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Comparative Studies in Rangeland Management: Examining the Foundational Assessments Relationship to the Greater Sage-Grouse Habitat Assessment Framework and Assessment of Predicted Cattle Distributions Using GPS Collars in Rich County, Utah

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COMPARATIVE STUDIES IN RANGELAND MANAGEMENT: EXAMINING THE

FOUNDATIONAL ASSESSMENTS RELATIONSHIP TO THE GREATER SAGE-

GROUSE HABITAT ASSESSMENT FRAMEWORK AND ASSESMENT OF

PREDICTED CATTLE DISTRIBUTIONS USING GPS COLLARS IN RICH

COUNTY, UTAH

by

Michael T. Anderson

A thesis submitted in partial fulfillment
of the requirements for the degree

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in

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ABSTRACT

Comparative Studies in Rangeland Management: Examining the Foundational

Assessments Relationship to the Greater Sage-grouse Habitat Assessment

Framework and Predicted Cattle Distributions Assessed Using GPS

Collars in Rich County, Utah

by

Michael T. Anderson, Master of Science

Utah State University, 2022

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Management of Rangelands seeks to continuously improve and maintain
ecosystem functions and productivity of land resources. Greater sage-grouse
(*Centrocercus urophasianus*) are regarded as an umbrella species to focus the
conservation of 350 plant and animal species that also depend on sagebrush dominated
communities. Sage-grouse habitat quality has been measured using multiple methods.
Standard sage-grouse methods, line intercept and Daubenmire frames, described by
Connelly et al 2003, were adopted broadly among sage-grouse biologist and used to
develop habitat objectives for the greater sage-grouse. Federal land management agencies
now use Habitat Assessment Framework (HAF) methods employing line-point intercept,
rather than standard sage-grouse methods to assess sage-grouse habitat within the context
of the previously defined habitat objectives. While there is evidence that the different

methods are not entirely compatible in their specific plant cover estimates, researchers who developed the HAF protocols used by land management agencies suggested that the suitability of habitat outcomes with respect to habitat objectives would be similar to those of standard sage-grouse methods. To date there has been no effort to evaluate standard sage-grouse methods and HAF methods with respect to their outcomes within the context of the sage-grouse habitat objectives. To do this, standard sage-grouse methods and HAF methods were employed at the same site in Rich County Utah. Defining the similarity of outcomes will allow a determination of method outcome comparability. Of the 74 sites sampled 19 fell within the range of implication and demanded the outcomes of standard sage grouse biologist and HAF methods be reconciled. Over all 19 sites secondarily sampled 67% showed agreement in outcomes. More specifically shrub sites secondarily sampled showed agreement at 83% of the sites and herbaceous sites sampled secondarily showed agreement at 60% of the sites.

The most ubiquitous use of rangelands in the U.S. is livestock grazing. Rangeland managers are often looking for tools to help inform grazing decisions. Open Range Consulting has developed a Piosphere tool that uses abiotic GIS data to predict cattle distribution across a landscape. Cattle GPS location data were used to build a resource selection function (RSF). The RSF controls for telemetry bias associated with collar data and produced a landscape scale analysis that was used for comparison to the Piosphere tool's predicted output. Validation of a Piosphere tool may provide managers data to inform or defend their decisions about grazing management in an economical and consistent manner, without the need of expensive telemetry/GPS collars and the expertise necessary to use the collar data. Validation was performed in two ways. First a collar

capture and secondly a regression of the value produces by each modeling process. 96% of collar locations fell within the predicted distribution of the Piosphere tool. Regressing each of the landscape analyses produced and R^2 of 0.64.

<div align="right">(63 pages)</div>

PUBLIC ABSTRACT

Comparative Studies in Rangeland Management: Examining the Foundational

Assessments Relationship to the Greater Sage-grouse Habitat Assessment

Framework and Predicted Cattle Distributions Assessed Using GPS

Collars in Rich County, Utah

Michael T. Anderson

The greater sage-grouse (*Centrocercus urophasianus*) is being used as an

umbrella species to manage for 350 plant and animal species that also depend on

rangeland communities. Sage-grouse habitat assessments have been carried out using

multiple methods. Standard sage-grouse methods described by Connelly et al 2003,

include line intercept (LI) and Daubenmire frames (DF) measuring canopy cover. These

methods were adopted broadly among sage-grouse biologist and used to develop habitat

objectives for greater sage-grouse. Federal land management agencies now use the

Habitat Assessment Framework (HAF). Specifically, HAF employs line-point intercept

(LPI), to assess foliar cover in sage-grouse habitat. While there is evidence that the

different methods are not entirely compatible in their specifics plant cover estimates,

researchers who helped develop the methods used by land management agencies suggest

that when determining the suitability of habitat, outcomes would be similar. To date there

has been no effort to reconcile the outcomes of standard sage-grouse methods and HAF

methods in the context of the sage-grouse habitat objectives framework. Of the 74 sites

sampled 19 fell within the range of implication and demanded the outcomes of standard

sage grouse biologist and HAF methods be reconciled. Over all 19 sites secondarily

sampled 67% showed agreement in outcomes. More specifically the sites produced the same outcome 83% of sites sampled for shrub species and 60% of sites sampled for herbaceous species.

The primary commercial use of rangelands in the U.S. is livestock grazing. An economical and consistent means of predicting and visualizing cattle distributions in rangelands could help inform managers to make grazing decisions. Open Range Consulting has developed the Piosphere tool that uses abiotic GIS data to quantify and predict cattle distributions. The intent of this study is to evaluate the Piosphere tool using observed global positioning system (GPS) cow collar data. The GPS collar data was combined with the same set of abiotic GIS data that informs the Piosphere tool and was used to build a resource selection function (RSF) independently of the Piosphere tool. This RSF controls for the telemetry bias associated with collar data and produces a landscape scale analysis that was used to evaluate the Piosphere tool's predicted distribution. Validation was performed in two ways. Firstly, calculating the proportion of cow collar locations captured within the predicted distribution of the Piosphere tool and secondly a comparison of pixel values for each landscape scale analysis across the whole study area. 96% of collar location fell within the predicted distribution of the Piosphere tool. Regressing each of the landscape analyses produced and R^2 of 0.64.

ACKNOWLEDGMENTS

CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

ORIGINS OF MANAGEMENT IN THE WEST

In the US rangelands occupy around 770 million acres, about 30 percent of the US terrestrial area (NRCS 2020; Reeves et al., 2018). Throughout the 1800s livestock grazing was the priority use across rangelands in the US (Mitchell, 2000). As use increased, demand for management precipitated the forest service's system of range regulation in 1906 (Poling 1991; USFS 2020). Management was further solidified with the Taylor grazing act of 1934 which created grazing districts where grazing was apportioned and regulated (BLM 2020). Today rangeland use has expanded from extractive uses like mining, grazing, and hunting to include a large suite of non-consumptive uses such as recreation, open space, and species conservation (USU Extension 2020). Although the uses of rangelands are diversifying, livestock grazing remains one of the most ubiquitous uses (NRC 1994). However, because rangelands now support more diverse uses rangeland managers are now asked to balance management of sensitive wildlife species like sage-grouse while maintaining livestock grazing objectives. Therefore, managers need better tools and information to ensure proper management of multiple rangeland uses.

SAGE-GROUSE FROM PETITION TO MONITORING FRAMEWORK

Greater sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse has become a species of conservation importance across the intermountain west. In 1999, the first petition was filed with the United States Fish and Wildlife Service (USFWS) for

listing the sage-grouse under the Endangered Species Act (Connelly et al. 2000).

