Network Design - Ecological Assets

Includes high quality forest lands, wetlands, riparian, scrub/shrub, and desert lands. Also includes protected lands (including public lands and conservation easements), important bird habitat areas, wildlife reserves, and wilderness areas.

Project Goals for the Wasatch Front's Regional Ecological Green Infrastructure:
Protect and enhance the natural landscapes, ecosystems, and biodiversity of the Wasatch Front, providing habitat for the region's plant communities, wildlife and fisheries, including unique ecological communities and rare, threatened or endangered species, and other areas of environmental concern.

ECOLOGICAL NETWORK CRITERIA		
CORES	**SIGNIFICANCE/EXPLANATION**	**FURTHER RESEARCH**
1. Protected lands or public lands with ecological assets within them	Protected lands have a higher likelihood of providing permanent GI services. Inclusion of protect lands is well-documented[1].	*Need to determine if a minimum size or buffer area is needed for these protected or public lands.*
2. High quality wetlands - min. size of 50 m in diameter and not "too" isolated	Based off the American white pelican and black-necked stilt habitats. Based on literature and conversations with UDWR staff. Working with UDWR staff to identify a freshwater wetlands species.	*1. Need to determine if a minimum size or buffer area is needed for wetlands. 2. For wetlands and the remaining land cover types, future research should incorporate plant species as indicators as well.*
3. High quality uplands - lands indicated by UDWR as crucial for the mule deer and potential habitat for the northern goshawk	These species are listed as indicator species by UDWR (mule deer) and USFW (northern goshawk in the Uinta-Cache National Forest). See end of document for specific criteria.	*Future research should incorporate plant species as indicators as well. A suggestion was made to also include Rocky Mountain Elk, as these habitats are often different and elk is an important species to the WF.*
4. High quality riparian areas – all streams with documented occurrences of the Bonneville Cutthroat Trout (with a 50 foot buffer), and potential beaver habitat (open water, permanent streams adjacent to woody vegetation).	Recommended by UDWR and used by the Uinta-Cache National Forest as an indicator species. Based on discussions with UDWR and USFS.	*Future research should incorporate plant species as indicators as well.*
5. High quality scrub/shrub areas - lands indicated as critical or substantial for the Greater Sage Grouse	Based off the greater sage grouse habitat layer provided by UDWR.	*Future research should incorporate plant species as indicators as well.*
6. Areas of Critical Environmental Concern	A BLM designation – includes the Bonneville Salt Flats and Horseshoe Springs within this study area.	
Exclusion Factors:		
1. For priority saline wetlands – remove areas of high human disturbance	Includes marinas, recreational trails, fishing areas, etc. Conversation with John Neill, UDWR - 9/13/2010	*Fishing areas should be evaluated on a case-by-case basis- recommend including this in future research*

2. Remove areas affected by development	Buffer recommendations – 180 m (Odell and Knight 2001), Bock 1999 - 200 m (see Lenth 2006 paper for reference)	
3. Remove areas affected by invasive species	Based on data downloaded from AGRC, including invasive species and dominant vegetation shapefiles.	
4. Remove riparian areas with diversions, dams, culverts and de-watered reaches; For beavers remove recreational areas and mineral developments.	These areas serve as barriers to BCT migration (pers. comm. with UDWR 2010). As per the USFS Suitability analysis, beavers will not establish colonies where significant human disturbance is located.	*Culverts should be evaluated on a case-by-case basis – recommend including this on a more site-specific study.*
5. Exclude major roads.	Species will be negatively affected by roads, through mortality or avoidance.	
HUBS	**SIGNIFICANCE/EXPLANATION**	**FURTHER RESEARCH**
1. Reservoirs	American white pelican utilizes these areas.	
2. High priority forest lands	DFFSL completed a planning process in 2010 that identified priority forest lands.	
3. For upland habitats – lands indicated as substantial habitat for mule deer and areas with aspen as dominant vegetation cover for goshawks.	Substantial mule deer habitat based on data from UDWR. Based on breeding and foraging requirements (from USFS), aspen is important for the northern goshawk (USFS).	
4. Wildlife Action Areas within the study area & important wildlife areas	As per the Wildlife Action Plan developed by UDWR and Ogden Valley important wildlife areas	
5. For scrub/shrub habitat for sagegrouse - all areas of sagebrush within 1 mile of masked species locations	Habitat data provided by UDWR was masked up to 1 mile, as per confidentiality reasons, these hub areas would encompass all possible habitats. As this species is a sagebrush-obligate species, hubs should include areas with sagebrush as the dominant vegetation species.	
6. Riparian areas - all permanent streams that have surrounding forest land cover.	Beaver criteria reviewed by USFS.	
7. Important Bird Areas	Areas identified as important for a suite of bird species throughout the region (UDWR, pers. comm. 2010)	
Exclusion Factors:		
1. Exclude roads that create barriers for species travel, e.g. major highways	Species will be negatively affected by roads, through deaths in crossing or avoidance.	
2. Remove areas affected by development	Buffer recommendations – 180 m (Odell and Knight 2001), Bock 1999 - 200 m (see Lenth 2006 paper for reference)	

