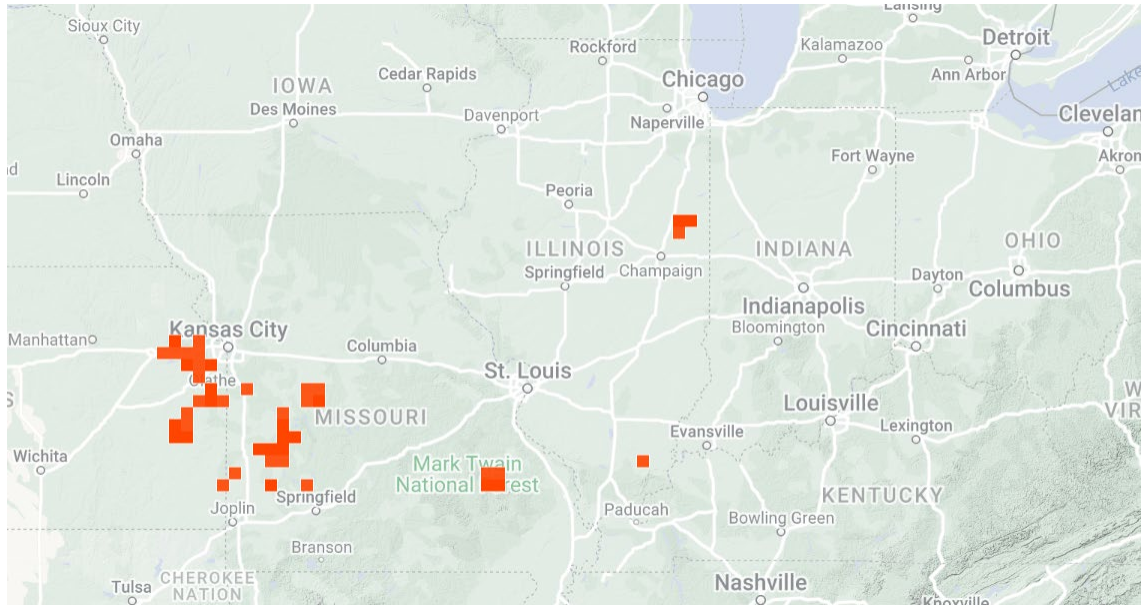
Figure A1-9. iNaturalist Known Location Information

- Strengths and limitations of known occurrence data for the Meads' Milkweed:

  In general, known location data do not represent all areas where a species may be located because a plant can go undetected, sites are not consistently monitored, the monitoring data that exists is out of date for this species (5 Year Review 2022), and most known sites have not been consistently monitored for 15 years (5 Year Review 2022).

  In Wisconsin, "three populations have been surveyed in the last 10 years and continued monitoring of these locations is planned. Interest has been expressed in identifying optimal habitat for future reintroductions (R. Henderson, pers. Comm. 2022)" (5 Year Review 2022).

  NatureServe (**Figure A1-7**), GBIF (**Figure A1-8**), and iNaturalist data (**Figure A1-9**) are all research grade observations, but they all contain uncertainty in their precision. When checked, points were near the FWS range data. There were not any cases of known locations falling outside of the FWS provided range.

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

Faculty from the University of Georgia (UGA) extension services provided technical assistance for this map development and documentation.

This biological information core map is based on habitat, including elevation and slope data from the USGS and overlapped NLCD and GAP prairie data (**Table A2-1**). Landfire prairie data was also overlapped with NLCD and GAP prairie data, but this did not change the shape of the core map. Cultivated land was then removed, and the resulting map was overlayed with known occurrences to create the core map.

1. **Datasets References and Software**

- Habitat information: U.S. FWS (2003) Mead's milkweed (*Asclepias meadii*) Recovery Plan. https://ecos.fws.gov/docs/recovery_plan/030922b.pdf
- ESRI Living Atlas – NLCD: https://www.arcgis.com/home/item.html?id=3ccf118ed80748909eb85c6d262b426f
- MRLC: https://www.mrlc.gov/
- ESRI Living Atlas – GAP: https://www.arcgis.com/home/item.html?id=3a2065904112474eb1ec49bd7f61db0b
- USGS – GAP: https://www.usgs.gov/programs/gap-analysis-project/science/land-cover-data-overview
- ESRI Living Atlas – Elevation: https://www.arcgis.com/home/item.html?id=0383ba18906149e3bd2a0975a0afdb8e
- USGS – Elevation: https://www.usgs.gov/3d-elevation-program
- ESRI Living Atlas – Slope: https://www.arcgis.com/home/item.html?id=a1ba14d09df14f42ad6ca3c4bcebf3b4
- USGS – Slope: https://www.usgs.gov/3d-elevation-program
- USFS and DOI – Landfire: https://www.landfire.gov/
- Habitat Size Information: U.S. FWS (2022) Mead's milkweed (*Asclepias meadii*) 5-year Review: Summary and Evaluation. https://ecosphere-documents-production-public.s3.amazonaws.com/sams/public_docs/species_nonpublish/3695.pdf
- FWS Species Range: https://ecos.fws.gov/ecp/species/8204
- Software used: ArcGIS Pro 3.2

2. **Data Datasets Used in Core Map Development**

All datasets used in core map development are described in EPA's process document.

