Nevada Conservation Credit System: Greater Sage-Grouse Habitat Quantification Tool

Scientific Methods Document




Version 0.9

DRAFT

For Sagebrush Ecosystem Council Review

Acknowledgements

This document describes the scientific approach for quantifying impacts and benefits to greater sage-grouse habitat for use in the Nevada Conservation Credit System (Credit System).

This work is the product of EcoMetrix Solutions Group and Environmental Incentives. It incorporates design and content from documents developed by EcoMetrix Solutions Group, Environmental Incentives, and Environmental Defense Fund, among others. Further, it would not have been possible without the following highly qualified scientists and technical experts who provided the project team with Nevada specific science.

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[[This draft of the Nevada Conservation Credit System: Greater Sage-Grouse Habitat Quantification Tool is provided to the Sagebrush Ecosystem Council (SEC) for review in advance of the February 24th SEC meeting. It is expected that this draft will be submitted for incorporation into the Draft Environmental Impact Statement for the Northeast California/Nevada Sub Region of the National Strategy to Preserve, Conserve, and Restore Sagebrush Habitat. The Draft EIS will only incorporate the general concepts so the specifics are permitted to change over time.

This draft contains context to assist the SEC with their review in double brackets and yellow font. This draft is also written in the current tense so that the document does not have to be rewritten in a different tense once it is finalized.]]

Contents

Executive Summary

The Nevada Conservation Credit System's Habitat Quantification Tool (HQT) is the method for quantifying impacts ("debits") or benefits ("credits") to Greater Sage-grouse (*Centrocercus urophasianus*; hereafter GRSG) habitat characteristics generated by participants in the Nevada Conservation Credit System (Credit System). It is intended to provide an effective means for targeting credits and debits to the most beneficial locations for the GRSG, and tracking the contribution of the Credit System to GRSG habitat and population goals.

This is the Scientific Methods Document for the HQT and the contents describe, explain and operationalize the scientific approach to quantifying credits and debits. This document includes a description and definition of the attributes measured, methods of measurement for each attribute, and supporting documentation (e.g., peer-reviewed literature, gray literature, expert opinion) illustrating why those specific attributes and methods were chosen. This document informs the development of the HQT Calculator Tool and accompanying User's Manual.

Uses and Users of HQT

The HQT is intended to be used by Credit Developers and Buyers to quantify credits and debits, respectively. In order to use the HQT, a user must have access to site-specific field data and possess technical skills in Geographic Information Systems (GIS). Thus, Credit Developers and Buyers will likely need the assistance of technical service providers to operate the HQT.

Framework for Quantifying Habitat Function

This document describes the fundamental structure of the HQT, how its components relate to each other, and the approach used for measuring habitat impacts and benefits. The HQT uses a set of measurements and methods applied at multiple spatial scales, to evaluate vegetation, anthropogenic, and environmental conditions related to GRSG habitat quality and quantity, over space and time. There are four scales of application which are related to GRSG habitat evaluation (Figure 1):

- **1st Order** – the range for the species in Nevada;
- **2nd Order** – habitats that have been identified as key for maintaining the species at statewide scales with different seasonal habitats (landscape scale);
- **3rd Order** – habitat surrounding a proposed project site (local scale);
- **4th Order** – habitat conditions at the site of proposed activities (site scale).

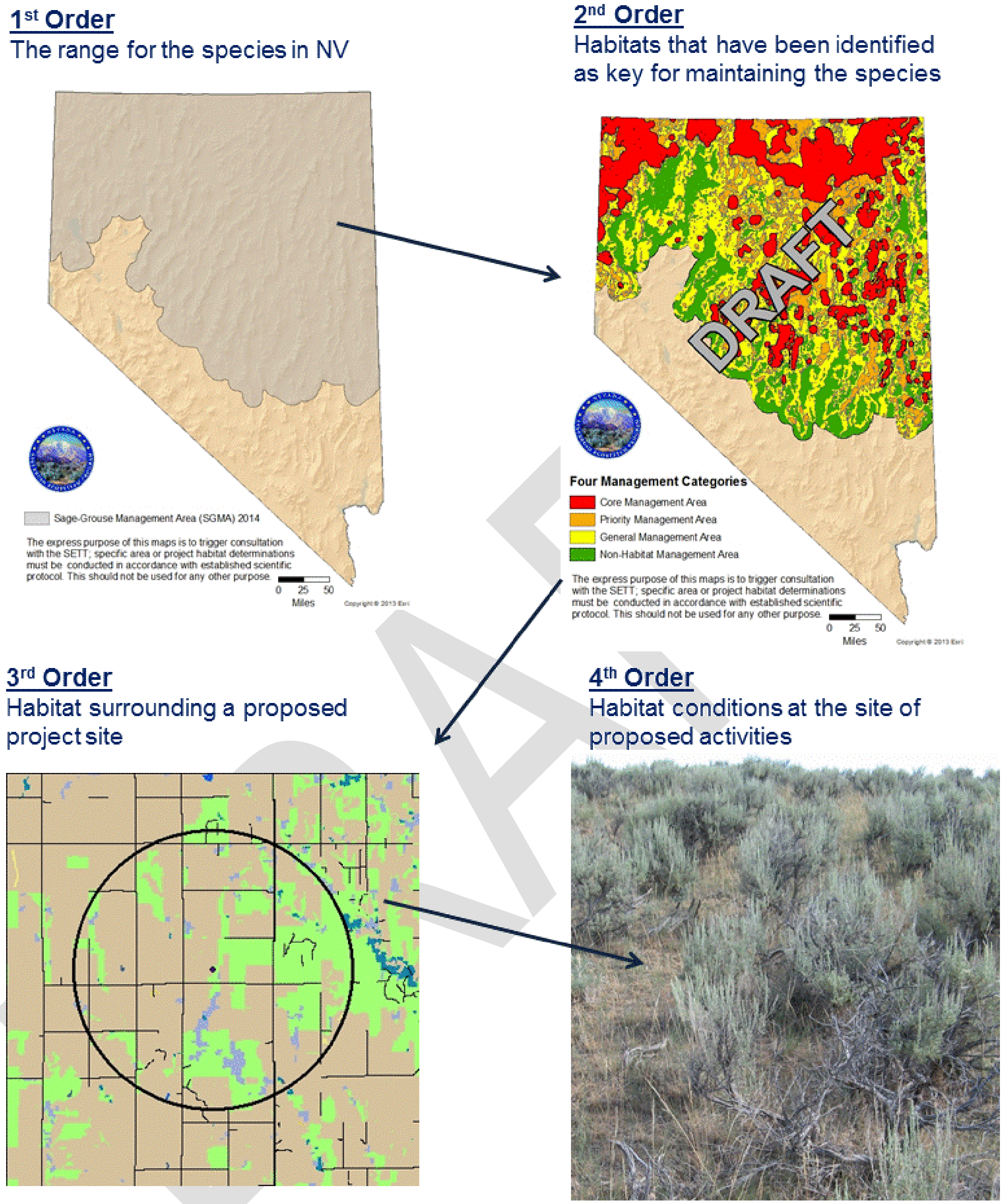


Figure 1. Multiple spatial scales within the HQT

Habitat Quantification Attributes

A summary of the area assessed and specific attributes measured by the HQT at each scale is listed in Table 1.

Table 1. HQT Area Assessed and Attributes Measured, by Scale

Scale	Area Assessed	Attributes Measured or Delineated
1st Order	The range for the species in Nevada	Statewide population recovery goals
2nd Order	Key habitat for maintaining the species at statewide scales	Key habitat / service area in NV
3rd Order	Habitat surrounding a proposed project site (local scale)	• Density of anthropogenic features • Contiguous sagebrush cover • Extent of conifer cover
4th Order	Delineated acreage of credit or debit project	• **Nesting habitat:** sagebrush cover; perennial grass cover; shrub cover; perennial forb cover, mesic perennial forb availability • **Late Brood-Rearing habitat:** sagebrush cover; perennial forb cover, mesic perennial forb availability • **Winter habitat:** sagebrush height, cover, • Modified by noise, distance to anthropogenic activity, invasive annual grass, hydrologic condition, sagebrush cover, (and distance to sagebrush for late brood-rearing habitat)

Scoring Approach

Six steps are used to score either a debit or a credit project: 1) conduct pre-site visit desktop analysis; 2) conduct site visit; 3) calculate 4th order scores; 4) apply 3rd order modifications; 5) calculate total seasonal habitat scores for the site; and 6) apply the mitigation ratio (as described in the Nevada Conservation Credit System Manual) to determine the number of credits that are necessary to offset the debit (Figure 2). Note that the 1st order assessment does not

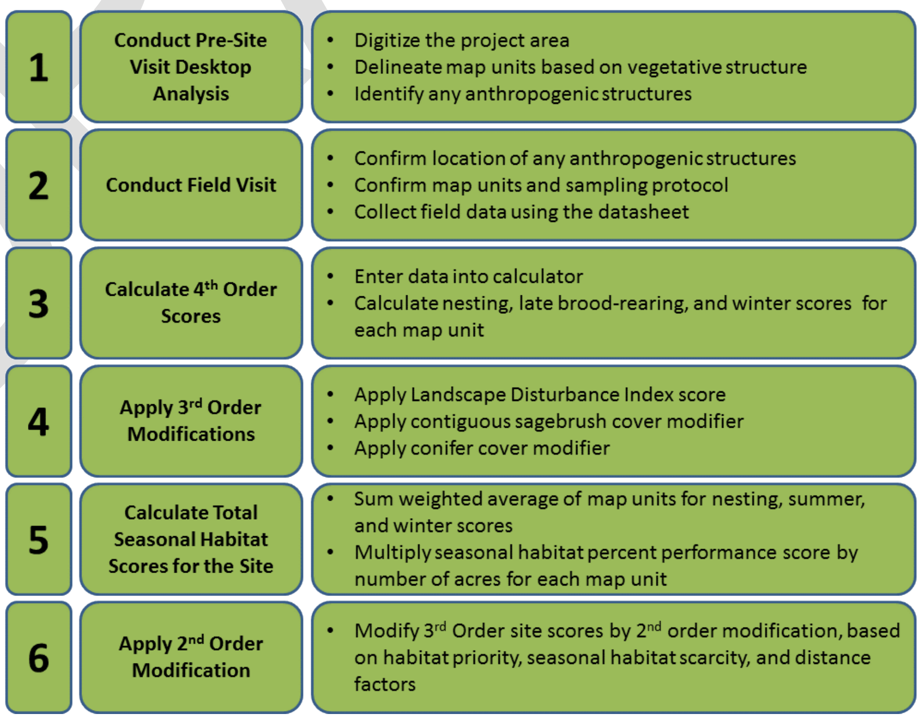


Figure 2. Scoring Steps in the HQT

impact scoring and instead just defines the geographical scope for tracking the benefits of the Credit System.

4th Order Quantification Approach

A conceptual model of the life history requirements of the GRSG was developed to illustrate the conditions being measured and the role they play in providing suitable nesting, late brood-rearing, and winter habitat (Figure 3).

These attributes determine scores for a site and the magnitude of habitat change resulting from a debit or a credit project. Habitat condition is expressed in “functional acres”, which are units of habitat quality (“function”) and quantity (“acres”) relative to optimal conditions.

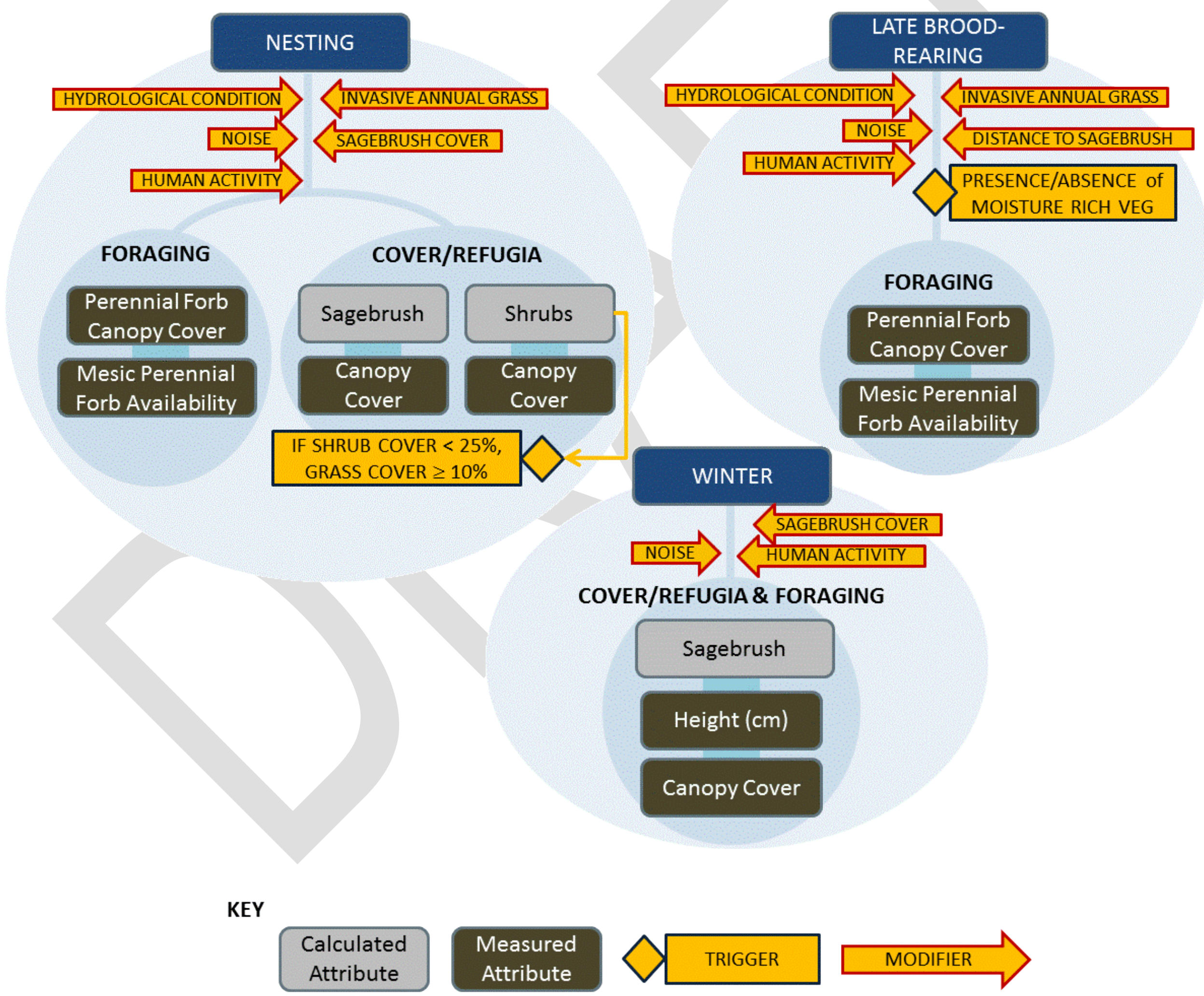


Figure 3. Conceptual Model of GRSG Life History Requirements

3rd Order Quantification Approach

The functional acre debit or credit score calculated for the 4th order is adjusted to account for the indirect effects that the change in site condition is estimated to have on the surrounding landscape's ability to function for the GRSG, as well as the indirect effects of the surrounding landscape on the condition of the site (Figure 4). These adjustments can increase or decrease the site score.

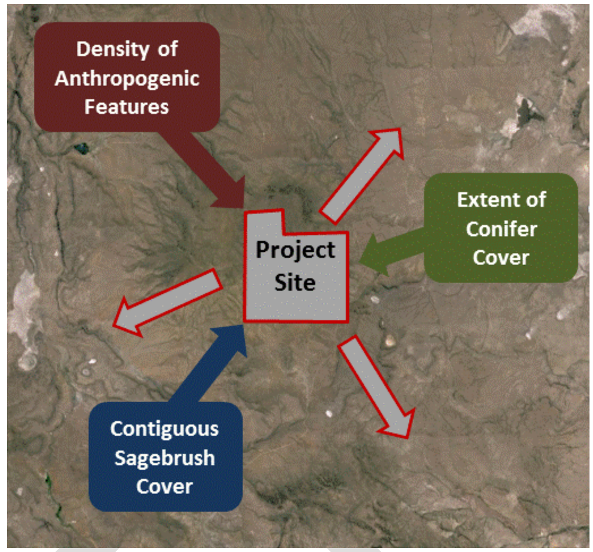


Figure 4. Indirect Effects of Surrounding Landscape on Project Site, and of Effects of Project Site on the Surrounding Landscape

2nd Order Quantification Approach

The adjusted functional acre score—the combination of the site score with the surrounding landscape adjustment—determines the credit or debit amount for the project. The 2nd order attributes are focused on targeting credits and debits on the landscape based on priority areas within the State and the scarcity of specific seasonal habitat types for each population. The 2nd order attributes are currently incorporated into the quantification of credits and debits through the Mitigation Ratio defined in the Nevada Conservation Credit System Manual.

