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FOCAL HABITAT FEATURE IDENTIFICATION PROJECT  
TETON COUNTY, WYOMING  

INTRODUCTION

Biota Research and Consulting, Inc. was contracted to identify, describe and map Focal Habitat Features (FHF) and Valuable Matrix Features (VMF) in Teton County, Wyoming. A primary goal of the recently adopted Jackson/Teton County Comprehensive Plan (2012) is to “maintain healthy populations of all native species”, and the identification of valuable habitat features for a range of wildlife species will inform revised Land Development Regulations and requirements to achieve this goal.

The Jackson/Teton County Comprehensive Plan calls for the protection of the health of native species through a system of regulations and requirements that are based on relative value of habitat. Teton … [developed] a Geographic Information System (GIS) digital layer of designated vegetation and non-vegetation cover-types on all lands in Teton County, Wyoming, excluding those under federal ownership by the US Forest Service, US Fish and Wildlife Service, and National Park Service. Teton County intends to use the vegetation map along with the work product out of this proposal to update its Land Development Regulations regarding habitat protection.

Focal Habitat Features (FHF) refer to vegetation, aquatic, wetlands, riparian, and topographic features that combine in some fashion to provide important habitat that is crucial to the health and survival of a number of native wildlife species. Valuable Matrix Features (VMF) refers to the relative value of areas within a landscape “matrix” that surrounds and/or lies between FHF. Matrix Tiers refer to the relative value of VMF based on the ecological value and function of land within the project area (i.e., private lands in Teton County).

The Focal Habitat Feature project represents a comprehensive, multi-disciplinary approach to characterize landscape-level habitat affinities for numerous species against a backdrop of highly variable human development density. Biota in cooperation with the Natural Resource Technical Advisory Board (NRTAB) and Teton County Planning and Development staff, solicited all available public and private wildlife and natural resource data to accomplish the overriding project objective of identifying, describing and mapping FHF and VMF in Teton County, Wyoming. Very few wildlife studies are conducted within the urban or semi-urban municipal zones, and therefore assessment of relative habitat values for individual species must be extrapolated from the most relevant and nearby regional studies, or from passive observations of individual animals throughout the developed landscape. The framework for this study is unique in that it integrates a number of native species, vegetation cover, and abiotic datasets into a geographical information system (GIS) for analysis, and a great deal of effort was invested in developing the most accurate methods to address the stated objectives of the study. To develop a final GIS layer of FHF in Teton County map layers were generated in the process of developing the final work product as specified under Task A in the Request for Proposal (RFP): GIS overlays of FHF for each wildlife species (mule deer, moose, elk, bighorn sheep, pronghorn antelope, cutthroat trout, trumpeter swan, greater sage-grouse and bald eagle) were developed (Task A in the Request for Proposal) along with county-wide thematic map layers pertinent to FHF identification (regional vegetation classes, slope, aspect elevation, distance to roads and distance to water). The final work product is a map of FHF accumulated across species, along with VMF that are grouped into tiers based on a combination of habitat value and detailed vegetation cover classes (mapped for Teton County by Cogan Technologies Inc., 2012 and hereafter referred to as” the CTI vegetation map”; Cogan and
Johnston 2012) The map is interactive and allows Teton County Planning and Development staff to query any location in the County to view exactly what habitat values and VMF tiers are present, and the underlying vegetation classes upon which the VMF Tiers are derived.

SCOPE OF WORK

TASK A – COMPILE AVAILABLE WILDLIFE DATA

Initial efforts involved developing GIS overlays for all wildlife species relevant to Teton County. Importantly, it was necessary to identify all available datasets that could be used as part of this project. Ultimately, these point and polygon coverages were rasterized so that they could be integrated into a GIS for geospatial analysis and identification of FHFs in Teton County.

In addition to developing GIS overlays for all wildlife species, thematic map layers were compiled for all public and private lands in Teton County and included vegetation cover, elevation, slope, aspect, distance from roads and distance from water.

Metadata for final map products follow Federal Geographic Data Committee (FGDC) standards and would accompany the distribution of all GIS data layers to ensure appropriate use by a wider range of communities working in the Greater Yellowstone Ecosystem.

TASK B – DEVELOP A CLASSIFICATION SYSTEM FOR FHFS

In an attempt to identify FHFs and relative values of areas within the landscape matrix lying between the identified FHFs (i.e., VMFs), Biota participated in a series of meetings with members of the Natural Resource Technical Advisory Board (NRTAB) to:

- Develop the identifying criteria for FHFs and matrix tiers relative to all private lands in Teton County.
- Develop text and a spreadsheet table describing the ecological function of each identified FHF and the ecological relationships and connectivity between FHFs.
- Develop text and spreadsheet table regarding the ecological relationships and connectivity between the VMFs and the FHFs.

TASK C – MAP AND DESCRIBE VMFS

The last task was to develop a GIS layer illustrating the boundaries of single species of the FHFs and a combined species FHF in Teton County using criteria developed in Task B such as clear vegetation cover-type edges, clear topographic features or private property boundaries where cover-type edges and/or clear topographic features are absent. Once completed, a GIS layer illustrating the VMFs overlaying all private lands in Teton County was developed using the criteria developed in Task B, such as pertinent cover-type array boundaries, topographic features, soil data, documented wildlife occurrence and movement data, and established relationships with FHFs.

METHODS

TASK A – COMPILE AVAILABLE WILDLIFE DATA

Task A was initiated through outreach to known private and public entities conducting wildlife research within Teton County. A letter introducing the project was drafted and distributed by Biota, along with a letter of support drafted and signed by the then Chair and Vice Chair of the Teton County Board of County Commissioners, to potential sources of useful data. The intent was to request any and all
available wildlife data that included locational information such as latitude and longitude. When required, data sharing agreements were drafted to suit each individual collaborator and their specific expectations and conditions. The intent of data sharing agreements was to provide, in writing, the exact stipulations under which data would be contributed to and used as part of the project. Collaborators were provided assurances that there was no risk of loss of intellectual property through redistribution of data or disclosure of proprietary information to third parties. For this reason, raw datasets provided to Biota as part of this project are not a deliverable component of the Focal Habitat Feature study.

Efforts began on November 6 of 2013, and our final dataset was delivered on July 14', 2014 (Table 1). During this 7-month timeframe, data that was received from collaborators required numerous steps, from project introduction and data handling discussions to thoroughly vetting all collaborators’ concerns about data usage. Once a potential agreement with a collaborator was established, a follow-up “contract” for data sharing was developed, which in itself became an iterative process with each contributor. In total, 7 unique data sharing “contracts” were formulated in the interest of meeting the various concerns about misuse of data from each of the project contributors.

It was assumed that the Focal Habitat Feature Identification project would be conducive to collaboration with area researchers, and that potential collaborators would contribute important datasets to this substantial municipal initiative. Although some potential collaborators willingly shared their data, other potential collaborators in both the private and public sector clearly articulated their unwillingness to share data, or failed to provide data that they agreed to share. It is possible that in the future, these or other potential collaborators may provide presently unavailable datasets, and that these datasets might be used to update the work products generated to date.