Between 1999 and 2005, another nine petitions were filed for all or some part of the sage-grouse range (NDOW 2020), culminating in 2005, with a range-wide finding that sage-grouse were not warranted for listing under the Endangered Species Act (1973) (ESA) (FWS 2015). This decision was challenged in 2007, and subsequently remanded to the USFWS. In 2010, the USFWS found sage-grouse did warrant protection under the ESA but precluded from listing, due to other species that had a higher listing priority. In large part, the reasons for a warranted distinction were identified as inadequacy of regulatory mechanisms, and the present and threatened destruction, modification, or curtailment of the range of the sage-grouse posed a significant threat to the sage-grouse now and into the foreseeable future (FWS 2015). In 2013, the USFWS released its draft assessment for the sage-grouse candidacy. In 2015 USFWS announced that sage-grouse did not warrant protection under the ESA, with a stipulation to be reevaluated in five years (Finch et al. 2016).

Currently, federal agencies assess sage-grouse habitat using the Sage-Grouse Habitat Assessment Framework (HAF) (Stiver et al. 2006). The HAF was developed in 2010 and updated in 2015, through a cooperative effort between state, federal, and non-governmental experts in the field. This framework outlined objectives and methods to evaluate sagebrush habitats for sage-grouse at multiple spatial scales (Stiver et al 2015). These scales are referred to as orders. The 1st order reflects the geographic range of all sage-grouse populations. The 2nd order reflects distinct populations or sub-populations. The 3rd order addresses seasonal habitats within the home ranges. The 4th order evaluates the specific habitat characteristics within sagebrush (*Artemesia* spp.) communities that

occur within the 3rd order (Connelly et al. 2003). Connelly et al. (2000) developed habitat guidelines to manage sage-grouse populations and their habitat throughout their various life cycle stages.

Connelly et al. (2000) reviewed past research and provides objectives to manage sage-grouse populations and their habitats into the future (Knick et al. 2013). These objectives were developed from a synthesis of available peer-reviewed publications, theses and dissertations that used similar vegetation sampling methods hereafter referred to 'standard sage-grouse methods' (see Connelly et al. 2003). Standard sage-grouse methods obtained vegetation estimates using line intercept (LI) for shrub cover (Canfield 1941) and Daubenmire frames (DF) for canopy cover (Daubenmire 1969). Objectives are illustrated as thresholds of canopy cover values for plant functional groups (Table 1) within sage-grouse habitats that include shrubs (primarily sagebrush), perennial grasses, and forbs (Connelly et al. 2000).

As part of the 2015 decision, the USFWS stipulated that federal land management agencies must analyze impacts of land management decision on sage-grouse. To meet this obligation, the BLM created a Record of Decision and Approved Resource Management Plan Amendments (ROD ARMPA) for the Great Basin Region which precipitated ARMPA documents for individual states in the Great Basin (BLM 2015a). The state specific ARMPA documents (Table 1) provides habitat objectives outlined in Connelly et al. (2003) as desired conditions or objectives. The objectives are displayed by life cycle stage or season (i.e., nesting, brooding, winter) and illustrates desired canopy cover thresholds by plant functional groups. This Table is further broken down by county to reflect the differences in habitat across that state (BLM 2015b). These county specific

objectives are to be assessed by the BLM within the HAF. The HAF methods used by the BLM employ line-point intercept (LPI) to obtain foliar cover estimates for all plant functional groups. Conversely, standard sage-grouse methods were used to develop canopy cover estimates that define sage-grouse habitat objectives (Connelly et al. 2003). The question remains, does the BLM HAF and standard sage-grouse methods produce the same habitat assessment outcomes with respect to the habitat objectives?

Some work has compared specific cover estimates yielded by the two methods mentioned above. Thacker et al. (2015) found Daubenmire and line-point intercept did not yield similar results for herbaceous cover (Thacker et al. 2015). In a rebuttal to this study the conclusions reached in Thacker et al. 2013 were attributed to differing aspects of vegetation cover that each method measured, foliar versus canopy cover (Karl et al. 2016). In another rebuttal to Thacker et el. 2013 a simulation concluded that 16 Daubenmire frames may not be enough to capture the variation present (Martyn et al. 2015). However, neither of these rebuttals disputed the facts that DB, LI and LPI yield different cover estimates. For My study, rather than comparing specific cover estimates for each plant functional group I propose to address whether assessment outcomes, with respect to the habitat objectives, using standard sage-grouse methods and HAF methods are reconcilable. The objective of chapter two is to determine if standard sage-grouse methods and HAF field methods used at the same site provide the same assessment outcome at that site.

AN OVERVIEW OF METHODS USED IN DEFINING CATTLE DISTRIBUTIONS

Factors influencing cattle's selection and distribution have been a part of rangeland resource management since its inception. Cattle distributions have been studied

through a variety of ways. The simplest of these is direct visual observation which can be done in multiple ways. One process employs unique collars or ear tags for each animal, its location is observed visually and recorded onto a map of the study area (Howery et al. 1998). A second process uses observation from dawn till dusk along predetermined routes. Along these routes the number of cattle, cattle activity, and their location on a map are recorded for each cattle sighting (Gillen et al. 1984). These types of direct observations can be used to infer the distribution preferences of cattle and their offspring. Direct visual observation can be difficult, variable, costly, and time consuming. Track patterns are another way to define ungulate distributions (Lange 1969). Others have mapped cattle distributions using aerial reconnaissance, finding radial patterns emanating away from watering points. These patterns were used to identify the existence of the Piosphere (Lange 1969). Dung counts and distributions have also been used to understand cattle distributions. Dung density has been used to estimate time spent per unit area (Lange 1969). Similarly, some have used indirect observations like plant utilization patterns to describe grazing distribution patterns (Gillen et al. 1984). Radio-telemetry using very high frequency (VHF) collars are yet another way to map cattle distributions. This technology provides the ability to identify spatial and temporal utilization patterns. One important pattern identified from VHF collars was cattle's distance from water increased as forage resources were depleted closer to water, or as resources became limited during a drought year (Pinchak et al 1991). The most recent method of defining distributions comes with the use of global positioning system (GPS) radio collars. This type of monitoring has advantages with its continuous and automatic tracking of animal positions (Ungar et al., 2005). The latest GPS capabilities have

provided opportunities for data to be taken at temporal resolutions as low as five-minute intervals. These types of data can then be imported for use into statistical or geospatial tools to determine a large suite of cattle characteristics (R core team 2018; Turner et al. 2000).

Modeling using VHF or GPS collar data can be used to inform home range estimates or more complex analyses like resource selection functions (RSF) that can provide inference at a deeper level. Using an RSF eliminates GPS telemetry bias created by only having a portion of the herd fitted with GPS collars. Just because a GPS marked cow did not use a certain location does not mean that that area is not used by or important to the rest of the unmarked population (Dahlgren et al. 2018).

An RSF models a habitat suitability index using a bottom up approach informed by collar GPS locations. GPS locations intersecting resources displayed as raster pixels across a landscape are conceived as resource units and predictor variables associated with that particular raster resource (Boyce et al. 2002). Mathematical models used in an RSF create a representation of the whole population with GPS collar data obtained from a subset of the population (Dahlgren et al. 2018). The mathematical models use the known GPS locations of cattle and compares these with resource units available across the landscape. Many types of resources can be displayed in a raster format like distance from water, slope, elevation, aspect, etc. Using GPS data in concert with statistical or geospatial tools gives the ability to identify used and unused pixels of resource units that cattle are selecting for. This process can define resource selection for individual species as well as difference in selection between species (Kohl et al. 2013). Using these resource units together gives powerful insight towards selection and distribution of cattle.

Open Range Consulting has created a tool using GIS applications that employs the concept of the Piosphere. This tool addresses cattle's distribution across a landscape from a top down approach using limitations to cattle presented in the literature associated with abiotic raster geospatial information, while an RSF addresses cattle's distribution from a bottom up approach employing GPS collar locations to inform estimations across a landscape. The intent of chapter three is to assess the Piosphere tool's ability to predict cattle distributions across a given landscape with an independently derived resource selection function (RSF) informed by GPS collar location data. Both methods will use the same set of abiotic geospatial information.

