Planning Trails for People and Wildlife

GIS Technical Data Notes

New Hampshire Fish and Game Department, Nov. 2017 (revised August 2020)

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Summary - Model updated with new locations of tracked species, new land cover, and WAP 2020.

The NH Fish and Game Department was funded by the U.S. Fish and Wildlife Service to assess the impacts of recreational trails on wildlife in New Hampshire. The approach was to review current published research, establish parameters, and develop a geospatial analysis tool to help with trail planning. The GIS process was used to assess the impact of existing trails and will provide information to help plan new trails (or relocations) that minimize disturbance to wildlife. Spatial data layers were assembled, and future outreach materials will include recommended best management practices, that address the following issues:

- zones of trail influence (wildlife alert and flight distances)
- keep unfragmented trail-free areas as large as possible
- avoid small patches of high quality or special habitats
- avoid riparian areas, permanent features in the landscape serving as wildlife corridors
- avoid locations of tracked wildlife species and exemplary natural communities

Objectives

1.) Complete a Literature Review of current research on the impact of trails on wildlife
2.) Develop a GIS process to assess existing trails and guide location/planning new trails
3.) Prepare guidance documents: GIS Technical Data Notes; Trails BMPs
4.) Case Studies: Lower Shaker WMA; Stonehouse Forest

Planning new trails or relocations

Guided by findings in the literature review, we created resistance curves based on minimizing trail impact on wildlife and protecting water quality. Statewide raster data sets were created representing five variables (Table 1). These were combined using a weighted sum approach. The output is sometimes referred to as a "cost" surface, where trail cost (or resistance) represents the relative impact to wildlife.

Table 1. Five variables, input to the trails GIS analysis, were combined using a weighted sum:

Weight (*based on input from multiple agencies/organizations at the Oct. 10, 2017 workshop*):

2.0 x	Avoid special habitat types
1.8 x	Route trails outside riparian areas
1.8 x	Route trails along habitat edges to help maintain larger unfragmented habitat patches
1.1 x	Avoid known locations of tracked species
1.0 x	Avoid steep slopes

Trail and Wildlife Experts Review - October 10, 2017 included representatives from:

- Ibis Wildlife Consulting
- Lakes Region Conservation Trust
- Monadnock Conservancy
- National Park Service
- NH Audubon
- NH Dept. of Transportation
- NH Fish and Game Dept.
- NH Trails Bureau
- Society for the Protection of NH Forests
- Southeast Land Trust of NH
- UNH Cooperative Extension
- US Forest Service
- Upper Valley Trails Alliance
- Washington Conservation Commission
- White Mountain National Forest

1.) Avoid patches of Special Habitats, including:

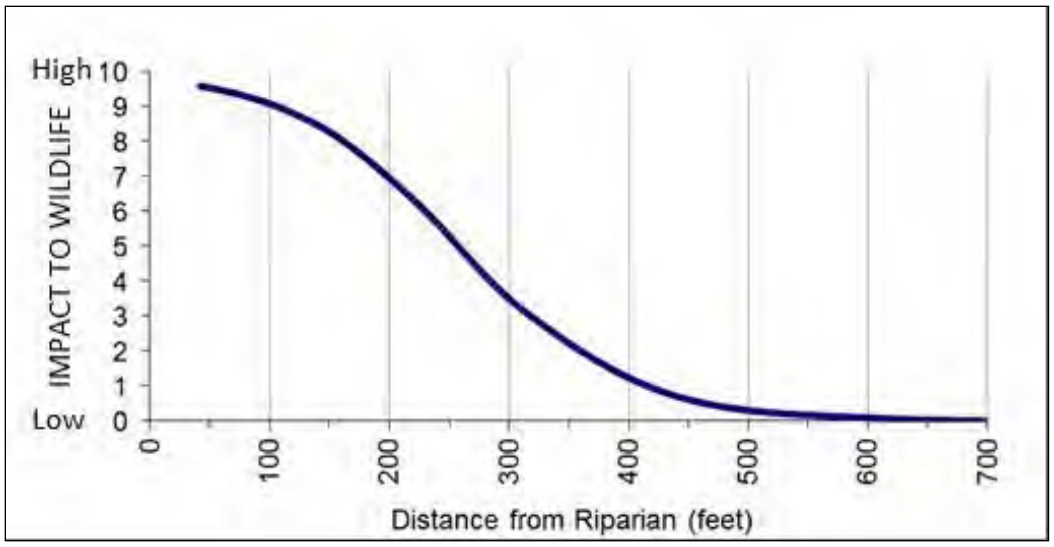
- Pine barrens
- Shrublands
- Gravel pits
- Wetland/aquatic habitat
- Very poorly drained soils
- Grasslands (over 25 acres)
- Alpine and cliff/talus/rocky ridge habitat where tracked species occur
- Natural Communities tracked in the NH Natural Heritage Bureau database

Model does not use a resistance curve for these special habitat features, nor any buffer. Instead a fixed cost (impact) is applied and the effect should be to direct new trails, or trail relocations, just outside of these special habitats.