Datasets that were collected and made available for the completion of this project include large GPS-based point location datasets of single species from 7 separate local research projects. Species represented by these studies consists of moose (Becker 2008, Vartanian 2011), elk (USFWS National Elk Refuge 2014), mule deer (Campbell 1982-1992; Riginos et al. 2013; CRC-TSS 2002-2009), pronghorn (Wildlife Conservation Society, Grand Teton National Park, Wyoming Game and Fish Department 2014), and greater sage-grouse (Craighead Beringia South 2014). The Wyoming Game and Fish Department (WGFD) contributed nest location data for bald eagles and trumpeter swans, and additional species’ point location data were derived from databases contributed by the WGFD Wildlife Observation System (WOS: WGFD 2014), University of Wyoming-Wyoming Natural Diversity Database (WYND), and the local Nature Mapping Jackson Hole (Nature Mapping Jackson Hole/ Jackson Hole, Wildlife Foundation 2014), Wyoming project. Through consultation with Steve Kilpatrick (NRTAB) and Morgan Graham (Teton Science School), we determined that the year 1990 was the most appropriate cutoff date for the Wyoming Observation System database records and the records were truncated accordingly, prior to analysis. The WOS, WYND and Nature Mapping datasets represent the most widespread observable fauna datasets available throughout Teton County, but locational accuracy was not nor could be assessed.
Table 1. Data contributed to the Teton County Focal Habitat Feature Study.

<table>
<thead>
<tr>
<th>Organization</th>
<th>Dataset</th>
<th>Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biota</td>
<td>Mule Deer Winter Observations</td>
<td>Tom Campbell</td>
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<tr>
<td>JH Wildlife Foundation</td>
<td>Nature Mapping JH Database</td>
<td>Cory Hatch</td>
</tr>
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<td>Grand Teton National Park</td>
<td>Vegetation Map and report w/ app.</td>
<td>Kelly McCloskey</td>
</tr>
<tr>
<td>US Forest Service</td>
<td>Bridger-Teton National Forest Veg Map</td>
<td>Sanford Moss</td>
</tr>
<tr>
<td>Caribou-Targhee National Forests</td>
<td>Caribou-Targhee National Forest Veg Map</td>
<td>Sanford Moss</td>
</tr>
<tr>
<td>Craighead Beringea South</td>
<td>Sage-Grouse, GPS collar &amp; telemetry study</td>
<td>Bryan Bedrosian</td>
</tr>
<tr>
<td>Teton Science School</td>
<td>Mule Deer, GPS collar study</td>
<td>Morgan Graham</td>
</tr>
<tr>
<td>Wildlife Conservation Society</td>
<td>Pronghorn, GPS collar study</td>
<td>Renee Seidler, Jon Beckmann</td>
</tr>
<tr>
<td>JH Conservation Alliance</td>
<td>NRO Project</td>
<td>Siva Sundaresan</td>
</tr>
<tr>
<td>WY Game and Fish Dept.</td>
<td>Eagle nest sites, Swan nest sites and obs.</td>
<td>Susan Patla</td>
</tr>
<tr>
<td>Univ. of Wyoming - Co-Op</td>
<td>WOS, non-game and game species</td>
<td>Bob Lanka</td>
</tr>
<tr>
<td>WY NDD</td>
<td>Moose</td>
<td>Matt Kaufmann</td>
</tr>
<tr>
<td>USFWS, National Elk Refuge</td>
<td>WY NDD Database for Teton County</td>
<td>Melanie Arnette</td>
</tr>
<tr>
<td>Teton County</td>
<td>Teton County Development Density</td>
<td>Alex Norton</td>
</tr>
</tbody>
</table>

**TASK A – DEVELOPMENT OF THEMATIC DATA LAYERS**

Thematic layers were generated for public and private lands in Teton County to meet project spatial and technical parameters related to identifying FHFs at the landscape scale in a GIS environment. The task of developing thematic layers included producing a comprehensive “cross-walked” vegetation layer that integrated the 54-class vegetation layer for Teton County (Cogan and Johnson 2013) with vegetation data from neighboring federal lands including Bridger-Teton (Gillham at al. 2007) and Caribou-Targhee National Forests (USDA Caribou Targhee National Forest 2013), Grand Teton National Park (Cogan et al. 2005), and the National Elk Refuge (USFWS NER 2014). Through collaboration with NRTAB, it was decided that the Teton County vegetation map could be condensed into a 16-class vegetation map as basis for the comprehensive “cross-walk” vegetation layer. Additional County-wide thematic layers included a digital elevation model (DEM); slope and aspect (derived from the DEM)); a distance to roads layer; and a distance to water layer.

All thematic map layers were generated in raster versus vector data format. Pixel resolution for all layers matched the resolution of the DEM (i.e., 10.3 m X 10.3 m) because it was the layer with the coarsest resolution (Bolstad 2012). A raster framework was necessary when GIS layers are combined for advanced spatial analysis, such as suitability modeling, because MapAlgebra operations were used to overlay and perform calculations on a per cell basis. In addition, thematic layers such as the DEM represent continuous data that is best represented in raster format, which allowed for the derivation of surface products such as aspect and slope (also using MapAlgebra operation).

**Elevation** – The most current and highest pixel resolution elevation dataset that covers all land in Teton County Wyoming was obtained from the USGS and is 1 arc-second (10.3 m pixels).

**Slope** – The slope layer was derived from the elevation layer using ESRI Spatial Analyst Surface and MapAlgebra Tools. Resolution: 10.3 meter pixels
Aspect (Cosin and Sin) – Aspect layers were derived from the elevation layer using ESRI Spatial Analyst Surface and MapAlgebra Tools. Resolution: 10.3 m pixels

Distance to Roads – The distance to roads raster was calculated using the Euclidean Distance tool in ESRI ArcMap; using the 2013 TIGER roads dataset (see metadata below) as the basis. All public/private roads were used. Resolution: 10.3 m pixels.

Distance to Water – The Distance to Water raster was calculated using the Euclidean Distance tool in ArcMap at a 10.3-m pixel resolution. The primary datasets consisted of a “water layer” dataset developed by Dave Adams and the Teton Conservation District (TCD) and the National Hydrography Dataset (NHD). A merged dataset was created by including all of the NHD water features that did not overlap the TCD water layer. Water features at the outer bounds of the TCD layer were visually examined and features from the NHD were manually selected for inclusion in the merged dataset if the features intersected only a small part of the TCD water layer AND did not represent a distinguishable water feature using aerial imagery provided by ESRI’s imagery service.

Cogan Technologies Inc. (CTI) Vegetation Mapping for Teton County Wyoming – The CTI vegetation map contains 54 different classes and provided as a vector polygon file (shapefile; Cogan and Johnson 2013). In order to perform raster analysis operations, the polygon features were converted to a raster with 10.3-meter pixel resolution in ArcMap. Conversion was performed using a Polygon to Raster conversion tool in ESRI ArcMap 10.2, with the option to use Maximum Area (the single feature with the largest area within the cell yields the attribute to assign to the cell) or the “MAXIMUM_COMBINED_AREA” option (if there is more than 1 feature in a cell with the same value, the areas of these features will be combined). The combined feature with the largest area within the cell determined the value to assign to the cell rather than simply the “CELL_CENTER” option, which assigns the vegetation polygon value using the polygon that overlaps the center of the 10.3-meter raster cell.

Regional Cross-walked Vegetation Mapping – Regional vegetation mapping was “cross-walked” through a process of generating a polygon shapefile by merging vegetation mapping prepared for Teton County, Bridger Teton National Forest (BTNF), Caribou-Targhee National Forest (CTNF), Grand Teton National Park (GTNP) and the National Elk Refuge. The cross-walked vegetation map was developed with 16 final vegetation classes:

- Montane Xeric Forb Herbaceous Vegetation
- Montane Mesic Forb Herbaceous Vegetation
- Upland Low Shrub
- Upland Tall Shrub
- Lowland Riparian Shrub
- Landscaped, and Wetlands
- Disturbed
- Upland Deciduous Forest
- Upland Coniferous Forest
- Rocky Mountain Juniper Woodland
- Riparian Forest
- Sparse Vegetation
- Agricultural

The cross-walked vegetation map was converted to raster format at a 10.3-m pixel resolution.

