Resilient and Connected Landscapes

The Nature Conservancy's North America **protection vision** is to *conserve a network of resilient sites and connecting corridors that will sustain North America's natural diversity by allowing species to adapt to climate impacts and thrive.* The corresponding **resilient and connected landscape project** is a decade long effort by over 100 scientists to map such a network using the latest science and building on a solid foundation of existing conservation plans such as TNC's Ecoregional Assessments and State Wildlife Action Plans.

The ability of a site to support biodiversity and ecological functions even as the biotic composition changes in response to climatic change is known as **site resilience**. The **resilient and connected network** analysis identifies places with higher site resilience and links them into a network. In the US, the analysis was based on three factors:

1) **Resilient Sites** (sites with connected microclimates representing all physical environments)

2) **Confirmed Biodiversity** (sites recognized for their current biodiversity values)

3) **Climate Flow** (corridors or flow zones that facilitates population movement for climate adaptation)

Resilient Sites: To identify a representative portfolio of places with high resilience, we first identified the physical drivers that underly current biodiversity patterns such as soils, geology, elevation, and topography, and used them to create a template for conservation that will endure under any climate. This approach to conservation planning, called **Conserving Nature's Stage,** recognizes that the biotic actors/actresses will likely change over time, but the different physical stages will continue to support distinct species. Collectively a network of representative sites could sustain the full spectrum of diversity into the future. For each physical setting we next identified the places with the most microclimates and highest local connectedness. These characteristics increase site resilience by offering the resident species many climate options that buffer them from the regional climate and allow their communities to persist longer and change more slowly.

Confirmed Biodiversity: To identify sites recognized for their biodiversity value, we compiled The Conservancy's Ecoregional Assessments which identified a portfolio of sites for each of 92 ecoregions. The portfolios were based on the current location of rare species populations and exemplary examples of natural communities. We also compiled the conservation areas from each State's Wildlife Action Plans (SWAP) which mapped the most important sites for wildlife and their habitats. We overlaid the compiled sites on the resilience map and identified the resilient portion of each.

Climate Flow: To map the corridors and flow zones that facilitates population movement for climate adaptation, we developed a spatially comprehensive "resistance" grid comprised of roads, development, energy infrastructure, industrial agriculture and forestry, powerlines, and other anthropogenic features that create resistance to species movement. We analyzed the grid using wall-to-wall Circuitscape, a software which simulates electricity flowing over a surface. Using Circuitscape, we simulated populations moving over the landscape in response to climatic gradients and identified high flow areas important to many moving populations (flow zones) and concentrated flow areas where movement is likely to get channeled into narrow corridors. We prioritized them where they intersected high resilience.

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Figure 1. The Resilient and Connected Network for the Great Lakes, Tallgrass Prairie and Great Plains regions. The map integrates climate resilience, recognized biodiversity, and climate flow.