CORRIDORS	SIGNIFICANCE/EXPLANATION	FURTHER RESEARCH
1. For riparian areas -Least-cost path analysis between the core areas, using acceptable habitat types, e.g. the streams in the cores/hubs listed above, with preferred connections between higher quality streams and streams with woody riparian vegetation.	Based off the Bonneville cutthroat trout and Beaver, based on discussions with UDWR and USFS.	
2. For shrub/scrub and mule deer habitat areas, prioritize connections between summer and winter ranges (e.g., for mule deer and Greater Sage Grouse) and connections via preferred habitat	Based on conversations with UDWR staff, species need connections between winter and summer ranges first, then other connections.	*Species movement modeling was beyond the scope of this project and so was not included in the ecological corridor modeling. It should be considered in future planning efforts.*
3. Least-cost path analyses between the core and hub areas, using acceptable habitat types.	See least cost path analysis process below.	
4. For wetlands, utilize discharge areas, hydric soils and shallow aquifer areas for connections.	Emphasize hydrological connections to support wetland connectivity.	

[1]See Utah DFFSL 2010 Statewide Assessment document available at http://www.ffsl.utah.gov/stateassessment.php.

References:

Lenth, B. A., R. L. Knight, and W. C. Gilgert. 2006. Conservation value of clustered housing developments. Conservation Biology 20:1445-1456.

Odell, E. A., and R. L. Knight. 2001. Songbird and medium-sized mammal communities associated with exurban development in Pitkin county, Colorado. Conservation Biology 15:1143-1150.

U.S. Forest Service. (1993). The Northern Goshawk in Utah: Habitat Assessment and Management Recommendations. http://www.fs.fed.us/rm/pubs/rmrs_gtr022.pdf

Experts consulted:

Utah Division of Wildlife Resources – avian biologists, big-game biologists, upland game biologists, Utah Natural Heritage Program

Utah State University – wildlife biologists, foresters

Utah Division of Forestry, Fire, and State Lands – GIS staff, urban foresters

National Park Service Rivers, Trails, and Conservation Assistance Program

US Forest Service – wildlife biologists

Ecological Asset Network Criteria – Design Process

Ecological Cores

Species criteria for the design of the core areas:

Upland and Riparian Species:

Beaver – areas with known/documented beaver populations (data from US Forest Service), those permanent streams with woody riparian vegetation with a minimum of 0.5 miles of stream length, perennial ponds, lakes, and reservoirs with dimmable outlet (not Currant Creek, Tibble Fork, Silver Lake Flat, or Strawberry Reservoirs). Appropriate vegetation within 300' of the water body and stream gradient less than 15%. For hubs, include streams with less than 0.5 miles of length when connected to another body of water within 600 feet. Reaches of intermittent streams connected to perennial streams and ponds are considered capable. Remove recreational areas, mineral developments, administrative and development sites, and roads.