TASK B – DEVELOP A CLASSIFICATION SYSTEM FOR FHFS

As a means to develop species-specific FHF layers, the utility of multivariate regression modeling techniques uniquely suitable for predicting suitable wildlife habitat from point observations was explored. In the final analysis, we selected a more simplistic and adaptable framework that relied on
frequency histogram analyses of point observation data to identify, locate and map attributes from the thematic layers that correlated with areas of high use.

Adequate amounts of data were provided by collaborators associated with specific research projects, or more generalized databases that maintain observation records. The data provided were used to develop 12 unique FHF layers; Bald Eagle, Trumpeter Swan, Greater-Sage Grouse, Cutthroat Trout, Pronghorn year-round, Bighorn Sheep winter, Mule Deer winter and year-round, Moose winter and year-round, and Elk winter and year-round (Appendix 1). Habitat selection and habitat utilization were determined by overlaying observations with vegetation and abiotic thematic layers; analysis was conducted on a per species basis. Some of the wildlife datasets include year-round observations. From these datasets, data associated with crucial seasons (i.e., winter) were parsed out, and then these subsets were refined so thematic relationships could be derived for moose, mule deer, bighorn sheep, and elk for their respective crucial winter ranges.

Species’ associations with vegetation and abiotic thematic layers (i.e., slope, aspect, elevation, distance from roads, distance from water) were derived from a combination of GPS collar datasets of locations and point observations from the Wildlife Observation System, which incorporates the Nature Mapping Jackson Hole dataset. Point locations throughout public and private lands in Teton County were queried to derive vegetation covertype associations from a set of 16 vegetation classes (binned from the CTI vegetation map), as well as associations with other pertinent thematic layers (i.e., sin aspect [“eastness”], cosin aspect [“northness”], elevation, distance to roads, distance to water, and slope). Thematic layer values were extracted for each observation point for the purpose of generating histograms of overall frequency of observations across the range of thematic layer values. High levels of association with a particular thematic layer guided the selection of applicable threshold levels for that thematic layer. In many cases, FHF's were derived from a subset of thematic layers, particularly in cases where any given variable was not viewed as influential on the overall distribution of a species. For example, thresholds were identified from the frequency of animal counts or locations associated with topographic or vegetation thematic layers, as illustrated in histograms generated from the point location analysis (Appendix 2).

As a means of avoiding spatial autocorrelation errors from extensive GPS point file datasets, one unique location on any given calendar day was used for analysis for all species, in all seasons. The one exception to this was the sage-grouse GPS dataset, which was reduced to 3 observations per day when available (i.e., dawn, midday and dusk), to potentially capture any variation in lekking, foraging and roosting habitat.

Threshold selection was an iterative process, based on the distribution of the data and how inclusive or restrictive the species use was of certain thematic layers. Most commonly, initial runs with a greater number of thematic layers resulted in large FHF's with sometimes questionable relationship to the actual species habitats, as verified by point observation data derived from the respective datasets used to develop the FHF's. The goal was to develop the closest relationship between FHF's and either 1) existing, available data or 2) where data was lacking, expert opinion on relevance of the thematic layer to the species’ distribution and habitat use. It is possible that some of the data underlying the layout of the WGFD big game overlays include data that pre-dates the cutoff date that was established and used for the WOS observational dataset.

Once thresholds were created for the topographic, water resource and vegetation variables for each species, overlay analyses were performed with the “Raster Calculator geoprocessing” tool in ArcMap 10.2 by using the thresholds to delineate suitable and unsuitable habitat for each thematic variable for
each species. For example, an intermediate vegetation suitability raster was created by applying a binary reclassification to the regional vegetation raster using the “Reclassify” geoprocessing tool in ArcMap 10.2 to assign a value of “1” or “suitable” to pixels with vegetation covertypes occupied most frequently by moose and assigning all other pixels a value of “0” or unsuitable (Fig. 1). In this case the suitable vegetation categories were Upland Deciduous Forest, Upland Coniferous Forest, Upland Low Shrub, Riparian Forest and Lowland Riparian Shrub.

![Cross-walked vegetation variable reclassified to examine only vegetation classes where moose (year-round) have been observed most frequently.](image)

**Figure 1** Cross-walked vegetation variable reclassified to examine only vegetation classes where moose (year-round) have been observed most frequently.

The elevation gradients where moose were observed most frequently were determined by plotting a frequency histogram of individual moose observations and the corresponding elevation. An intermediate elevation raster was then created by performing a conditional statement in the “Raster Calculator” tool in ArcMap 10.2 to select elevation gradients:

\[ \text{Con(“TC\_DEM.tif” > 1770,1,0) and Con(“TC\_DEM.tif” \leq 2440,1,0)}, \text{ where all elevations between 1770 and 2440 meters were selected and all other elevations outside this range were eliminated. This conditional statement created a final raster that displayed only the queried elevation range (Fig. 2).} \]
Figure 2. Elevation variable created to examine an elevation gradient where moose is known to exist.

The slope variable was created in the “Raster Calculator” tool in ArcMap 10.2 with a conditional statement to select pixels within the percent slope range where moose were most frequently observed (Appendix 2).

Con(“TC_slope.tif” ≤ 40,1,0), where all slopes less than or equal to 40 degrees were selected and all other slope gradients outside this range were eliminated. This conditional statement created a final raster that only displayed the queried slope range (Fig. 3).
The distance to water variable was also created in the “Raster Calculator” in ArcMap 10.2 with a conditional statement that selected the range in distance from a water resource where moose were frequently observed. In this instance 87% of all moose observations were less than or equal to 1,000 feet from hydrologic features included in this layer:

Con(“TC_DistToWater.tif” ≤ 1000,1,0), where all distance to water pixels up to and including 1,000 meters were selected and all other pixels with slope gradients outside this range were not selected. This conditional statement created a final raster that only displayed the queried range of distance to water pixels (Fig. 4).
Figure 4. Distance to Water variable created to examine a range in distances to water where moose is known to exist.

Once these variables were created, a simple overlay analysis was conducted using the “Raster Calculator” tool in ArcMap 10.2.

For example: “Moose_RegVeg.tif” + “Moose_DistToWater.tif” + “Moose_Slope.tif” + “Moose_DEM.tif”. This final Raster Calculator “Addition” function created the Focal Habitat Feature layer that depends on the thresholds for moose, year-round habitat selection (Fig. 5).
Once the respective FHF raster was created, the raster values with the highest pixel value were extracted by using the “Extract by Attributes” geoprocessing tool in ArcMap 10.2 and then converted to a feature class by using the “Raster to Polygon” geoprocessing tool in ArcMap 10.2. By completing this series of steps with ArcMap 10.2 geoprocessing tool, a final feature class was created for moose displaying its Focal Habitat (Fig. 6).
Figure 6. Final map displaying Focal Habitat Features for moose year-round, Teton County, Wyoming.
The methodology described above was repeated for each species in the FHF study. Once the FHF rasters were created for all species, another raster overlay analysis was performed to create a final (combined-species) FHF displaying critical wildlife habitat.

The process of “drilling down” through the thematic and vegetation covertype layers at each unique point within a given species’ dataset resulted in a point observation based numeric value for each variable. Histograms showing the relative frequency of observations that met a given range of values were the foundation upon which our initial Focal Habitat Feature draft mapping was based. For any cell in the Teton County project area grid where a species’ threshold criteria for vegetation and thematic layer value ranges where met, it was included in the first draft FHF.

Subsequent examination and scrutiny of FHF (Step 1 “accuracy assessment”) was performed in an iterative process to determine if and how threshold levels of the Thematic Layers could or should be adjusted so that FHFs accurately reflected actual use of the landscape by individual species. Species-specific point data was displayed on the draft FHF map, and scrutinized in terms of the relative accuracy, and shortcomings of each draft FHF map.