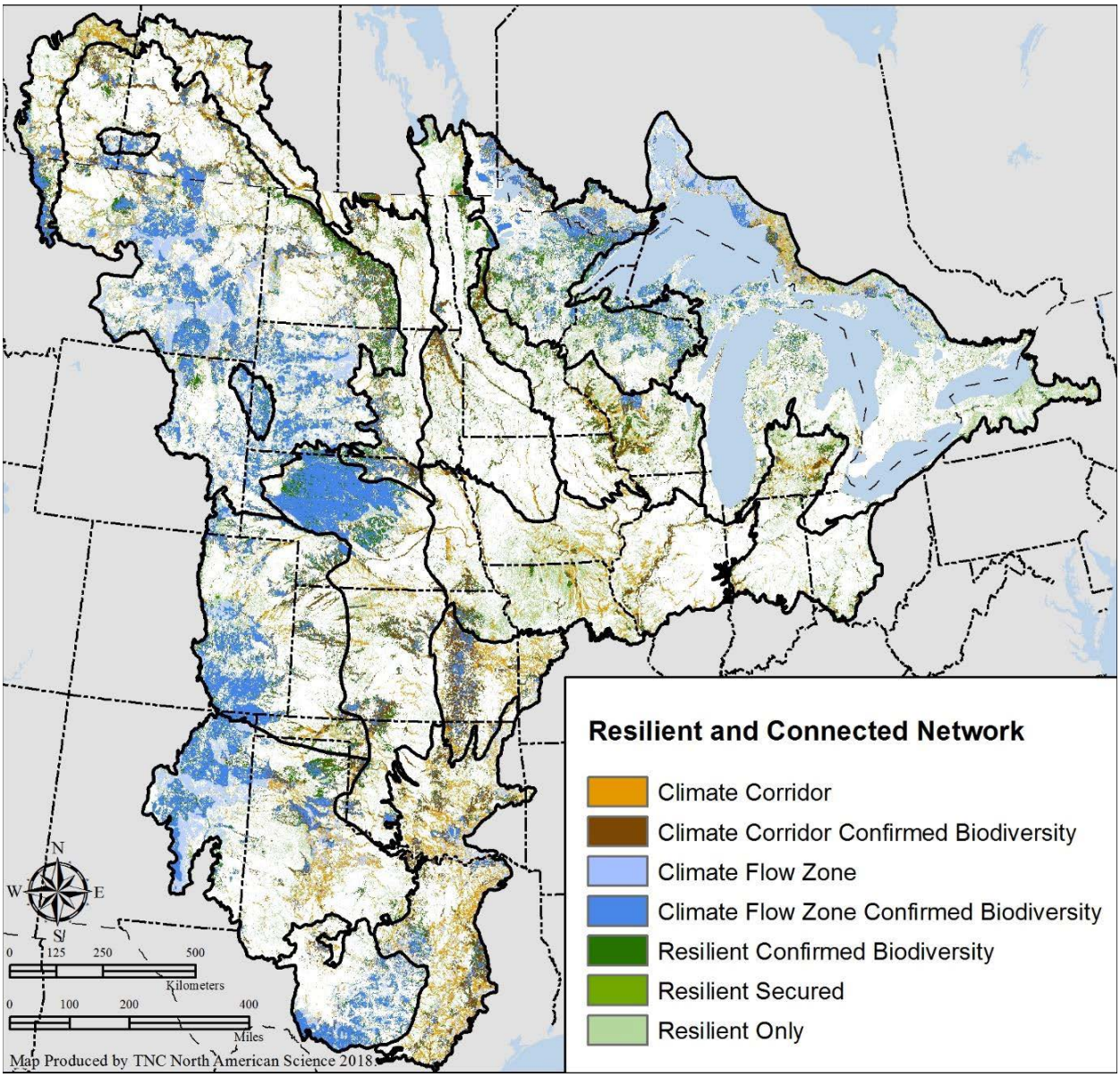

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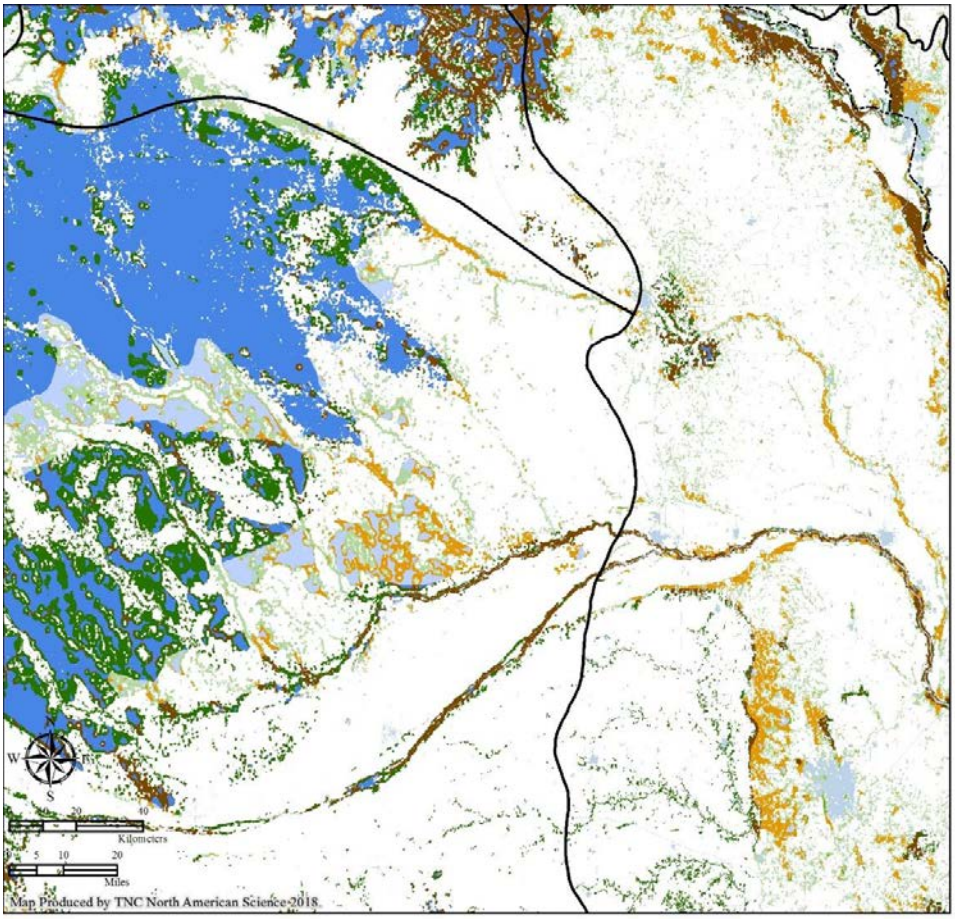
Figure 2. Zoom-in of the Resilient and Connected Network with descriptive legend.