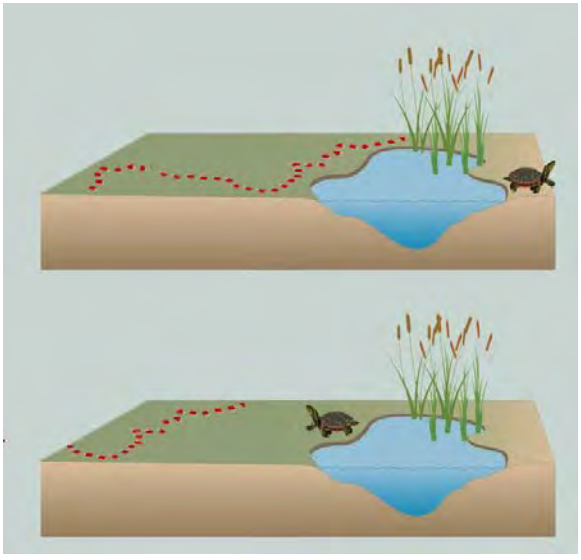
2.) Route trails outside of riparian areas

Riparian = all streams, rivers, lakes, ponds, estuaries, National Wetlands Inventory (NWI) wetlands (fresh and tidal) including the new NWIplus data for southern NH, and potential MHHW extent for intermediate Sea Level Rise for Year 2100.
Euclidean distance is calculated to all of these riparian features (data layer = "dist_rip")

Resistance curve based on NH wetland buffers:
30 ft critical, high impact within 100 ft, moderate at 330 feet, no impact at 650 feet



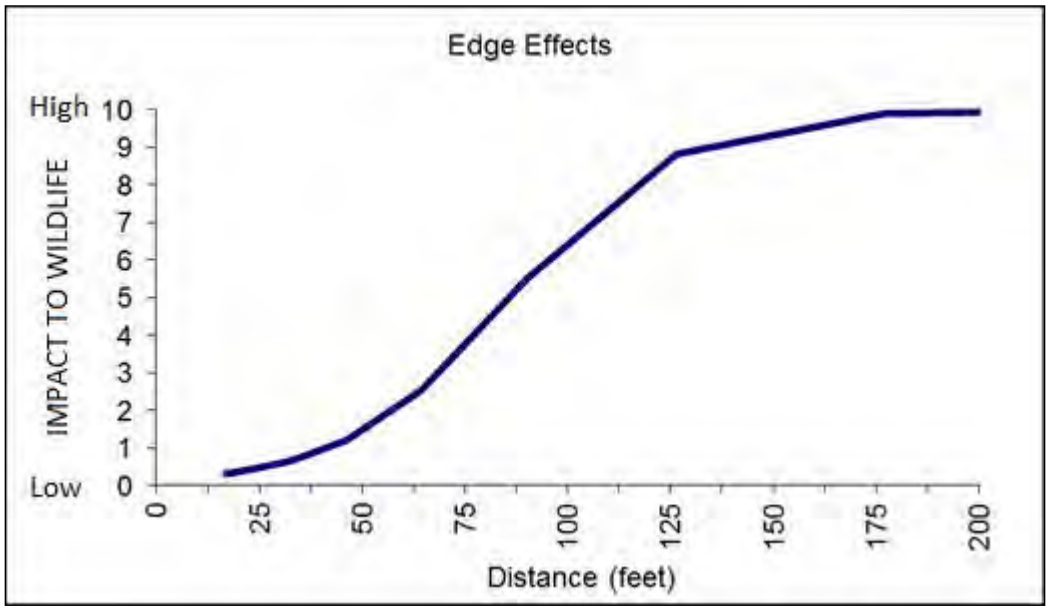
ArcGIS Raster Calculator expression: RipImpact = 10 / (1 + (0.025 * (Exp(0.02 * ("dist_rip")))))



Route trails away from riparian areas.

100 feet = benefit for multiple species

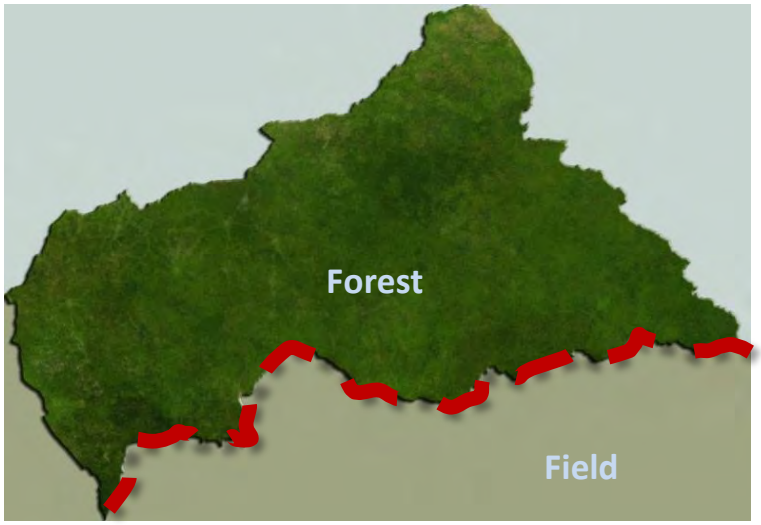
3.) Locate trails along habitat edges to maintain unfragmented habitat patches