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CHAPTER 2

EXAMINING THE FOUNDATIONAL ASSESSMENTS RELATIONSHIP TO THE

GREATER SAGE-GROUSE HABITAT ASSESSMENT FRAMWORK

ABSTRACT

The greater sage-grouse (*Centrocercus urophasianus*) is being used as an umbrella species to protect 350 plant and animal species that also depend on rangeland communities. Sage-grouse habitat quality has been measured using multiple techniques. Standard sage-grouse methods described by Connelly et al (2003), include line intercept (LI) and Daubenmire frames (DF) to measure canopy cover. These methods were used broadly among sage-grouse biologist and were used to develop habitat management objectives for the greater sage-grouse (Table 1). However, Federal land management agencies now use the Habitat Assessment Framework (HAF) methods, line-point intercept (LPI), to assess sage-grouse habitat. While there is evidence that the different methods are not entirely compatible, researchers who helped develop the methods used by land management agencies suggested that when determining the suitability of habitat objectives, outcomes would be similar. To date there has been no effort to reconcile the outcomes of standard sage-grouse methods and HAF methods in the context of the sage-grouse habitat objectives. Reconciling outcomes between standard sage-grouse methods and HAF methods is the objective of this chapter. To do this, 74 sites were sampled (Table 4). Standard sage-grouse methods and HAF methods were employed together at 19 sites in which the initial outcomes fell near the thresholds for sage grouse suitability (Table 2). The same outcome was seen at 67% of the 19 sites. More specifically, 83% of

the sites assessed for shrub species (Table 5) produced the same outcomes while 60% of the sites assessed for herbaceous species (Table 6) produced the same outcomes.

INTRODUCTION

Greater sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse) are sagebrush (*Artemesia* spp.) obligates and have become a species of concern throughout western North America. Following Endangered Species Act (1973) (ESA) listing decisions in 2005 and 2010 that were unwarranted but overturned and warranted but precluded, respectively, in 2015, the U.S. Fish and Wildlife Service (USFWS) concluded that listing under the ESA sage-grouse was unwarranted due to range-wide collaborative efforts designed to ensure the species persistence (USFWS 2015). Additionally, sage-grouse have been considered an umbrella species for over 350 plant and animal species that also depend on sagebrush communities, further increasing their conservation status (Knick et al. 2013). Although sage-grouse were not federally listed, many measures designed to conserve this species now guide management across rangelands that support sage-grouse. The Sage-grouse Habitat Assessment Framework (HAF) was developed to monitor sage-grouse habitats at multiple scales on federal lands (Stiver et al. 2010; Stiver et al. 2015).

The HAF framework outlines objectives and methods to evaluate sagebrush communities for sage-grouse habitat suitability at multiple temporal and spatial scales (Stiver et al. 2015). These scales are referred to as orders. The 1st order reflects the geographic range of all sage-grouse populations. The 2nd order reflects distinct populations or sub-populations. The 3rd order addresses seasonal habitats within the home ranges. The 4th order evaluates the specific habitat characteristics within sagebrush

(*Artemesia* spp.) communities that occur within the 3rd order (Connelly et al 2003). Connelly et al. (2000) produced habitat guidelines to manage sage-grouse populations and their habitat throughout their various life cycle stages.

As sage-grouse conservation has moved forward on federal lands, the HAF has been established on a state-by-state basis. The Utah Greater Sage-Grouse Approved Resource Management Plan Amendment (UARMPA) set habitat objectives for sage-grouse specific to Utah's federal lands manage by U.S.D.I. Bureau of Land Management (BLM) and the U.S.D.A. Forest Service (USFS) (Table 1). To address potential variation in vegetation communities across the state, county specific habitat objectives were established.

Habitat objectives within the HAF guidelines consist of thresholds of canopy cover for vegetation functional groups that comprise sage-grouse habitat; i.e., shrub, perennial grass, and forb canopy cover (Table 1). Habitat objectives were based on published sage-grouse habitat objectives (Connelly et al. 2000, Hagen et al. 2007, and Dahlgren et al. 2019). These previously published habitat objectives were developed from research that employed vegetation sampling methods commonly used to monitor sage-grouse habitat (Connelly et al. 2003). These methods consist of line intercept (Canfield 1941) (LI) and Daubenmire frames (Daubenmire 1969) (DF) to estimate shrub and herbaceous canopy cover respectively, hereafter referred to as standard sage-grouse methods. Line intercept addresses shrub communities documents the total canopy of shrubs intercepting a transect to populate an estimate of canopy cover. Daubenmire on the other hand is used to address herbaceous communities by determining the proportion of a particular species present within a Daubenmire frame. Multiple frames placed along

a transect are used to populate an estimate of herbaceous canopy cover. The HAF employs a different sampling methodology, line-point intercept (LPI), to obtain foliar cover estimates for all plant functional groups for monitoring sage-grouse habitat. Line-point intercept is carried out by dropping a pin along a transect at predetermined increments. With each pin drop the vegetation of shrub and herbaceous species touching the pin are documented to populate foliar cover estimates of for all plant species present.

Potential underlying conflict currently exists when using the HAF. Standard methods and LPI have potential to produce disparate results (Thacker et al. 2015; Karl et al. 2016). Because the underlying methods (i.e. standard sage grouse field methods) used to establish habitat guidelines are different from methods employed by the HAF (i.e., LPI). It is possible habitat assessment outcomes when using the HAF could be compromised. Our overall objective is to assess outcomes in brooding habitat for sage-grouse habitat monitoring within the 4th order using standard sage-grouse methods (LI and DF) compared to HAF methods (LPI) (Figure 5).

STUDY AREA

The study area is in the Wyoming Basin ecoregion (Bailey 2004) of Utah, more specifically Rich County in northern Utah. The project area for my research focused on sage-grouse brooding habitat on BLM lands in Rich County, Utah managed by the Salt Lake BLM field office. The study area elevation ranges from 1800 to 2700 meters and consists of 135,440 acres (Payne 2011). Precipitation ranges between 9-12 inches annually. The dominant soils include Mollisols, Inceptisols, Aridisols, and Alfisols. The study area includes Private (22,820 acres), BLM (66,520 acres), USFS (37,010 acres),

and SITLA (9,090 acres). Mean temperatures for summer range between 7-27 degrees Celsius.

The study area can be classified as Sagebrush Steppe with patches of sub-alpine vegetation (Payne 2018). Dominant plant species include but are not limited to Artemisia species: Wyoming Sagebrush (*Artemisia tridentata*), Black Sagebrush (*Artemisia Nova*), Mountain sagebrush (*Artemiesia tridentata subsp. Vaseyana*), Spineless Horsebursh (*Tetradymia canescens*), Snowberry (*Symphoricarpos spp.),* and Antelope Bitterbrush (*Purshia tridentata*). Perennial Grass Species; Bluebunch Wheatgrass (*Pseudoroegneria spicata*), Sandberg Bluegrass (*Poa secunda*), Western Wheatgrass (*Pascopyrum smithii*), Basin Wildrye (*Leymus cinereus*), Crested Wheatgrass (*Agropyron cristatum*). Annual Grass species; Cheatgrass (*Bormus tectorum*). Forb Species; Hollyleaf clover (*Trifolium gymnocarpon*), low pussytoes (*Antennaria dimorpha*), Stemless goldenweed (*Stenotus acaulis*). Within the study area predetermined sites have been selected by the BLM and stratified by dominant vegetation type. Sites were named for the dominant vegetation present. WYBS indicating Wyoming Sagebrush (*Artemisia tridentata*), MBS indicating Mountain sagebrush (*Artemiesia tridentata subsp. Vaseyana*), LS indicating Little Sagebrush (*Artemisia arbuscula*), and lastly OT indicating Black Sagebrush (*Artemisia Nova*), Yellow Rabbitbrush (*Chrysothamnus viscidiflours)* or Rubber Rabbitbrush, (*Ericameria nauseosa*).