Resilient Area: A place buffered from climate change because it contains many connected micro-climates that create climate options for species.

Resilient Areas with Confirmed Diversity: A resilient area that contains known locations of rare species or unique communities based on ground inventory. Unconfirmed areas may contain the same species

Climate Corridor: a narrow conduit in which the movement of plants and animals becomes highly concentrated, often a riparian channel or linear ridgeline.

Climate Corridor with Confirmed Diversity: A climate corridor that contains known locations of rare species or unique communities based on ground inventory. Unconfirmed areas may contain the same species.

Climate Flow Zone: areas with high levels of plant and animal movement that is less concentrated than in a corridor, typically an intact forested region. Flow refers to the movement of species populations over time in response to the climate.

Climate Flow Zone with Confirmed Diversity: A climate flow zone that contains known locations of rare species or unique communities based on ground inventory. Unconfirmed areas may contain the same species.

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Base Network: The base network was created by prioritizing resilient sites with confirmed diversity or high climate flow or both (Figure 1 and 2). The network reflects the dominant patterns of resilience and flow and covers 23% of the region.

Add-ins: The climate flow values were prioritized using regional criteria and ecoregional thresholds and they reflect the major flow patterns in the region. However, in some places the linkages do not quite connect because they pass through an area where the flow density fell below the threshold. In these places, users can view three add-in datasets to see the connecting patterns of flow and resilience. Users building a conservation plan can add these linkages to the network. The three add-ins are:

- **High resilience**: resilience score greater than 84% of comparable settings (e.g. >1 SD)
- **High resilience and flow**: the combined score of resilience plus flow greater than 84% of other cells (e.g. >1 SD)
- **All resilience**: this add-in displays all areas with a resilience score greater than 69% of comparable settings (e.g.>0.5 SD, slightly above average or higher)

Three examples illustrate how users can use the add-ins on the resilient and connected network web tool to study potential areas needed to connect fine-scale linkages (Figure 3-5).

Resources

Resilient and Connected Landscapes for the Central US.
https://tnc.app.box.com/s/hppzli6rkfymvmcbi79dl0luukkkl9i4

Resilient Sites for Terrestrial Conservation in the Great Plains
https://easterndivision.s3.amazonaws.com/GP_Resilience/Great_Plains_Resilience.pdf

Resilient Sites for Terrestrial Conservation in the Great Lakes and Tallgrass Prairie
https://easterndivision.s3.amazonaws.com/Terrestrial/Great_Lakes_Resilience/Great_Lakes_and_Tallgrass_Prairie_Resilience_05_11_18.pdf

Resilient Land Mapping Tool
http://maps.tnc.org/resilientland/

Estimating Climate Resilience
https://onlinelibrary.wiley.com/doi/full/10.1111/cobi.12272

Conserving Nature's Stage
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0011554