Edges are defined by first grouping the 2020 NH Wildlife Action Plan (WAP) habitats:

- Forest
- Grassland
- Pine barrens
- Wetlands/Aquatic
- Rocky ridge/talus slopes/cliffs
- Alpine
- Developed* (NOAA C-CAP 2016 land cover). *very close proximity to buildings = high cost to avoid social conflicts of different land use

Euclidean distance is then calculated from the edges of these grouped habitats.
A resistance curve is used to estimate relative impact from trails:
Raster Calculator expression: EdgeImpact = 10 / (1 + (75 * (Exp(-0.05 * ("dist_edge")))))



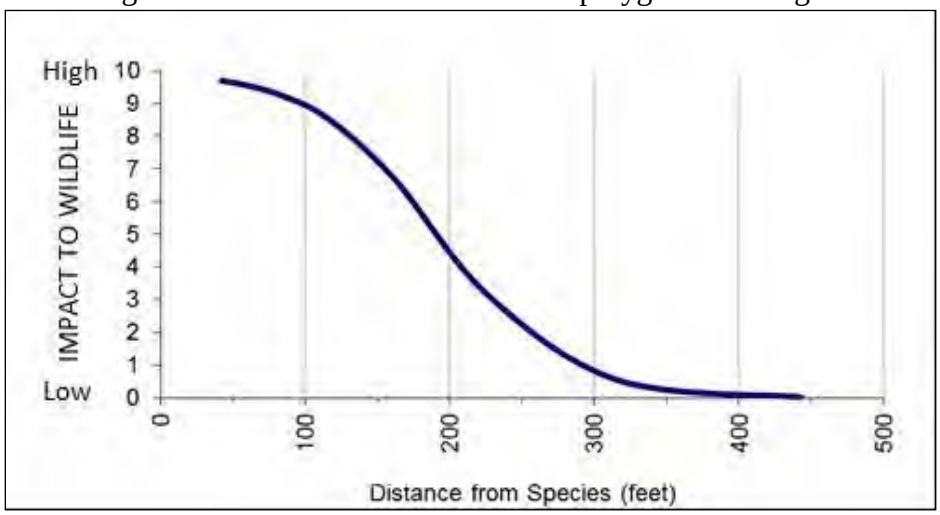
Impact to riparian areas takes precedent over distance to edge. In ArcGIS this was determined using cell statistics tool and the maximum value of the two cost surfaces (riparian impact and habitat edges).

4.) Avoid known locations of tracked species and core populations.

Animal Species tracked in the NH Natural Heritage Bureau rare species database (Biotics), occurring since 1975 and high accuracy location.

Selection of NHB records in ArcGIS: PACE = 'A' AND EOPrec = 'High' AND YEAR > 1975

+ Added great blue heron rookeries and cliff polygons w/Peregrine nests.



Raster Calculator expression: SpeciesImpact = 10 / (1 + (0.012 * (Exp(0.02 * ("dist_eo")))))

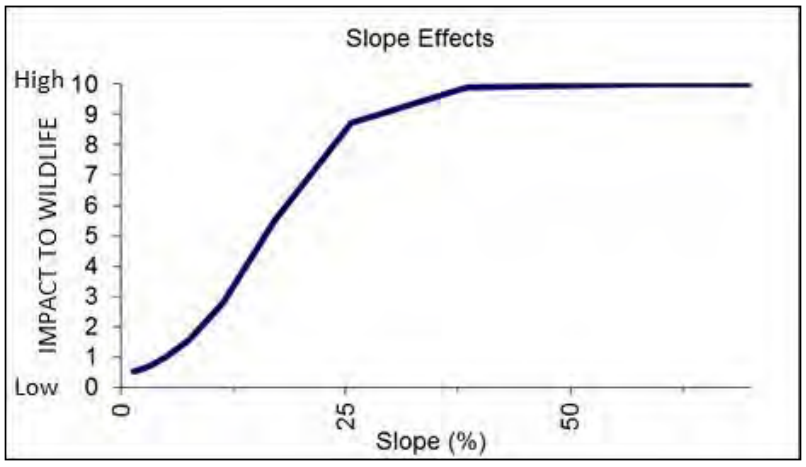
+ Also added the **2020 NH Wildlife Action Plan** (WAP) Tiers where selected rare wildlife occur: Animal occurrence records were extracted from the NH Natural Heritage Bureau database and overlaid on the WAP habitats. For some species, known core populations, population models or reproductive data were used to refine locations to core populations. Except where noted, the presence of these species elevated the habitat patch to Tier 1: Highest Ranking by Ecological Condition in New Hampshire. Criteria used to select species: Endangered or threatened in NH, Limited populations known or likely to occur, Isolated or restricted in NH.