Components of the HQT

There are five components of the HQT:

1) HQT Scientific Methods Document (this document)
2) HQT Data Collection Guide [[currently under development]]
3) HQT Calculator (spreadsheet) [[currently under development]]
4) HQT User's Guide [[currently under development]]
5) HQT Monitoring and Adaptive Management Plan [[currently under development]]

1.0 Overview of the Habitat Quantification Tool

The Nevada Conservation Credit System's Habitat Quantification Tool (HQT) is a multi-scaled approach for assessing vegetation conditions, habitat and conservation outcomes for Greater Sage-grouse (*Centrocercus urophasianus*; hereafter GRSG). The HQT uses a set of metrics (i.e. measurements and methods), applied at multiple spatial scales, to evaluate vegetation and environmental conditions related to GRSG habitat quality and quantity, over space and time. The purpose of the HQT is to quantify impacts ("debits") or benefits ("credits") to GRSG habitat characteristics through debit and credit projects.

The HQT has been specifically designed for use in the Nevada Conservation Credit System (Credit System). However, it could have broad applicability for use in Nevada in GRSG mitigation and conservation efforts beyond the Credit System. For example, the HQT could be used to strategically invest conservation funds for the GRSG not related to the Credit System by providing an effective and consistent quantification method to estimate the GRSG benefits from conservation projects.

The methods described in the HQT quantify the quality of GRSG habitat. The methods can determine site conditions relative to GRSG habitat requirements and changes to habitat based on credit and debit projects. Changes to habitat quality include the indirect effects those changes have on the ability of the surrounding landscape to function for the species. Conditions that support each seasonal habitat type for GRSG are measured, including nesting habitat (mating and early brood-rearing areas), late brood-rearing habitat, and winter habitat. Accordingly, the HQT provides scores for each type of seasonal habitat. Habitat condition is expressed in "functional acres", which are units of habitat quality ("function") and quantity ("acres") relative to optimal conditions. The Nevada Conservation Credit System Manual (Credit System Manual) defines how these scores are used by the Credit System.

To quantify the quality of GRSG habitat, first the pre-project conditions at the site are measured to determine the current ecological performance of the site. The functional acre debit/credit score is adjusted to account for the indirect effects of the local area surrounding the site, which can decrease or increase the site score. Next the projected (not actual) post-project condition is evaluated to determine the extent to which the site's ability to support the species is projected to change as a result of the project. The post-project condition is the basis for the credit/debit estimate for the proposed project. Once the project is underway, the actual conditions are verified using the HQT and credits are released according to the actual credit/debit amount and the credit release schedule for the project, as defined in the Credit System Manual.

1.1 Framework for Quantifying Habitat Functionality

Species' habitat occupancy and population viability respond to conditions and processes at multiple scales (Hilden 1965, Johnson 1980, Weins 1987, Orians and Wittenberger 1991, Morrison et al. 1992, Fuhlendorf and Smeins 1996). The HQT delineates and quantifies the relevant habitat selection criteria corresponding to GRSG survival and reproduction at the appropriate spatial scales. Addressing the multiple spatial scales (Johnson 1980) relevant to a species' habitat use and performance is essential for effective and efficient conservation and management. The HQT clearly defines the measurement methods at each scale and the interrelationships between the scales.

The HQT measures and delineates habitat selection criteria using the following four orders, which are derived from and corresponding to Johnson (1980):

- **1st order:** the range for the species in Nevada;
- **2nd order:** habitats that have been identified as key for maintaining the species at statewide scales (e.g. priority and core management areas) within the range associated with different seasonal habitats (landscape scale);
- **3rd order:** habitat surrounding a proposed project site (local scale)
- **4th order:** habitat conditions at the site of proposed activities (site scale).

These orders are illustrated in Figure 5. All of these orders offer the potential to incorporate species population data in conjunction with independent researchers in an adaptive effort to refine the HQT over time.

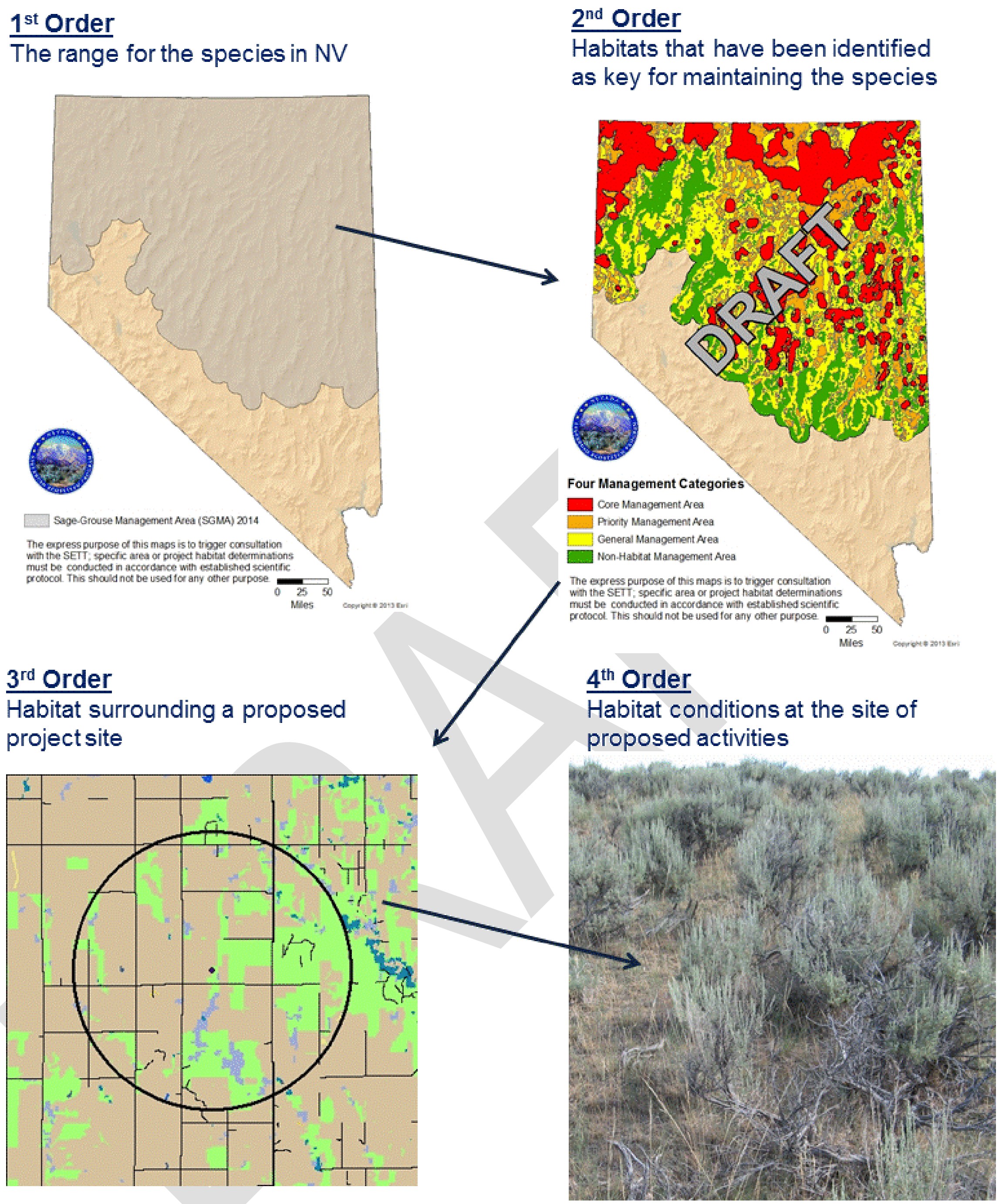


Figure 5. Four Orders Addressed in the HQT, adapted from Johnson (1980)

The use of multiple scales of measurement enables the HQT to accomplish three essential tasks to program management:

1. **Measure impacts (debits) and benefits (credits) for transactions.** This is a measurement of the functionality at the 4th order (site) and how it affects and is affected by the 3rd order (local

context). This measure is generated by the HQT and becomes the basis for calculating debit and credit amounts as defined within the Credit System Manual.

2. **Ensure an effective strategy for targeting transactions to the most beneficial locations to the species.** This is a measurement of the mitigation needs and opportunities within respective estimated areas of high levels of use at the landscape scale (2nd order). This measure is generated using the mitigation ratio defined within the Credit System Manual.
3. **Track the contribution of the Credit System to species habitat and population goals in Nevada over time.** This measures the overall performance of the Credit System by evaluating the program's contribution to population recovery goals in Nevada (1st order). It will be used to adaptively manage Credit System policies and protocols over time.

1.2 Components of the HQT

There are five components of the HQT:

1. This **HQT Scientific Methods Document** includes: a description and definition of the attributes measured and scored at each of the four orders, methods of measurement for each attribute, and supporting documentation (e.g., peer-reviewed literature, gray literature, expert opinion) illustrating why those specific attributes and methods are used.

2. The **HQT Data Collection Guide** is a manual for field data collection techniques for the HQT quantification process, including credit or debit project planning, credit or debit quantification, credit verification, or monitoring at each scale.

3. The **HQT Calculator** is a Microsoft Excel-based spreadsheet that performs the calculation using field data and the information contained in the HQT Methods Document.

4. The **HQT Calculator User's Guide** is a basic description of how to apply the HQT that is clear and concise for users of the HQT Calculator.

5. The **HQT monitoring and adaptive management plan** describes the process for monitoring and evaluation of the accuracy, effectiveness, and efficiency of the HQT and subsequent adaption of the HQT over time. This process includes not only information collected directly through monitoring of participating sites, but also uses an adaptive process to review and incorporate new research on the species ecology, population and demographic data, habitat relationships, landscape conditions, measurement methods, etc.

1.3 HQT Development Process

The HQT is based on a well-established and academically-supported framework, which is described above. For the first release of the HQT, the State hired EcoMetrix Solutions Group and Environmental Incentives to define the important habitat attributes needed to measure habitat functionality for GRSG and identified the methods to measure those attributes. The State and consultants pulled together a group of local biologists and ecologists to vet the scoring curves for each attribute to ensure they reflect the best available local and range-wide science.

Appendix F describes the process for the continued development of the HQT over time.

2.0 Habitat Quantification Methods and Attributes

The use of multiple spatial scales results in a more ecologically comprehensive approach to broad-scale siting of anthropogenic structures and conservation decisions (2nd order and 3rd order) in conjunction with site-based assessments of local environmental suitability conditions (3rd and 4th order). The Credit System uses the information provided at the respective scales through either a top-down (1st order to 4th order) or a bottom-up (4th order to 1st order) manner. For example, using it in a top-down manner provides for effective conservation planning and targeting; applying the information in a bottom-up manner provides an essential perspective for understanding cumulative benefits and impacts of landscape integrity over time (Figure 6).

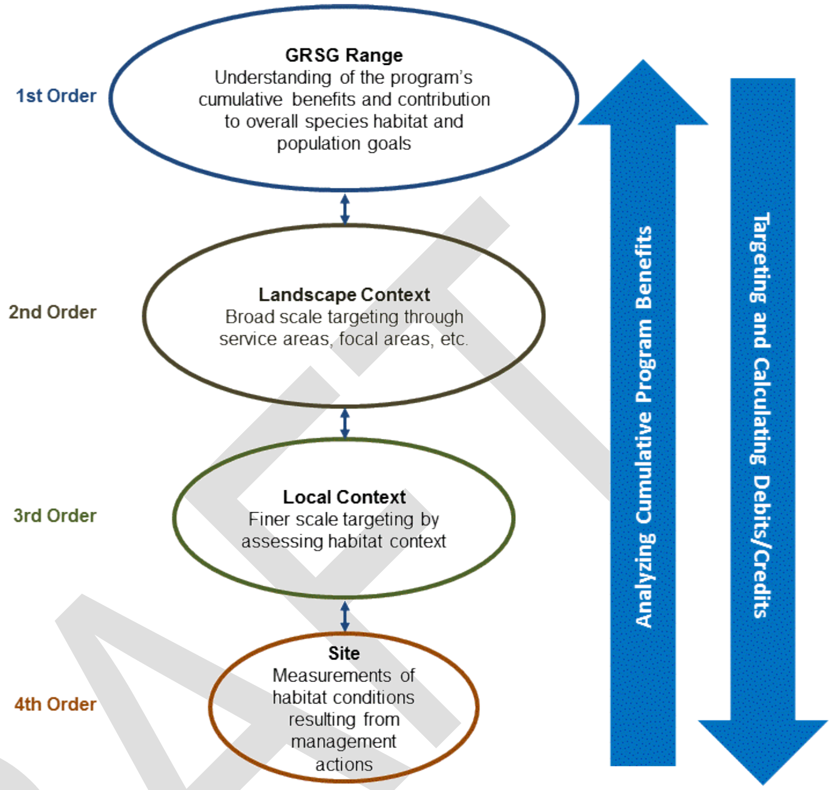


Figure 6. Top-Down and Bottom-Up Application of Orders

2.1 1st Order

2.1.1 Estimated Range in Nevada

The 1st order is the current estimated range of GRSG in Nevada. The species' distribution is thought to have varied substantially over the species' history. GRSG occupies 56% of its potential pre-settlement distribution (Schroeder et al. 2004). The reduction in distribution appears to be a consequence of altering sagebrush habitat quality and quantity (Schroeder et al. 2004). Documented changes to the estimated range will be tracked and incorporated into the HQT over time through the Credit System Management System described in the Credit System Manual.

An important objective at this scale is to estimate the contribution of changed habitat conditions resulting from site level management actions (4th and 3rd order) to regional or statewide habitat and population recovery goals. The ultimate objective of the Credit System is to contribute to recovery of the GRSG by providing net habitat benefits. However, these habitat benefits must ultimately lead to larger and more secure GRSG populations. Therefore, the Credit System must have a means of measuring aggregate cumulative habitat impacts and benefits, and relating the net contribution of habitat benefits achieved through the Credit System to populations.

To make this link, an estimate of population impacts from activities at the 4th and 3rd orders is needed. Unfortunately it is not currently possible to make this link directly through published literature and thus site level management actions cannot be quantified for the number of GRSG "produced" or "eliminated." However, as long as debits are offset by credits, and as credits accumulate beyond debits, the Credit System will have contributed to increases in high quality habitat that is more likely to sustain resilient populations over time.

2.2 2nd Order

At this scale, information about conditions surrounding a project site that may affect GRSG seasonal habitat use, dispersal, local persistence, and overall population trends is incorporated. In order for the Credit System to maximize net benefit to the species in high value areas, debits should be guided to those areas that will have the least impact to the species, and credits should be prioritized towards areas that would have the largest benefit for species recovery. For example, creating new habitat (e.g. by restoring cheatgrass (*Bromus tectorum*) monocultures to native sage-brush habitat) within landscapes with more optimal conditions will have more beneficial impact on GRSG than if that same habitat were within a landscape with less optimal landscape conditions, thus making the area unlikely to be used by GRSG.

These goals necessitate an effective targeting mechanism. The Credit System accomplishes this by applying mitigation ratios to credits and debits generated by the HQT. For example, the following factors determine the debit mitigation ratio used to generate the credit obligation for debit projects (Figure 7):

1. Habitat importance
2. Seasonal habitat scarcity
3. Proximity of credit site to debit site

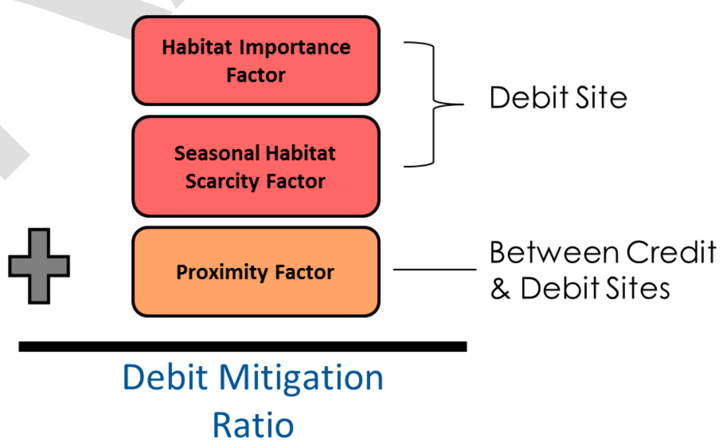


Figure 7. Mitigation Ratio Factors

This debit mitigation ratio provides appropriate incentives and disincentives for debit projects. A credit mitigation ratio based on habitat importance and seasonal habitat scarcity factors is used to provide appropriate incentives and disincentives for credit projects. These broad scale targeting strategies are applied at the 2nd order and described in greater detail below.