Once Step 1 had been performed, a second “accuracy assessment” step was employed. Step 2 was employed when species-specific thematic layer associations (best described as raw FHF distributions) were in need of a tighter fit than that was achieved through post-processing of the raw FHF coverages. In certain cases, the extent of a given species-specific FHF was subsequently evaluated using a 99% Kernel Density home range estimate (KDE), but only when datasets were sufficiently robust (e.g., bald eagle, trumpeter swan, pronghorn, bighorn sheep, and sage-grouse). In these cases, the extent of the available data reflected in the KDE appeared to more accurately represented a species distribution and modeled habitat from the FHF maps that was undocumented as being occupied habitat or where habitat affiliations where not documented for the species were removed.

Conversely, a Step 2 “accuracy assessment” was not performed on elk, mule deer, and moose FHFs because big game species’ KDE could easily be underestimated, which would in turn lead to an underestimation of actual habitat use at a countywide scale. However, prior to the delivery of our Final FHF mapping, it became clear that the elevation gradient across such a large study area was causing a loss in precision of certain FHFs in the southern extent of the County (especially for ungulates). Refining or tightening FHFs based on elevations resulted in a loss of important habitat that WGFD had mapped as crucial winter ranges, primarily for elk and moose. A decision was made, in consultation with Teton County Planning staff, to view the WGFD Big Game Habitat Seasonal Overlay mapping of crucial winter ranges as a source of expert opinion that should be included as an FHF identification criteria. In many areas the Big Game Habitat overlays coincided with delineated FHFs, but in other areas the respective FHFs were much more constrained and did not incorporate mapped crucial winter ranges. Therefore, elk, mule deer, moose and bighorn sheep winter FHFs were attributed with WGFD crucial winter ranges, and year-round elk, moose, and mule deer FHFs were attributed with WGFD non-crucial habitats (see list below).

The draft FHF mapping was delivered to Teton County Planning Staff, and made available to the NRTAB. The initial 2 rounds of draft FHF deliveries produced no requests for modification from Teton County or NRTAB.

Final FHFs were adjusted, to the greatest degree possible, through manipulation of thematic layers, and associated threshold levels; however, the extensive geographic area included in each model resulted in FHF shortcomings that could not be addressed through adjustment of thematic layer and vegetation
threshold levels alone. After the delivery of final species-specific FHFs, NRTAB provided feedback on the trumpeter swan FHF, the only actual FHF revision requested by NRTAB throughout the duration of the project. The request to remove spurious upland sagebrush vegetation that fell within the initial FHF model from the final trumpeter swan FHF mapping was subsequently made.

In addition to previously described and subsequently utilized dataset for FHF generation, the following information summarizes the information used to generate the final each species-specific FHF.

<table>
<thead>
<tr>
<th>Species</th>
<th>Data Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutthroat Trout</td>
<td>Reaches of watercourse known to be used for spawning</td>
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<tr>
<td>Bald Eagle</td>
<td>Year-round data; clipped by 99% KDE home range</td>
</tr>
<tr>
<td>Trumpeter Swan</td>
<td>Year-round data; clipped by 99% KDE home range</td>
</tr>
<tr>
<td>Greater Sage-Grouse</td>
<td>Year-round data; outer perimeter incorporates WY Core Area v.3</td>
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<tr>
<td>Bighorn Sheep</td>
<td>Winter data, clipped by 99% KDE home range; incorporates WGFD crucial winter range</td>
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<td>Pronghorn</td>
<td>Year-round data, clipped by 99% KDE home range</td>
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<td>Elk, year-round</td>
<td>Year-round data, incorporates WGFD non-crucial ranges (except SSF)</td>
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<tr>
<td>Elk, winter</td>
<td>Winter data, incorporates WGFD crucial winter range</td>
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<td>Moose, winter</td>
<td>Winter data, incorporates WGFD crucial winter range</td>
</tr>
<tr>
<td>Mule Deer, year-round</td>
<td>Year-round data, incorporates WGFD non-crucial ranges (except SSF)</td>
</tr>
<tr>
<td>Mule Deer, winter</td>
<td>Winter data, incorporates WGFD crucial winter range</td>
</tr>
</tbody>
</table>

**TASK C: MAP AND DESCRIBE VMFS**

The development of a comprehensive matrix of habitat values was the final step of the Focal Habitat Feature Identification project. Valuable Matrix Features were broken out into a “tiered” (priority ranking) format that represents four levels based on the number of overlapping FHFs, ranking as native vegetation per the CTI vegetation map, or both (Table 2). The values used in the reclassification system are a means of giving unique values in the raster grid under the following conditions: where FHF layers overlap ranked vegetation; where FHF layers do not overlap ranked vegetation; where ranked vegetation exists without any FHF layer overlap; or where there are no FHF layers and no ranked vegetation. A definition of ranked and unranked vegetation classes is provided below.

**Combined Species FHF Raster**

The initial step was the development of a combined species FHF raster, where the value of each pixel in the grid was equivalent to the number of species-specific FHFs present. The grid values for the combined species FHF raster were all increased by one (1), so that locations where no FHFs overlapped had a grid value of “1”. This was done, because the value of “0” was used in the matrix to define all pixels where greater than 5 FHFs occurred. As a result, Column 1 in Table 2 reflects N (number of FHF Layers) + 1. Note that the highest value of N+1 is 10. This illustrates that there is no location within the project area where more than 9 FHF layers overlap in single location.
Table 2. Input used to calculate pixel values for the final tiers of the Valuable Matrix Features (VMFs).

<table>
<thead>
<tr>
<th>FHF Layers (n (# of FHF Layers)) +1</th>
<th>FHF Multiplier = 0</th>
<th>Veg multiplier (Ranked)</th>
<th>Veg Multiplier (Unranked)</th>
<th>Value w/ Veg Ranked¹</th>
<th>Value w/ Veg Un-Ranked²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-</td>
<td>10</td>
<td>1</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>-</td>
<td>10</td>
<td>1</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>-</td>
<td>10</td>
<td>1</td>
<td>30</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>-</td>
<td>10</td>
<td>1</td>
<td>40</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>-</td>
<td>10</td>
<td>1</td>
<td>50</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>-</td>
<td>-</td>
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</tr>
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<td>8</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
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<td>9</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

¹ Pixel Value based on Number of FHF layers present where Pixel overlaps Ranked Veg polygon
² Pixel Value based on Number of FHF layers present where Pixel does not overlap Ranked Vegetation polygon

**Vegetation Layer**

Vegetation mapping prepared by CTI, which contains 54 classes, was reclassified as either a “ranked” vegetation class or an “unranked” vegetation class in order to incorporate fine scale native vegetation information into the VMF layer. Pixels containing a ranked vegetation class were assigned a value of “10” and pixels containing unranked vegetation were assigned a value of “1”. Ranked vegetation classes (Table 3) were deemed to have broad conservation value, for both species that had FHFs developed and for other species or guilds of species (e.g. migratory songbirds, amphibians) for which FHFs could not be generated due to lack of data. We used the high resolution CTI map (54 classes) for this purpose. For the purposes of developing the VMF Tiers, 53% of the total Teton County Vegetation Layer (46,521 acres) was classified as ranked vegetation.
Table 3. Ranked vegetation classes used for development of the VMF map.