WAP Tier 1 Add-in → trails model resistance score = 10 (overrides SpeciesImpact, if higher)

WAP Tier 2 Add-in → trails model resistance score = 5 (overrides SpeciesImpact, if higher)

5.) Avoid steep slopes

Percent slope was calculated from a 10-meter resolution Digital Elevation Model using ArcGIS with the Spatial Analyst extension.



Raster Calculator expression: SlopeImpact = 10 / (1 + (25 * (Exp(-0.2 * ("slopepct")))))

Note: All of the resistance curves can be applied using either these raster calculator equations or the **Rescale by Function tool in ArcGIS**

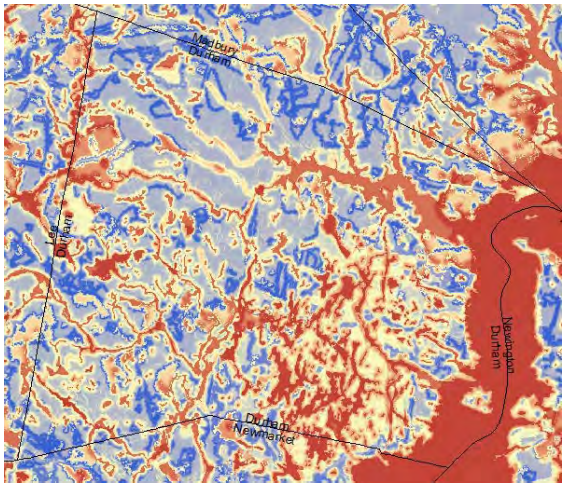
Final step: weighted sum of the 5 variables

Using ArcGIS calculate the weighted sum of the five raster data sets:

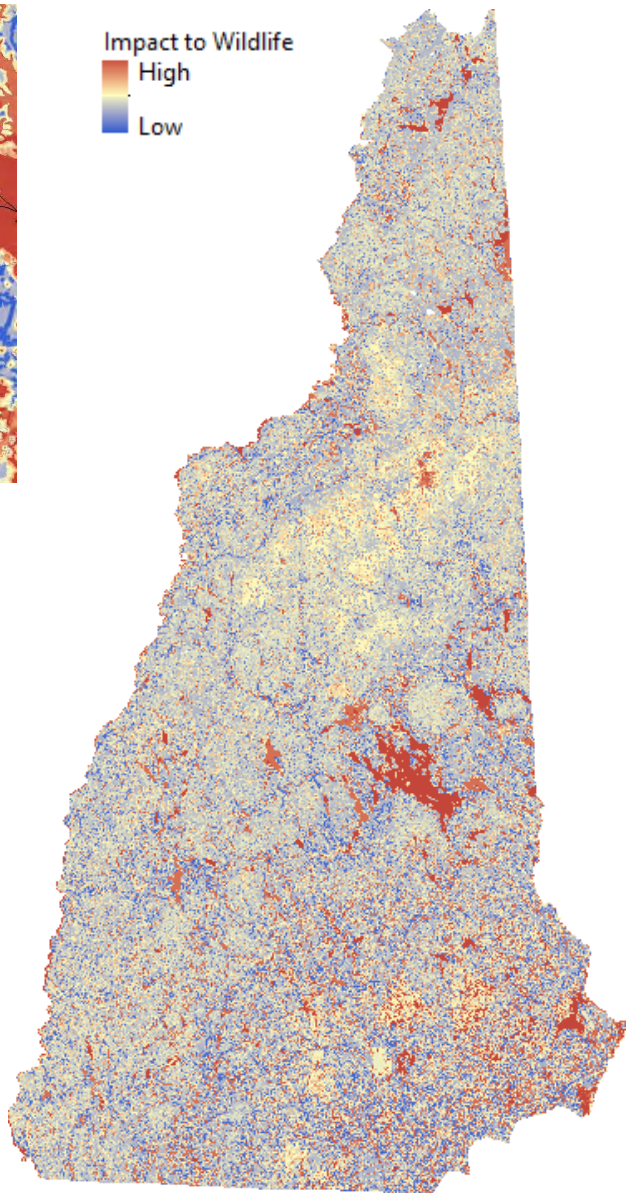
1. Avoid special habitat types
2. Route trails along habitat edges to help maintain larger unfragmented habitat patches
3. Route trails outside of riparian areas
4. Avoid known locations of tracked species
5. Avoid steep slopes over 20%

The weighting is based on results of experts review at the October 2017 workshop:
(Special habitats * **2)** + (Riparian * **1.8)** + (Edges * **1.8)** + (Tracked Species * **1.1)** + (Steep slopes * **1)**

The result is then normalized to statewide raster, values of 1-100 (low-to-high, impact to wildlife); and building footprints are masked out of the surface.



Example Durham, NH



Dataset: TrailsImpact (format grid)
Available from: www.granit.unh.edu

RIPIMPACT = value 0-to-10 low-to-high riparian impact, closer to riparian has higher impact to wildlife
EDGEIMPACT = value 0-to-10 low-to-high edge habitat impact, further from edge has higher impact to wildlife
HABSPECIMPACT = value 0-to-20 combined low-to-high impact of special habitats and species of concern
SLOPEIMPACT = value 0-to-10 low-to-high impact to wildlife
TRAILIMPACT = value 1-to-100 this is the weighted sum or total relative impact of trails on wildlife.
use this field to symbolize data

Evaluating existing trails

Step 1: Use the Add Surface Information tool in the ArcGIS 3D Analyst extension. Calculates elevation, 3D length, and slope of trail segments.