2.2.1 Service Area

A service area is the mapped geographic region where credits and debits are tracked, exchanged and reported. Credits and debits must occur within the same service area. The Credit System's service area is the 2014 Sage-grouse Management Area, depicted in Figure 8 below, which was developed by the Sagebrush Ecosystem Program

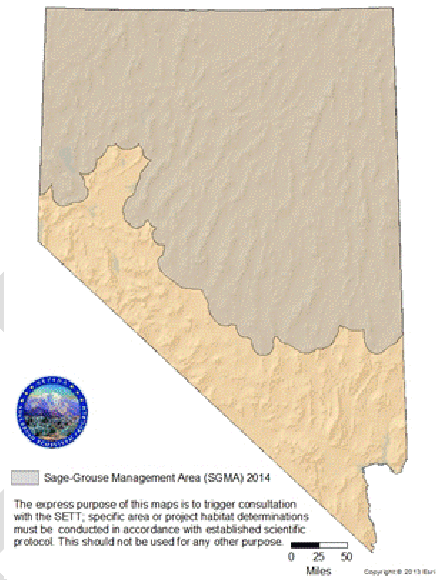


Figure 8. Service Area for NV Credit System

2.2.2 Habitat Importance

At the 2nd order, the Credit System assigns mitigation ratios based on habitat quality and importance with respect to GRSG. These decisions need to be spatially explicit and based on science and data. The Sagebrush Ecosystem Program's Habitat Management Categories map is used determine habitat importance for credit and debit projects..

Because the Habitat Management Categories map is based on land cover data including vegetation communities, agricultural areas, topographic indices, elevation models, and anthropogenic attributes, it serves as a defensible and objective modifier of habitat quality on which to base mitigation ratios at the 2nd order. This provides the Credit System with an empirical basis for decisions, and can be of broad value to managers, decision makers, industry, and the conservation community.

2.2.3 Seasonal Habitat Scarcity

Given that the purpose of the 2nd order is to provide a means of delineating the best areas for conservation and thus, identifying where development should be avoided, the accurate estimation of the extent, location, and quality of potential GRSG habitat is an important factor for effectively guiding credit and debit projects at this scale. Research suggests that GRSG generally move between nesting, late brood-rearing and winter ranges as resource requirements differ during these seasons (Fedy et al. 2012). This means GRSG are typically found within a landscape context that includes the seasonal habitats within a distance that GRSG are capable of moving. The location and juxtaposition of seasonal habitat can be assessed through predictions of GRSG occurrence as it varies throughout potential suitable nesting, late brood-rearing, and winter habitat in relation to environmental characteristics. The specific methods to determine the relevant range for the population of birds using a specific project area and the limiting habitat type for those birds will be developed. Radio-telemetry has been used in Colorado to determine seasonal habitats (Rice et al. 2013), or a method that enables a site specific analysis may be developed. [1]

2.2.4 Resilience and Resistance

[[Jeanne Chambers was unable to review this section before distributing this draft, and she has volunteered to review this section the week of Feb. 17.]]

The USFWS Conservation Objectives Team's final report recognizes fire and invasive weeds as the primary issue in the western portion of the species' range (USFWS 2013). Specifically, the report finds that "restoration activities to restore habitat and connectivity in those areas must be a priority; management actions must strive to maintain or improve existing habitat conditions so that when a fire occurs, there is greater chance for successful habitat recovery." (USFWS 2013, p. 38). As such, at the 2nd order, management strategies can incorporate resilience and resistance concepts—protection, prevention, restoration, and monitoring and adaptive management—to determine priority management areas. Resilience is characterized as the magnitude of disturbance a system can absorb while still retaining essentially the same function, structure, identity, and feedbacks (Walker et al. 2007).

Given this objective, the Credit System proposes to use a resilience matrix in conjunction with the HSM as a modifier of habitat quality within Nevada (Table 2):

Table 2. 2nd Order Resistance and Resilience Matrix

Resistance & Resilience Matrix		
Ecosystem Type	**Resilience & Resistance**	**2nd order modifier***
Cold & moist	Resilience – Moderately High Resilience – High	A
Cool & moist	Resilience – Moderately High Resilience – Moderate	B
Warm & moist	Resilience – Moderate Resilience – Moderately Low	C
Cool & dry	Resilience – Low Resilience – Moderate	D

[1] We propose a model that depicts predicted GRSG presence in nesting, late brood-rearing and winter seasons, and which is aligned with the HSM. Colorado Parks & Wildlife built a similar model, analyzing regional species distribution models based on radio-telemetry datasets from multiple studies to predict GRSG location counts during breeding, summer, and winter seasons (Rice et al. 2013). The HSM results in conjunction with the seasonal habitats in Nevada will provide a complete 2nd order valuation of a given site as potential habitat for GRSG. USGS has proposed a similar model and we would work with USGS to align methods.

Warm & dry winter	Resilience – Moderately Low Resilience – Moderately Low	E
Warm & dry summer	Resilience – Low Resilience – Low	F

** The values in this column are illustrative only.*

2.3 3rd Order

The purpose of the 3rd order measurement is to understand how a site's habitat value is affected by its local surroundings, and is intended to evaluate conditions that may affect GRSG performance in an area smaller than the 2nd order to provide a more comprehensive understanding of the value of that site for GRSG. Based on the experience of the Technical Review Group (TRG), GRSG move up to 20 km between seasonal habitats in Eureka County, Nevada. Using this as a frame of reference, 3rd order measurements are taken within a 20 km (12 mi) buffer including and around the site of impact or benefit. [[The temporal aspect of habitat quality is an important factor that may need to be integrated into the HQT. A rigorous yet practical approach has not yet been identified and will continue to be pursued by the project team.]]

Surrounding conditions that may be related to GRSG performance include the extent of suitable seasonal habitat, developed land cover, and other features. Research suggests that this scale is ecologically important to GRSG and is therefore a useful one at which to evaluate conditions relating to GRSG habitat suitability and quality (Stiver et al. 2010; Connelly et al. 2011). For example, habitat occupancy probabilities decrease as the amount of sagebrush within 18 km of a location decreases; the probability of an active lek decreases as the linear distance of highways within 5 km increases; and nesting habitat suitability decreases in habitats within 1 km of anthropogenic infrastructure (Holloran et al. 2010, Wisdom et al. 2011, Knick et al. 2013).

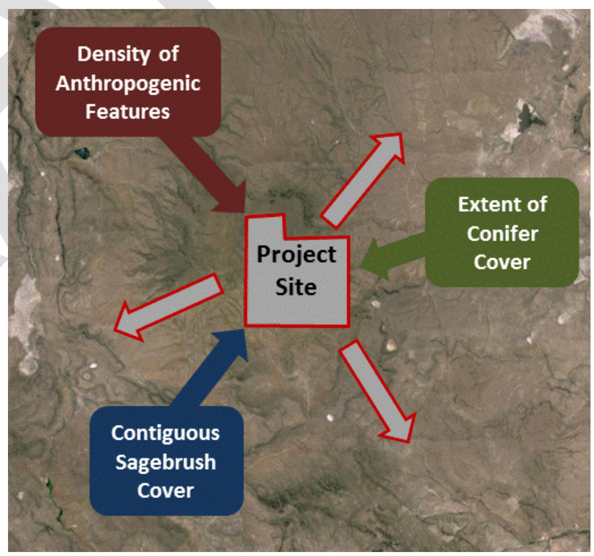


Figure 9. Order Measurements Capture the Influence of the Surrounding Landscape on the Site, and the Influence of the Site on the Surrounding Landscape

The HQT quantifies both the extent to which site changes affect the ability of the surrounding landscape to fulfill its function for the species, and the extent to which the surrounding landscape affect the site's ability to perform up to its full potential (Figure 9). In other words, debits and credits to neighboring/adjacent areas are accounted for at this order. At the project scale, simple "distance-to-features" may be a good indicator of avoidance behavior in GRSG (Holloran 2005). However at this scale, patterns of habitat use relative to density of features may be more informative. To this end, the following characteristics are quantified:

- Density of anthropogenic features (LDI, see Section 2.3.1 below)
- Contiguous sagebrush cover
- Conifer cover

With respect to the scoring approach, the 3rd order measurements adjust the 4th order functional acre credit or debit score (see description of 4th order scoring below).

2.3.1 Density of Anthropogenic Features

The presence of anthropogenic features, activity and development surrounding a site can reduce the integrity of the site itself as habitat—even if the site is otherwise fully functional. For example, yearling female GRSG avoided nesting within 950 m (0.5 mi) of the infrastructure of natural gas fields (Holloran et al. 2010), male and female GRSG may abandon leks if repeatedly disturbed by vehicle traffic on nearby roads (Lyon and Anderson 2003); or by noise and human activity associated with energy development during the breeding season (Holloran 2005; Blickley et al. 2012). Collisions with power lines and vehicles may increase mortality of GRSG at leks (Ellis 1984, LeBeau 2012).

At the 3rd order, we propose to develop and apply a Landscape Disturbance Index (LDI) to account for the direct and indirect effects of disturbance on local habitat values. The LDI is based on mapped anthropogenic disturbances and peer reviewed data on the sensitivities of GRSG to those disturbances. The LDI is generated through GIS using spatial data for anthropogenic activities that have a known impact on the quality of GRSG habitat. In Nevada, base data layers that are available to develop an index specific to GRSG include roads, development, mines, oil and gas wells, agriculture, transmission lines, and renewable energy development. The extent of these impacts portrays the “human footprint” in the surrounding conditions—the direct impacts. In addition, the effects of anthropogenic changes to the landscape often cause indirect impacts, extending some distance into the surrounding environment beyond the actual footprint of the disturbance (Holloran 2005). The effect generally decreases, or decays, with increasing distance. Hence, distance-decay functions for each type of anthropogenic disturbance are included in the LDI to capture the full scope of the impact of disturbance on GRSG.

The relative level of anthropogenic influence (e.g., highly impacted, moderately impacted, lightly impacted) at the 3rd order can be computed using GIS to generate a composite 3rd order anthropogenic disturbance score (Table 3).

Table 3. Draft Values for Landscape Disturbance Index

Landscape Disturbance Index (LDI)	
Impact Level	**LDI ***

Highly Impacted	X
Moderately Impacted	Y
Lightly Impacted	Z
No Impact	0

** The LDI values in this column are illustrative so that the scoring approach can be demonstrated below.*

Each 4th order seasonal habitat score (nesting, late brood-rearing, and winter) is reduced by the LDI value. For example, if the nesting score is 75% and LDI = 0.8*, or lightly impacted, the calculation is:

75% multiplied by 0.8 = 60%

** The LDI value in this example is illustrative so that the scoring approach can be demonstrated.*

2.3.2 Contiguous Sagebrush Cover

[[This will describe the importance of contiguous sagebrush cover for GRSG and is currently under development.]]

2.3.3 Conifer Cover

[[This may be more appropriate as a 4th order modifier rather than a 3rd order modifier based on personal communication with Brett Walker (2013). The TRG will review this and the scoring table.]]

Research estimates that as much as 90% of conifer encroachment in the western U.S. is occurring in sagebrush habitats (Davies et al. 2011; Miller et al. 2011). Suring et al. (2005) determined that 35% of the sagebrush area in the eastern Great Basin was at high risk of displacement by piñon-juniper woodlands. Encroachment of trees has significant potential to influence processes within sagebrush communities once suitable for GRSG, transforming them to a less suitable state (Patten et al. 2005). In its early stages, conifer encroachment into sagebrush communities reduces shrub and herbaceous species diversity and increases bare ground, impairing habitat quality for GRSG (Knapp and Soulé, 1998; Miller et al. 2000).

On-going research in Colorado has found that GRSG use intact sagebrush habitats more frequently than similar areas which have encroaching piñon and juniper trees (Walker 2013). The degree of tree encroachment required to preclude GRSG seems to be very small. A study in Oregon found a linear decline in the probability of lek use with increasing conifer cover, with a 0% probability of use with only 6% conifer cover (Baruch-Mordo et al. 2013).

Because lek use and habitat use may not be synonymous, and because precise data on how conifer cover affects late brood-rearing and winter use is lacking, the TRG recommended a somewhat higher threshold for conifer cover may be appropriate. Therefore, when conifer cover reaches 25%, then the nesting, late brood-rearing and winter habitat functionality scores are reduced to zero. Scores are decreased according to a linear relationship for conifer cover values less than 25% (Table 4). [[The values in this table are currently being developed.]] The scale of avoidance for nesting includes a 1 km radius (Baruch-Mordo et al 2013). Therefore, conifer cover is calculated for the project area plus a 1-km buffer.

Table 4. 3rd Order Modifications for Conifer Cover

Conifer Cover	Percent Adjustment

A modifier which reduces GRSG habitat functionality according to conifer cover provides incentive for piñon-juniper removal projects. Removal of the piñon-juniper cover can restore the productivity of shrubs and herbaceous vegetation in the understory, which is important for GRSG. However, not all piñon-juniper stands are suitable for this type of treatment. Miller et al. (2005) found that as sagebrush declines, the ability of the understory to respond positively to tree removal is decreased, with a threshold occurring at approximately 20% juniper cover (Miller et. al 2005).

Therefore, a piñon-juniper project may only be eligible for credit generation if the pre-treatment piñon - juniper cover is 20% or lower. This criterion may aid in preventing unintended negative consequences of tree removal such as expansion of non-natives, such as cheatgrass (*Bromus tectorum*), which has been reported in several studies of piñon-juniper removal (Owen et al 2009, Ross et al 2012, Huffman et al 2013).

The HQT is cautious about the amount of influence Credit System participants have on conditions outside of their control. However, the significance of the effect of surrounding context conditions on the quality of any given area is an important consideration (Stiver et al. 2010; Connelly et al. 2011). As such, the HQT is designed to balance these factors by including these features within the scoring system to provide incentives and disincentives to guide credit projects to areas where they will be most effective and debit projects to where they will be least impactful.

2.4 4th Order

The HQT measures baseline conditions and change at the 4th order, which is defined as the area of the debit project (i.e., the project footprint) or the area of the credit project (i.e., the area that has been delineated for credit generation within a participant's contract). Measurements include attributes that are indicative of habitat suitability and quality for the GRSG, including conditions that support nesting, late brood-rearing, and winter habitats. The measurements focus on vegetation and the presence and extent of anthropogenic features.

The concept model below illustrates the conditions being measured at the 4th order and the role they play in providing suitable nesting, late brood-rearing, and winter habitat (Figure 10).

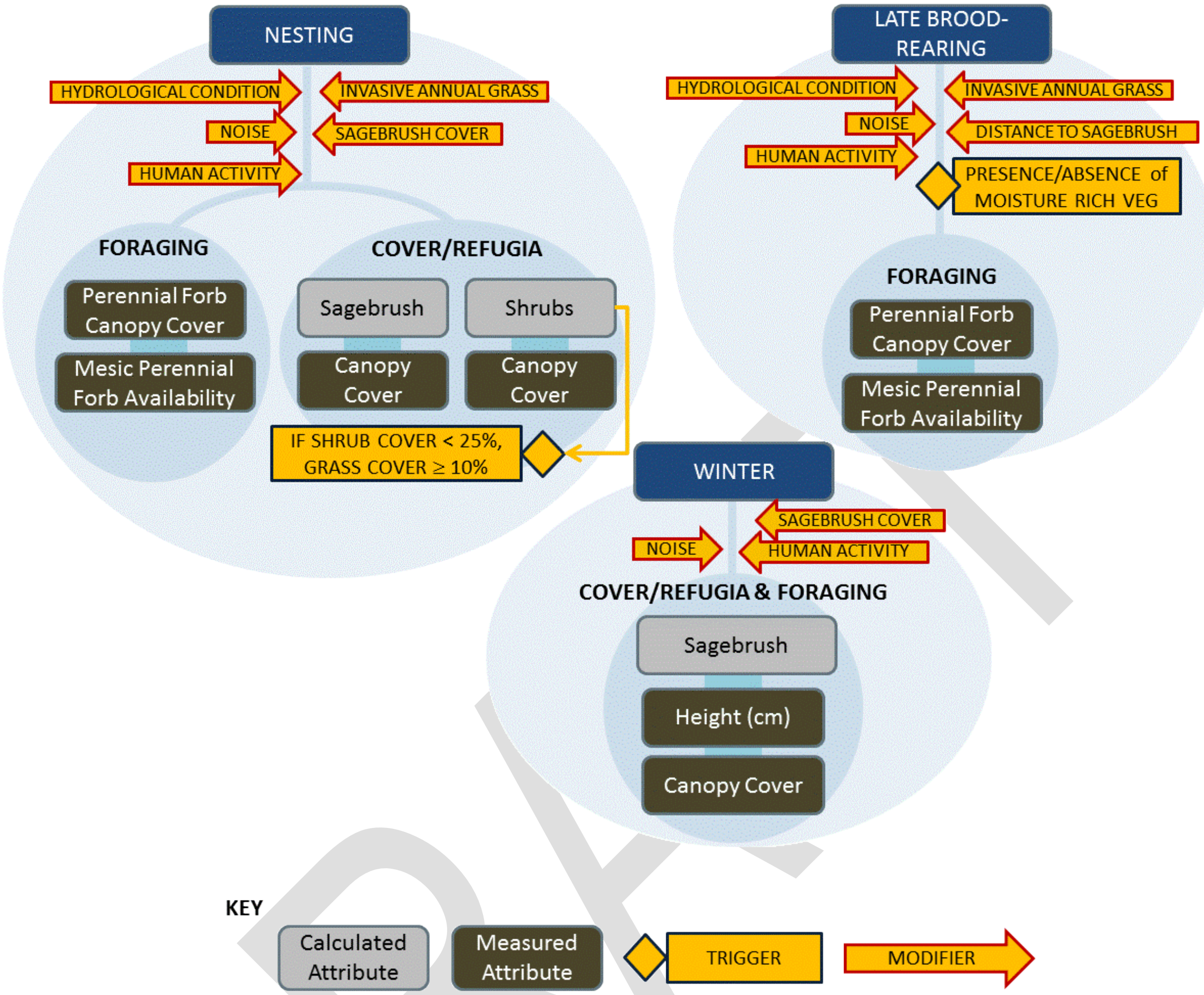


Figure 10. Conceptual Model Depicting GRSG Life History Requirements

2.4.1 Measuring Vegetation Conditions

The 4th order quantifies the extent to which the site provides conditions suitable for nesting, late brood-rearing and winter habitat. The following attributes of site vegetation are measured:

NESTING		
Cover / Refugia	Sagebrush canopy cover	This serves as nesting horizontal overstory substrate. The presence of sagebrush in nesting habitat is an active variable in all studies of GRSG. (Connelly et al. 2000; Blomberg et al. 2012; Kolada et al. 2009a; Kolada et al. 2009b). This is estimated with line intercept or point-line intercept.
	Perennial grass canopy cover	Grass canopy provides concealment for nests and chicks and can be critical for reproductive success. When sagebrush canopy cover declined to below 25%, perennial grasses began to show a direct effect on nesting success (Coates et al. 2011; Coates and Delehanty 2010). Percent canopy cover is estimated with line intercept or point-line intercept.
	Shrub canopy cover	Shrub species such as rabbitbrush (*Chrysothamnus spp.*), antelope bitterbrush (*Purshia tridentata*), and horsebrush (*Tetradymia canescans*) have been used for nesting and hiding cover. Where sagebrush canopy cover is high, other brush species play a positive role. Total canopy cover of all species is a positive attribute for nest success (Coates and Delehanty 2010; Kolada et al. 2009). This is estimated with line intercept or point-line intercept.
Foraging	Perennial forb canopy cover	Forbs are an important food resource and is a primary habitat component affecting brood persistence (Casazza et al 2011). This is estimated with line intercept or point-line intercept.
	Mesic perennial forb availability	This is a measure of the variety of forbs available across the early brood-rearing period. Data indicate there is a direct correlation between the number of forb species present and GRSG persistence (Casazza et al. 2011). Sampling for this attribute should be done over a standard-sized area of 10 square meters. Species are tallied using a $1m^2$ quadrat.

LATE BROOD-REARING		
Cover / Refugia	Sagebrush canopy cover	Sagebrush does not have to be present to be late brood-rearing habitat. However it must be accessible to GRSG.
Foraging	Perennial forb canopy cover	Forbs are an important food resource and is a primary habitat component affecting brood persistence (Casazza et al 2011). This is estimated with line intercept or point-line intercept.
	Mesic perennial forb availability	This is a measure of the variety of forbs available across the early brood-rearing period. Data indicate there is a direct correlation between the number of forb species present and GRSG persistence (Casazza et al. 2011). Sampling for this attribute should be done over a standard-sized area of 10 square meters. Species are tallied using a $1m^2$ quadrat.
	Presence/absence of moisture-rich vegetation	This is an indicator that forb species may remain green over the course of the late brood-rearing season.

WINTER		
Cover / Refugia and Foraging	Sagebrush canopy cover	During winter, sagebrush canopy cover serves as both food and cover for GRSG (Connelly et al. 2000). This is estimated with line intercept or point-line intercept.
	Sagebrush height	Access to sagebrush during winter conditions is important (Connelly et al. 2000). This measures the average height of sagebrush. It is collected along line transects within a Daubenmire frame.

A set of scoring curves has been developed with the TRG for each attribute to reflect the potential for supporting GRSG for a given level of the attribute, representing how a site's functional performance changes as the attribute values change. The scoring curves, which are in the form of scoring tables, and the conceptual models they feed into, are the key to the functional performance scoring. More detailed information on how the scoring curves are used to calculate scores is available in Section 3.1.

2.4.2 Modification of Vegetation Conditions

At the 4th order, the presence of anthropogenic structures and the presence of invasive annual grass are two examples of conditions that can limit or reduce habitat use or quality. The following modifiers are applied to the 4th order functional habitat scores (Table 5):

Table 5. Modifiers Applied to 4th Order Functional Habitat Scores

	Nesting	Late Brood-Rearing	Winter
Invasive annual grass	✓	✓	
Hydrologic condition	✓	✓	
Sagebrush cover	✓		✓
Noise	✓	✓	✓
Human activity	✓	✓	✓
Distance to sagebrush		✓	

Invasive Annual Grass

Big sagebrush ecosystems of the Intermountain West are especially vulnerable to invasions by annual exotic grasses such as cheatgrass, which can become dominant in the herbaceous understory community (Miller et al. 2011). Table 6 shows the 4th order adjustment for annual exotic grass is a multiplier on each of the nesting, late brood-rearing, and winter scores [[This table needs to be confirmed with TRG.]]:

Table 6. 4th Order Modifications for Cheatgrass

% Cover of Cheatgrass	<5%	5-10%	10-15%	15-20%	20-25%	25-30%	30-35%
Percent Adjustment	100%	80%	65%	50%	30%	20%	10%

% Cover of Cheatgrass	35-40%	40-45%
Percent Adjustment	5%	0

Hydrologic Condition

The wide range of the GRSG results in different vegetation potentials in different regions in Nevada. This may be due to variation in factors such as topography and soil characteristics. Encouraging the identification of suitable and high quality habitat within each region of the state requires some flexibility in how attributes are scored. For example, vegetation height in lower precipitation areas may not attain the same levels as vegetation in wetter areas, even though the former area may otherwise be high quality habitat for GRSG.

The HQT addresses this potential for variability by using different scoring curves and table sites in mesic and arid habitat. The relative scoring structure may evolve over time as local conditions and habitat availability change. As the relative quality of conditions changes over time, it may be useful to reevaluate the standard for these scoring curves given improved understanding or changes in climate.

Sagebrush Cover

GRSG require a minimum amount of sagebrush during the nesting and winter seasons. Accordingly, the 4th order adjustment is as follows:

- Nesting habitat: If sagebrush < 20%, the score is reduced to 0
- Winter habitat: If sagebrush < 10%, the score is reduced to 0

Noise and Activity

[[The TRG was not able to review this section on Noise and Human Activity before distributing this draft, and will review this section the week of Feb. 17.]]

Research suggests that the noise and activity associated with anthropogenic sources may cause a disturbance to GRSG, reducing the overall quality of the site for late brood-rearing and winter habitat and influencing nesting habitat selection of females breeding on leks influenced by that activity (Manier et al. 2013).

Noise

Acoustic communication is important in the reproductive behaviors of GRSG, and noise generated from anthropogenic sources may affect GRSG breeding biology (Blickley and Patricelli 2012). Male GRSG produce acoustic signals in a similar frequency range as noise produced from infrastructure associated with natural gas development, so noise from these sources may mask communication between males and females (Blickley and Patricelli 2012). Other noise-related factors may interfere with foraging, resting, and breeding behaviors (Patricelli et al. 2013).

For example, Holloran (2005) found observational evidence that noise may be at least partly responsible for impacts from natural gas development on GRSG populations in the Pinedale Anticline Project Area in Wyoming. These effects were more pronounced downwind of the drilling sites where noise levels were higher, suggesting that noise contributed substantially to these declines (Holloran 2005). Holloran (2005) reported that declines in lek counts on leks within 3 km of roads were positively correlated with increased traffic volumes, and that vehicle activity on roads within 3 km of leks during the time of day GRSG were present on leks influenced the number of males on leks more negatively than leks where roads within 3 km had no vehicle activity during the strutting period. Remington and Braun (1991) reported that the upgrade of a haul road accessing a coal mine was correlated with a 94% decline in the number of GRSG on leks <2 km from the road over a 5-year period—although traffic levels were not measured, and the potential for increased traffic was inferred from upgraded road surface. Lyon and Anderson (2003) reported that traffic disturbance (1 to 12 vehicles/day) within 3 km of leks during the breeding season reduced nest-initiation rates and increased distances moved from leks during nest site selection of female sage-grouse breeding on those leks.

The percent adjustment to the nesting, late brood-rearing and winter habitat functionality scores is based on the distance of noise source to a lek and ambient levels of noise. [[As noted earlier, the TRG was not able to review this section and thus how noise will affect 4th order scores is to be determined.]]

Human Activity

Several authors have reported a “distance-effect” associated with the infrastructure of energy fields whereby GRSG are negatively influenced to a greater extent near infrastructure, with the response diminishing as distances from infrastructure increase (Manier et al. 2013 and references therein). For example, Walker et al. (2007) found a strong negative effect of infrastructure within 0.8 and 3.2 km of leks on lek persistence, but impacts to lek persistent were apparent to 6.4 km; and Dzialak et al. (2011) reported that the closer a nest was to a natural gas well that existed or was installed in the previous year, the more likely that nest was to fail.

Additionally, the distance-effect of infrastructure with higher levels of human activity may be larger than that of infrastructure with lower levels of activity. Holloran (2005) reported that impacts of development to the number of males occupying leks were greatest when infrastructure was located near the lek, but that impacts were discernable to 3 km for lower activity sites (well pads) and 6 km for higher activity sites (drilling rigs); and Dzialak et al. (2011) documented sage-grouse during the winter avoiding the infrastructure of a gas field during the day, but not at night, suggesting that avoidance was of human activity rather than the infrastructure itself. It should be noted that sightings of individual GRSG near energy development may be a result of site fidelity or the presence of remnant habitat (Manier et al 2013), but fitness of such individuals could be compromised (Holloran 2005) and anecdotal sightings of individuals should not be confounded with their ability to contribute to local and regional populations (Hagen 2011).

The HQT has two categories of anthropogenic features based on their level of disturbance: medium activity disturbance structures and high activity disturbance structures. High activity disturbance structures are those that have consistently high levels of human activity, and medium activity disturbance structures are those that have intermittently high levels of human activity or have consistently low levels of human activity. The anthropogenic structures listed in Table 7 are potential sources of disturbance to GRSG, and are categorized by their level of activity. However, for many of these structures there is very little research on the type and magnitude of disturbance. Given this uncertainty, there are some structures that are placed in an “Inconclusive” category. For these structures, future research is needed in order to further refine the categorizations applied by the HQT.

Table 7. Anthropogenic Structures by Level of Human Activity

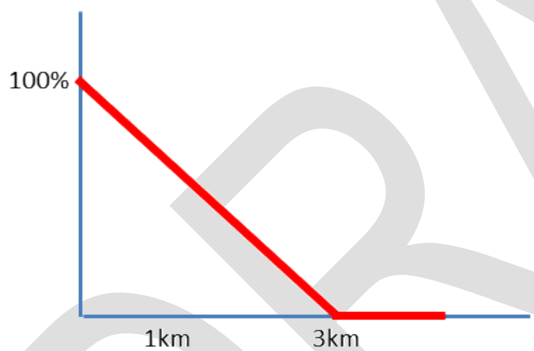
Anthropogenic Structure	Medium	High	Inconclusive
Transmission lines			✓
Power lines			✓
Non-oil and gas related two lane pave road	✓		
Non-oil and gas related improved gravel road	✓		
Interstate highway		✓	
Nonwind-power related vertical structures [1]			✓
Infrastructure associated with oil and gas development:			
• Two lane paved road; improved gravel road	✓		
• Well pad	✓		
• Active drilling site		✓	
Wind energy developments:			
• Turbines [2]			✓
• Access roads	✓		
• Power lines			✓
In situ uranium			✓
Oil shale and tar sands			✓
Solar and associated infrastructure			
• Access roads	✓		
• Transmission lines			✓
Mining			✓

1 Nonwind-power related vertical structures: Research suggests that these structures (primarily communication towers) negatively influence lek counts (Wisdom et al. 2011). However, the correlation between the location of these vertical structures and high activity sites such as interstate highways and urban centers is not clear. In any case, the 3rd order is likely to include the effect of these structures through the LDI.

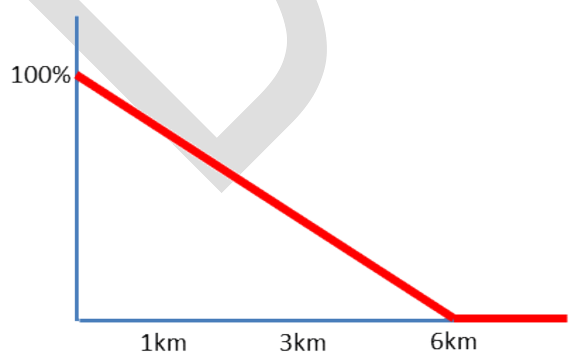
2 Wind turbines: Ongoing research in Wyoming indicates that the risk of a nest or brood failing decreased by 7.1% and 38.1%, respectively, with every 1-km increase in distance from the nearest wind turbine (personal communication with Matt Holloran, reference pending). [[The TRG could use these values to create a distance-decay curve specific to wind turbines, or could modify the current “medium activity disturbance” curve to fit these results better.]]

The percent adjustment to the nesting, late brood-rearing and winter habitat functionality scores is based on the distance of type of anthropogenic features to a sample point within the project area. Research suggests that the effect on GRSG is greater the closer the anthropogenic structure; as the distance from the structure increases, the effect on GRSG decreases (Manier et al. 2013). However, the literature is inconclusive on a specific magnitude of effect over distance for specific anthropogenic structures. The main conclusion that can be drawn from the research is there is a significant effect near the source, and the effect fades gradually as distance from the source increases.

Given this distance effect and the varying degrees of influence over distance in the literature, the TRG developed conservative estimates for the linear rate of decrease for the two categories of disturbance noted above (Figure 11).



Medium Disturbance Activity	
Distance	Percent Reduction
0 km to 3 km	100% to 0%
> 3 km	0%



High Disturbance Activity	
Distance	Percent Reduction
0 km to 6 km	100% to 0%
> 6 km	0%

Figure 11. Decay Curves for Medium and High Activity Disturbance Anthropogenic Structures

Distance to Sagebrush Cover, For Late Brood-Rearing Habitat

This modifier highlights the type of meadow system selected by GRSG during the late brood-rearing season. The interface between the sagebrush and meadow edge is the most highly forb-productive area for GRSG, and provides immediate available escape cover (Connelly et al. 2000). Based on the expert opinion of the TRG, GRSG may use habitat during the late brood-rearing season that does not have sagebrush present, as long as sagebrush is accessible to them. Meadows, riparian areas, or other moist areas adjacent to sagebrush habitat can provide foraging areas during the late brood-rearing season. Given the range of distances presented in the literature across which GRSG will travel between meadows and similar areas to sagebrush cover, the TRG chose a conservative estimate. Thus as long as sagebrush is located with 300m of each sample point, it is considered viable late brood-rearing habitat and there is no effect to the score. If sagebrush is located beyond 300m of the sample point, the score is reduced to zero.

Triggers

A trigger indicates that the functions associated specific habitats will only be scored when appropriate conditions are present. In the concept model, there are two triggers: presence/absence of moisture-rich vegetation for late brood-rearing habitat and shrub cover that is less than 25% for nesting habitat.

Presence/Absence of Moisture-Rich Vegetation for Late Brood-Rearing Habitat

During nesting and early brood-rearing, GRSG use uplands area for raising chicks or nesting (Connelly et al. 2011). As the vegetation loses moisture, GRSG move into late brood-rearing habitat with abundant mesic forbs. GRSG will preferentially select sites that are closer to sagebrush, but seek the areas where moisture allows forbs to grow throughout the late brood-rearing season (Connelly et al. 2011). Accordingly, the HQT classifies late brood-rearing habitat based on the presence or absence of moisture-rich vegetation that indicates that the vegetation at the site will remain green over the course of the late brood-rearing season.

Sagebrush Cover Less than 25% for Nesting Habitat

For nesting habitat, when sagebrush cover is less than 25%, there should be at least 10% of perennial grass cover (Coates et al. 2011; Coates and Delehanty 2010).