Land uses include oil production, agriculture, irrigated hayland, wildlife habitat, pasture, and rangelands (Woods et al 2001). The Utah Sage-Grouse Approved Resource Management Amendment (UARMPA) has defined this area as a Priority Habitat Monitoring Area (PHMA). This classification makes the study area an important place in

Utah that has management implications with respect to sage-grouse, livestock and other wild game species.

METHODS

Training and Calibration

To ensure proper execution of standard and non-standard monitoring protocols, Training for observers consisted of 12 hours spent in a classroom setting at the Salt Lake City BLM Field Office. Field training occurred in the spring of 2018 at the mouth of Green Canyon, Logan, UT. All monitoring techniques were practiced by each individual and each crew member's estimates were compared to calibrate observations. Additionally, 6 hours was spent in the field at the study site with the BLM range monitoring specialist practicing all monitoring protocols. When monitoring began in May of 2018, both crews monitored the first three sites together to increase calibration among observers. Once a month all crew members monitored a plot together to calibrate between observers.

Primary Sampling

We used the Assessment Inventory Monitoring (AIM) protocol, which included LPI, as defined within the HAF and currently employed by the BLM. A set of 74 AIM plots were sampled across the BLM lands in Rich County. Each AIM plot was sampled using BLM protocols that included three transects stemming from the center point of the plot. The transects were arranged at zero degrees 120 degrees and 240 degrees. Each transect was first established with a tape measure pulled out to 30 meters and aligned on its bearing. Once aligned a stake was placed at the five-meter mark and the starting point

of the transect was then hooked to that stake. This created our zone of exclusion in the middle of the transects. The end of the 30 meter transect was then staked down along the assigned bearing to complete a 25 meter transect. Along each transect line-point intercept (LPI) was executed dropping a plumb-bob every half meter and recording and vegetation or abiotic material touching the pin into the Database for Inventory Monitoring and Assessment (DIMA). After all, transects were sampled, we populated vegetation cover estimates by plant functional group using DIMA (Courtright et al. 2011). If any of the plant functional group cover estimates fell within ±5% of the cover thresholds outlined in UARMPA, a secondary sampling was executed for that functional group.

Secondary Sampling

The lower bound for shrub cover was set at 10 percent canopy cover (Table 1). Therefore, when LPI estimated shrub foliar cover between 5 and 15 percent cover (Table 2) we sampled using the standard methods. The total canopy of shrub in centimeters intersecting all three transects was summed and divided by the total length of all three transects. The lower threshold of habitat objectives for perennial grasses was 10 percent canopy cover (Table 1). If LPI estimated perennial grass foliar cover between 5 and 15 percent cover or forb cover below 10 percent cover (Table 2) we secondarily sampled along all three transects using Daubenmire frames as part of standard methods. Daubenmire frames were placed every 5 meters on all three transects for a total of 15 frames at each plot (Connelly et al. 2003). Daubenmire frames were sampled in accordance with standard methods as described by Connelly et al (2003). For Daubenmire sampling, functional group canopy cover was separated into 6 classes (Table 3) to reduce bias between individual observers (Daubenmire 1969). Each herbaceous

species was recorded and assigned a class from one to six based upon the proportion of its canopy cover occupying the Daubenmire frame. The species estimates were calculated using the midpoint of each class (Daubenmire 1969). These values were averaged over all the frames in the sampling plot to ascertain herbaceous vegetation canopy cover estimates for all plots (Martyn et al. 2015). This estimate taken in the context of sage-grouse habitat guidelines (Table 1) informed the suitability between standard and LPI assessment outcomes. We minimized the number of observers, i.e., three, for all field observations to help decrease observer error and variation.

RESULTS

Seventy-four sites were sampled, 74% (55/74) of the sites met the sage-grouse habitat objectives and did not require secondary sampling (Table 1). Of the remaining sites 26% (19/74), 21 assessments were carried out to determine if the standard sage-grouse methods assessed the site in accordance with HAF methods (Table 1). Some sites demanded assessments on multiple plant functional groups hence 21 assessments for 19 sites.

Outcomes were similar when looking at all sites that were secondarily sampled. When comparing the outcomes of shrub cover comparisons, (Figure 1) standard sage-grouse methods and HAF methods agreed 83% (5/6) of the time (Table 5). There was only one instance where perennial grass was cover was assessed using both methods and the outcomes were not in agreement (Table 6). There were 14 comparisons between standard sage-grouse methods and HAF methods, with respect to forbs the outcomes agreed 64% (9/14) times (Table 7).

DISCUSSION

My study found the assessment of sage-grouse habitat using the standard sage-grouse and HAF methods agreed most of the time. Even though previous research had suggested that the standard sage-grouse methods and HAF protocols yielded differing specific cover estimates when monitoring sagebrush communities (Thacker et al. 2015). However, when comparing the outcomes of the two methods within the context of sage-grouse guidelines there is a lot of agreement. The Sage-grouse habitat Assessment Framework manual indicates that the authors were confident that the range of functional plant cover was broad enough to mitigate any differences due to the differing methods. There are currently few studies that have assessed habitat objective outcomes with relation to standard sage-grouse and HAF sampling methods. Sage-grouse habitat objectives were developed from standard sage-grouse methods producing specific canopy cover estimates for functional vegetation groups within sagebrush communities and may differ from the HAF methods specific foliar cover estimates. Although when assessing sage-grouse habitat objective outcomes standard sage-grouse methods and HAF methods differed infrequently.

In sagebrush sites where both standard sage-grouse methods and HAF were carried out, outcomes show agreement at 5 of 6 comparisons (Table 5). The only site that showed disagreement had a difference of 7% (Figure 1) in the estimated sagebrush cover. This was the largest difference in cover estimate of all sagebrush sites. When comparing Herbaceous communities there was only one case where perennial grass demanded a comparison of outcomes. This site demonstrated a disagreement in outcomes (Table 6) although the cover estimates differed by only 3% (Figure 2). Forb outcomes showed the

weakest agreement overall with 9 of 14 sites showing agreement in outcomes (Table 7) while also displaying some of the larger variations in specifics plant cover estimate (Figure 3). This may be due to the highly variable and sporadic nature of forbs in sagebrush ecosystems. If forb cover estimates were below 5% foliar cover, there was 100% agreement in outcomes between the methods. If HAF forb estimates were above 5% foliar cover the methods only yielded the same outcome 37% of the time. The HAF generally produced higher forb cover estimate than standard sage-grouse methods. It is important to note that as forb and grass cover increased, the variation between HAF and standard sage-grouse estimates also increased (Thacker et al. 2015). This may be an important caveat since forbs may be just as important to sage-grouse as sagebrush cover (Dahlgren et al., 2006).

The cover estimates for perennial grass and forbs derived from standard sage-grouse methods and HAF methods in this study had a mean difference of 3% in their respective estimates. Using standard sage-grouse methods with HAF protocols, Martyn et al. 2015 found that cover estimates of perennial grass and forbs had a mean difference of 9% and 7%, respectively (Martyn et al. 2015). This helps to give context to the variation seen within the dataset collected for this study.

The differences in outcomes that I did identify are limited and are likely due to differences in vegetational structure that the two methods are measuring. Standard sage-grouse methods (LI & DF) estimate canopy cover whereas HAF methods (LPI) estimate foliar cover (Karl et al., 2016). Foliar cover is defined as the area of ground covered by the vertical projection of the aerial portion of the plant measuring just the exposed plant

area. Canopy cover is defined as area of ground covered by the vertical projection of the outermost perimeter of the plant.