<table>
<thead>
<tr>
<th>Map Unit Name</th>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspen Forest</td>
<td>6137.6</td>
</tr>
<tr>
<td>Blue Spruce Riparian Forest</td>
<td>856.2</td>
</tr>
<tr>
<td>Cottonwood Riparian Forest</td>
<td>5257.7</td>
</tr>
<tr>
<td>Douglas-fir Forest</td>
<td>2449.2</td>
</tr>
<tr>
<td>Mixed Evergreen - Aspen Forest</td>
<td>2458.7</td>
</tr>
<tr>
<td>Rocky Mountain Juniper Woodland Stand</td>
<td>144.9</td>
</tr>
<tr>
<td>Limber Pine Forest</td>
<td>57.9</td>
</tr>
<tr>
<td>Lodgepole Pine Forest</td>
<td>1830.2</td>
</tr>
<tr>
<td>Mixed Conifer Forest</td>
<td>793.5</td>
</tr>
<tr>
<td>Mixed Cottonwood - Blue Spruce Riparian Forest</td>
<td>1758.3</td>
</tr>
<tr>
<td>Subalpine Fir - Engelmann Spruce Forest</td>
<td>178.2</td>
</tr>
<tr>
<td>Aspen Woodland Regeneration</td>
<td>213.3</td>
</tr>
<tr>
<td>Alder Shrubland</td>
<td>7.7</td>
</tr>
<tr>
<td>Sagebrush - Antelope Bitterbrush Mixed Shrubland</td>
<td>722.5</td>
</tr>
<tr>
<td>Mixed Tall Deciduous Shrubland</td>
<td>1521.0</td>
</tr>
<tr>
<td>Mixed Shrubland</td>
<td>3912.0</td>
</tr>
<tr>
<td>Sagebrush Dry Shrubland</td>
<td>9047.5</td>
</tr>
<tr>
<td>Sagebrush/Shrubby Cinquefoil Mesic Shrubland</td>
<td>81.8</td>
</tr>
<tr>
<td>Willow Shrubland</td>
<td>3160.7</td>
</tr>
<tr>
<td>Low Sagebrush Dwarf Shrubland</td>
<td>2.4</td>
</tr>
<tr>
<td>Herbaceous Aquatics</td>
<td>60.7</td>
</tr>
<tr>
<td>Montane Mesic Forb Herbaceous Vegetation</td>
<td>56.5</td>
</tr>
<tr>
<td>Mixed Grassland Herbaceous Vegetation</td>
<td>2465.8</td>
</tr>
<tr>
<td>Flooded Wet Meadow Herbaceous Vegetation</td>
<td>563.8</td>
</tr>
<tr>
<td>Streams and Rivers</td>
<td>2783.0</td>
</tr>
</tbody>
</table>

Populating the VMF Matrix
The combined species FHF raster values were reclassified for mapping purposes as follows: 0 = 1, 1 = 2, 2 = 3, 3 = 4, 4 = 5, 5 = 6, etc. FHF values were then multiplied by the “Veg Map Rank Status” value (reclassified so unranked vegetation had a value of 1 and ranked vegetation had a value of 10). This results in FHFs greater than 5 equaling zero, which is then equated to the highest tier. The value “0” is assigned to these FHF pixels in order that their higher tier identity persist throughout subsequent layer multiplication steps. The highest tier was thus developed by selecting pixels meeting the criteria “(Total FHF Layers per pixel + 1)>5” and reassigning them a value of “0”.

Lower tiers were produced by multiplying reclassified FHF values less than 5 by ranked, or unranked vegetation multipliers (10 and 1, respectively). Tier thresholds were then subjectively selected. Pixels were reclassified as follows:
Total # of FHF s greater than 5 = 0
Ranked Vegetation with no FHF s = 10
Ranked Vegetation with total # of FHF s present (either 2, 3, 4, or 5) = 20, 30, 40 or 50
Unranked Vegetation with no FHF s = 1
Unranked Vegetation with total # of FHF s present (either 2, 3, 4, or 5) = 2, 3, 4 or 5

The colors highlighting selected values in Table 2 correspond to the pixel colors representing Tiers I-IV in the Valuable Matrix Feature maps (Appendix 3).

IF (FHF Layers per pixel + 1)>5 THEN pixel value = 0;
IF (FHF Layers per pixel + 1>1) AND (FHF Layers per pixel + 1<6) AND pixels overlap ranked vegetation, THEN pixel values equal 20, 30, 40, or 50; at least one FHF layer present;
IF (FHF Layers per pixel + 1>1) AND (FHF Layers per pixel + 1<6) NOT overlapping ranked vegetation, THEN pixel values equal 2, 3, 4, or 5; at least one FHF layer present.
IF (FHF Layers per pixel + 1=1; meaning no FHF layers present) AND Pixel overlaps ranked vegetation THEN pixel value =10;
IF (FHF Layers per pixel + 1=1; meaning no FHF layers present) AND Pixel does not overlap ranked vegetation THEN pixel value =1

Various VMF Tier outputs selections were vetted through a subjective process based on scrutiny of each version of the Tier outputs that have been developed to date. Not all versions of the VMF Tier outputs were provided to County Planning Staff or NRTAB because some draft tier output were simply unusable. After an internal selection process, a broad and representative suite of VMF Tier output scenarios were presented to Teton County Planning Staff and the NRTAB Chairman. Following this collaborative selection process, the Final VMF Tier selection criteria were identified and jointly selected prior to finalizing the VMF Tier maps (Appendix 3)

Final VMF Matrix Tiers

Tier I: Total # of FHF s greater than 5; total # of FHF s 3, 4, 5 that overlap Ranked Vegetation [0, 30, 40, 50]
Tier II: # of FHF s = 2 that overlap Ranked Vegetation and total # of FHF s = 4 or 5 that do not overlap Ranked Vegetation [20, 4, 5]
Tier III: All Ranked Vegetation where no FHF s occur (10), or # of FHF s = 2 & 3 that do not overlap Ranked Vegetation [10, 2, 3]
Tier IV: Unranked Vegetation with no FHF layers present [1]
RESULTS

FOCAL HABITAT FEATURES

The following results are presented so that that Appendix 1 and Appendix 2 can be viewed side-by-side for each focal habitat species in order to understand how the predictive models create a species-specific FHF. Threshold selection illustrates the results of the drill-down methodology, and selection of the most important thematic parameters that correlate best with species distribution. After identifying the “drill down” results that most accurately depict species distribution and habitat utilization, final species-specific FHF maps were generated.

Moose Year-round FHF

Threshold Selection

- Appendix 2, Exhibits 1b-1d
- Vegetation: Upland Coniferous Forest, Lowland Riparian Shrub, Upland Low Shrub, Upland Deciduous Forest, and Riparian Forest; 84.0% of observations.
- Elevation: >1,770 m and <2,440 m; 79.1% of observations
- Slope: $\geq 0$ degrees and $\leq 20$ degrees; 92.6% of observations
- Distance to Water: $\geq 0$ meters and $\leq 1,000$ meters; 87.2% of observations

Focal Habitat Feature Map – Appendix 1, Exhibit 1a

The moose point observation file was generated from a composite of the WGFD Observation System (WOS; WGFD 2014) records and GPS collar locations from the University of Wyoming Cooperative Research Center Moose Research study Phases 1 and 2 (Becker 2008, Vartanian 2013). The moose year-round FHF was not refined by using a KDE derived from the point data available for this study because of a strong geographic bias to the data that would have functionally minimized coverage of the FHF in the southern portion of the project area. However, WGFD Big Game Seasonal Overlays (non-critical year-long, winter year-long and winter ranges) were used to augment the moose year-round FHF, functionally increasing coverage in areas of Teton County where the model may have missed important year-round habitat.