3.0 Scoring Approach

3.1 Description of Scoring Approach

This section describes how a credit or debit score is calculated (Figure 12). As previously described in the overview section of this document, site scores are first calculated (4th order) and then modified by conditions within the surrounding context (3rd order). This functional performance output is multiplied by the area of the map unit (see Section 3.2 on map units) to provide a functional acre score. Finally, the net mitigation ratio is applied to the functional acre score to determine the final score (2nd order), which is the basis for a credit or debit. Each credit or debit project has a nesting, late brood-rearing, and winter functional acre score.

Calculate 4th Order Scores

Nesting	Late Brood-Rearing	Winter
60%	50%	40%

Apply 3rd Order Modifications

	4th Order Score	Modifier: LDI	Modifier: Sagebrush cover	Modifier: Conifer cover	MODIFIED 3rd Order Score
Nesting	60%	Multiply by 0.9	Multiply by 1	Multiply by 0.8	43%
Late B-R	50%	Multiple by 0.9	Multiply by 1	Multiply by 0.8	36%
Winter	40%	Multiply by 0.9	Multiply by 1	Multiply by 0.8	29%
All Modifier Values in this Table are **Illustrative Only**					

Calculate Total Seasonal Habitat Scores for the Site

	3rd Order Score	Map Unit Size (Acres)	Functional Acres
Nesting	43%	Multiply by 165 acres	71 functional acres
Late B-R	36%	Multiply by 225 acres	81 functional acres
Winter	29%	Multiply by 350 acres	101 functional acres
All Values in this Table are **Illustrative Only**			

Apply 2nd Order Modification

	Functional Acres	Net Mitigation Ratio	Credit/Debit
Nesting	71 functional acres	Multiply by 2.6	185
Late B-R	81 functional acres	Multiply by 9.4	761
Winter	101 functional acres	Multiply by 5.3	535
All Values in this Table are **Illustrative Only**			

Figure 12. Calculation of Credit or Debit

Once the field attribute information has been collected on site, the scores for pre-project conditions can be calculated (4th order). To "convert" field measurements to functional performance scores, a set of scoring curves and scoring tables are referenced within the Calculator spreadsheet. The scoring tables were developed with the Technical Review Group for each attribute to reflect the potential for supporting GRSG habitat for a given level of the attribute, or the percent of potential optimal performance (see Appendix A for scoring curves). In the example below in Figure 13, the attribute is measured at 10% cover. Within the Calculator spreadsheet, the field measurement is looked up in the scoring table, which corresponds with a percent performance value for that field measurement. In this case, 10% cover corresponds to 0.8 or 80% functional performance.

% Cover of Attribute	0	1-5	5-7	7-10	10-15	15-20	10-20	>20
% Performance	0	0.5	0.5	0.8	0.8	1	1	1

Figure 13. Example of Scoring Table for Converting Field Data to Functional Performance Output

The performance scores for all of the attributes are combined in weighted scoring algorithms pursuant to the relationships identified in the concept model (Section 3.1.1 species scoring steps for each seasonal habitat).

3.1.1 4th Order Calculation Descriptions

NESTING SCORE

The **Nesting** score combines cover/refugia and foraging scores in a weighted additive process. Cover/refugia and foraging combine respective attributes also in a weighted additive process (Figure 14).

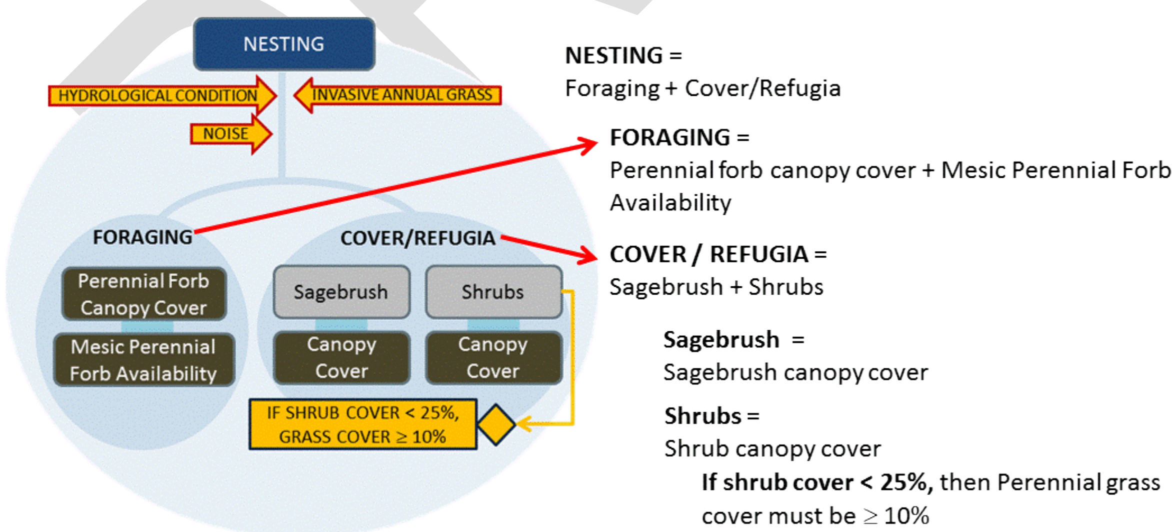


Figure 14. Scoring Algorithms for Calculating Nesting Habitat Score

To calculate the Nesting score, the Foraging and Cover/Refugia scores are each calculated. Figure 15 depicts the how the field measurements for perennial forb canopy cover and mesic perennial forb availability are converted to percent performance outputs, and then added in a weighted average.

% Forb Cover	0	1-5	5-7	7-10	10-15	15-20	10-20	>20
% Performance	0	0.5	0.5	0.8	0.8	1	1	1

The values in this table are **ILLUSTRATIVE** only.

# Mesic Forbs	<5	5	6	7	8	9	10	11	12	>12
% Performance	0	0.4	0.6	0.75	0.85	0.95	1	1	1	1

The values in this table are **ILLUSTRATIVE** only.

Figure 15. Draft Scoring Tables Converting Field Measurements to Percent Performance Outputs

FORAGING = Perennial Forb Canopy Cover + Mesic Perennial Forb Availability

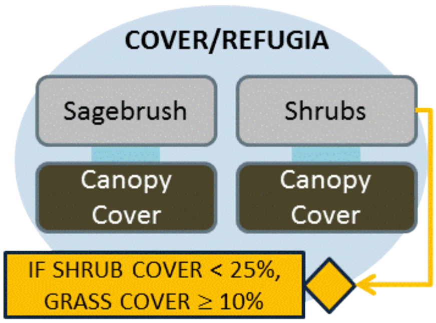
Perennial Forb cover = 10% → 0.8 or 80% performance

Mesic Perennial forb availability = 6 species → 0.6 or 60% performance

Each attribute contributes equally to Foraging, so they are combined in a weighted average:

Foraging = (80% + 60%) ÷ 2 = 70%

To calculate the Cover/Refugia score, the same process of referring to the scoring tables to convert field measurements (for sagebrush cover and shrub cover) to percent performance outputs and then combining them in a weighted average is repeated (Figure 16).



Sagebrush % cover	<20	20-25	25-30	30-40	>40
% Performance	0	0.75	0.8	0.9	1

The values in this table are ILLUSTRATIVE only.

Shrub % cover	<30	30-40	40-50	>50
% Performance	0	0.5	0.75	1

The values in this table are ILLUTRATIVE only

Figure 16. Draft Scoring Tables for Converting Field Measurements to Percent Performance Outputs

COVER / REFUGIA = Sagebrush canopy cover + Shrub canopy cover

Sagebrush canopy cover = 30% → 0.8 or 80% performance

Shrub canopy cover = 40% → 0.5 or 50% performance

Each attribute contributes equally to Foraging, so they are combined in a weighted average:

Cover / Refugia = (80% + 50%) ÷ 2 = 65%

Once the Cover/Refugia score is calculated, it is combined in a weighted average with the Foraging Score (because Cover/Refugia and Foraging each contribute equally to Nesting).

Foraging = 70%	Cover/Refugia = 65%
Preliminary Nesting Score = (70% + 65%) ÷ 2 = 68%	

Apply 4th Order Modifiers

The Calculator applies the 4th order modifications for invasive annual grass, sagebrush cover, noise, human activity and hydrologic condition to the preliminary 4th order nesting score. For hydrologic condition, unique scoring tables were developed for forb cover and grass cover in mesic and arid sites. The remaining modifiers are applied to the preliminary 4th order score as illustrated below:

Prelim 4th order score	Modifier: Cheatgrass	Modifier: Sagebrush cover	Modifier: Noise	Modifier: Human activity	Modified 4th Order Score
68%	Multiply by 0.8	Multiply by 1	Multiply by 1	Multiply by 0.75	41%

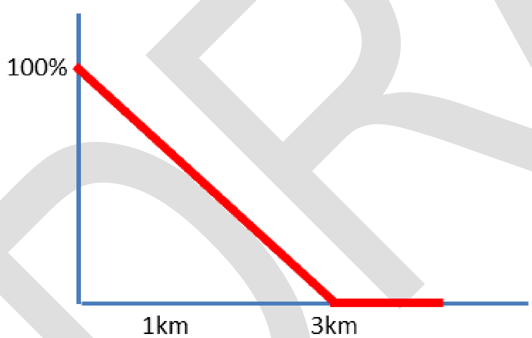
* All values in this table are ILLUSTRATIVE only to demonstrate scoring steps.

In this example, the modifier values are based on the following:

- Cheatgrass: the spreadsheet Calculator refers to the scoring table for Cheatgrass. For example, cheatgrass = 10%, which corresponds to 0.8 or 80% performance.

% Cover of Cheatgrass	<5%	5-10%	10-15%	15-20%	20-25%	25-30%	30-35%
Percent Adjustment	100%	80%	65%	50%	30%	20%	10%

- Sagebrush cover: for Nesting habitat, if sagebrush < 20%, the score is reduced to zero. For example, sagebrush = 30%, so there is no effect on the Nesting score. The modifier value is 1.
- Noise: [[This is currently being developed, and a modifier value of 1 is used as a placeholder.]]
- Human activity: this modifier is based on the distance-decay curve developed for the type of human activity. For example, for a two-lane access road located 2-km from the sample point within the map unit, the spreadsheet Calculator refers to the following table, as a two lane access road is considered a medium level disturbance activity:



Medium Disturbance Activity	
Distance	Percent Reduction
0 km to 3 km	100% to 0%
> 3 km	0%

Given the 2-km distance, the modifier value is 0.75.

LATE BROOD-REARING SCORE

The **Late Brood-Rearing** score is triggered based on the presence of moisture-rich vegetation. If there are forbs present which stay green throughout the late brood-rearing period, then the late brood-rearing habitat score will be calculated. If these forbs are not present, then the area is not viable late brood-rearing habitat and the site will score zero for late brood-rearing habitat.

The **Late Brood-rearing** score is based on the Foraging score. Foraging combines forb-related attributes also in a weighted additive process (Figure 17).

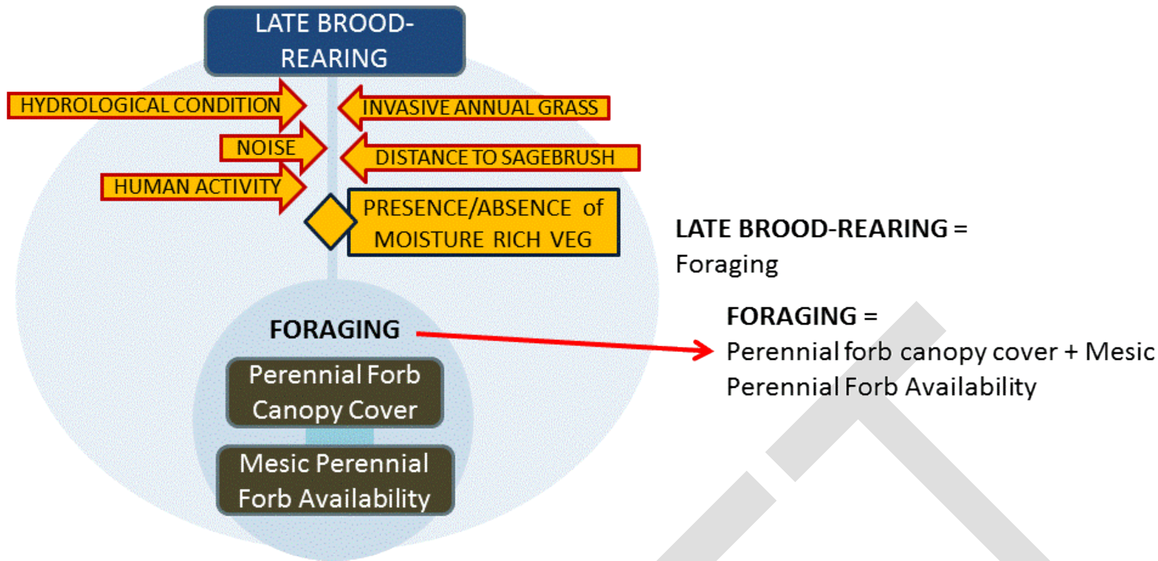
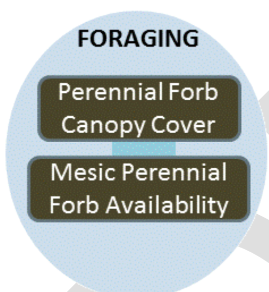


Figure 17. Scoring Algorithms for Calculating Late Brood-Rearing Habitat Score

The process of converting field measurements to percent performance outputs using the scoring tables and then combining them in an additive process is repeated for the Foraging score (Figure 18).



% Forb Cover	0	1-5	5-7	7-10	10-15	15-20	10-20	>20
% Performance	0	0.5	0.5	0.8	0.8	1	1	1

The values in this table are **ILLUSTRATIVE** only.

# Mesic Forbs	<5	5	6	7	8	9	10	11	12	>12
% Performance	0	0.4	0.6	0.75	0.85	0.95	1	1	1	1

The values in this table are **ILLUSTRATIVE** only.

Figure 18. Draft Scoring Tables Converting Field Measurements to Percent Performance Outputs

FORAGING = Perennial Forb Canopy Cover + Mesic Perennial Forb Availability

Perennial Forb cover = 10% → 0.8 or 80% performance

Mesic Perennial forb availability = 6 species → 0.6 or 60% performance

Each attribute contributes equally to Foraging, so they are combined in a weighted average:

Foraging = (80% + 60%) ÷ 2 = 70%

Apply 4th Order Modifiers

The Calculator applies the 4th order modifications for invasive annual grass, distance to sagebrush, noise, human activity, and hydrologic condition to the preliminary 4th order late brood-rearing score. For hydrologic condition, unique scoring tables were developed for forb cover in mesic and arid sites. The modifiers are applied to the preliminary 4th order score as illustrated below:

Prelim 4th order score	Modifier: Cheatgrass	Modifier: Distance to Sagebrush	Modifier: Sagebrush Cover	Modifier: Noise	Modifier: Human activity	Modified 4th Order Score
59%	Multiply by 0.8	Multiply by 1	Multiply by 1	Multiply by 1	Multiply by 0.75	35%

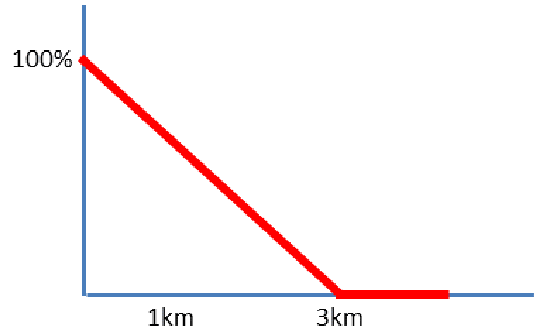
* All values in this table are ILLUSTRATIVE only to demonstrate scoring steps.

In this example, the modifier values are based on the following:

- Cheatgrass: the spreadsheet Calculator refers to the scoring table for Cheatgrass. For example, cheatgrass = 10%, which corresponds to 0.8 or 80% performance.

% Cover of Cheatgrass	<5%	5-10%	10-15%	15-20%	20-25%	25-30%	30-35%
Percent Adjustment	100%	80%	65%	50%	30%	20%	10%

- Distance to sagebrush: this modifier is only relevant for late brood-rearing habitat, and is based on the distance to sagebrush from a sample point within the map unit. For example, if sagebrush is 50m away it is accessible to GRSG, so there is no effect on the late brood-rearing score. If sagebrush is greater than 300 yards from the sample point, the score is reduced to zero.
- Sagebrush cover: for late brood-rearing habitat, if sagebrush < 10%, the score is reduced to zero. For example, sagebrush = 30%, so there is no effect on the late brood-rearing score.
- Noise: [[This is currently being developed, and a modifier value of 1 is used as a placeholder.]]
- Human activity: this modifier is based on the distance-decay curve developed for the type of human activity. For example, for a two-lane access road located 2-km from the sample point within the map unit, the spreadsheet Calculator refers to the following table, as a two lane access road is considered a medium level disturbance activity:



Medium Disturbance Activity	
Distance	Percent Reduction
0 km to 3 km	100% to 0%
> 3 km	0%

Given the 2-km distance, the modifier value is 0.75.