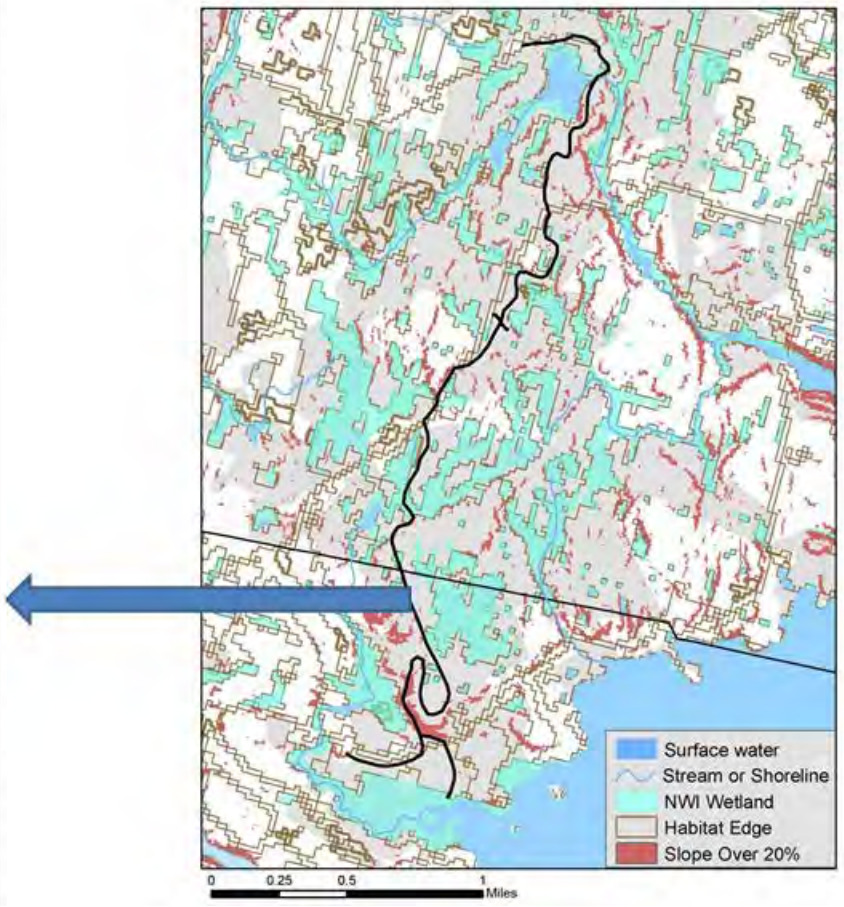
Step 2: In ArcGIS use basic spatial queries to identify trails in close proximity to eagle areas, raptor nests, heron rookeries, riparian areas, and deer wintering areas. *Note: the only spatial data for eagles, raptors and historic GBH rookeries are occurrences in the NH NHB records. Attributes should be updated with current local data sources whenever possible.

Step 3: In GME, use the isectlinerst tool to create, for each trail segment, a summary of values from distance raster layers (that were prepared for the trails impact model). Min., Max., and Length weighted mean.
Beyer, H.L. (2012). Geospatial Modelling Environment (Version 0.7.3.0). (software). URL: http://www.spatialecology.com/gme

Step 4: Buffer trails based on wildlife species' Alert and Flight response distances (based on Literature Review). Overlay these buffers on parcel or habitat data layers to visualize impact of trails on wildlife.