Moose Winter FHF

Threshold Selection

- Appendix 2, Exhibits 2b-2c
- Winter is defined as December 12 through April 15
- Vegetation: Upland Coniferous Forest, Lowland Riparian Shrub, Upland Low Shrub, and Riparian Forest; 79.9% of observations.
- Elevation: >1,770 m and <2,440 m; 92.8% of observations; this represents the range of elevations that are relevant to the defined study area (i.e., private land and land in proximity to private property in Teton County).
- Slope: $\geq 0$ degrees and $\leq 5$ degrees; 66.3% of observations

Focal Habitat Feature Map – Appendix 1, Exhibit 2a

The moose point observation file was generated from a composite of the WGFD Observation System (WOS) records and GPS collar locations from the University of Wyoming Cooperative Research Center Moose Research study Phases 1 and 2. Winter is defined as December 12 through April 15. The moose year-round FHF was not refined by using a KDE derived from the point data available for this study because of a strong geographic bias to the data that would have functionally minimized coverage of the FHF in the southern portion of the project area. However, WGFD Big Game Seasonal Overlays (crucial
winter year-long and winter ranges) were used to augment the moose year-round FHF, functionally increasing coverage in areas of Teton County where the model may have missed important year-round habitat.

**Elk Year-round FHF**

**Threshold Selection**

- Appendix 2, Exhibits 3b-3d
- Vegetation: Upland Deciduous Forest, Sparse Vegetation, Montane Mesic Forb Herbaceous Vegetation, Upland Coniferous Forest, Lowland Riparian Shrub, Upland Low Shrub, Lowland Herbaceous, Riparian Forest and Agricultural; 91.7% of observations.
- Elevation: >1,770 m and <2,440 m; 79.1% of observations; this represents the range of elevations that are relevant to the defined study area (i.e., private land and land in proximity to private property in Teton County).
- Slope: ≥ 0 degrees and ≤ 30 degrees; 95.7% of observations

**Focal Habitat Feature Map – Appendix 1, Exhibit 3a**

The elk point observation file was generated from a composite of Wyoming Game and Fish Department Wildlife Observation System (WOS) records and the US Fish and Wildlife Service National Elk Wildlife Refuge elk GPS collar location dataset. The elk dataset exhibits a strong geographic bias in the central and eastern portions of the project area. For this reason the year-round Focal Habitat Feature was not refined by using a KDE derived from the point data available for this study. Non-crucial Wyoming Game and Fish Department Big Game Overlay Ranges (year-long, winter year-long, winter and parturition areas) were used to refine the moose year-round FHF, functionally increasing coverage in areas of Teton County where the model may have missed important year-round habitat.

The year-round elk FHF is the most inclusive layer in the entire suite of FHFs. This makes sense, given the high mobility of elk, and the preference for habitat mosaics that offer access to forage, cover, and movement corridors. What is not apparent in this FHF is where human development reaches a density that might impede elk movement. The question remains whether or not there are development density parameters that might result in precluding some of the denser subdivisions where elk are either physically constrained from accessing or where avoidance is a behavioral pattern.

**Elk Winter FHF**

**Threshold Selection**

- Appendix 2, Exhibits 4b-4d
- Winter is defined as December 12 through April 15
- Vegetation: Upland Coniferous Forest, Lowland Riparian Shrub, Upland Low Shrub, Lowland Herbaceous and Agricultural; 79.0% of all winter observations categories; 70.5% of observations from January 1 through March 31 removing potential mild, shoulder season habitat usage.
- Elevation: ≥ 1,770 m and ≤ 2,250 m; 72.0% of observations.
- Slope: ≥ 0 degrees and ≤ 15 degrees; 79.4% of observations

**Focal Habitat Feature Map – Appendix 1, Exhibit 4a**

The winter elk point observation file was generated from Wyoming Game and Fish Department Wildlife Observation System (WOS; WGFD 2014) records and the US Fish and Wildlife Service National Elk Wildlife Refuge elk GPS collar location dataset (2014). Winter is defined as December 12 through April 15. The elk dataset exhibits a strong geographic bias in the central and eastern portions of the project area.
area. For this reason the winter FHF was not refined by using a population home range estimate derived from the point data available for this study. The crucial WGFD Big Game Seasonal Overlays (crucial winter and crucial winter year-long) were used to supplement the elk winter FHF, functionally increasing coverage in areas of Teton County where the model may have missed important crucial winter habitat.

High elevation observations of wintering elk, and inclusion of the agricultural vegetation classification have led to an extensive winter FHF for elk. Examples would include high elevation conifer forests on the east slope of the Snake River Range; examples of agricultural land inclusions are the South Park area throughout Melody Ranch and Rafter J, areas north of Moran, and the US Highway 89 North corridor.

**Mule Deer Year-round FHF**

**Threshold Selection**

- Appendix 2, Exhibits 5b-5d
- Vegetation - Upland Deciduous Forest, Upland Coniferous Forest, Upland Low Shrub, Upland Tall Shrub, Rocky Mountain Juniper Woodland, Sparse Vegetation and Lowland Herbaceous; 85.9% of year-round observations.
- Elevation - ≥1,750 m and ≤ 2,250 m; 92.7% of observations.
- Distance to Water – 92.8% of observations occurred where distance to water was ≤ 1,200 m.

**Focal Habitat Feature Map** – Appendix 1, Exhibit 5a

The mule deer year-round point dataset combines the WOS observations from 1990 to present, including Nature Mapping Jackson Hole observations (Nature Mapping Jackson Hole/ Jackson Hole Wildlife Foundation 2014), the Biota–Conservation Research Center (Teton Science Schools) winter point observation data (Campbell 1982-1992; CRC-TSS 2014), and the Conservation Research Center GPS Collar data for WYDOT (Riginos et al. 2013).

The mule deer dataset exhibits a strong geographic bias that does not reflect the entirety of population distribution within the project area. For this reason the year-round FHF was not refined by integrating a KDE derived from the point data available for this study. The non-crucial WGFD Big Game Seasonal Overlays (winter year-long and winter) were used to supplement the mule deer year-round FHF, functionally increasing coverage in areas of the County where the model may have missed important year-round habitat.

**Mule Deer Winter FHF**

**Threshold Selection**

- Appendix 2, Exhibits 6b-6e
- Winter defined as December 1 to May 14
- Vegetation - Upland Low Shrub, Rocky Mountain Juniper Woodland, Upland Tall Shrub, Lowland Herbaceous, and Sparse Vegetation; 91.4% of winter observations.
- Cosin of Aspect - All negative values up to and including 0, (0 through -1.0); locations with any degree of "southness" appeared important and represent 89.9% of all observation records.
- Slope - Slopes >10 degrees and ≤ 40 degrees constitute 96.0% of mule deer winter observations.
- Elevation – >1,770 meters and ≤ 2,120 m; 90.2% of winter observations.

**Focal Habitat Feature Map** – Appendix 1, Exhibit 6a

Winter Mule Deer observations are derived from the long-term winter mule deer observation study started by Biota in 1982, and completed by the Conservation Research Center (TSS) in 2009 (Campbell 1982-1992; CRC-TSS 2014). The range of dates from this study are December 1 – May 14. The mule
deer dataset exhibits a strong geographic bias that does not reflect the overall population distribution throughout the project area. For this reason the winter Focal Habitat Feature was not enhanced by integrating a population home range estimate derived from the point data available for this study. The crucial WGFD Big Game Overlay Ranges (Crucial Winter and Crucial Winter Year-long) were used to supplement the mule deer winter Focal Habitat Feature model, functionally increasing coverage in areas of the County where the model may have missed important crucial winter habitat.