Mule deer – areas classified by UDWR as crucial or substantial habitat for this species; and

Northern goshawk – includes areas listed as nesting or post fledgling habitat areas as classified by the USFS, foraging areas will be incorporated as hubs.

Nesting habitat – appropriate forest cover types, e.g., aspen, aspen/conifer, dense conifer, etc.; minimum canopy cover of >70%, minimum patch size of 30 acres.

Post Fledgling Habitat – minimum patch of 450 acres (at least 30 acres of nesting habitat), same covers as for nesting with a canopy cover >50%, must be within .25 miles of another polygon of post fledgling habitat or nesting habitat.

Foraging habitat (hubs) – include aspen, aspen/conifer, other deciduous forest types with large trees, conifer, and oak tree types; minimum patch size of 5400 acres (excluding nest and PF habitat), all foraging habitat within 1.72 miles of nesting habitat, all canopy cover types and must include 30 acres of nesting habitat.

Note: for this study, percent canopy cover data was not available – goshawk habitat areas were based exclusively on appropriate land cover types.

1. Create a new toolbox in ArcCatalog for Recreational modeling - ~EcologicalAssets
    A. #1 Core Criteria – protected and public lands with ecological assets
        i. Select all lands with protection designation – BLM Wilderness, US Forest Service Wilderness, National Conservation Association parcels, Division of Natural Resources wildlife reserves, and ecological easements. Merge into one layer→ecolands_protected2
        ii. Convert to raster→prot_ecoland1
        iii. Reclassify to 0 and 1 for analysis→***rc_ecoprot1***
    B. #2 Core Criteria – high priority wetlands
        i. Select those wetlands (from USFWS National Wetland Inventory) greater or equal to .6 acres (as per species habitat information and conversations with UDWR staff)→ NWI_wetlands_over6ac
        ii. Remove tailings ponds south of the Great Salt Lake (as per conversations with water quality experts)
        iii. Convert to raster→all_wetlands1
        iv. Reclassify to 0 and 1 for analysis→***rc_wetlands4***
    C. #3 Core Criteria – high quality uplands

i. Select crucial mule deer habitat from data received from UDWR → MuleDeerHabitat_Crucial, convert to raster → mdeer_crucial, reclassify → rc_mdeer_cruc
ii. Extract vegetation used by the northern goshawk from the SWreGAP data → Goshawk_GAP_veg2, convert to raster→ goshawk1, reclassify → rc_goshawk1
iii. Use single output map algebra to add the above two layers → uplandhab2
iv. Reclassify to 0 and 1 for analysis→***rc_uplandhab1***

D. #4 Core Criteria – high quality riparian
i. Buffer by 50 feet streams where Bonneville Cutthroat Trout occur and streams with permanent woody riparian vegetation and merge together → riparianforcore_50ftbuff , convert to raster →riparian50ft, reclassify to 0 and 1 for analysis → rc_ripar50ft
ii. Extract from SWreGAP data all riparian vegetation types, open water and wet meadow → beaver_water; merge with streams_perm2_pgon → beaver_water2; extract from SWreGAP data all vegetation types useable by the beaver → beaver_usable_veg; select by location all features within beaver_water2 that are within 600 feet of beaver_usable_veg (per USFS beaver habitat criteria) →beaver_habitat; merge this layer with beaver_water2 → beaver_habitat2; convert to raster → beaver_hab1; reclassify to 0 and 1 for analysis → rc_beaverhab1
iii. Buffer rivers by 50 ft → rivers_50ft_buff, convert to raster → rivers_50ft, reclassify → rc_rivers50ft
iv. Use single output map algebra to add the above three layers → ripcore, reclassify to 0 and 1 → ***rc_ripcore3***

E. #5Core Criteria – high quality scrub/ shrub areas
i. Merge together sagegrouse brooding and winter habitat from AGRC →sagegrouse_habitat
ii. Convert to raster → sagegrse_hab
iii. Reclassify to 0 and 1 for analysis→***rc_sagehab***

F. #6 Core Criteria – areas of environmental concern
i. Select BLM Areas of Critical Environmental Concern →BLM_areasenvtalconcernt
ii. Convert to raster→BLM_AEC
iii. Reclassify to 0 and 1 for analysis→***rc_blm_aec2***