When the secondarily sampled estimates are examined within the context of the sage-grouse habitat objectives there is an overall trend of agreement with 67% of all secondary assessments producing the same assessment outcome. Shrubs showed the most agreement, forbs and perennial grasses had more dissenting outcomes. Since transect data are averaged and suitability classes are broad the differences between techniques likely have minimal sway upon the end result (Stiver et al,. 2015). My findings confirm the assumption that there is generally a high degree of agreement in assessment outcomes between standard sage-grouse methods and HAF methods.

My work may not apply all habitat types and sage-grouse life cycle stages. All this work has been carried out in northern Utah and in brooding habitat limiting the inference to northern Utah brooding habitats in Rich County. Firstly, consideration of the differing habitat objectives the exist between state or county could create dissenting outcomes. Secondly In drier parts of Utah it may be likely that a larger proportion of sites sampled would produce cover estimates near the threshold for resampling, increasing the sample size of assessment comparisons and possibly the variation in assessment outcomes.

CONCLUSIONS

Assessment of habitat objective outcomes showed few differences. When assessments did produce conflicting outcomes the average variation in plant cover estimates was low at 3%. Though the specific plant functional group canopy estimates

may differ this does not necessarily produce different habitat objective assessment outcomes.

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TABLES AND FIGURES

Table 1. Showing the brooding habitat objectives for plant functional groups counties across Utah.

Brood-Rearing/Summer (April 15-August 15)[1]		
Cover	% of Seasonal habitat meeting desired condition	>40% of the mapped brood-rearing/summer habitat meets recommended habitat characteristics where appropriate (relative to ecological site potential, etc.)[8]
	Sagebrush cover[6, 8, 9]	>10%
	Total shrub cover[6, 8, 9]	10-25%: Box Elder, Bald Hills, Hamlin Valley, Panguitch, Rich, Parker Mountain, Uintah 10-30%: Carbon, Emery, Sheeprocks, Ibapah,
	Sagebrush height[6, 8, 9]	>12 inches (30 cm): Box Elder, Bald Hills, Hamlin Valley, Sheeprocks, Ibapah >10 inches (25 cm): Rich, Carbon, Emery, Uintah north of Highway 40 >8 inches (20 cm): Parker Mountain, Panguitch, Uintah south of Highway 40
	Perennial grass cover and forbs[6, 8, 9]	>15% (Grass: >10%; Forb: >5%): Box Elder, Rich, Sheeprocks, Ibapah, Parker Mountain, Panguitch, Uintah, Carbon, Emery >15% (Grass: >8%; Forb: >7%): Bald Hills, Hamlin Valley,

Table 2. Secondary sampling thresholds for species functional groups. Representing ±5% of the lower threshold illustrated in the sage-grouse habitat guidelines for Rich County Utah.

Plant Functional Groups	Species Cover
Shrub species	5-15
Forb species	0-10
Perennial grass species	5-15

Table 3. Connelly et al. (2003) Cover classes associated with Daubenmire method for canopy cover percentages.

Class	Percentage of Daubenmire frame occupied by individual species canopy
1	0-1
2	1-5
3	5-25
4	25-50
5	50-75
6	75-100

Table 4. Summary of sites sampled in Rich County Utah. Sites are named for the dominant shrub cover each site. Low Sage represents *Artemisia arbuscula*, Mountain big sagebrush represents *Artemiesia tridentata subsp. Vaseyana*, Wyoming big sage brush represents *Artemiesia tridentate* and other shrub represents one of three species of rabbit brush, *Ericameria nauseosa*, or *Chrysothamnus viscidiflours*.

Cover type	Total sites completed 2017	Total sites completed 2018	Total sites completed	Total sites secondarily sampled	Line intercept completed	Daubenmire completed
Low Sagebrush (LS)	0	2	2	1	1	0
Mountain Big Sagebrush (MBS)	6	30	36	8	2	6
Other Shrub (OT)	1	14	15	5	1	4
Wyoming Big Sagebrush (WYBS)	1	20	21	7	2	5
Total	8	66	74	21	6	15

Table 5. Comparison of habitat quality assessments of Shrub species in Rich County Utah. The HAF column indicates the estimate for shrub species produced by line-point intercept. The STD column indicates the shrub estimate produced by Daubenmire frames. The agreement column has a one if the assessment of the site was the same and a zero if the assessment of the site was different. Total agreement indicates the proportion of all shrub sites that produced the same assessment at each individual site.

Line intercept assessment Shrub species			
Site name	HAF	STD	Agreement
LS 62	9.4	3.6	1
MBS 24	1.3	7.2	1
MBS 192	14.0	14.7	1
OT 35	12.0	4.9	0
WYBS 45	9.3	8.5	1
WYBS 55	14.0	16.9	1
total agreement			83%

Table 6. Comparison of habitat quality assessments of perennial grass species in Rich County Utah. The agreement column has a one if the assessment of the site was the same and a zero if the assessment of the site was different. Total agreement indicates the proportion of all perennial grass sites that produced the same assessment at each individual site.

Daubenmire Agreement Perennial grass species			
Site name	HAF	STD	Agreement
MTNSAGE 227	12.0	9.1	0
total agreement			0.00%

Table 7. Comparison of habitat quality assessments of forb species in Rich County Utah. The HAF column indicates the estimate for forb species produced by line-point intercept. The STD column indicates the forb estimate produced by Daubenmire frames. The agreement column has a one if the assessment of the site was the same and a zero if the assessment of the site was different. Total agreement indicates the proportion of all forb sites that produced the same assessment at each individual site.

Daubenmire Agreement Forb species			
Site name	HAF	STD	Agreement
MBS 04	4.0	0.2	1
MBS 05	8.5	8.4	1
MBS 25	10.0	2.0	0
MBS 29	5.4	1.0	0
MTNSAGE 227	10.0	9.2	1
OT 33	8.1	7.1	1
OT 36	7.9	0.7	0
OT 41	4.0	2.8	1
OT 91	10.0	3.1	0
WYBS 44	2.0	0.9	1
WYBS 45	1.4	0.4	1
WYBS 48	4.7	1.4	1
WYBS 51	10.0	4.4	0
WYBS 54	1.4	0.2	1
total agreement			64%

Figure 1. Illustrates the spread in functional group cover estimates between HAF methods (HAF) under the Habitat Assessment Framework and standard sage-grouse methods (STD) for shrub species in rich county. The red line indicates the minimum threshold of shrub cover deemed suitable for sage-grouse habitat in Rich County Utah.