**Bighorn Sheep Winter FHF**

**Threshold Selection**

- Appendix 2, Exhibits 7b-7e
- Winter is defined as December 12 through April 15
- Vegetation: Sparse Vegetation, Upland Coniferous Forest, Upland Low Shrub, and Lowland Herbaceous; 88.2% of observations occurred within these vegetation categories.
- Elevation: >1,850 m and ≤ 2,450 m = 85.4% of observations.
- Cosin of Aspect: ≥ -1 and ≤ -0.5 = 59.4% of observations
- Distance to Water: ≥ 0 meters and ≤ 1,200 meters = 91.6%

**Focal Habitat Feature Map** – Appendix 1, Exhibit 7a

The initial bighorn sheep FHF needed refinement because large areas of unused habitat were captured in the FHF. This was primarily because the large suite of points derived from the WOS database resulted in skewing the FHF towards what appeared to be a more generalized, year-round FHF instead of the intended winter FHF. Manual cleanup of the FHF was achieved by clipping the extent by a 99% KDE based on all point observations from 1990 to the present entered in the WOS database. In addition, the WGFD Big Game Seasonal Overlays (crucial winter year-long and crucial winter ranges) were used to augment the bighorn sheep winter FHF. Doing so resulted in increasing the FHF coverage in areas of Teton County where the initial model missed winter habitat deemed by the WGFD.

**Pronghorn Antelope Year-round FHF**

**Threshold Selection**

- Appendix 2, Exhibits 8b-8d
- Vegetation: Sparse Vegetation, Montane Mesic Forb Herbaceous Vegetation, Upland Low Shrub and Lowland Herbaceous; 81.3% of observations.
- Elevation: > 1,850 m and ≤ 2,150 m; 54.6% of observations; this represents the range of elevations that are relevant to the defined study area (i.e., private land and land in proximity to private property in Teton County).
- Slope: ≥ 0 degrees and ≤ 15 degrees = 84.6% of observations

**Focal Habitat Feature Map** – Appendix 1, Exhibit 8a

The pronghorn point observation file was generated from the Wyoming Game and Fish Department Wildlife Observation System (WOS) records and the Wildlife Conservation Society (WCS) pronghorn dataset utilizing GPS collar locations (WCS, GTNP, and WGFD 2014).

The influence of elevation gradients, slope and aspect on vegetation distribution and habitat use varies greatly throughout Teton County. In particular, elevation thresholds that include higher elevations in one part of Teton County resulted in the inclusion of areas elsewhere in the County that do not represent important or actually used habitat. An illustrative example is the inclusion of upland low shrub covertypes located west of Fall Creek Road on the Bridger-Teton National Forest, where there are no point observations and it is known that the species does not utilize this area of the County. For this reason, the FHF was refined by clipping the FHF using a 99% KDE based on all point observations from

**Bald Eagle Year-round FHF**

Threshold Selection

- Appendix 2, Exhibits 9b-9e
- Vegetation: Riparian Forest, Upland Coniferous Forest, Hydrologic, and Upland Low Shrub; 69.9% of observations.
- Elevation: >1,770 m and ≤ 2,150 m; 91.6% of observations.
- Slope: ≥ 0 degrees and ≤ 5 degrees; 81.6% of observations.
- Distance to Water: ≥ 0 meters and ≤ 200 meters; 74.2% of observations.

**Focal Habitat Feature Map** – Appendix 1, Exhibit 9a

Refinement of the bald eagle FHF was achieved by clipping the FHF extent with a 99% KDE based on recently active nests and point observations entered from 1990 to the present in the Wyoming Observation System (WOS) database (WGFD 2014).

**Greater Sage-Grouse Year-round FHF**

Threshold Selection

- Appendix 2, Exhibits 10b-10c
- Vegetation: Upland Low Shrub and Lowland Herbaceous. 91.2% of observations.
- Elevation: >1,880 m and ≤ 2,800 m; 100% of observations.

**Focal Habitat Feature Map** – Appendix 1, Exhibit 10a

This dataset is derived from the WOS dataset sage-grouse observations from 1990 to present, and the Craighead Beringia South (2014) greater sage-grouse GPS collar-based research project. The locations of greater sage-grouse at high elevations located in the upper Gros Ventre, and possibly Buffalo Valley resulted in the inclusion of substantial areas in the west southwest quadrant of the study area that do not represent sage-grouse habitat. Refinement of this FHF was accomplished by clipping the FHF using a 99% KDE based on point observations entered from 1990 to the present in the WOS database and a subset of the Craighead Beringia South GPS dataset that reduced potential autocollinearity of sequential points.

A high percentage of all sage-grouse observations are captured within the FHF. However, the accuracy of the FHF was improved by making the outer perimeter of the FHF largely consistent with the Greater Sage-Grouse Core Population Area, with the exception of areas within the core area that did not fit the FHF vegetation or elevation parameters.

**Trumpeter Swan Year-round FHF**

Threshold Selection

- Appendix 2, Exhibits 11b-11e
- Vegetation: Upland Coniferous Forest, Upland Low Shrub, Agricultural, Disturbed, Hydrologic and Lowland Herbaceous; 84.3% of observations; small hydrological features and foraging habitat exists in a broader matrix that includes upland vegetation types that would not be normally associated with trumpeter swan habitat, such as mature cottonwood forest.
- Elevation: ≥ 1,770 m and ≤ 2,150 m; 86.8% of observations; this represents the range of elevations that are relevant to the defined study area (i.e., private land and land in proximity to private property in Teton County).
• Slope: \( \geq 0 \) degrees and \( \leq 5 \) degrees; 75.8% of observations.
• Distance to Water: \( \geq 0 \) meters and \( \leq 200 \) meters; 58.7% of observations.

Focal Habitat Feature Project – Appendix 1, Exhibit 11a

Refinement of the FHF involved clipping with a 99% KDE based on point observations in the WOS database (1990 to present) and recent active nests locations provided by Wyoming Game and Fish Department (2014).

Cutthroat Trout Spawning FHF

Threshold Selection
• Not determined via threshold selection

Focal Habitat Feature Map – Appendix 1, Exhibit 12a

The dataset used for defining the cutthroat trout spawning FHF was from several sources, including the Wyoming Game and Fish Department (J. Kiefling 1991, pers. comm.; R Huddleston, R. Gipson and T. Stephens 1978 to present, pers. comm.); from unpublished data collection, reports, and other fieldwork performed by Biota Research and Consulting, Inc. between 1980 and present. A number to creeks known to represent cutthroat trout spawning habitat on private land in Teton County, Wyoming have been identified and are included in this dataset. These creeks include the following:

- **Price Spring Creek** (from northern boundary of Bar B Bar Ranch to confluence with the Snake River)
- **Owl Creek/Owl Ditch** (lower reach from Zenith Drive to confluence with Price Spring Creek)
- **Fleischmann Spring Creek** (within Bar B Bar Ranch; tributary to Price Spring Creek)
- **Three Channel Spring Creek** (north of and tributary to the Gros Ventre River)
- **Lower Bar BC Spring Creek** (south of and tributary to the Gros Ventre River in northern Spring Gulch; includes Lower, Upper and Little Bar BC Creek reaches)
- **Spring Creek** (south of Wyoming Highway 22 to confluence with the Snake River)
- **Blue Crane Creek** (within South Park; headwater to confluence with Spring Creek)
- **Cody Creek** (south of Boyles Hill Road to confluence with Blue Crane Creek)
- **Fish Creek** (upper; north of Wyoming Highway 22)
- **Fish Creek** (lower; south of Wyoming Highway 22 to confluence with the Snake River)
- **Spring Creek #1** (Crescent H Ranch; tributary to Fish Creek)
- **Spring Creek #2** (Crescent H Ranch; tributary to Fish Creek)
- **Spring Creek #3** (Crescent H Ranch; diverted from and tributary to Fish Creek)

A qualitative ranking of spawning spring creeks largely derived from the Wyoming Game and Fish Department (Kiefling, 1991, pers. comm.) except Blue Crane Creek (Annear 1989) is provided below.