WINTER CALCULATION

The **Winter** score is based on the sagebrush calculation of sagebrush height and canopy cover (Figure 19).

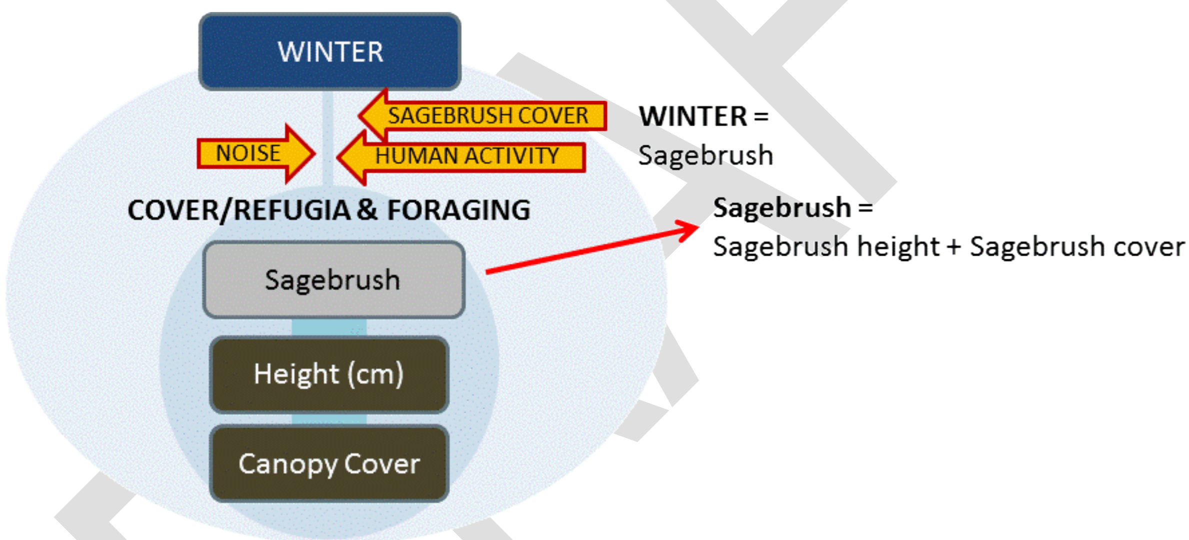
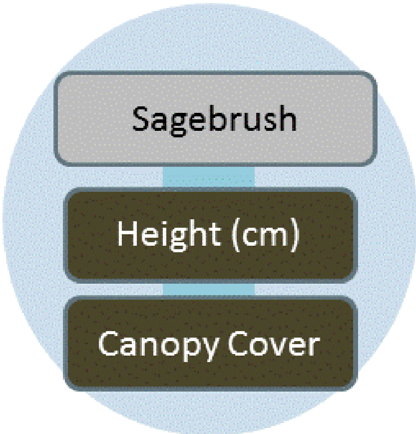


Figure 19. Scoring Algorithms for Calculating Winter Habitat Score

The process of referring to the scoring tables to convert field measurements to percent performance outputs using the scoring tables and then combining them in an additive process is repeated for the sagebrush score. For winter habitat, GRSG depend on sagebrush for both cover/refugia and foraging, and as such sagebrush is 100% of the score.



Sagebrush Height (cm)	<18	18-30	30-40	> 40
% Performance	0	0.5	1	1

The values in this table are **ILLUSTRATIVE** only.

Sagebrush % cover	<5	5-15	15-20	> 20
% Performance	0	0.5	0.5	1

The values in this table are **ILLUSTRATIVE** only.

WINTER = Sagebrush

Sagebrush height = 35 cm → 1 or 100% performance

Sagebrush cover = 15% → 0.5 or 50% performance

Each attribute contributes equally to Cover/Refugia & Foraging, so they are combined in a weighted average:

Cover/Refugia & Foraging = (100% + 50%) ÷ 2 = 75%

Preliminary Winter Score = 75%

Apply 4th Order Modifiers

The Calculator applies the 4th order modifications for sagebrush cover, noise, and human activity to the preliminary 4th order winter score. The modifiers are applied to the preliminary 4th order score as illustrated below:

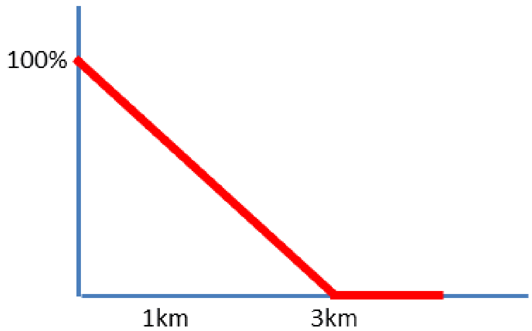
Prelim 4th order score	Modifier: Sagebrush Cover	Modifier: Noise	Modifier: Human activity	Modified 4th Order Score
75%	Multiply by 1	Multiply by 1	Multiply by 0.75	56%

* All values in this table are ILLUSTRATIVE only to demonstrate scoring steps.

In this example, the modifier values are based on the following:

- Sagebrush cover: for winter habitat, if sagebrush < 10%, the score is reduced to zero. For example, sagebrush = 30%, so there is no effect on the late brood-rearing score.
- Noise: [[This is currently being developed, and a modifier value of 1 is used as a placeholder.]]
- Human activity: this modifier is based on the distance-decay curve developed for the type of human activity. For example, for a two-lane access road located 2-km from the sample point

within the map unit, the spreadsheet Calculator refers to the following table, as a two lane access road is considered a medium level disturbance activity:



Medium Disturbance Activity	
Distance	Percent Reduction
0 km to 3 km	100% to 0%
> 3 km	0%

Given the 2-km distance, the modifier value is 0.75.

3.1.2 3rd Order Calculation Description

There are three 3rd order adjustments that can adjust the amount of credits and debits:

1. The nesting, late brood-rearing and winter 4th order scores are each adjusted based on the density of anthropogenic features (LDI);
2. The nesting, late brood-rearing and winter 4th order scores are each modified based on percent of contiguous sagebrush cover; and
3. The nesting, late brood-rearing and winter scores are each modified based on the extent of conifer cover.

The following table shows the 4th order scores for each of the habitat types from the examples above:

4th Order Scores		
Nesting	Late Brood-Rearing	Winter
41%	35%	56%

The 3rd order modifications are applied to each seasonal habitat score, as shown below:

3rd Order Modifications					
Seasonal Habitat	**4th Order Score**	**Modifier: LDI**	**Modifier: sagebrush cover**	**Modifier: conifer cover**	**MODIFIED 3rd Order Score**
Nesting	41%	Multiply by 0.8	Multiply by 1	Multiply by 0.9	30%
Late Brood-Rearing	35%	Multiply by 0.8	Multiply by 1	Multiply by 0.9	25%
Winter	56%	Multiply by 0.8	Multiply by 1	Multiply by 0.9	40%

* All values in this table are ILLUSTRATIVE only to demonstrate scoring steps.

Now that the 3rd order seasonal habitat scores have been calculated, each score is multiplied by the acreage of the map unit to determine the functional acre score (see Section 3.2 on description of map units):

Functional Acre Scores			
Seasonal Habitat	**3rd Order Score**	**Acres**	**Functional Acre Score**
Nesting	30%	150	45 functional acres
Late Brood-Rearing	25%	150	38 functional acres
Winter	40%	150	60 functional acres

3.1.3 2nd Order Calculation Description

There are three factors that contribute to the debit mitigation ratio:

1. Habitat priority
2. Seasonal habitat scarcity
3. Proximity of credit site relative to debit site

The application of the mitigation ratio is described in detail in the Credit System Manual. Once the Net Mitigation Ratio is determined, it is applied to the functional acres scores:

Credit / Debit Scores			
Seasonal Habitat	**Functional Acre Score**	**Net Mitigation Ratio**	**Credits / Debits**
Nesting	45 functional acres	2.3	104
Late Brood-Rearing	38 functional acres	3.5	133
Winter	60 functional acres	4.1	246

3.2 Map Units

[[This section has not been reviewed by the TRG.]]

Before attributes are measured, the credit or debit project site is divided into "map units." A map unit is a relatively homogeneous area within a project site that is scored individually based on attributes unique to that homogeneous area. All data are collected at the map unit level and each map unit is scored individually for each seasonal habitat type, both in terms of percent performance and functional area.

Though map units are somewhat open to interpretation, in general a map unit encompasses a relative homogenous area of habitat. Major changes across the landscape, such as change from water to terrestrial, woodland to pasture, and roads to undeveloped areas, are relatively straight-forward to delineate via GIS. However, other distinctions such as changes in topography, changes in vegetation community, slope and aspect, or density of trees or shrubs should also be considered.

4.0 Project Examples

The hypothetical attribute measurements for a single map unit that is 175 acres are shown below. There are no anthropogenic structures in the area.

Sagebrush	Grass	Shrub	Forbs
Canopy Cover: **40%**	Perennial Grass Cover: **10%**	Canopy Cover: **30%**	Perennial Forb Cover: **10%**
Height: 20cm	Cheatgrass: **15%**		
Distance to sagebrush: 55m			Mesic Perennial Forb Availability: **2**
Hydrologic condition: **mesic**			
Conifer cover: **5%**			

4.1 Pre-Project Condition

Using the scoring tables to determine the percent performance for the measured attributes above, the Calculator computes the following **preliminary** 4th order scores. All values in this example are illustrative only.

- Nesting habitat: 54%
- Late Brood-Rearing habitat: 42%
- Winter habitat: 65%

The Calculator applies the 4th order modifications directly, and the description here describes the calculation that takes place within the Calculator to modify the preliminary scores above (hydrologic condition is not shown below because the use of the mesic scoring tables for forb cover and perennial grass cover applies the necessary modifications):

- Cheatgrass modifier = 0.65, based on the scoring table
- Sagebrush cover modifier = 1.0, because there is more than 20% sagebrush present
- Distance to sagebrush = 1.0, because there is sagebrush within 300m of the sample point (applied to late brood-rearing habitat score)
- Noise = 1.0, because there are no noise sources present
- Human activity = 1.0, because there are no anthropogenic structures present

PRE-PROJECT CONDITION							
	Prelim 4th order score	Modifier: Cheatgrass	Modifier: Sagebrush cover	Modifier: Distance to sagebrush	Modifier: Noise	Modifier: Human activity	**Modified 4th Order Score**
Nesting	54%	Multiply by 0.65	Multiply by 1.0	N/A	Multiply by 1.0	Multiply by 1.0	35%
Late Brood-Rearing	42%	Multiply by 0.65	Multiply by 1.0	Multiply by 1.0	Multiply by 1.0	Multiply by 1.0	27%
Winter	65%	N/A	Multiply by 1.0	N/A	Multiply by 1.0	Multiply by 1.0	65%

The 3rd order modifiers are applied to the 4th order (site) scores above to adjust for the context of the surrounding area. The measurements are made in an area that includes the project area including a 20-km buffer around it.

- Landscape Disturbance Index (LDI) modifier = 0.9, because there is little to no human activity or anthropogenic structures in the surrounding area. This is an illustrative example only; the LDI values for disturbance levels are currently under development.
- Contiguous sagebrush cover modifier = 0.7 [[The determination of this modifier is under development.]]
- Conifer cover modifier = 1.0, because conifer cover is less than 25%.

PRE-PROJECT CONDITION					
3rd Order Modifications					
Seasonal Habitat	**4th Order Score**	**Modifier: LDI***	**Modifier: sagebrush cover**	**Modifier: conifer cover**	**MODIFIED 3rd Order Score**
Nesting	35%	Multiply by 0.9	Multiply by 0.7	Multiply by 1	22%
Late Brood-Rearing	27%	Multiply by 0.9	Multiply by 0.7	Multiply by 1	17%
Winter	65%	Multiply by 0.9	Multiply by 0.7	Multiply by 1	41%

*The LDI value in in this table is ILLUSTRATIVE only to demonstrate the scoring steps.

These scores are multiplied by the number of acres to determine the functional acre score.

PRE-PROJECT CONDITION			
Pre-Project Functional Acre Scores			
Seasonal Habitat	**3rd Order Score**	**Acres**	**Functional Acre Score**
Nesting	22%	175	39 functional acres
Late Brood-Rearing	17%	175	30 functional acres
Winter	41%	175	72 functional acres

The three seasonal habitat scores in the table above represent the pre-project condition. The examples that follow illustrate a credit project and a debit project using this pre-project condition as a starting point.

4.2 Credit Project

The landowner plans to carry out the following activities to enhance the existing habitat:

- Seed perennial grass capable of competing with annual species; also seed native grass species
- Remove Cheatgrass through application of herbicide
- Manage livestock grazing to protect seeded areas, residual grass areas, and areas around water sources and wet meadows

It is expected that these activities will change the perennial forb cover, mesic perennial forb availability, and cheatgrass values. The projected post-project condition for **preliminary** 4th order (site) scores are:

- Nesting habitat: 58%
- Late Brood-Rearing habitat: 52%
- Winter habitat: 65%

Among the 4rd order modifiers, only the cheatgrass modifier value changes. Based on the cheatgrass removal activity, cheatgrass is projected to decrease from 15% pre-project to 5% post-project. Based on the cheatgrass scoring table, this changes the modifier value from 0.65 to 0.8, as highlighted below.

CREDIT PROJECT: POST-PROJECT CONDITION							
	Prelim 4tn order score	Modifier: Cheatgrass	Modifier: Sagebrush cover	Modifier: Distance to sagebrush	Modifier: Noise	Modifier: Human activity	**Modified 4th Order Score**
Nesting	58%	Multiply by 0.8	Multiply by 1.0	N/A	Multiply by 1.0	Multiply by 1.0	46%
Late Brood-Rearing	52%	Multiply by 0.8	Multiply by 1.0	Multiply by 1.0	Multiply by 1.0	Multiply by 1.0	42%
Winter	65%	N/A	Multiply by 1.0	N/A	Multiply by 1.0	Multiply by 1.0	65%

The 3rd order modifiers do not change from pre-project to post-project.

CREDIT PROJECT: POST-PROJECT CONDITION					
3rd Order Modifications					
Seasonal Habitat	**4th Order Score**	**Modifier: LDI***	**Modifier: sagebrush cover**	**Modifier: conifer cover**	**MODIFIED 3rd Order Score**
Nesting	46%	Multiply by 0.9	Multiply by 0.7	Multiply by 1	29%
Late Brood-Rearing	42%	Multiply by 0.9	Multiply by 0.7	Multiply by 1	26%
Winter	65%	Multiply by 0.9	Multiply by 0.7	Multiply by 1	41%

*The LDI value in in this table is ILLUSTRATIVE only to demonstrate the scoring steps.

Functional acres are calculated for the post-project condition:

CREDIT PROJECT: POST-PROJECT CONDITION			
Post-Project Functional Acre Scores			
Seasonal Habitat	**3rd Order Score**	**Acres**	**Functional Acre Score**
Nesting	29%	175	51 functional acres
Late Brood-Rearing	26%	175	81 functional acres
Winter	41%	175	72 functional acres

Comparing the pre-project and post-project condition:

CREDIT PROJECT: PRE- AND POST- COMPARISON			
Pre-Project and Post-Project Functional Acre Scores			
Seasonal Habitat	**Pre-Project**	**Post-Project**	**Difference**
Nesting	39 functional acres	51 functional acres	+ 12 functional acres
Late Brood-Rearing	30 functional acres	81 functional acres	+ 51 functional acres
Winter	72 functional acres	72 functional acres	No change

4.3 Debit Project

A two-lane access road is planned for the project area:

- A two-lane access road is considered a medium level disturbance activity (see Table 7 Anthropogenic Structures by Level of Human Activity)
- The noise associated with the road is projected to increase ambient noise level. There are no leks present within a 20km buffer around the project area.
- The road is located 2-km from the sample point

It is expected that these activities will change the 4th order modifiers for human activity and noise, and 3rd order LDI modifier. The projected post-project condition for **preliminary** 4th order (site) scores do not change, because vegetation attributes did not change:

- Nesting habitat: 54%
- Late Brood-Rearing habitat: 42%
- Winter habitat: 65%

As noted, among the 4rd order modifiers, only the human activity and noise modifiers may change.

- Based on the 2-km distance from the sample point to the road, the human activity modifier changes from pre-project 1.0 value to post-project 0.75 value.

- [[The determination of this modifier value is under development.]] Because there is no lek within a 20-km buffer around the project area, the increased level of ambient noise has no effect on the score.