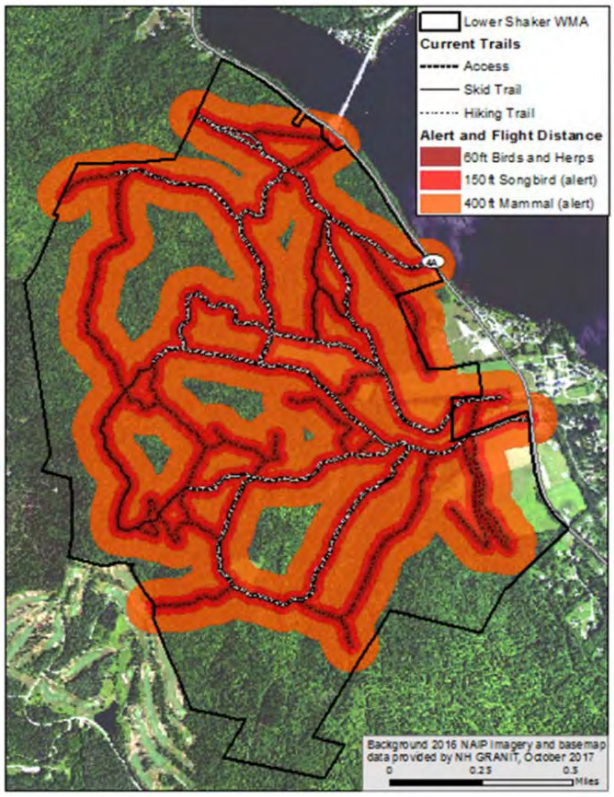
Attribute	Definition
ELEVMIN	minimum elevation of trail section (feet)
ELEVMAX	maximum elevation of trail section (feet)
ELEVMEAN	mean elevation (feet)
LENGTH3D	3D length (feet)
MILES3D	3D length (miles)
SLOPE_MIN	minimum slope of trail (%)
SLOPE_MAX	maximum slope
SLOPE_AVG	average slope
EAGLE650	Y = within 650 feet of eagle nest or roosting area
RAPTOR330	Y = within 330 feet of raptor nest (peregrine EOs)
HERON330	Y = within 330 feet of great blue heron rookery
DWA100FT	Y = trail is within 100 feet of mapped deer wintering area (VT, NH, ME)
RIPBUFFT	length of portion of trail that is within 100 feet of riparian features
RIPBUFPCT	Percent of trail segment within riparian buffer
EDGELWM	Distance to habitat edge (length weighted mean)
EDGEMIN	Minimum distance to habitat edge
EDGEMAX	Maximum distance to habitat edge
RIPLWM	Distance to riparian (length weighted mean)
RIPMIN	Minimum distance to riparian
RIPMAX	Maximum distance to riparian
SLPLWM	% Slope trail crosses (length weighted mean)
SLPMIN	Minimum % Slope trail crosses
SLPMAX	Maximum % Slope trail crosses
HABSPPCLWM	Special Habitat and Species combined Cost 0-10 (length weighted mean of impact)
HABSPPCMIN	Minimum Habitat & Species Cost (impact)
HABSPPCMAX	Maximum Habitat & Species Cost (impact)
COSTLWM	Length weighted mean of overall trail cost (relative impact to wildlife)
COSTMIN	Minimum trail cost
COSTMAX	Maximum trail cost

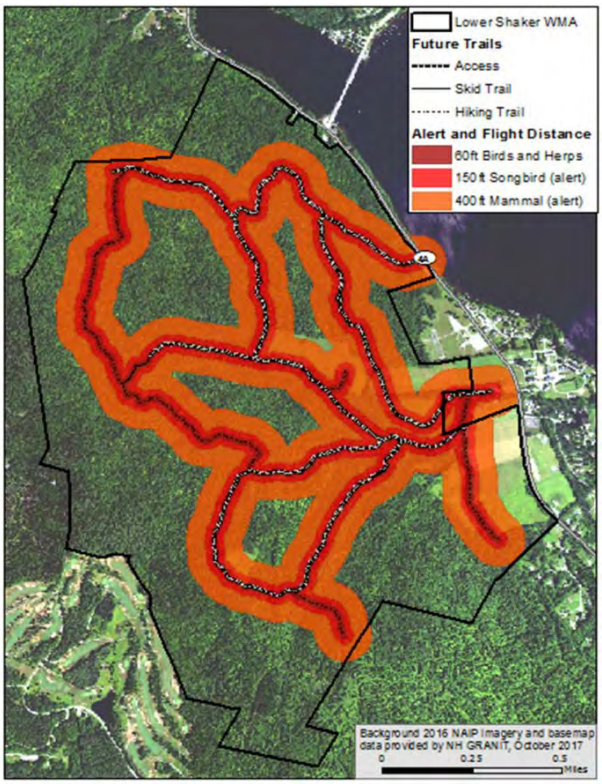
NAME	Sweet Trail
PROPNAME	Crommet and Lubberland Creek
ACCURACY	3
MILES	1.335996
BLAZECOLOR	
CATEGORY	Single-Use
TYPE	Hiking Trail
SNOWMACHIN	N
OHRV	N
ELEVMIN	37
ELEVMAX	131
ELEVMEAN	95
MILES3D	1.34142
SLOPE_MIN	0.00656
SLOPE_MAX	38.4936
SLOPE_AVG	6.82795
EAGLE650	N
RAPTOR330	N
HERON330	Y
DWA100FT	Y
RIPBUFFT	3960
RIPBUFPCT	56.1379
EDGELWM	162.158825
EDGEMIN	0
EDGEMAX	440.169983
RIPLWM	203.041049
RIPMIN	0
RIPMAX	624.22113
SLPLWM	13.587764
SLPMIN	0.039529
SLPMAX	66.788078
TRAILID	19074
HABSPPLWM	0
HABSPPMIN	0
HABSPPMAX	0
CSTLWM	51.836174
CSTMIN	36.963554
CSTMAX	78.699722