3. **Core Map Development**

Methods and Data

- **Review of the GAP and NLCD habitat layers**

For a better understanding of the potential locations of suitable habitat for Mead's milkweed, datasets identifying landcover classification, elevation, slope, and habitat size were evaluated, identifying parameters that make the site suitable to host the species. Detailed information including data type, habitat description, spatial data set, justification, and sources are included in **Table A2-1** (found on the next page).

Both the NLCD and GAP data sources provide spatial data identifying generalized landcovers (classes); however, the GAP dataset further refined these landcovers to include subcategories, including subclass, form, division, macro, group, and ecosystem. For purposes of creating a core map, acreages were calculated for all GAP levels to determine representation within the total GAP class coverage layer, along with representation within the ECOS boundaries. Considering "MACRO" as the greatest level of refinement for the mapping project, any MACRO with less than 5% representation in GAP coverage within the ECOS species range was considered minor and removed from the map. At this refinement (<5%), GAP coverages at the MACRO level are minimally represented in the ECOS range; therefore, may not be conducive to habitat of the species. Additionally, these sites often appear sporadically across the range in small, isolated areas, and by removing these MACRO levels, there is minimal change to habitat identification.

To provide additional evidence that suitable landcover for the species was identified using spatial data, the NLCD and GAP datasets were overlapped, with the intersecting areas extracted for further analysis. This ensured that areas that were initially identified as a suitable landcover through the NLCD were confirmed with the GAP dataset as a second verifying source. Overlapping the NLCD and GAP identified larger areas of suitable habitat present in both datasets, while removing some spurious pixels or blips/errors in the spatial data.

Table A2-1. Data type, habitat description, spatial data utilized, justification, and sources for habitat parameters of Meads's Milkweed.

Data Type	Habitat Description	Spatial Data Set	Justification	Source
Landcover Classification	Moderately dry-mesic upland tallgrass prairie or glade/barren habitat characterized by vegetation adapted to drought and fire; persists in stable late-successional prairie	National Landcover Database (NLCD)	Based on the specific habitat descriptions of Mead's Milkweed, the following NLCD land classes were selection for inclusion: Barren Land (31), Shrub/Scrub (52), and Grassland and Herbaceous (71).	The NLCD was accessed through ESRI Living Atlas. The main webpage for NLCD can be accesses through MRLC.
		Gap Analysis Project (GAP)/LANDFIRE National Terrestrial Ecosystems Data	Based on the specific habitat descriptions of Mead's Milkweed, the following GAP NVC_Class categories were included: Shrubland and Grassland, Introduced and Semi Natural Vegetation, and Recently Disturbed or Modified.	The GAP dataset was accessed through ESRI Living Atlas. The main webpage for GAP can be accesses through USGS.
Elevation	243-366 meters (800-1,200 feet) elevation	Ground Surface Elevation - 30m dataset	Dataset is a product of the USGS's 3D Elevation Program and provides dynamic image services utilizing numeric values representing ground surface heights, based on a digital terrain model (DTM).	The elevation dataset was accessed through ESRI Living Atlas. The main webpage for elevation data can be accesses through USGS.
Slope	Sites less than 20% slope (11.31°)	Slope Degree (SlpD)	Dataset is a product of the USGS's 3D Elevation Program and provides dynamic image services utilizing numeric values representing ground surface heights, based on a digital terrain model (DTM).	The elevation dataset was accessed through ESRI Living Atlas. The main webpage for slope data can be accesses through USGS.

- **Review of the elevation and slope GIS layers**

Within the FWS Mead's milkweed Recovery Plan, elevation and slope parameters for suitable habitat were specified; therefore, elevation spatial data was used to refine habitat to these areas only. These areas were then further refined to those only containing the specified slope using an additional spatial data set that focused on land slope (**Table A2-1**).