2. Merge together the core criteria 1 – 6
A. Use single output map algebra to add the above final, reclassified rasters together → eco_cores5
B. Use the reclassify tool to change any value above 1 to a 1, and then all nodata values to 0 → ***rc_ecocores5***

3. Create exclusion layers
A. Create exclusion factor #1 – areas of high human disturbance – marinas (note: marinas to be included with recreational areas, see exclusion factor #4), trails
i. Buffer trails and regional trails by 50 meters and merge → all_trails_50ftbuff, convert to raster → trails_50m, reclassify for analysis → ***rc_trails50m***

B. Create exclusion factor #2 – areas affected by development
i. Select developed lands from AGRC land cover →developed_land_all
ii. Buffer by 200 m →dev_land_all_200mbuff
iii. Convert to raster → urbanareas2
iv. Reclassify to 0 and 1 for analysis→***rc_urban6***

C. Create exclusion factor #3 – areas affected by invasive spp.
i. Clip noxious weeds layer from AGRC to project boundary →noxiousweeds_AGRC

ii. Select noxious weeds from dominant vegetation shapefile (from AGRC, include cheatgrass, which is not on the noxious weed list but has significant ecological and productivity ramifications)→noxiousweeds_cheatgrass
iii. Merge the noxious weeds layer →noxiousweeds_all
iv. Convert the noxiousweeds_all layer to raster (noxiousweeds) and reclassify for analysis→***rcnoxweeds1***

D. Create exclusion factor #4 – riparian barriers and human disturbance
i. Buffer dams by 50 feet →dams_50ftbuffer, merge buffered dam layer with mining lands → dams_mines, and convert to raster → dams_mines
ii. Reclassify to 0 and 1 for analysis → ***rc_mine_dam1***
iii. Use reclassified recreation area file from Recreational Core Criteria #5 (includes ski areas, marinas and golf courses) →***Rc_recareas1***
iv. Conduct single output map algebra to add these two areas → ***Rc_recmindam1***

E. Create exclusion factor #5 – road creating barriers for species travel
i. Select major roads from AGRC Roads shapefile → Roads_Major
ii. Buffer by 40 m (Forman 1995) → MajorRoads_40mbuff
iii. Convert to raster → roads_40mbuff
iv. Reclassify to 0 and 1 for analysis → ***rc_roads40m1***

F. Use single output map algebra to multiply the 5 exclusion layers together → ***ecocoreexfac2***

4. Remove exclusion layers
A. Use single output map algebra to multiply the final cores layer with the exclusion layer → ***eco_cores6*** – vector file is ecocores7

Ecological Hubs

1. Develop hub criteria
A. #1 Hub Criteria – reservoirs
i. Select the reservoirs layer → reservoirs_clip
ii. Convert to raster → reservoirs
iii. Reclassify to 0 and 1 for analysis → ***rc_reservoir***

B. #2 Hub Criteria – high priority forest lands
i. Select all Tier 1 lands from DFFSL priority areas layer→priority_areas
ii. Convert to raster→fs_priority
iii. Reclassify to 0 and 1 for analysis→***rc_fs_prior1***

C. #3 Hub Criteria – substantial mule deer habitat and areas dominated by aspen
i. Select areas dominated by aspen→aspen_dominant, convert to raster→aspen, reclassify to 0 and 1 for analysis→***rc_aspen***
ii. Extract substantial mule deer habitat from data received from UDWR → MuleDeerHabitat_Substantial, convert to raster → mdeer_subst, reclassify → rc_mdeer_subs
iii. Use single output map algebra to add the above two layers → upland_hub, reclassify → ***rc_uplandhub***