Figure 2. Illustrates the range of cover estimates between HAF methods (HAF) under the Habitat Assessment Framework and standard sage-grouse methods (STD) for perennial grass species in Rich County. The red line indicates the minimum threshold of perennial grass cover deemed suitable for sage-grouse habitat in Rich County Utah. Mountain big sagebrush (MTNSAGE) represents (*Artemiesia tridentata subsp. Vaseyana*)
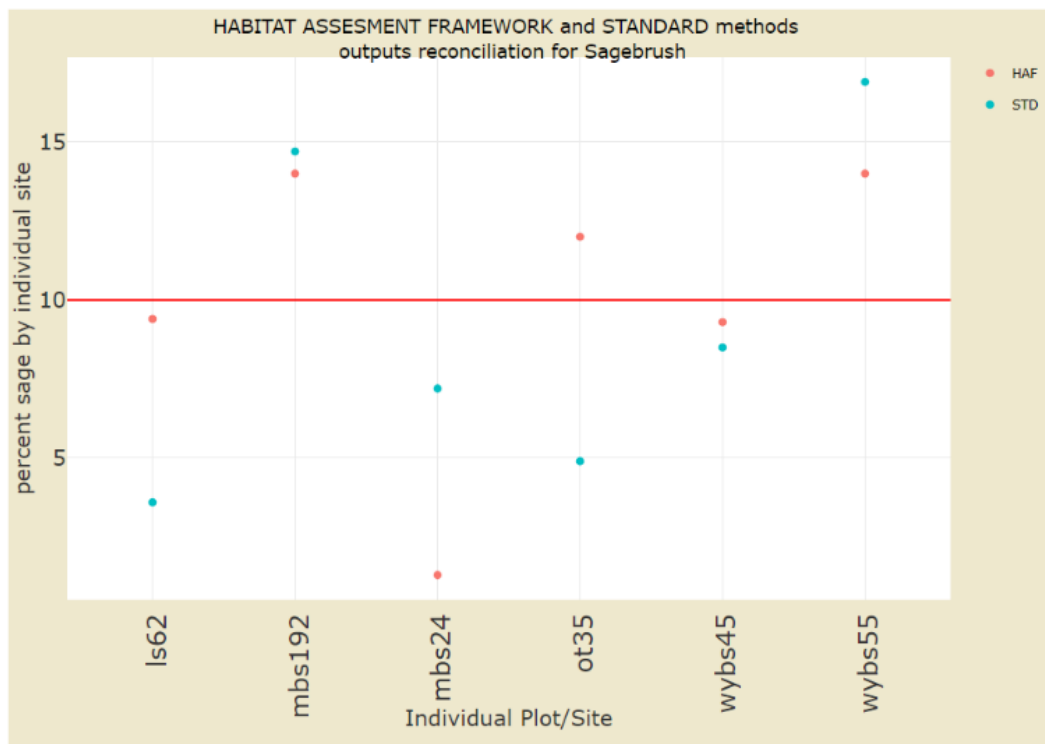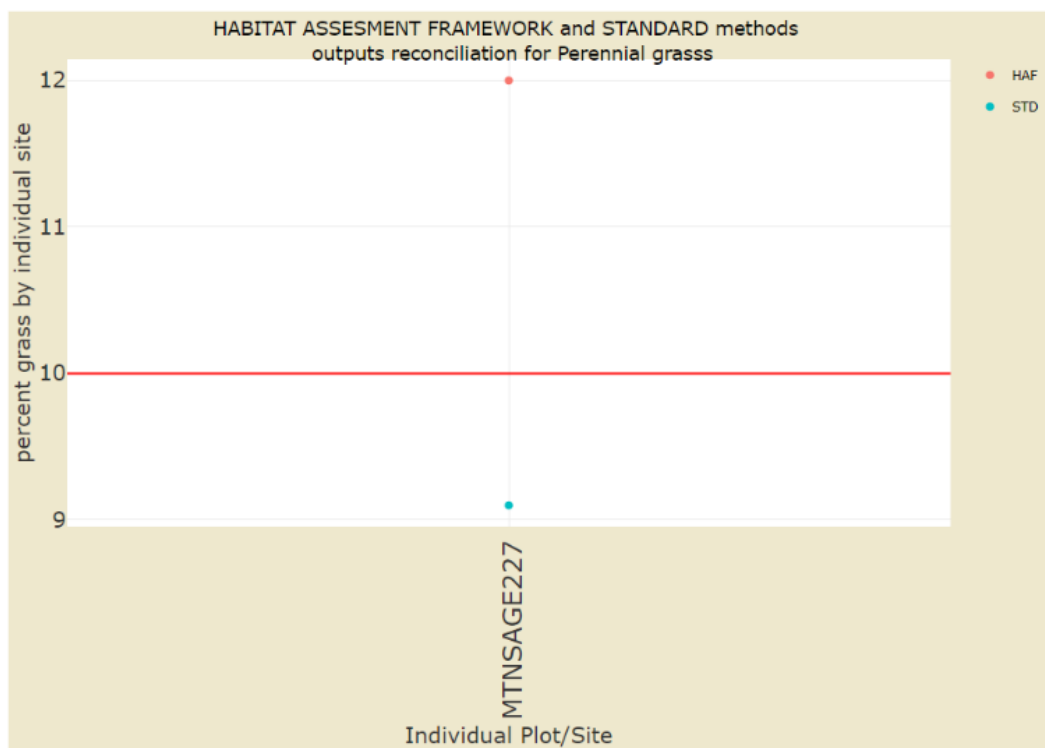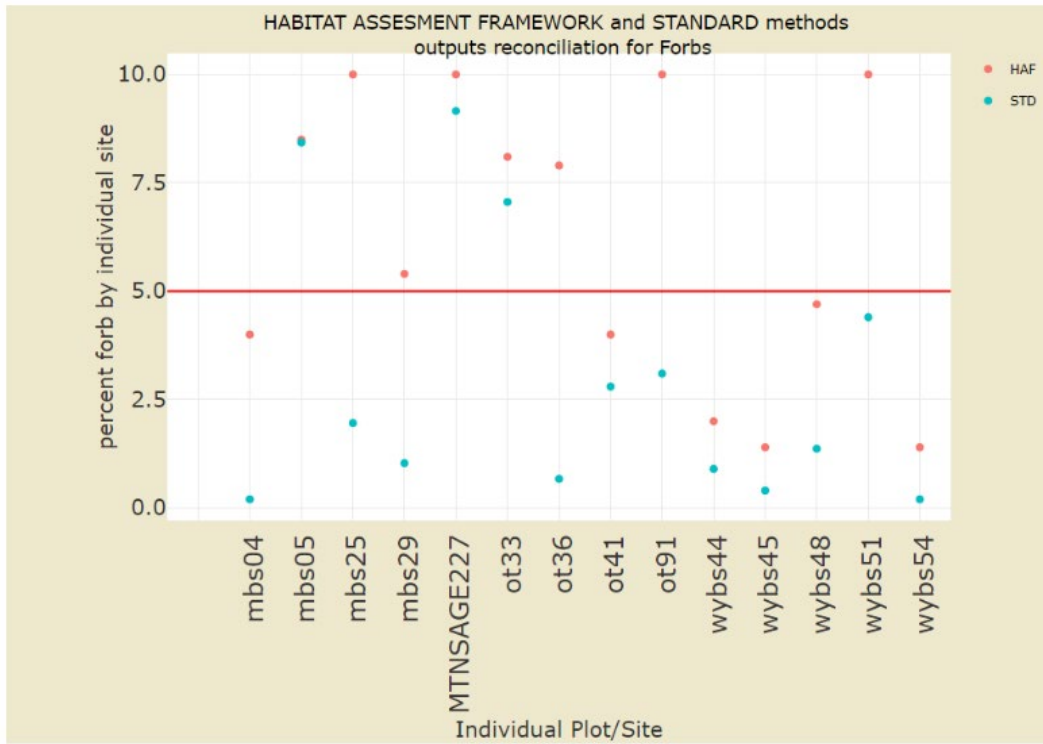
Figure 3. Illustrates the spread in estimates between HAF methods (HAF) under the Habitat Assessment Framework and standard sage-grouse methods (STD) for forb species in Rich County. The red line indicates the minimum threshold of forb cover deemed suitable for sage-grouse habitat guidelines in Rich County Utah.

CHAPTER 3

PREDICTED CATTLE DISTRIBUTIONS ASSESSED USING GPS COLLARS IN

RICH COUNTY, UTAH

ABSTRACT

The primary commercial use of rangelands in the U.S. is livestock grazing. An economical and consistent means of predicting and visualizing cattle distributions in rangelands could help inform managers to make grazing decisions. Open Range Consulting has developed the Piosphere tool that uses abiotic GIS data to quantify and predict cattle distributions. The objective of this chapter is to evaluate the Piosphere tool using observed global positioning system (GPS) cow collar data. The GPS collar data was combined with the same set of abiotic GIS data that informs the Piosphere tool and was used to build a resource selection function (RSF) independently of the Piosphere tool. This RSF controls for the telemetry bias associated with collar data and produces a landscape scale analysis that was used to evaluate the Piosphere tool's predicted distribution. Validation was performed in two ways. Firstly, calculating the proportion of cow collar locations captured within the predicted distribution of the Piosphere tool and secondly a comparison of pixel values for each landscape scale analysis across the whole study area. Ninety-six percent of cow collar locations were captured within the predicted Piosphere tool's output. A pixel comparison between each landscape scale analysis produced an R squared of 0.64 (Figure 4). These results together indicate that the predictive output from the Piosphere tool and the independent RSF built from observed collar data produce similar predictions of cattle distributions across the study area.