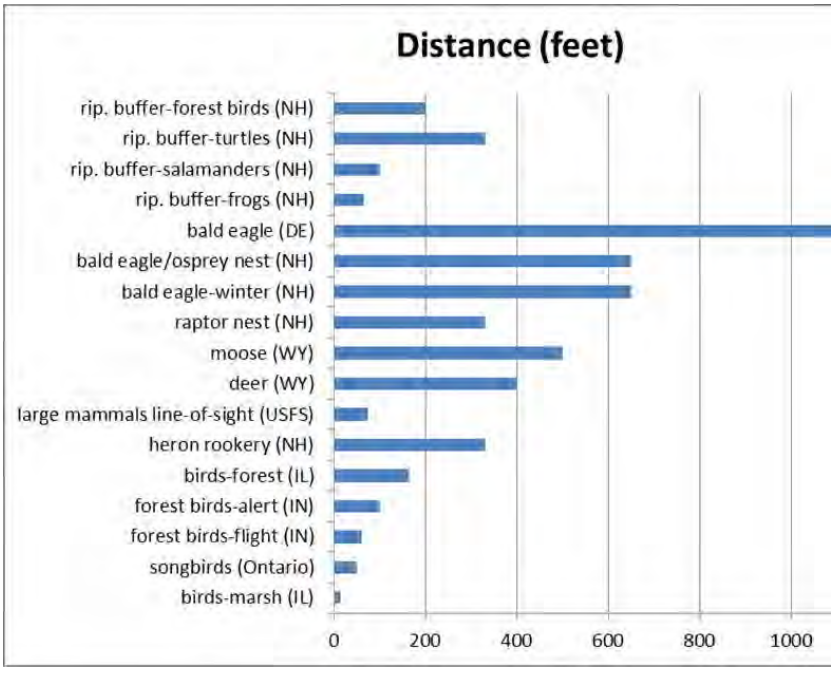


Attributes used to evaluate potential trails impact on wildlife were assigned to each trail segment. The trail segment identified in the example above indicates there is a partial issue with steep slope; and there may be high impact to wildlife as the trail segment is near a heron rookery, near a deer wintering area, and more than half the trail segment is within the riparian buffer. A GIS analysis on how to evaluate existing trails and plan new trails, or relocating trails, to help reduce impact to wildlife and water quality, is described in the following pages.

CASE STUDY: Lower Shaker Wildlife Management Area – Current & Future Trails



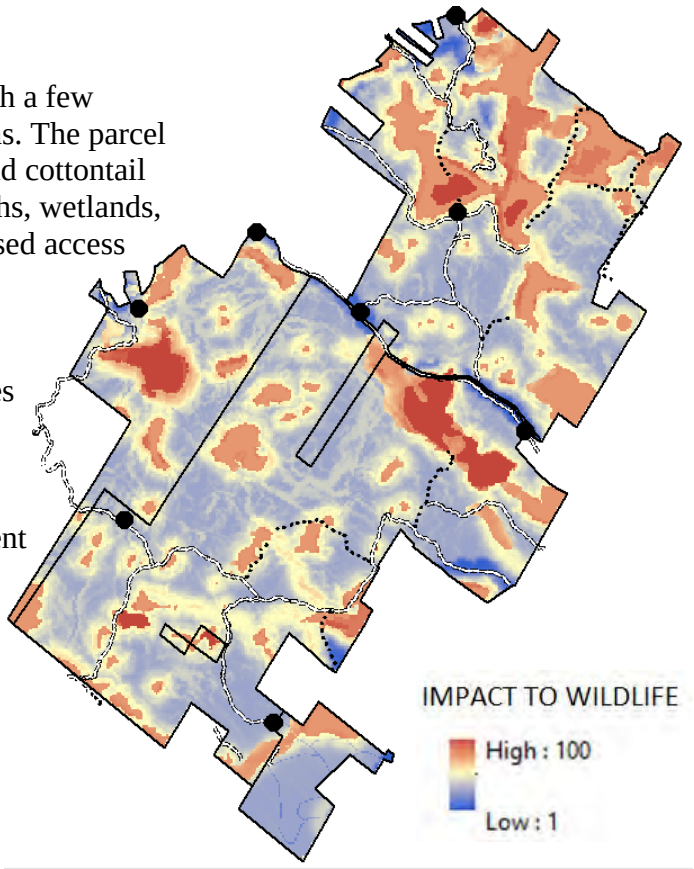




"Alert" and "Flight" ←response distances by wildlife when disturbed by human activity occurring on recreational trails. Distances averaged for species groups. Source information limited to research conducted in the Northeast. The example above illustrates what portion of the Lower Shaker WMA is being impact by recreational trails (orange-red shading). Currently there are 10 miles of trails on this 1,056 acre property, 73% of the property is impacted. After NHFG decommissioned some of the trails, the image on the right shows that impact diminished by 21% while still providing access and reducing conflict between different recreational activities.

CASE STUDY: Stonehouse Forest

A 1,500 acre parcel in southeastern NH with a few existing woods roads and informal footpaths. The parcel includes habitat for turtles and New England cottontail rabbits. Local data, such as the existing paths, wetlands, vernal pools, significant habitat, and proposed access were incorporated into the model.



Black circles represent mock destinations, such as access points, viewpoints or features of interest which would be desirable to connect with new trails.

The underlying raster data, shown in gradient blue-to-red, represents a resistance surface of low-to-high impact to wildlife. This by itself could be used in trail planning → as a visual guide.