- **Review of the Known Locations and Occurrence Data**

Once the habitat, slope, and elevation refinements were completed, the layers were compared against the available known locations data for the Mead's milkweed from GBIF, iNaturalist and NatureServe.
  - GBIF (https://www.gbif.org/species/3170259). The GBIF data is summarized in more detail in **Appendix 1**.
  - iNaturalist (https://www.inaturalist.org/observations?place_id=any&subview=map&taxon_id=158749) research-grade known locations were compared as well. We overlaid the GBIF and iNaturalist datasets, which verified that the iNaturalist observations were already included in the GBIF data. A visual comparison between this observation data and the known locations described in the FWS 5-Year Review and recovery plan indicated the FWS location are in the same general areas as the point data.
  - Public NatureServe Explorer[3] did not include precise location data but presented occurrence as generalized polygons (these were polygons shaped like cogwheels). The data intersected with the available GBIF/iNaturalist known locations or delineated polygons in the original Fish and Wildlife Service (FWS) Environmental Conservation Online System (ECOS) range. The only known locations NatureServe captured that iNaturalist/GBIF did not were in the state of Illinois. The Illinois known locations depicted in NatureServe coincided with the patches/polygons drawn in Illinois in the original ECOS FWS range. Consequently, EPA decided to isolate the Illinois patches/polygons from the rest of the FWS range and stored them in a GIS layer. This was done because the ECOS polygons accounted for physiographic regions described in the 2003 FWS recovery plan for the species compared to the generalized areas from NatureServe.

- **Additional Habitat Refinements**

For the final step, EPA removed the cultivated lands from the core map since those are not suitable habitat for the species. This was done by importing EPA's modified cultivated land layer[4], which is based on the 2023 cultivated layer from USDA. Updated each year, the USDA cultivated layer helps remove any remaining cultivated areas that were misclassified as suitable habitat in the NLCD or GAP.

By default, the selection of suitable habitat made using the "Select by Attributes" query from the NLCD and GAP layers will exclude any unsuitable habitats for this species. Unsuitable is any habitat not identified in **Table A2-1.** No additional action was needed to remove these areas.

EPA considered whether or not to include sites in Illinois due to reduced habitat quality associated with the range of this species in Illinois. EPA ultimately included sites in Illinois because omitting those

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[3] https://explorer.natureserve.org/pro/Welcome/

[4] https://epa.maps.arcgis.com/home/item.html?id=159e70ce4c284f5b972c687037f8a668,

locations did not align with recovery goals described in the FWS recovery plan. Additional information on the sites in Illinois is included in **Appendix 1**.

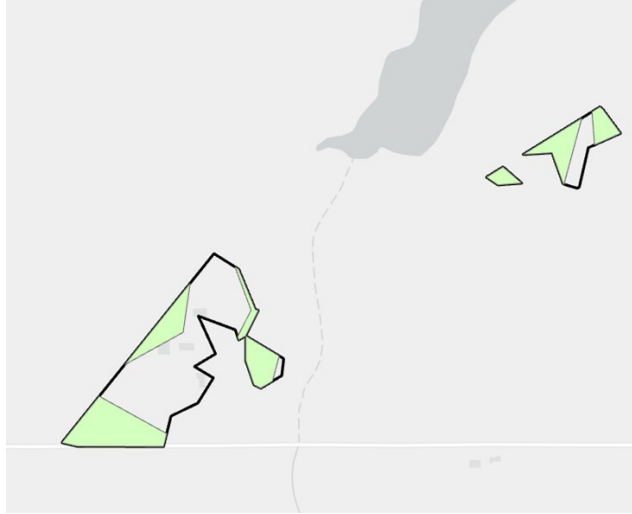### 4. Selecting Species Habitats and Creation of the Habitat Layers