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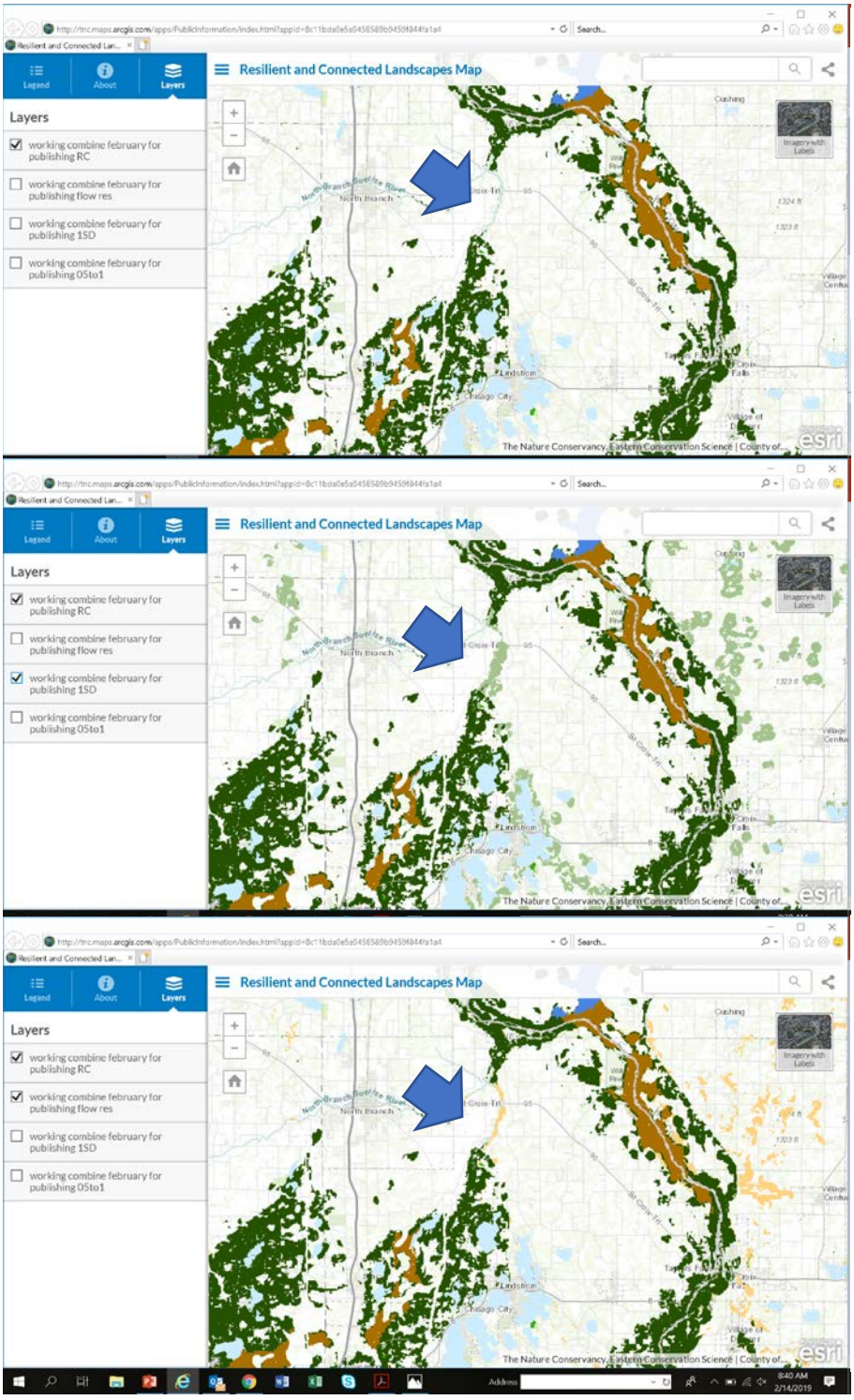
Figure 3. Add-in Example: Sunrise River, MN, Superior Mixed Forest Ecoregion



Resilient and Connected Network: This picture shows the base layer for the RCN. The arrow shows a section of the Sunrise River (MN) that was not included in the network because it did not have confirmed diversity or meet the minimum flow threshold.

High Resilience Area (Add-in): This picture shows the **add-in** layer for **high resilience** (resilience greater than 1 SD above the mean). When it is turned on it becomes clear that the missing section has high resilience. The section could be added to the network to complete the linkage

High Resilience/Flow Area (Add-in): This picture shows the **add-in** layer for **high resilience and high flow** (combined score greater than 0.5 SD above the mean). When this is turned on it becomes clear that this missing section has relatively high resilience and high flow, although it did not meet the minimum threshold for the region. This section could be added to the network to complete the linkage.