B. #4 Hub Criteria – Wildlife Action Areas and Important Wildlife Areas
i. Merge the Wildlife Action Areas as designated by the Wildlife Action Plan with Ogden Valley's Important Wildlife Habitat→wildact_impwild
ii. Convert to raster→wildact_imp1

iii. Reclassify to 0 and 1 for analysis→***rc_wild_imp3***

D. #5 Hub Criteria – shrub habitat
   i. Select all shrub lands (from GAP data) within 1 mile of masked species locations→sagebrush_adjtomaskedlocations
   ii. Convert to raster →shrub_hub1
   iii. Reclassify to 0 and 1 for analysis→***rc_shrb_hub2***

E. #6 Hub Criteria – riparian areas
   iv. Select all permanent streams adjacent to forest lands → perm_streams_adjacenttoforests
   v. Convert to raster →stream_forest
   vi. Reclassify to 0 and 1 for analysis → ***rc_stm_fores2***

F. #7 Hub Criteria – Important Bird Areas
   i. Convert the ImportantBirdAreas shapefile to raster → IBAs1
   ii. Reclassify to 0 and 1 for analysis → ***rc_IBAs2***

2. Merge together the hub criteria 1 – 7
   A. Use single output map algebra to add the above final, reclassified rasters together → eco_hubs3
   B. Use the reclassify tool to change any value above 1 to a 1, and then all nodata values to 0 → ***rc_eco_hubs2***
3. Create exclusion layers
   A. Use single output map algebra to multiply the hub exclusion factors together (rc_urban4 and rc_roads40m1) → ***ecohubexfact1***
4. Remove exclusion layers from hubs
   A. Use single output map algebra to multiply the final hubs with the hub exclusion layer → ***ecohubs_excl4***

Ecological Corridors – Least Cost Path Analysis

1. Create the cost surface raster
   a. Convert the ecocores_exc4 raster to vector → ecocores5
      i. Dissolve by value field → eco_cores_dissolve
      ii. Add field – label; start editing session – add "Cores" to the one attribute field under "label"
   b. Convert the ecocores_exc4 raster to vector → ecohubs1
      i. Erase the cores from the hubs (erase tool only available with ArcInfo license) → ecohubs_erase
      ii. Dissolve by value field → eco_hubs_erase_dissolve
      iii. Add field – label; start editing session – add "Hubs" to attribute field under label
   c. Merge together hydric soils (hydric70pct), shallow groundwater areas (grndh20_0ft) and aquifer recharge zones (aquifer_10km_boundary) → hydric_shallow_recharge
      i. Dissolve by value field → hydshallowrecharge_dissolve
      ii. Add label field; start editing session – add "Hydric soils, shallow groundh2o, aquifer recharge" to attribute field
   d. Buffer all streams by 15 m → streams_15mbuff
      i. Dissolve by buffer distance → streams_15mbuff_dissolve
      ii. Add label field; start editing session – add "All Streams" to attribute field
   e. Select all developed land from land cover layer → developed_land_all
      i. Dissolve by buffer value field → developed_land_dissolve
      ii. Add label field; start editing session – add "Developed Land" to attribute field
   f. Select appropriate habitat land cover types from NLCD layer – all forest, shrub, grassland and wetland types → forest_shrub_grass_wetland

i. Dissolve by value field →all_habitat_dissolve
ii. Add field – label; start editing session – add "Habitat Landcover" to the one attribute field under "label"

g. Select permanent streams adjacent to woody vegetation (from Hydrological criteria) → permstreams_adjtoforest_50ftbuff
   i. Dissolve by value field → streams_forestadj_dissolve
   ii. Add field – label; start editing session – add "Permanent Streams adjacent to Forests" to attribute field
h. Select parks from Community Criteria → all_parks
   i. Dissolve by value field → all_parks_dissolve
   ii. Add field – label; start editing session – add "Parks" to attribute field
i. Select major roads → major roads
   i. Dissolve by value field → major_roads_dissolve
   ii. Add field – label; start editing session – add "Roads" to attribute field
j. Select impaired water bodies
   i. Dissolve by value field → impaired_waters_dissolve
   ii. Add label field; start editing session – add "Impaired Waters" to attribute field
k. Merge eco_cores_dissolve, eco_hubs_erase_dissolve, hydshallowrecharge_dissolve, streams_15mbuff_dissolve, developed_land_dissolve, all_habitat_dissolve, streams_forestadj_dissolve, all_parks_dissolve, major_roads_dissolve, and impaired_waters_dissolve together → eco_corridor_perm (note, this should be the cost surface file – to be renamed in raster classification)
   i. Under value field, insert the following values (values assigned to dictate which layers will override other layers):