1) NLCD and GAP GIS layers were clipped to the species range using the "Clip Raster" geoprocessing tool and converted to polygons using the "Raster to Polygon" geoprocessing tool.
2) Suitable habitats found in **Table A2-1** from the NLCD and GAP layers were extracted using "Select by Attribute" and exported to a new feature class. This excludes any unsuitable habitats from the habitat layer for this species such as forest.
3) Areas found within the elevation requirements for this species (see **Table A2-1)** were extracted by importing the USGS elevation layer, clipping it to the species range using "Clip Raster," changing the symbology on the raster to 3 groups (class 1 upper value = 243, class 2 upper value = 366, class upper value = 799), reclassifying the raster file to match this symbology using "Reclassify," converting the file format using "Raster to Polygon," then running "Select by Attribute" to select Value = 2, which represents the suitable elevation range for the species.
4) Areas with the slope requirements for this species (see **Table A2-1**) were extracted by importing the USGS slope layer, clipping it to the species range using "Clip Raster," changing the symbology on the raster to two groups (class 1 upper value = 11.31, class 2 upper value = 48), reclassifying the raster file to match this symbology using "Reclassify," converting the file format using "Raster to Polygon," then running "Select by Attribute" to select Value = 1, which represents the suitable slope for the species.
5) The NLCD, GAP, elevation, and slope GIS layers were overlapped using the "Pairwise Intersect" tool.
6) The habitat layer that accounted for suitable habitat, elevation and slope was merged with the GBIF/iNaturalist known location data by overlaying the points on top of habitat, specifically by applying the "Merge" tool and applying the "Dissolve" tool. Prior to doing this, points were visually compared to the habitat layer. Any points that fell outside of suitable habitat would be scrutinized for their precision and uncertainty (these are standard fields included in the attribute table for GBIF points). If the points were within the distance of uncertainty from a habitat polygon, then they would be assumed to fall within the habitat polygons and could be moved to coincide with the habitat polygon before the merge. However, there was not really need to do this for this species – the suitable habitat and points matched up, so the points were incorporated into the habitat polygons by merging without additional modifications needed.
    a. The merged product was stored in a geodatabase called Meads_CoreMap.gdb. The feature class representing the habitat merged with GBIF/iNaturalist data is named meads_milkweed_HGBIF. The "H" stands for habitat.
7) Areas from Illinois (known location polygons were defined by FWS and coincided with NatureServe known location polygons, so the boundaries of the FWS polygons were used) were merged with the feature class named meads_milkweed_HGBIF using the "Merge" tool.
    a. The merged product was stored in a geodatabase called Meads_CoreMap.gdb as a third feature class named meads_milkweed_HKL (the HKL stands for "habitat and known locations").
    b. This feature class (**Figure A2-1**) accounts for habitat outside of Illinois (GAP, NLCD, Landfire slope, elevation datasets) and known locations including Illinois (FWS, GBIF, iNaturalist, and NatureServe datasets).
    c. Repeated the procedure described in steps 1 and 2 for selecting NLCD and GAP habitat. This meant a "Select by Attributes" query that only included the NLCD and GAP habitat classes identified as suitable in **Table A2-1** was run to make sure only suitable habitat was included

following the merge. This already had been done for the rest of the core map, so it needed to be done again to account for the addition of Illinois.

d. The elevation and slope procedure described in steps 3, 4, and 5 were completed again to account for Illinois. The resulting feature class was named meads_milkweed_HKL_updated.

e. Step 7 was completed because Illinois had been excluded from the core map before this point due to low habitat suitability ranking described in FWS documentation, but EPA determined that it should not be excluded based on goals described in the FWS Recovery Plan.
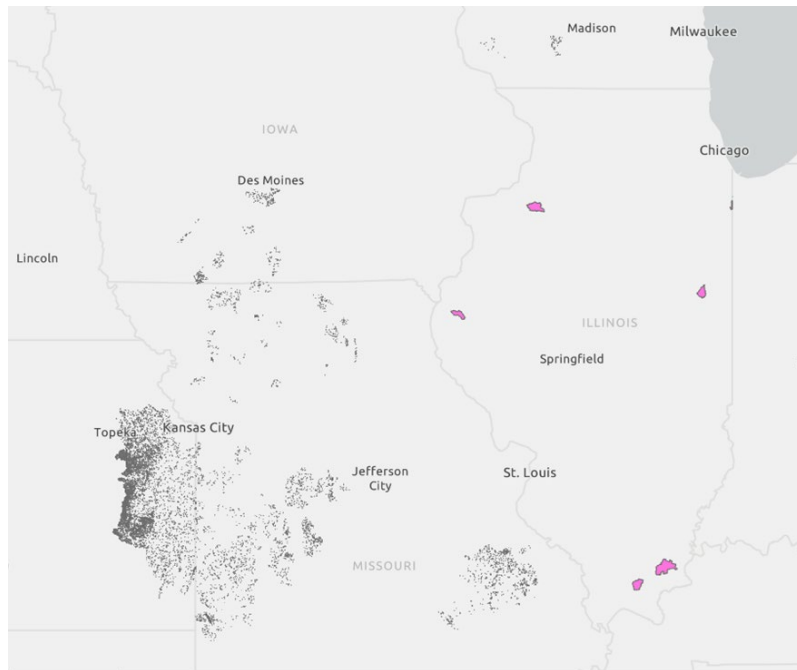
Figure A2-1. Intermediate map for Mead's Milkweed (pink) following the merge to include Illinois (feature class named meads_milkweed_HKL_updated). Total area was 380,383 acres.

8) Finally, any remaining cultivated areas were removed because this species does not use agricultural field as habitat. This was done using the "Pairwise Erase" geoprocessing tool on the output of step 7 (meads_milkweed_HKL_updated).

a. Resulting file was saved to the Meads_CoreMap.gdb and named meads_milkweed_HKL_uncultivated_updated

b. **Figure A2-2** provides an example image for a single location found in Kansas to highlight the removal of the cultivated land.

c. The core map depicted as **Figure 1** in the main document, **Figure A2-3**, and the various close-up maps in **Appendix 3** is the result of applying the smoothing process to remove data artifacts described in EPA's core map process documentation (https://www.epa.gov/endangered-species/process-epa-uses-develop-core-maps-draft-pesticide-use-limitation-areas) to meads_milkweed_HKL_uncultivated_updated.