DEBIT PROJECT: POST-PROJECT CONDITION							
	Prelim 4th order score	Modifier: Cheatgrass	Modifier: Sagebrush cover	Modifier: Distance to sagebrush	Modifier: Noise	Modifier: Human activity	**Modified 4th Order Score**
Nesting	54%	Multiply by 0.65	Multiply by 1.0	N/A	Multiply by 1.0	Multiply by .75	26%
Late Brood-Rearing	42%	Multiply by 0.65	Multiply by 1.0	Multiply by 1.0	Multiply by 1.0	Multiply by .75	20%
Winter	65%	N/A	Multiply by 1.0	N/A	Multiply by 1.0	Multiply by .75	49%

Among the 3rd order modifiers, only the LDI changes in value from pre-project 0.9 to post-project 0.7.

DEBIT PROJECT: POST-PROJECT CONDITION					
3rd Order Modifications					
Seasonal Habitat	**4th Order Score**	**Modifier: LDI***	**Modifier: sagebrush cover**	**Modifier: conifer cover**	**MODIFIED 3rd Order Score**
Nesting	26%	Multiply by 0.7	Multiply by 0.7	Multiply by 1	13%
Late Brood-Rearing	20%	Multiply by 0.7	Multiply by 0.7	Multiply by 1	10%
Winter	49%	Multiply by 0.7	Multiply by 0.7	Multiply by 1	24%

*The LDI value in in this table is ILLUSTRATIVE only to demonstrate the scoring steps.

Functional acres are calculated for the post-project condition:

DEBIT PROJECT: POST-PROJECT CONDITION			
Post-Project Functional Acre Scores			
Seasonal Habitat	**3rd Order Score**	**Acres**	**Functional Acre Score**
Nesting	13%	175	23 functional acres
Late Brood-Rearing	10%	175	18 functional acres
Winter	24%	175	42 functional acres

Comparing the pre-project and post-project condition:

DEBIT PROJECT: PRE- AND POST-PROJECT COMPARISON			
Pre-Project and Post-Project Functional Acre Scores			
Seasonal Habitat	**Pre-Project**	**Post-Project**	**Difference**
Nesting	39 functional acres	23 functional acres	-16 functional acres
Late Brood-Rearing	30 functional acres	18 functional acres	-13 functional acres
Winter	72 functional acres	42 functional acres	-30 functional acres

[[This is an initial draft of the HQT. All of the content is subject to change upon further review. The purpose of this section of the document is to describe some of the larger remaining gaps to be filled in subsequent drafts.

- 1st Order: develop criteria and approach for measuring the progress of the Credit System
- 2nd Order: develop seasonal habitat model
- 3rd Order: develop Landscape Disturbance Index
- Finalize User's guide
- Finalize field data collection methods
- Finalize field data sheets]]

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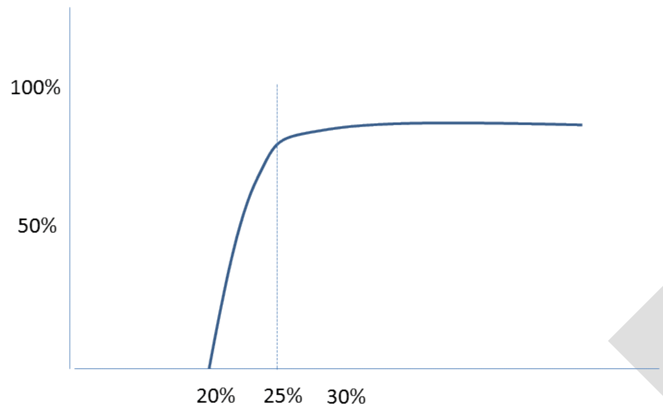
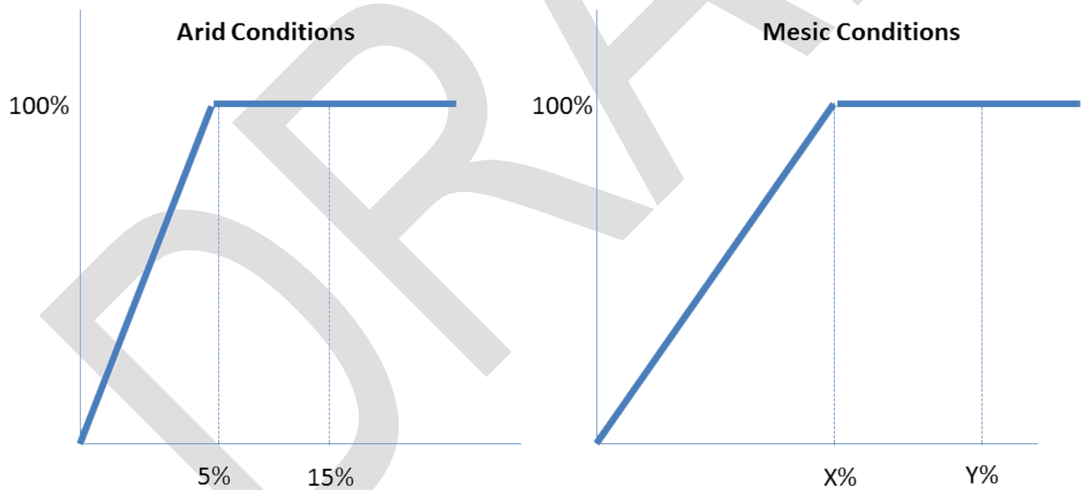
Appendix A. Scoring Curves and Tables

The specific shape of these curves is tentative and subject to additional scientific review. The scoring table that corresponds with each of these curves is currently under development.

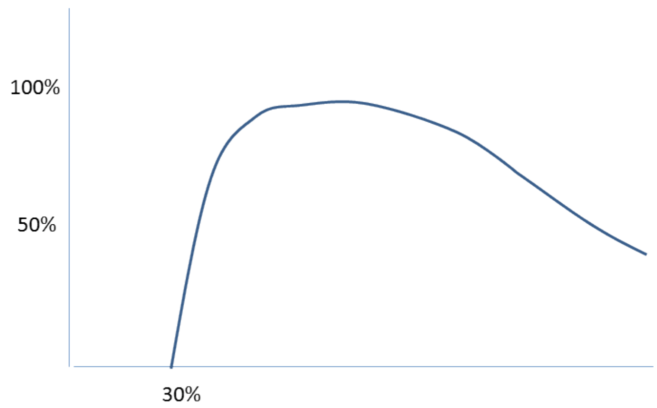
NESTING: Cover/Refugia – Sagebrush Cover



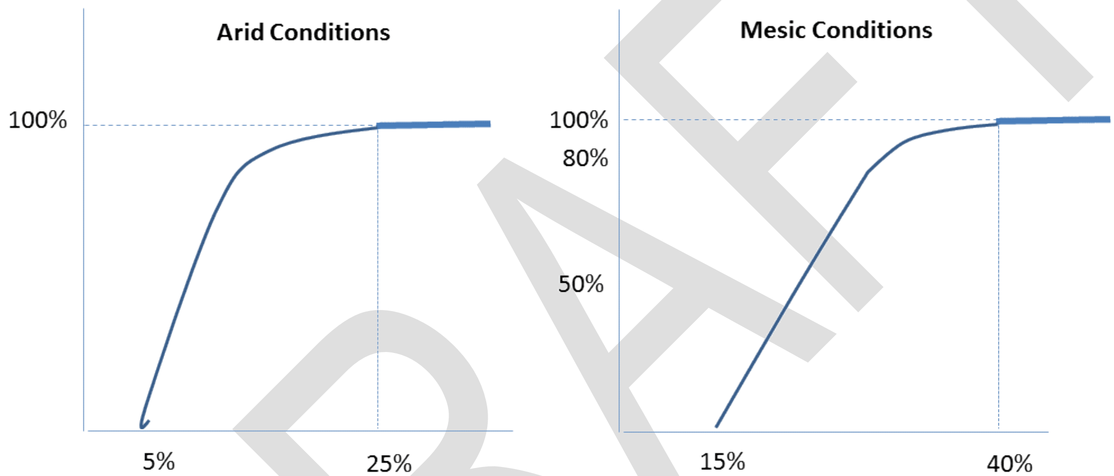
NESTING: Cover/Refugia – Perennial Grass Cover



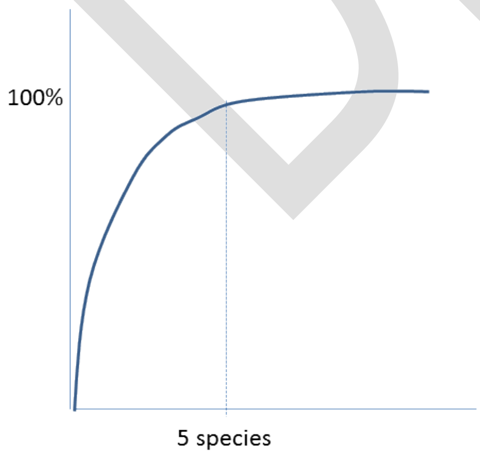
NESTING: Cover/Refugia – Shrub Cover



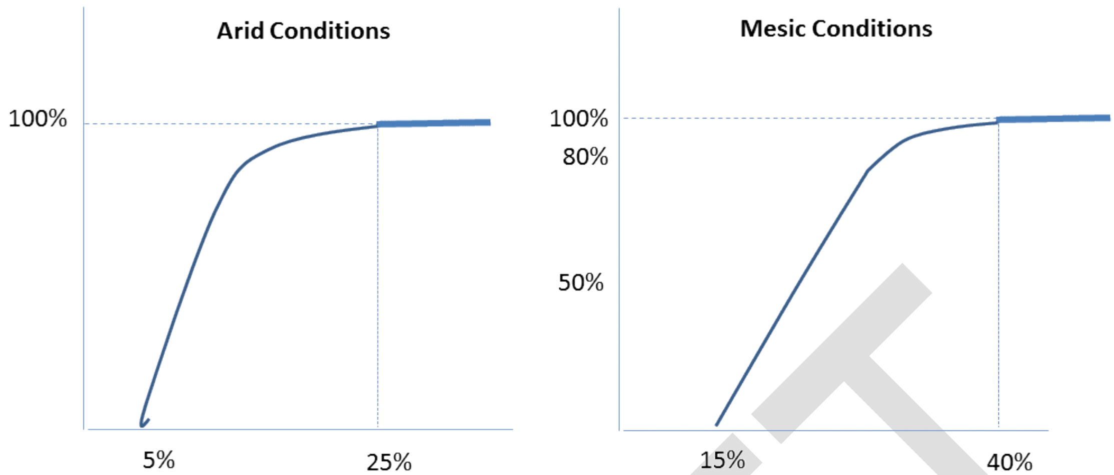
NESTING: Foraging – Perennial Forb Cover



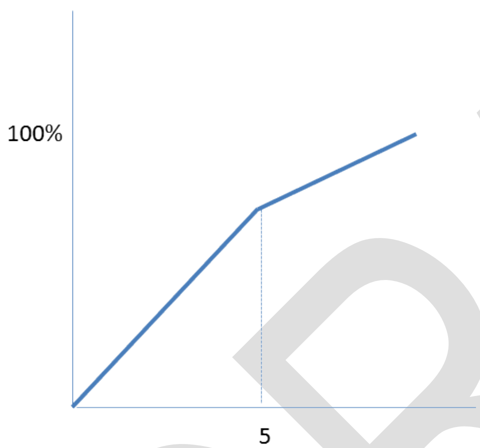
NESTING: Foraging – Mesic Perennial Forb Availability



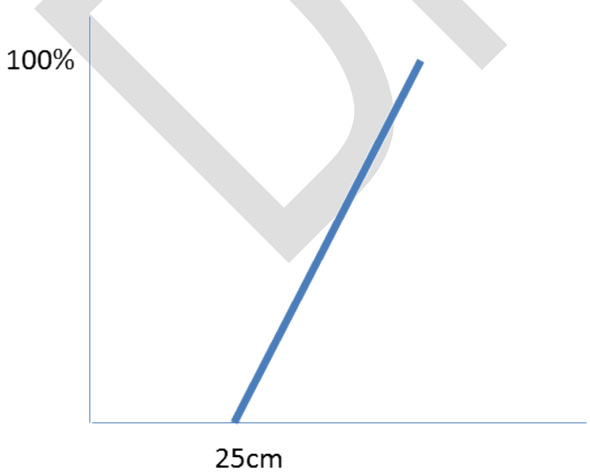
LATE BROOD-REARING: Foraging – Perennial Forb Cover



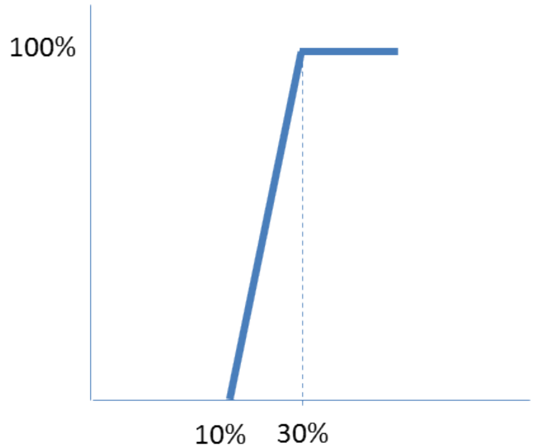
LATE BROOD-REARING: Foraging – Mesic Perennial Forb Availability



WINTER: Cover/Refugia & Foraging – Sagebrush Height



WINTER: Cover/Refugia & Foraging – Sagebrush Cover



Appendix B. Field Data Collection Methods

[[The field data sheets will be developed once the list of field attributes are finalized.]]

Appendix C. Field Datasheet

[[This section is currently under development.]]

Appendix D. Forb Species List

[[The following list is for illustration purposes and will be replaced with NV specific species.]]

Species Name	Common Name	Species Name	Common Name
Forbs		**Grasses**	
Achillea millefolium	Western yarrow	Agr. dasytachyum	Thickspike wheatgrass
Agoseris glauca	False dandelion	A. desertotum	Std/desert wheatgrass
Antennaria spp.	Everlasting	A. intermedium	Interm wheatgrass
Aster chilensis	Pacific aster	A. cristatum	Fwy crested whtgrass
A. glaucodes	Blueleaf aster	A. fragile	Sib. crested whtgrass
Balsamorhiza hooker	Hairy balsamroot	A. smithii	Western wheatgrass
B. macrophylla	Cutleaf balsamroot	Bluebunch whtgrass	A. spicatum
B. sagittata	Arrowleaf balsamroot	Slender wheatgrass	A. trachycaulum
Calochortus spp.	Sego lily	Blue grama	Bouteloua gracilis
Castillega spp.	Indian paintbrush	Mountain brome	Bromus carinatus
Collomia linearis	Tiny trumpet	Smooth brome	B. inermus
Crepis spp.	Hawksbeard	Orchard grass	Dactylis glomerata
Erigeron spp.	Fleabane	Great Basin wildrye	Elymus cinereus
E. umbellatum	Sulfur eriogonum	Russian wildrye	E. junceus
Eriogonum hereleoides	Wyeth eriogonum	Junegrass	Koeleria macrantha
Gayophytum spp.	Prairiesmoke	Indian ricegrass	Oryzopsis hymenoides
Grindelia squarrosa	Curlcup gumweed	Mutton bluegrass	Poa fendleriana
Hedysarum boreale	Utah sweetvetch	Sandberg bluegrass	P. secunda
Lactuca serriola	Prickley lettuce	Squirreltail	Sitanion hystrix
Lathyrus spp.	Pea	Sand dropseed	Spor. cryptandrus
Lepidium spp.	Pepperweed	Needle-and-thread	Stipa comata
Linanthus spp.	Gilia	Green needlegrass	S. lettermanii
Linum perenne	Lewis flax		
Lomatium spp.	Desertparsley		
Lupinus spp.	Lupine		
Medicago sativa	Alfalfa		
Minulus spp.	Monkey flower		
Orobanche spp.	Broomrape		
Penstemon eatonii	Firecracker penstemon		
P. palmeri	Palmer penstemon		
Phlox spp.	Pholx		
Potentilla spp.	Cinquefoil		
Sanquisorba minor	Small burnet		
Senecio spp.	Groundsel		
Sphaeralcea spp.	Globemallow		
Taraxacum officinale	Common dandelion		
Tragopogon spp.	Salsify		
Trifolium spp.	Clover		

Appendix E. Monitoring and Adaptive Management

This section is divided into three subsections: Biological Monitoring, Tool Evaluation, and Credit System Management System. The descriptions provided here represent only guidelines for monitoring and adaptive management and not a *plan* for carrying out these activities.

Biological Monitoring

Monitoring is an essential element of any conservation and management plan. For the purposes of the HQT, we define monitoring as *the collection and analysis of repeated observation or measurements to evaluate changes in condition, progress toward meeting a management goal (Elzinga et al. 1998), as well as, the overall utility and functionality of the HQT itself*. In this document, monitoring is *not* synonymous with verification, inventory, research, implementation or compliance monitoring.