<table>
<thead>
<tr>
<th>Name</th>
<th>Est. Spawning Fish</th>
<th>Quality Ranking¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring Creek</td>
<td>578</td>
<td>1</td>
</tr>
<tr>
<td>Blue Crane Creek</td>
<td>118</td>
<td>1</td>
</tr>
<tr>
<td>Lower Bar BC Spring Creek</td>
<td>485</td>
<td>1</td>
</tr>
<tr>
<td>Upper Bar BC Spring Creek</td>
<td>383</td>
<td>1</td>
</tr>
<tr>
<td>Little Bar BC Spring Creek</td>
<td>66</td>
<td>2</td>
</tr>
<tr>
<td>Three Channel Spring Creek</td>
<td>687</td>
<td>1</td>
</tr>
<tr>
<td>Price Spring Creek</td>
<td>247</td>
<td>2</td>
</tr>
<tr>
<td>Fish Creek (upper)</td>
<td>310</td>
<td>1</td>
</tr>
<tr>
<td>Fish Creek (lower)</td>
<td>?</td>
<td>2</td>
</tr>
<tr>
<td>Spring Creek #2 (Crescent H)</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Flat Creek/Nowlin Creek (NER)</td>
<td>311</td>
<td>2</td>
</tr>
<tr>
<td>Flat Creek (South Park)</td>
<td>?</td>
<td>3</td>
</tr>
<tr>
<td>Blacktail Spring Creek (GTNP)</td>
<td>383</td>
<td>1</td>
</tr>
<tr>
<td>Cowboy Cabin Creek (GTNP)</td>
<td>143</td>
<td>2</td>
</tr>
<tr>
<td>Snake River Bottom (GTNP)</td>
<td>99</td>
<td>2</td>
</tr>
</tbody>
</table>

¹ Quality ranking based on a scale of 1 to 3, with 1 being the highest possible ranking WGFD (1991, pers. comm.).
VALUABLE MATRIX FEATURES AND MATRIX TIERS

The development of the matrix was based on cumulative FHF score (i.e., the number of species-specific overlapping FHFs), and whether or not a given location falls within a ranked or unranked vegetation type. Developing this matrix resulted in a single map product in raster format that defines the concentration of important habitat for focal species. Table 4 shows the area and percent coverage of the 4 Matrix Tiers.

Table 4. Valuable Matrix Feature Tiers, Teton County, Wyoming.

<table>
<thead>
<tr>
<th>Tier</th>
<th>Area (ac)</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tier I</td>
<td>45,723</td>
<td>52</td>
</tr>
<tr>
<td>Tier II</td>
<td>21,747</td>
<td>25</td>
</tr>
<tr>
<td>Tier III</td>
<td>18,594</td>
<td>21</td>
</tr>
<tr>
<td>Tier IV</td>
<td>1,590</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td><strong>87,654</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

For any portion of the private property within Teton County, the VMF Tier mapping product can be utilized in a GIS environment in combination with other GIS layers to determine 1) the FHF attributes; 2) vegetation classes that resulted in the existing VMF classification; and 3) the tier level. The VMF Tier output is not constrained or in any way influenced by parcel boundaries and, for that reason, any given parcel can consist of more than one Tier.

Admittedly, there are single cell anomalies evident throughout the project area resulting from the conversion of vegetation mapping in vector format to a raster grid. A possible future refinement of the VMF raster would be to merge single cell anomalies with the most prevalent neighboring background VMF Tier. At this juncture, however, single 10.3 m x 10.3 m cell anomalies would likely have much less bearing on the evaluation of a given parcel or portion of a parcel within Teton County, than the prevalent VMF tier(s).
DISCUSSION AND CONCLUSIONS

The VMF Tier output represents the consolidation of 12 derived species-specific FHF layers and a layer representing important ranked native vegetation types. Each FHF layer has been scrutinized, modified, and in certain cases refined through the application of Kernel Density Estimations of home range or WGFD Seasonal Big Game Overlays. The variability in the underlying layers reflects the very nature of the inherent variability in the VMF Tier system.

The primary goal of the project was to produce science-driven GIS-based mapping products that would improve upon existing planning tools used by Teton County to inform and direct future development in a manner that would be consistent with the recently adopted Teton County Comprehensive Plan. If used as designed, the work products that were produced by this project successfully do this.

These products were developed using primarily objective parameters, but in some cases modified by some subjective decisions regarding these parameters, and should be viewed as a dynamic rather than a static planning tool. FHFsin and VMFs should be updated, refined, and improved upon wherever and whenever possible and/or warranted. In this regard, the Matrix Tiers should not be considered an immutable product of the Focal Habitat Feature Study because changes to the underlying FHFsin and VMFs and possibly other non-scientific factors may necessitate or warrant changes to the Tiers as well.

During the post-processing phase of the FHF review, it became apparent that the relatively large size of the project area alone created an inherent challenge within the scheme of the analysis. For example, vegetation community types found within the upper Gros Ventre River drainage reflected an elevational association that would, in some cases, be found at lower elevations in a montane setting in the southern portion of Teton County. Similarly, the distance to water parameter would likely indicate a much narrower association with riparian vegetation communities in lower order stream systems versus broader riparian habitat supported downstream. The result, when applying the “drill-down” methodology to derive common thematic parameters for species-specific FHF maps, was that some focal habitat models were broadly inclusive. Considerable refinement, primarily reduction, was required to avoid errors of commission. In retrospect, a suite of FHF models that were both species-specific and site-specific to the Upper Gros Ventre drainage, the Buffalo Fork valley, or the Alta area within the County, may have yielded tighter fits of FHF models in these locations. The challenge from the outset was to prepare a data driven model of significant habitat components for numerous species, across a developed or partially developed landscape, where relatively little quantitative habitat use data exists. The extrapolation of habitat associations based on datasets that are largely illustrative of habitat use away from our County development centers may have led to a somewhat more generalized final VMF output, due to the broadness of scale.
ACKNOWLEDGMENTS

Biota extends a special thanks to Susan Johnson (Planning Manager at the Teton County Planning and Development), and to the Teton County Natural Resource Technical Advisory Board (NRTAB) for their collaboration and important contributions throughout the development of the study. Past and current members of the NRTAB include Tom Segerstrom, Patrick Wright, Steve Kilpatrick, Renee Seidler, Siva Sundaresan, Dave Adams, and Hank Phibbs.

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Biota would like to specifically thank the following organizations and individuals for contributing time and valuable research results to help make the Focal Habitat Feature Study the very best product possible (presented in alphabetical order).

Craighead Beringia South: Bryan Bedrosian (Title)
Jackson Hole Conservation Alliance: Kniffy Hamilton (Board Chair), Siva Sundaresan (also NRTAB Board Member)
Jackson Hole Wildlife Foundation: Cory Hatch (Executive Director), Alyson Courtemanch (Board Member and Wyoming Game and Fish Department employee)
Nature Mapping of Jackson Hole
NPS, Grand Teton National Park: Kathy Mellander (GIS Specialist)
Teton County Conservation District: Robb Sgroi (TCD employee), Dave Adams (Supervisor)
Teton Science School: Morgan Graham and Corinna Riginos
USDA Bridger-Teton and Caribou-Targhee National Forest: Sanford Moss
USFWS National Elk Refuge: Steve Kallin (Refuge Manager) and Eric Cole (Biologist)
USGS Wyoming Cooperative Fish and Wildlife Research Unit: Matt Kauffman
Wildlife Conservation Society: Renee Seidler (Title), Jon Beckmann (Title)
Wyoming Game and Fish Department: Susan Patla (Nongame Biologist), Bob Lanka (Title)
Wyoming Migration Initiative: Bill Rudd (Title)
Wyoming Natural Diversity Database: Melanie Arnett (Title)
LITERATURE CITED AND REFERENCES


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