Figure A2-2. A close-up mapped view comparing the cultivated areas (in light green) to the rest of the biological information core map (boundaries in black). Those cultivated (light green) areas were removed from the final core map using the "Pairwise Erase" tool. The zoomed in area from the core map featured as an example here is in Kansas.

5. **Results**

EPA used the feature class named meads_milkweed_HKL_uncultivated_updated as the Mead's milkweed core map (smoothing was applied to it to remove data artifacts during GIS QA/QC), which was selected as the interim core map for Mead's milkweed. This area accounts for all suitable habitat and known locations regardless of the habitat quality of sites such as those in Illinois (**Figure A2-3**).
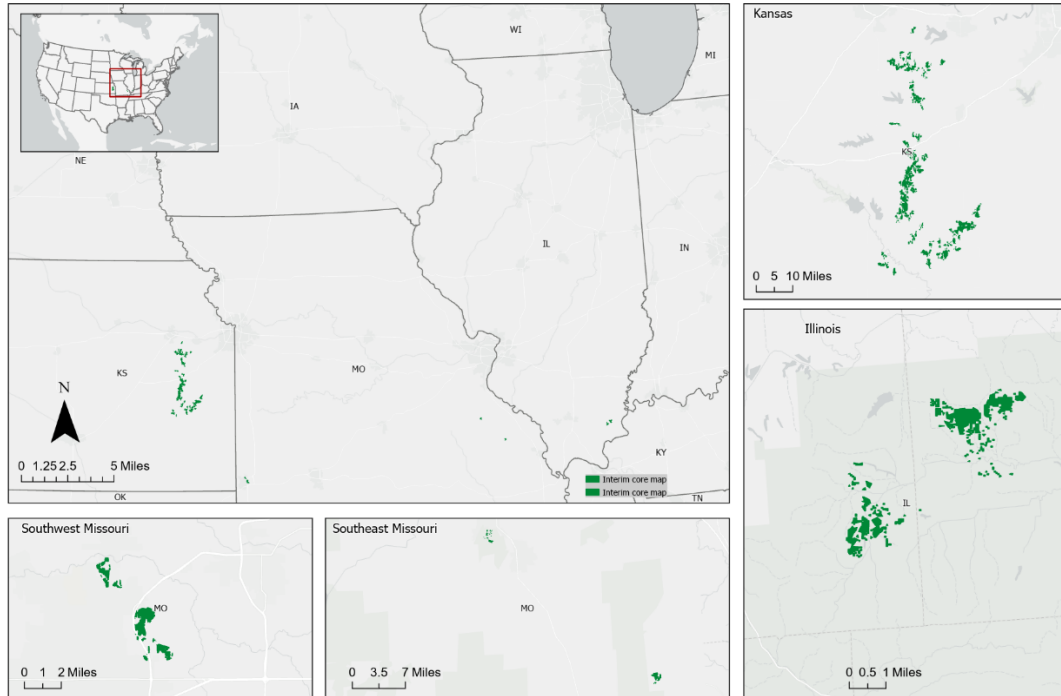
Figure A2-3. Interim core map for Mead's milkweed that accounts for all habitat and known location refinements. Cultivated area was excluded from the map. Total acreage is 29,600 acres (dark green). Note that the original range was 9,973,509 acres.
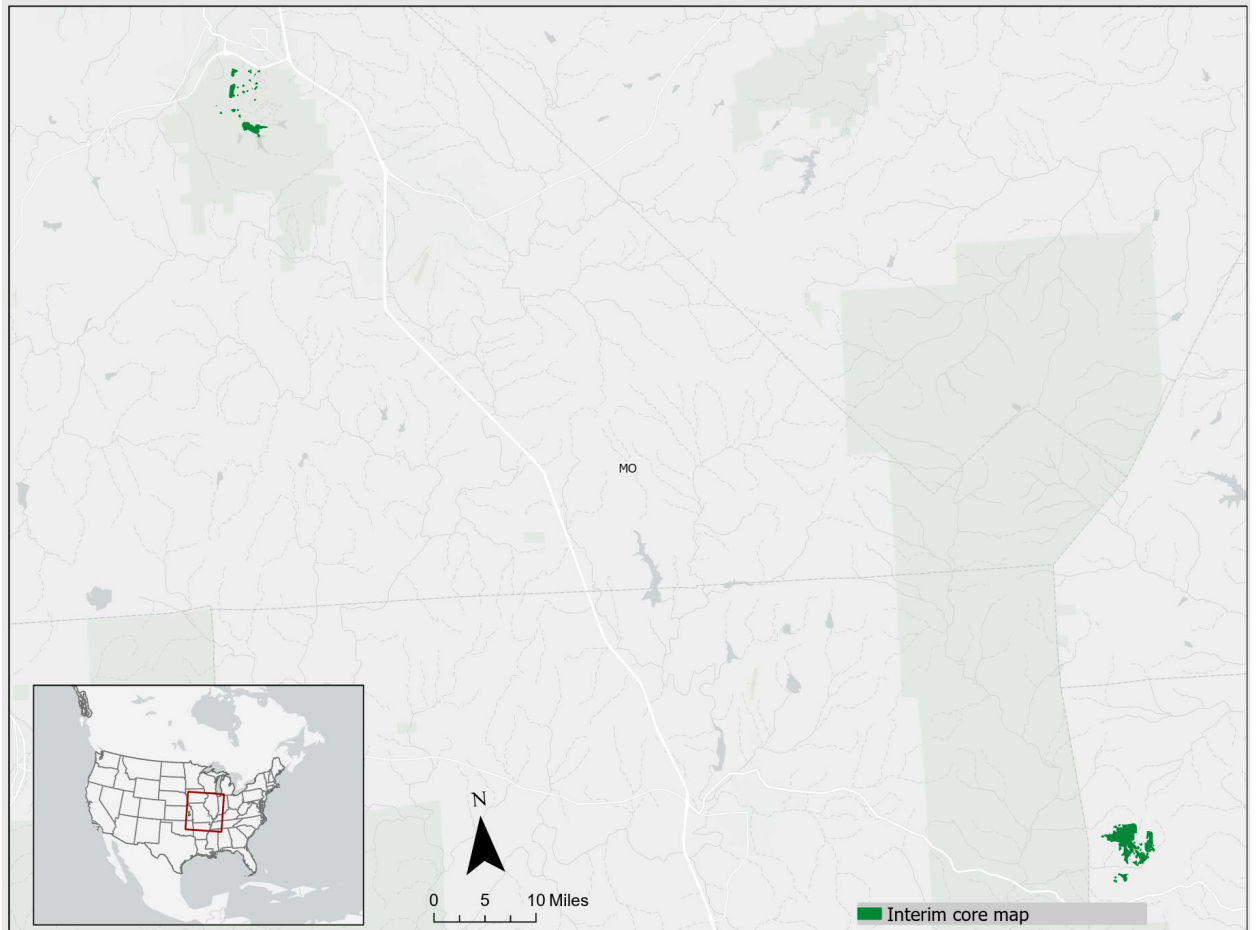
Appendix 3. Close-up views of key core map areas (dark green) in the different states