INTRODUCTION

The primary commercial use of rangelands in the U.S. is livestock grazing. An economical and consistent means of determining cattle distributions would be an effective tool to inform resource manager's grazing decisions. Tools that can help define how cattle utilize a landscape, can help determine the most effective locations to place range improvement projects, or contribute to understanding about interactions between cattle and wildlife (Cobon et al. 2020; Tueller 1989; Washington-Allen et al. 1994; Handcock et al. 2003). Factors influencing cattle distributions have been an important consideration for rangeland managers since management's inception. Past research has shown that distance from water, slope, and vegetation community were three of the leading factors found to influence cattle distribution across a given landscape (Valentine 1947; Gillen et al. 1984; Roath et al. 1982; Pinchak et al. 1991; Wade et al. 1998; Kohl et al. 2013). Factors influencing cattle distributions have been studied using track and dung patterns, direct observation, plant utilization, very high frequency (VHF) radio-telemetry collars, and global positioning system GPS radio collars (Lange et al. 1969; Gillen et al. 1984; Pinchak et al. 1991; Turner et al. 2000). The latest Global Positioning system (GPS) capabilities have provided more precise data with high temporal resolutions that can be used in R or GIS applications. Using GPS data with R or GIS applications gives the ability to identify used areas and the resources cattle are selecting in those used areas. Defining the resources selected is valuable information to resource managers (Dombeck et al. 1996). One of the more recent tools is a resource selection function (RSF) which makes use of GPS point information to inform a habitat suitability index or probability of use across a landscape (Boyce et al. 2002). Using an RSF eliminates GPS telemetry bias

created by from only having a proportion of individuals in the herd fitted with GPS collars. For example, just because a GPS marked cow did not use a part of the landscape described by a particular set of landscape variables does not mean that a cow from the unmarked portion of the heard may not use or value a part of the landscape with those same landscape variables. (Dahlgren et al. 2018). The GPS bias is eliminated by defining the selection preferences produced by a subset of a herd and applying those preferences derived from GPS locations across a given landscape. A resource selection function (RSF) serves as a method to assess use patterns more accurately for the entire population rather than relying on a few selected individuals (Manly et al. 2007). While RSF and GPS technology provide objective data on animal landscape use the data can be expensive to collect due to the cost of the collars and the expertise needed to analyze the data. This makes it difficult for most rangeland managers to assess such data outside of a research setting. Open Range Consulting created a tool using GIS applications that employs the concept of the Piosphere to fill this need without GPS collar data and its associated analysis requirements. The Piosphere tool predicts cattle distributions across a landscape using a top down approach, informed by geospatial information, such as distance from water and slope. Conversely an RSF predicts cattle's distribution using a bottom up approach employing GPS collar locations to inform predicitons across a landscape. The Piosphere tool could be cheaper and more accessible alternative for rangeland managers if it were determined to be accurate compared to the more intensive RSF methods. The intent of this chapter is to assess the Piosphere tool's capability to characterize cattle distribution across a landscape. To do this we will compare independently predicted distribution patterns built using an RSF and the Piosphere tool to determine if the results

are similar. The intent of this chapter is to evaluate the Piosphere tool's predicted output using a resource selection function informed by observed global positioning system (GPS) cow collar data.

METHODS

Study Area

The study area is characterized by the Wyoming Basin ecoregion (Bailey et al. 2004) of Utah, more specifically Rich County in northern Utah. The project area for my research focused on the BLM portion in Rich County, Utah managed by the Salt Lake BLM field office. The study area elevation ranges from 1800 to 2700 meters and consists of 135,440 acres (Payne 2011). Precipitation averages 9-12 inches annually. The dominant soils include Mollisols, Inceptisols, Aridisols, and Alfisols.

The total study area can be classified as Sagebrush Steppe with patches of sup-alpine vegetation (Payne 2018). Dominant plant species include but are not limited to *Artemisia* species: Wyoming Sagebrush (*Artemisia tridentata*), Black Sagebrush (*Artemisia Nova*), Mountain sagebrush (*Artemiesia tridentata subsp. Vaseyana*), Spineless Horsebursh (*Tetradymia canescens*), Snowberry (*Symphoricarpos spp.),* and Antelope Bitterbrush (*Purshia tridentata*). Perennial Grass Species; Bluebunch Wheatgrass (*Pseudoroegneria spicata*), Sandberg Bluegrass (*Poa secunda*), Western Wheatgrass (*Pascopyrum smithii*), Basin Wildrye (*Leymus cinereus*), Crested Wheatgrass (*Agropyron cristatum*). Annual Grass species; Cheatgrass (*Bormus tectorum*). Forb Species; Hollyleaf clover (*Trifolium gymnocarpon*), low pussytoes (*Antennaria dimorpha*), Stemless goldenweed (*Stenotus acaulis*).

Land uses include oil production, agriculture, irrigated hayland, wildlife habitat, pasture, and rangelands (Woods et al. 2001).

Data Collection

We used known functional watering points and reliable streams provided by Utah Department of Agriculture and Food (UDAF). Distance was estimated from these watering points using the Euclidian distance tool in ArcGIS version 10.7.1. Distance was estimated by each pasture individually to define availability at the management unit level. Slope was developed from the 10-meter resolution Utah Digital elevation model.

To assess the Piosphere tool I developed an RSF independently to produce a predicted distribution of cattle probability of use in Rich County Utah. I used 48,047 cattle Global Positioning System (GPS) collar locations taken from May 13th to September 30th of 2013. A total of 42 adult female cattle (n = 42) were fitted with Lotek 3300LR GPS collars. The GPS collars are owned by Utah Department of Agriculture, and they were placed on cattle owned by livestock owned by private producers in Rich County. Collars were scheduled to obtain locations every 2 hours from collar deployment on May 13th until September 30th of 2013. Collars remained on the same cow for the entirety of the study. The GPS locations were censored from analysis if cattle left the allotment.

Piosphere Tool Development

The Piosphere tool was developed using publicly available Digital Elevation Model (DEM) spatial data from the USDA NRCS geospatial data gateway. Some of the underlying assumptions or error associated with DEM data are addressed in Wechsler et

at. (2006). Cattle distributions were informed by applying a sigmoid curve to distance from water and slope raster layers. These raster layers were then multiplied together to create a final distribution prediction. The vegetation community was left out due the ubiquitous distribution of vegetation throughout the study area and lack of precise vegetation data available. Cattle distributions were modeled using priori limitations used to define a cosine curve for slope and distance to water according to limitations of cattle distributions found in the literature. The cosine curve was set to calculate continuous values on distance from water from a minimum of 0.5 miles to a maximum distance from water of 1.5 miles (Stuth et al 1991; Smith et al. 1986). Secondly the cosine curve was set to calculate continuous values on slope from a minimum of 5% to a maximum of 35% (Pinchak et al. 1991; Roath et al. 1982; Mueggler 1965; Gillen et al 1984). Values that were below the minimum were assigned a one and values that were above the maximum were assigned a zero. This was done to indicate areas that were completely accessible or inaccessible to cattle. The respective ranges of distance from water and slope were chosen in part due to pasture size, the ubiquitous presence of reliable water in the study area and the inherent topographical variation present across the study area (Hart et al. 1993; Smith et al. 1986; Thrash et al. 1999). Distance from water estimates and slope use reported in the literature were used to inform abiotic attribute limitations. After the cosine curves are applied to the respective abiotic attributes the layers are then multiplied together to create a final predicted distribution for cattle across the landscape at a 10-meter resolution.