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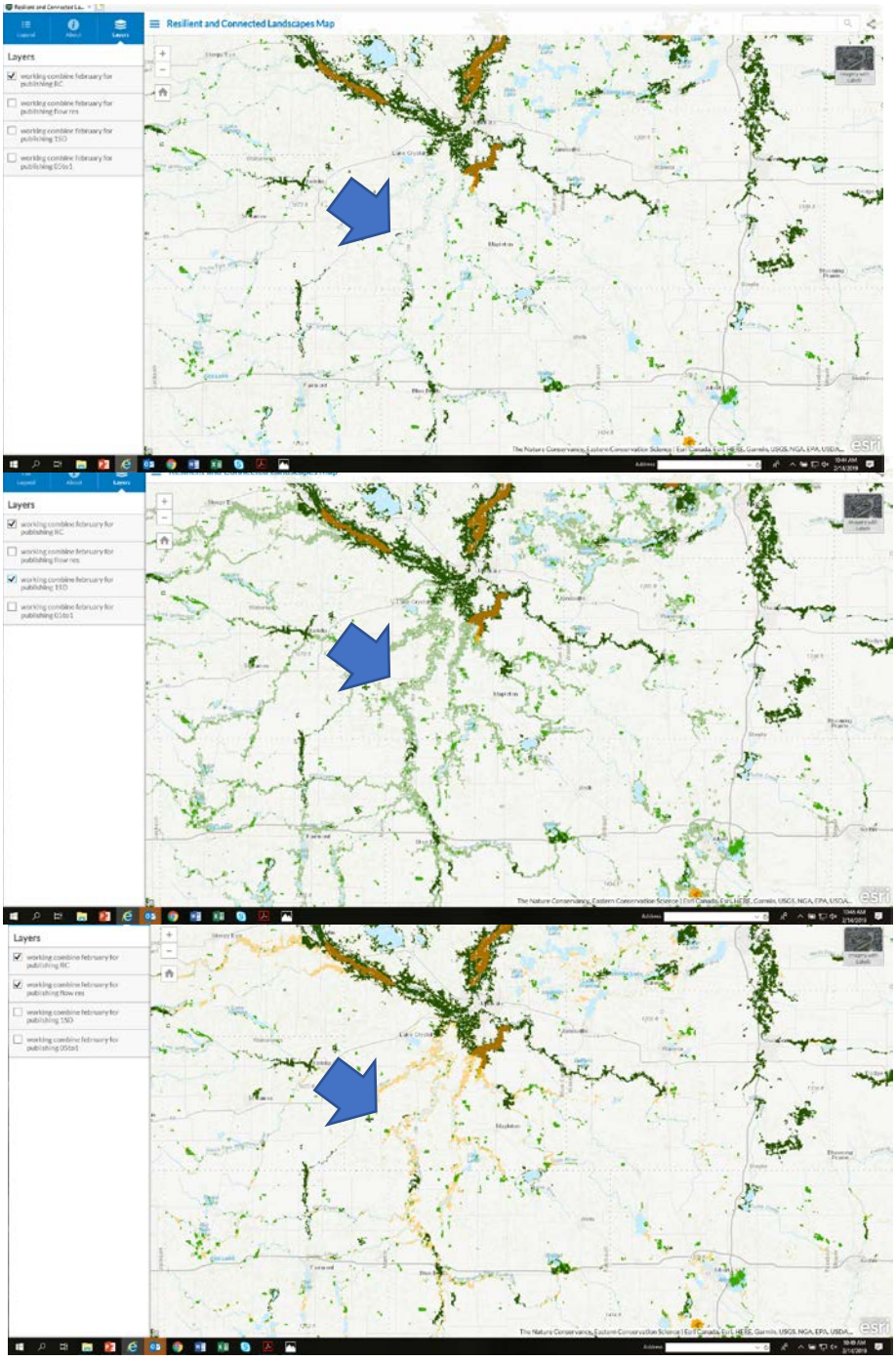
Figure 4. Add-in Example: Blue Earth River, MN, Northern Tallgrass Prairie Ecoregion.



Resilient and Connected Network: This picture shows the base layer for the RCN. The arrow shows a section of the Blue Earth River (MN) that was not included in the network because it did not have confirmed diversity or meet the minimum flow threshold.

High Resilience Area (Add-in): This picture shows the **add-in** for **high resilience** (resilience greater than 1 SD above the mean). When it is turned on it becomes clear that the missing section has high resilience. The section could be added to the network to complete the linkage

High Resilience/Flow Area (Add-in): This picture shows the **add-in** for **high resilience and high flow** (combined score greater than 0.5 SD above the mean). When this is turned on it becomes clear that this missing section has relatively high resilience and high flow, although it did not meet the minimum threshold for the region. This section could be added to the network to complete the linkage.