The close-ups do not necessarily show every habitat fragment contained in every state, but they do zoom in on the key clusters of habitat fragments.
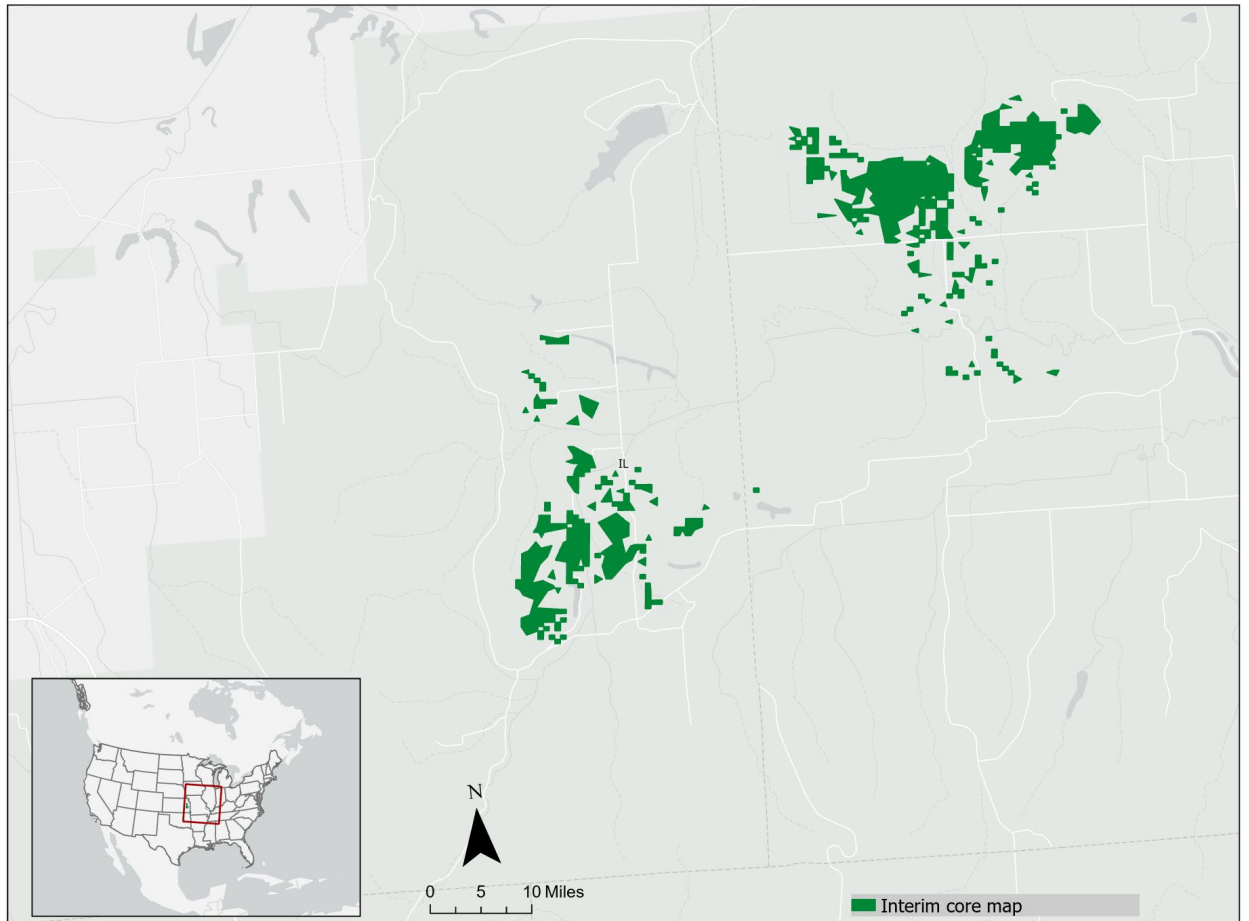