Value	Label
1	Habitat Landcover
2	Hydric soils, shallow groundh20, aquifer recharge
3	Cores
4	Hubs
5	Developed Land
6	Parks
7	Roads
8	Streams
9	Permanent Streams adjacent to Forests
10	Impaired Waters

ii. Convert file to raster→***eco_costsurf***
iii. Add PermValue field with the following values:

OBJECTID	Value	Label	PERMVALUE
0	1	Habitat Landcover	0.6
1	2	Hydric soils, shallow groundh2o, aquifer recharge	0.7
2	3	Cores	1.0
3	4	Hubs	0.9
4	5	Developed Land	0.1
5	6	Parks	0.5
6	7	Roads	0.1
7	8	Streams	0.7
8	9	Permanent Streams adjacent to Forests	0.8
9	10	Impaired Waters	0.0005

Ecological Corridors – Design Process

1. Create study map with cores, hubs, least cost paths and linear ecological features that could serve as corridors
    a. Add cores → ecocores5 and hubs → ecohubs_erase
    b. Add least cost paths to map → movement_prob
        i. In Symbology, select "Classified"; compute histogram; exclude data between 0 – 0.5686 (retains highest value paths)
    c. Add waterways → streams_rivers
2. Create new shapefile → Eco_Corridors_Existing
    a. Trace waterways that serve as connecting corridors between core and hub areas
3. Create new shapefile → Eco_Corridors_Proposed
    a. Assess areas where connectivity is lacking and draw in corridors using the following criteria
        i. Trace existing waterways first, even if they do not completely connect two core patches – such partial corridors are included in the existing corridor shapefile – draw in proposed corridors to complete these connections
        ii. Secondly, use least cost paths to draw in corridors where connectivity is still lacking

Final Shapefiles for Agencies & Organizations

Merged Cores	Ecological_Cores
Merged Hubs	Ecological_Hubs
Existing Corridors	Ecological_Corridors_Existing
Proposed Corridors	Ecological_Corridors_Proposed

Note – merged files have been dissolved by layer – data is extremely simplified.

Core #1 – Protected lands with ecological assets	Protected_Ecological_Lands
Core #2 – High quality wetlands	Wetlands_Over_6Ac
Core #3 – High quality uplands	Upland_Core
Core #4 – High quality riparian areas	Riparian_Core
Core #5 – High quality scrub/shrub areas	ShrubSteppe_Core
Core #6 – Areas of Critical Environmental Concern	BLM_AreasofEnvironmentalConcern
Core Exclusion #1 – Disturbed saline wetland areas *(marinas included in core exclusion #5)*	Trails_50ftbuffer
Core Exclusion #2 – Areas affected by development	Developed_Land_200mbuffer
Core Exclusion #3 – Invasive species	Noxious_Weeds
Core Exclusion #4 – Disturbed riparian areas	Disturbed_Areas
Core Exclusion #5 – Major roads	MajorRoads_40mbuffer
Hub #1 – Reservoirs	Reservoirs
Hub #2 – DFFSL high priority forest lands	DFFSL_Priority_Forest_Lands
Hub #3 – Substantial mule deer habitat & aspen-dominated areas	Upland_Hub
Hub #4 – Wildlife Action Plan areas and Ogden Valley important wildlife areas	WAP_Important_Wildlife_Areas
Hub #5 – Sagebrush areas with 1mile of masked sage grouse locations	ShrubSteppe_Hub
Hub #6 – Permanent streams with surrounding forest landcover	Riparian_Hub
Hub #7 – Important Bird Areas (IBAs)	Important_Bird_Areas
Hub Exclusion #1 – Major roads	MajorRoads_40mbuffer
Hub Exclusion #2 – Areas affected by development	Developed_Land_200mbuffer