The overarching goals of biological monitoring are to: 1) Assess the status and trend of species populations; 2) Assess the net contribution of habitat management outcomes (e.g. credits minus debits) to species habitat and population goals at a variety of spatial scales; 3) Assess whether management practices are achieving expected habitat outcomes; 4) Refine and revise the inner workings of the HQT (e.g. concept model, habitat attributes and scoring curves) with new information over time; and 5) Detect and address changed and/or unforeseen circumstances (e.g. shifts in species distribution due to climate change). A comprehensive monitoring effort is needed to achieve these goals.

Monitoring plans should be designed to provide information determining whether the biological goals and objectives of the overall conservation strategy are being met as well as to ensure compliance by participants in the conservation program. A sufficiently comprehensive monitoring effort is needed to:

- Evaluate the effectiveness of the strategy;
- Assess status and trends of the covered species;
- Ensure maintenance and enhancement of the conservation value of managed or protected habitat;
- Acquire a better understanding of accurately assessing how anthropogenic activities and natural changes on the landscape affect GRSG; and
- Inform the incorporation of adaptive management decisions into the conservation strategy under an adaptive management framework;

Ecological understanding of GRSG is not complete. The HQT is an expression of our *current* understanding of habitat selection at a variety of spatial scales. Therefore, assumptions about GRSG habitat and population relationships are inevitably a part of the HQT. However, biological monitoring and adaptive management affords us the opportunity to test those assumptions through the collection and analysis of on-the-ground data, and refine and update the HQT periodically.

Biological monitoring for GRSG responses across a subset of participating sites can provide essential information to confirm that the attributes measured at the site and landscape scales are tied to the enhanced potential for the species and the resilience of the landscape/vegetation composition. Biological monitoring for GRSG responses can also be used to inform adjustments to attributes and scoring curves to more accurately represent conditions correlating with GRSG performance. Response metrics assessed can include GRSG habitat use and occupancy, intensity of use, nesting success, and juvenile or adult survival on a site or landscape. The appropriate level of monitoring should be based on the current understanding of species response to habitat conditions and practical-logistical considerations such as constraints on survey effort. Understanding species responses to site and landscape context level characteristics is essential for interpreting broader scale information such as population status and trends and to be able to connect management actions and strategies on the ground to broader population responses.

3rd and 4th order: The HQT focuses on quantifying habitat conditions and species outcomes—the changes in the measured attributes such as vegetation conditions—as thought to represent the performance of habitat quality for GRSG. Information collected through field surveys quantifying outcomes can help ascertain whether on-the-ground management is producing the desired conditions. In contrast, excessive reliance on a practice-based approach provides insufficient information as to whether or not a practice was successful.

1. *Reproductive success*: Reproductive success through time will be a direct indicator of nesting habitat quality and will be used to evaluate quality of an area. Nest searching and monitoring are time intensive but is one of the more precise and informative ways to assess and monitor conservation value of habitat on a site or landscape. It can also provide essential information to inform whether measured attributes and scoring accurately represent the potential value of a site for producing positive reproduction responses.
2. *Survival/mortality*: This attribute is used to quantify adult or juvenile survival on an area, property, or habitat patch. Marking and tracking individuals can be time intensive but can provide information both on habitat use, intensity of use, and survival rates/mortality rates, providing a good indicator of the conservation value of habitat on a site or landscape. It can also provide essential information to inform whether measured attributes and scoring accurately represent the potential value of a site for enhancing survival.
3. *Abundance*: This is the estimate of the number of individuals in an area and could be measured through pellet surveys. This will also be evaluated at the landscape and state-wide scales.

4. *Detailed evaluation of vegetation and anthropogenic impacts that are thought to impair habitat quality for the species*. These are included to create a better understanding of the usefulness of the attributes currently included in the HQT, whether those attributes or the scoring curves, tables, methods need to change and/or any new attributes (e.g. bare ground) should be included in the HQT at the 3rd or 4th order.

1st and 2nd order: Biological monitoring of the 1st order should examine several attributes. These attributes are briefly outlined below:

1. *Quantification of habitat acreage*: This determines the total acres of suitable habitat for the GRSG at a site. This method is relatively simple, fast, and can be done with remotely acquired imagery and ground-truthing. This method can also broadly assess gains or losses in vegetation that is suitable for use by GRSG. Remotely acquiring imagery is one option for quantifying habitat acreage through monitoring. However, it should be noted that this method does not directly assess occupancy, abundance, survival, or reproductive success of the covered species. The accuracy of this method for estimating usable habitat is contingent on the accuracy of inputs. The extent to which species habitat use/nonuse or presence/absence data, rather than the reliance on expert opinion of preferred habitat, can be used to drive models and predictions will enhance the quality of the habitat estimation.
2. *Abundance*: This is the estimate of the number of individuals in an area, property, or habitat patch. At a minimum, assessing abundance would include multiple surveys, telemetry, or through lek counts. This monitoring method is more time intensive than the previous methods but provides a more accurate description of conservation value, both as a baseline and over time.
3. *Survival/mortality*: This attribute is used to quantify adult or juvenile survival on an area and is relevant at all scales. Marking and tracking individuals can be time intensive but can provide information both on habitat use, intensity of use, and survival rates/mortality rates, providing a good indicator of the conservation value of habitat on a site or landscape. It can also provide essential information to inform whether measured attributes and scoring accurately represent the potential value of a site for enhancing survival.

Tool Evaluation

Tool evaluation is defined as collection and analysis of data that pertains to the functionality and performance of the HQT. In particular, tool evaluation is concerned with: 1) Accuracy of the scores in measuring real and expected outcomes; 2) Utility (ease of use, efficiency, and cost) for a variety of users; 3) Repeatability of scores from one user to the next; and 4) Reliability of scores over time.

Credit System Management System

The Credit System Management System is a formal, structured programmatic adaptive management approach to dealing with uncertainty in natural resources management, using the experience of management and the results of research as an ongoing feedback loop for continuous improvement. The Credit System Management System requires an ongoing flow of information from 1) research and monitoring activities conducted by scientists, 2) the practical experiences of Credit Developers and Buyers, and 3) changing context from stakeholders to inform Credit System improvements. A systematic and transparent decision making process ensures that improvements to the Credit System do not cause uncertainty for participants. Figure 21 provides an overview of the Credit System Management System steps[2]. Adaptive management is used in the Credit System Management System to refine and update the HQT over time. In other words, none of the content or components of the HQT are meant to be static in time, rather the HQT is intended to evolve over time as needed according to new science and monitoring. The goal of adaptive management for the HQT is to make periodic changes that keep it up to date with the current state of ecological knowledge.

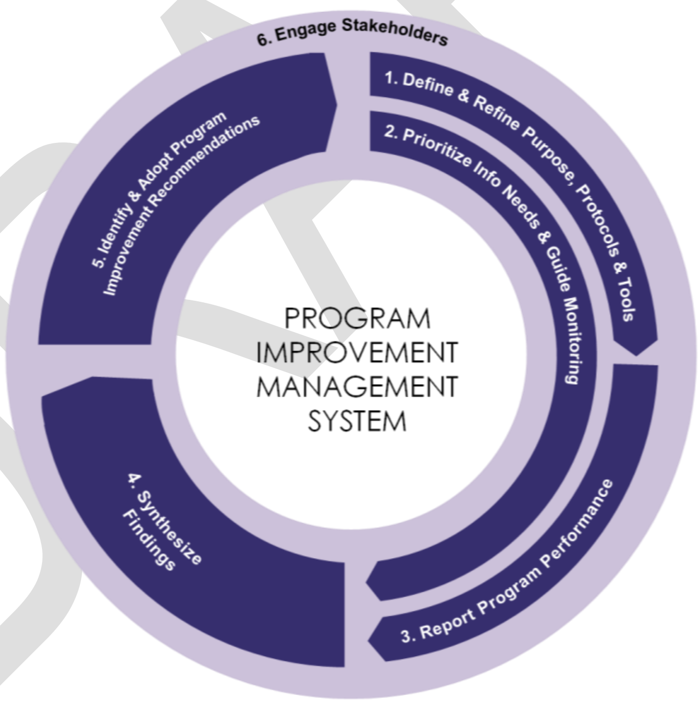


Figure 20. Steps in the Credit System Adaptive Management Process

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[2] This management process has been adapted from The Conservation Measures Partnership's Open Standards for the Practice of Conservation, which can be found at www.conservationmeasures.org. Significant changes were made to adapt the Open Standards to 1) a market context where individual projects are selected and implemented by individual market participants and 2) be a formally governed process that balances the needs for improvements with the needs to limit market uncertainty for all participants.

As specified in the Credit System Manual, the Credit System Administrator performs the day-to-day functions to manage the Credit System. The Administrator is accountable to the Oversight Committee (Sagebrush Ecosystem Council), which approves all changes to the Credit System Manual, HQT and other tools.

The Administrator convenes a Science Committee consisting of expert scientists to inform the development and revisions of technical decisions, products and tools, like the HQT. The Science Committee meets periodically to review and evaluate new information including new research on the species biology or ecology, new or changing threats to the species, recent substantial gains or losses of habitat for the species, and the establishment of new protected areas. The Science Committee then makes recommendations to the Credit System Administrator, based on the best-available science regarding the greater sage-grouse and sagebrush ecosystems. This review and evaluation process is also used to assess the overall status of the covered species, Credit System implementation and progress, and whether any adjustments are needed to the products and tools in order to further ensure conservation benefits to the species.

The Administrator decides whether any specific modifications are necessary according to Science Committee recommendations, and then the Administrator makes a recommendation regarding such modifications to the Oversight Committee. The Oversight Committee confers about the Science Committee's findings and Administrator's recommendations. Any modifications to the HQT are not applied retroactively.

Appendix F. HQT Development and Review

The HQT is the scientific underpinning of the Credit System. It is the approach to measure impacts and benefits, and is based on science. Science-related elements of the Credit System that are not entirely based on science (e.g. mitigation ratio factor related to the proximity of credits and debits) are defined in the Credit System Manual. The credibility of the Credit System and its effectiveness in generating net benefit for the species hinges upon the quality of the science upon which it is based and the integrity with which it is applied. It is therefore important to maintain the scientific integrity of the HQT over time as new science and implementation monitoring becomes available.

The HQT is not static. It is a working document that changes over time through the development and review processes outlined below as new scientific information becomes available. Transparent, fair, and consistent review processes are essential to ensure that the best and most recent scientific information is used incorporated over time.

Like any significant change to the Credit System, and changes to the HQT are under the control of the Oversight Committee, and the Administrator according to Credit System Management System . As such, the Administrator oversees the process of development and review, and the Oversight Committee approves all changes to the HQT.

This appendix outlines the processes, principles and schedule for internal and external development and review of the HQT. Outcomes of these processes inform the Credit System Management System defined in the Credit System Manual and summarize din Appendix E above. The table below summarizes the stages of development and review, including the participants and schedule.

Development or Review Stage	Description	Who	Expected Completion Date
Internal Development	Development of initial components	Administrator in collaboration with consultants	December 2014
Internal Review	Review early drafts, provide comments	Administrator in collaboration with Science Committee	December 2014
External Informal	Meeting presentations, expert elicitation, etc.	Experts from agencies, NGO's, agriculture, industry, etc.	December 2014
External Formal	Independently facilitated document review of later draft	Ten or fewer selected, independent published species and ecosystem experts from outside the Administrator and Science Committee	*TBD*

External Independent Peer Reviewed Journal	Review of manuscript	Independent experts selected by Journal	*TBD*

Internal Development and Review

Internal development and review is conducted by the Administrator and the Science Committee. The Science Committee is made up of peer-reviewed, published experts on species biology and/or landscape ecology.

Internal Development

Internal development of the HQT is conducted by the Administrator. Tasks associated with development include reviewing and compiling scientific information, developing concept models and scoring curves, and writing the HQT documents. While the HQT is in the development stage, decision-making and control over the content of the HQT is the responsibility of the Administrator. Members of the Administrator should declare any real or perceived conflict of interest with stakeholders, including offers or acceptance of funding.

Internal Review

Internal review is conducted by official members of the Science Committee. During internal review, members of the Science Committee are given the first opportunity to provide comments on the HQT. Internal review comments from the Science Committee adhere to the following format and principles:

- <u>Confidential</u> – internal reviewers may not share the draft HQT with any non-official members of the group at this stage, unless those persons are experts or consultants within their own organizations.
- <u>Constructive, practical, and cooperative</u> – we expect comments to come from a positive spirit of cooperation, to improve the potential for the Credit System to meet its goals in a practical manner.
- <u>Written</u> – all official comments must be provided in writing (e.g. letter, track changes to a document, e-mail). Multiple opportunities are provided for oral comment as well, but official comments must be written to be properly considered for incorporation into the HQT.
- <u>Documented</u> – all comments must be referenced and supported by scientific support (e.g. peer-reviewed research), independent analysis, expert opinion with a citation of “personal communication,” and/or a thorough, clear rationale. Reviewers clearly state the source of documentation they are using. General preferences and opinions are useful and welcomed, but may not be sufficient for incorporation into the HQT. All committee participants are listed by

name unless they request to remain anonymous, in which case they are acknowledged as an "anonymous reviewer."

External Review

External informal and formal review is coordinated by the Administrator with consultation of the Science Committee. External informal review is conducted by wide range of stakeholders, and external formal review is conducted by independently published species and ecosystem experts. Lastly, publishing the HQT in a peer-reviewed journal is desired and a responsibility of the Administrator.

External Informal

External informal review consists of informal feedback from stakeholders that is solicited by the Administrator through presentations, meetings, conferences, etc.

Incorporating feedback provided through external, informal review is the responsibility of the Administrator, after consultation with the Science Committee, and then with the SEC. The Administrator informs the Science Committee of the comments and provides an opportunity for the Science Committee to comment. Then, the Administrator incorporates changes based on Science Committee responses and the Administrator's own best judgment. A best attempt is made to come to consensus. However, if there are disputes between the Administrator and the Science Committee, then the conflict resolution policy in the Administrator charter is enacted. Science Committee members are then provided an additional opportunity by the Administrator to comment on the changes made by Administrator and if any disputes arise over those changes, the conflict resolution policy is enacted.

External Formal

External formal review begins after the Administrator provides verbal consent to the external reviewers. The Administrator identifies a referee for the peer review process in consultation with the Science Committee. The total number of outside reviewers is limited to 10 or fewer. The Administrator is responsible for observing the external formal review principles below, and evaluating and incorporating changes suggested by external formal reviewers using the same process described above for external informal reviewers.

External formal review consists of selected, independently published species and ecosystem experts from outside the Science Committee. External formal reviewers should be recommended and selected based on their expertise and independence, and must be subject matter experts. External formal reviewers are expected to adhere to principles of peer review below.

External Formal Review Principles

The Administrator observes and external formal reviewers adhere to the following principles:

Expert Assessment

- Only published subject matter experts that have not been involved with development or informal review are invited to participate in final round of independent, external peer review.

Transparency

- All developers of the documents are identified to reviewers
- The review process is tracked on a spreadsheet database throughout the process, including database manager & reviewer names, affiliations, contact information. All written reviews and relevant documentation are attached to the spreadsheet.
- With written consent, reviewers will be acknowledged by name in the acknowledgment section as having "reviewed an earlier version." Otherwise, the number of anonymous reviewers is accurately stated in the acknowledgments.

Impartiality

- Invited reviewers are asked to declare potential conflicting interests (e.g. political, professional, personal, financial) and a decision is made by the referee as to whether stated conflicts could potentially bias the review. If so, the request is withdrawn before releasing the document.
- External peer review is refereed by a third party that has not participated in development of the document and has no conflict of interest with the developers or process.

Fairness

- Reviewers are asked to decline the request if: they feel they are unable to provide a fair and unbiased review and/or have participated in preparation of the document.
- Reviewers are presented with a consistent set of questions and criteria by which to review the document.
- Reviewers are allowed a minimum of three (3) weeks to review and comment on the document. They are asked to notify the referee if they do not think they can complete a thorough review in that amount of time.

Confidentiality

- The manuscript and comments of reviewers are held in confidentiality by all parties until the time of release. Reviewers' identities are released by permission otherwise they are each listed as anonymous reviewers.

Integrity

- Reviewers should decline if: they have a conflict of interest, feel they cannot provide an unbiased or expert review, if they have issues with the peer review model, or if they have a very similar potentially competing document or framework in development.

Timeliness

- Reviewers are given a minimum of three (3) weeks for review and are asked to complete their review within that timeframe or notify the referees if they anticipate delays or are unable to thoroughly review the document within the allotted time.

Peer-reviewed Journal

Publishing the HQT in a peer-reviewed journal would be extremely valuable to the overall credibility and acceptability of the tool to regulatory agencies and other stakeholders (e.g. potentially critical non-governmental organizations). The Administrator is expected to pursue this goal after external formal and informal review is complete and with the consent and cooperation of the Science Committee and Oversight Committee. The Administrator appoints a lead author and coordinates the manuscript submission process.