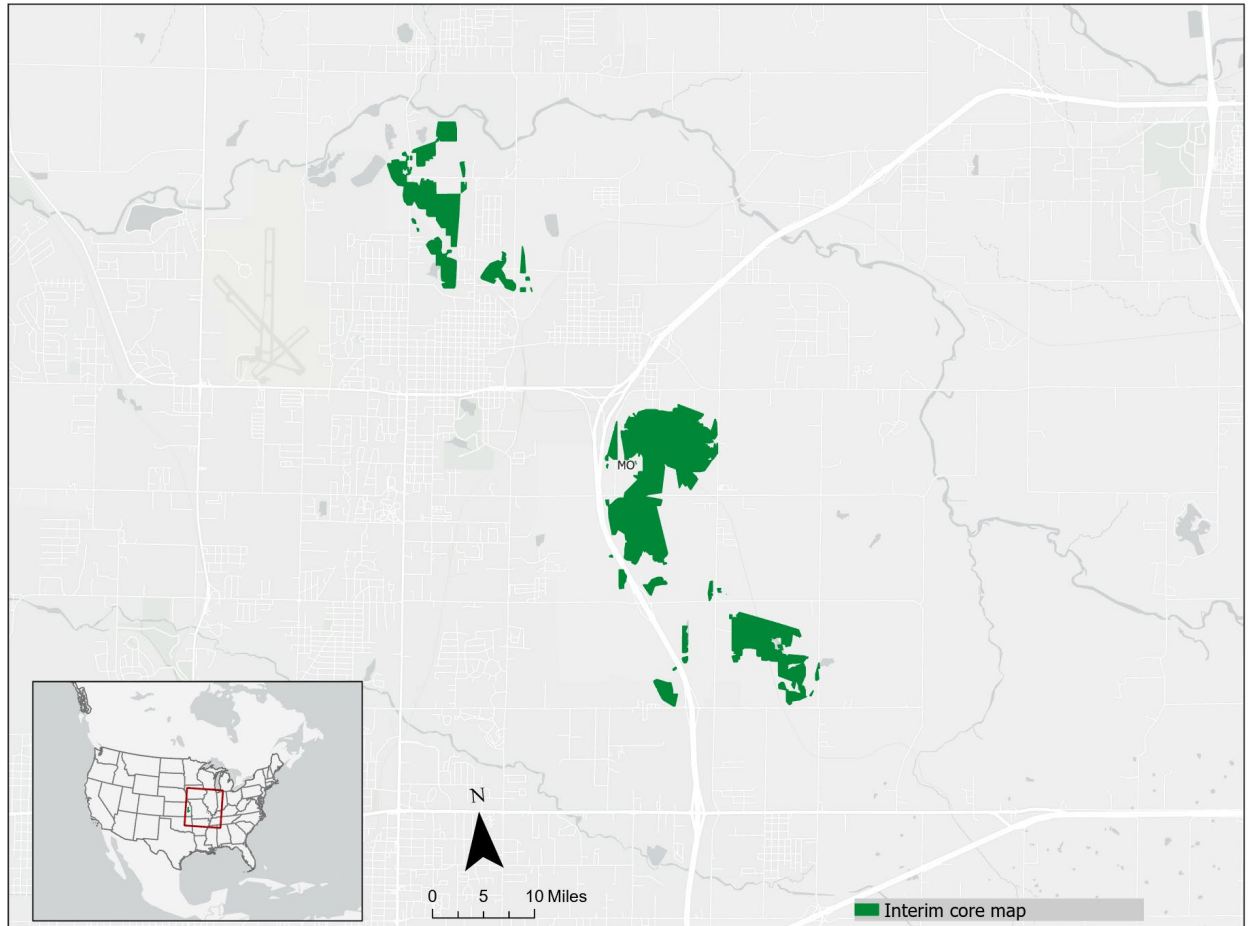
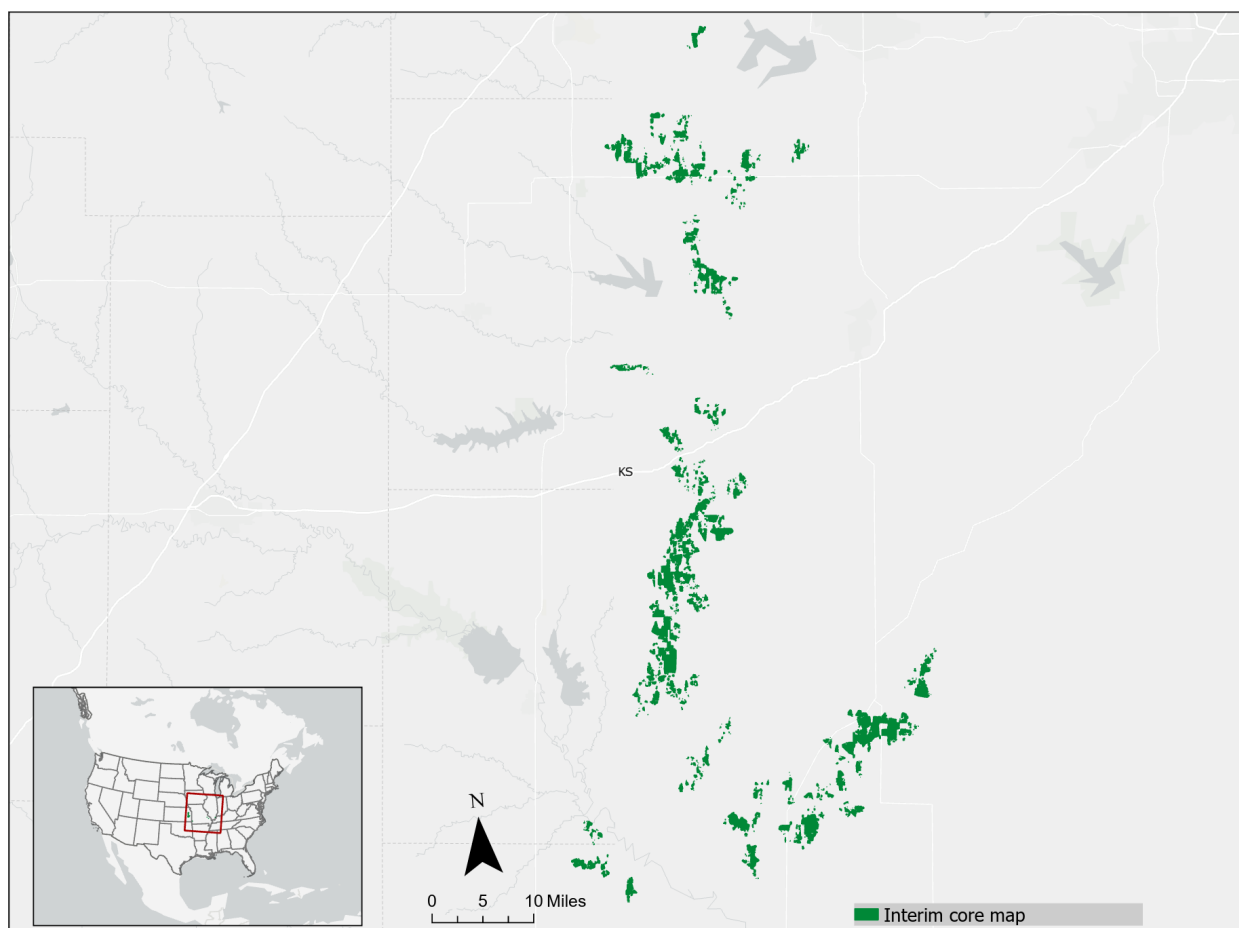**Figure A3-1. Southeast Illinois**

Figure A3-2. Southeast Missouri

Figure A3-3. Southwest Missouri

Figure A3-4. Kansas