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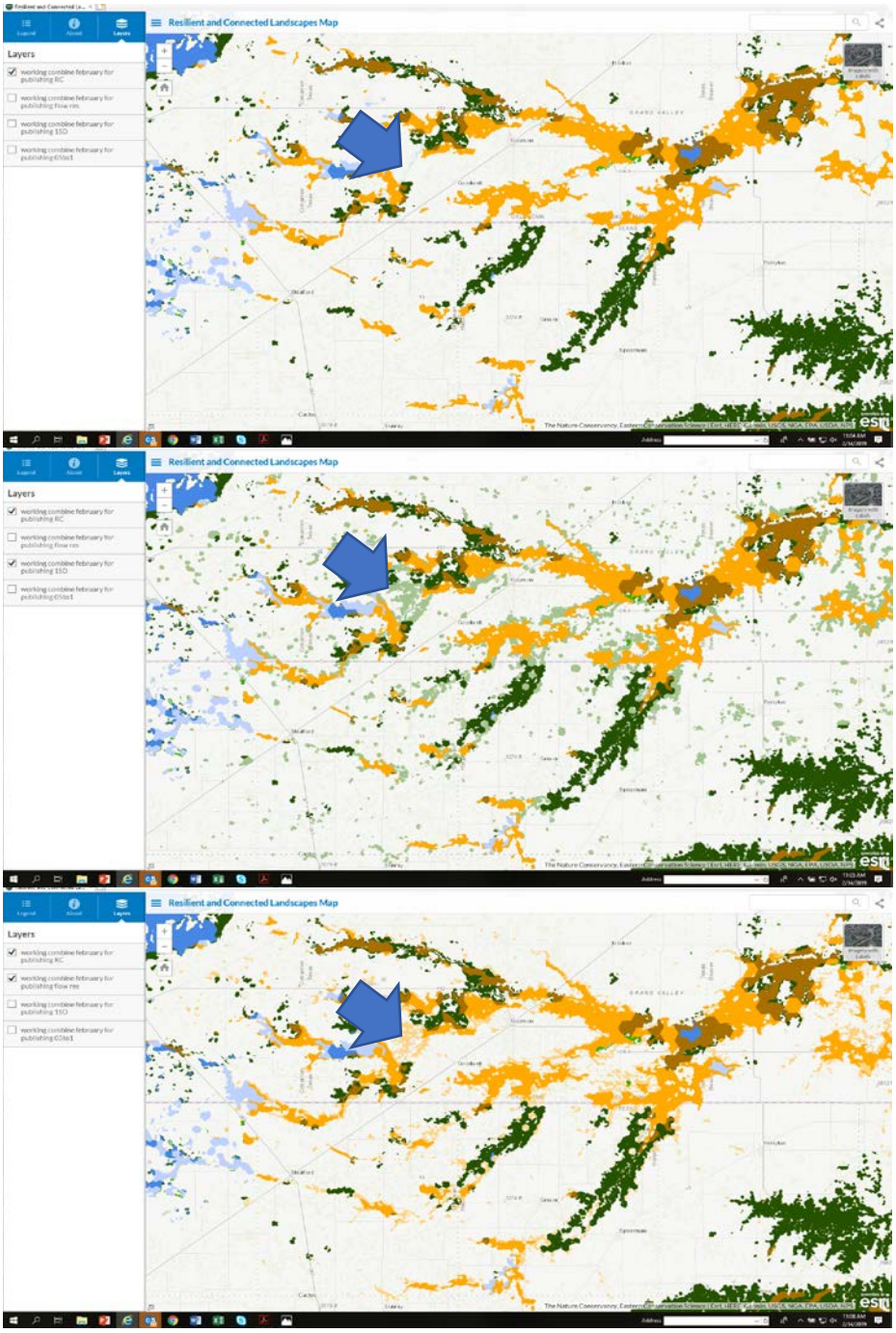
Figure 5. Add-in Example: Beaver River & Coldwater Creek, TX/OK, Central Shortgrass Prairie Ecoregion



Resilient and Connected Network: This picture shows the base layer for the RCN. The arrow shows sections of the Beaver River (OK), and Frisco and Clearwater Creek (TX) that were not included in the network because they did not have confirmed diversity or meet the minimum flow threshold.

High Resilience Area (Add-in): This picture shows the **add-in** for **high resilience** (resilience greater than 1 SD above the mean). When it is turned on it becomes clear that the missing sections have high resilience. The sections could be added to the network to complete the linkage

High Resilience/Flow Area (Add-in): This picture shows the **add-in** for **high resilience and high flow** (combined score greater than 0.5 SD above the mean). When this is turned on it becomes clear that this missing sections have both high resilience and high flow, although they did not meet the minimum threshold for the region. This section could be added to the network to complete the linkage.

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