This data layer can be used to model trail corridors with least impact to wildlife by connecting the destination spots. One software tool available from TNC is called **LINKAGE MAPPER**.

McRae, B.H. and D.M. Kavanagh. 2016. Linkage Mapper Connectivity Analysis Software Version 1.1 The Nature Conservancy.

Corridors shaded in pink/magenta represent lowest relative impact connections between destination spots.

A second tool, CIRCUITSCAPE, called from within Linkage Mapper, is used to identify pinch-points, or locations where deviating from the modeled path would significantly increase impact to wildlife. Whereas the wider (yellow) corridors represent areas with flexibility for locating the new recreational trail.

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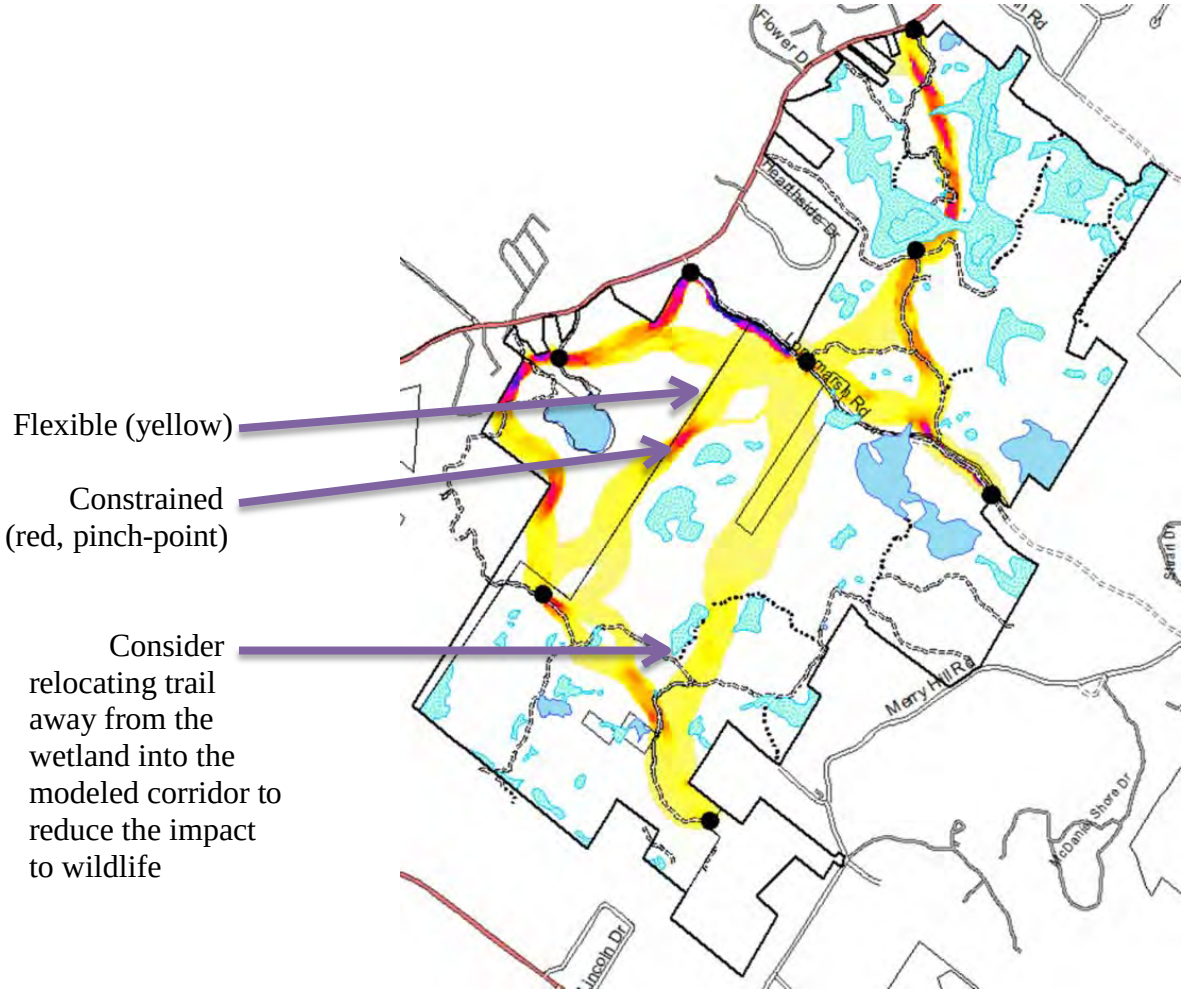

McRae, B.H., V.B. Shah, and T.K. Mohapatra. 2014. Circuitscape version 4.0.4. The Nature Conservancy. http://www.circuitscape.org

Both Linkage Mapper and Circuitscape software are free and open source. However, Linkage Mapper is provided as a toolbox for ESRI's ArcGIS Desktop software with the Spatial Analyst extension.

Technical assistance is available from the NH Fish and Game Department. Data are distributed as integer, to reduce file size; but original floating point rasters are available by request.

It is strongly encouraged that users incorporate best available local data sources and ground-truth results of corridor analyses.