Resource Selection Function Development

A resource selection function (RSF) was developed using the framework put forth in Manly et al. (2007). This was done independently of the Piosphere tool to compare to the respective predicted distribution (Manly et al. 2007). Covariates in the RSF included distance from water and slope. A generalized linear model (GLM) was used to estimate the relationship between used and available resource units within the study area. The resource selection function was made at the 2nd order level. This resolution defines home ranges to make inferences at the herd level and aligns with the objective of the study, identifying the extent of cattle's distribution at a herd level rather than the pattern of distribution across the landscape. Normally under a second order resource selection function (RSF) use would be defined by sampling within a home range estimate. This approach lends itself to describe preference of use rather than the limitations of use. Therefore, use was defined by the collar GPS points only. Availability was determined by systematically sampling every 3rd pixel at a 10-meter resolution across the entirety of the study area. A Generalized Linear Model (GLM) (Table 8) was estimated using the stats package (R Core Team 2018) for R 3.5.0. A null intercept model was run for comparison to the model informed by distance from water and slope. I used lme4 (Bates et al. 2015) package and AICcmodavg (Mazerolle 2017) to calculate an akaike information criterion (AIC) test to determine the better model. The more complex model (used/available ~ slope, distance to water) produced a lower AIC value, so it was used in the comparison to the Piosphere tool's output.

Model Evaluation

The Piosphere tool is a landscape analysis. A Resource Selection Function (RSF) (Manly et al. 2007) will serve as a landscape analysis for comparison. After analysis validation occurred in two ways. First, I calculated the proportion of GPS collar locations that fell within the predicted distribution of the Piosphere. Secondly, the pixel scores at each systematic sampling point across the study area were extracted and regressed to define the relationship between the Piosphere tool and the resource selection function predicted output.

RESULTS AND DISCUSSION

The resource selection function (RSF) indicated that cattle demonstrated significant selection for distances close to water and moderate slopes (Table 8). Maximum cattle distance from water was observed at 2574 meters (1.6 miles) and a maximum slope observed of 39%. Seventy five percent of collar locations were within 821 meters (0.52 miles) of water and on slopes 15% or less. The Piosphere tool predicted 96% of cattle locations was within 1.5 miles from water and on slopes less than 35%.

Each method estimates cattle distributions differently (Figure 6), however there is agreement in the overall distribution of cattle. Both models predict decreasing use as distance to water and slope increase. In the literature cattle were observed as far as 2 miles from water and as slopes as steep as 40% slopes. With my apriori limitations set at 1.5 miles from water and 35% slope it is promising that the Piosphere tool predicted 96% of collar locations. This evaluation however contains GPS telemetry bias because I am relying on apparent distributions based on only the marked animals instead of model data meant to reflect the distribution of the entire population or herd. To mitigate collar bias, I

extracted the probabilities of use for both models at each systematic availability point and

regressed the values to determine the relationship between the Piosphere tool model and

the resource selection function model. The R^2 was 0.64 (Figure 4). This is a more robust

comparison that eliminates GPS telemetry bias and demonstrates a high degree of

agreement between the models. A closer examination of the model comparisons shows

agreement in areas of mid to high probability and the lowest probabilities. The weakest

relationship is seen within predicted probabilities of use between 0.1 – 0.4 (Figure 4).

This disagreement may originate from an imperfect knowledge of water and its

distribution across the landscape. For example, if water exists but is not accounted for in

the spatial layers used to develop the Piosphere tool, it would inherently predict reduced

cattle distributions in those areas. Whereas the RSF could show moderate selection for

these areas or attributes. This could be due to difference in the way that each model

incorporates slope and distance from water or it could be rooted in differences due to the

RSF using cattle locations to build the model. Another possible cause of distributions

being misrepresented could be the lack of any vegetation, perhaps a playa. Although an

area like this could be within the accessible distances and slopes, the Piosphere could

over predict cattle distributions. Care should be taken to ensure accurate and

representative data layers are used when building distribution models. Both models rely

on accurate water information.

CONCLUSIONS

My research demonstrates that the Piosphere tool is reliable in predicting cattle

distributions in sagebrush communities of Northern Utah. It is likely that the Piosphere

tool should be used in conjunction with other data that would provide vegetation

abundance data before making grazing decisions. The Piosphere tool would be best employed with the input of local knowledge of land or resource managers that have knowledge of the respective landscapes. The question remains how distributions change as ecotype, seasonal variability, water availability, slope variation, cattle's local knowledge, or season of grazing change. It seems only reasonable to conclude that as these conditions change cattle distributions would also change. For this project area and ecotype the Piosphere tool has shown its ability to accurately define cattle distributions across the landscape. The Piosphere tool shows promise in its ability to predict cattle distributions.

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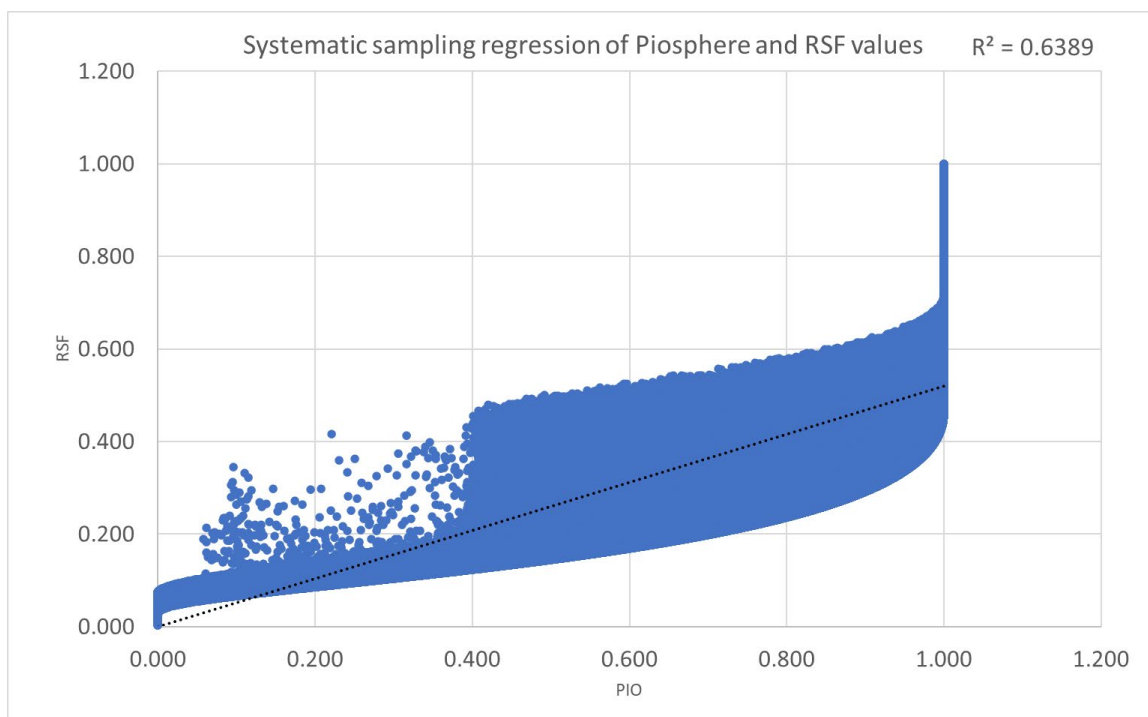
FIGURES

Figure 4. The regression of values occurring at systematically available points indicates an overall agreement between the Piosphere tool and the Resource selection Function with an r squared of 0.64. GPS locations taken from May 13th until September 30th of 2013 on the BLM portions of the Three Creeks Allotment in Rich County Utah.

CHAPTER 4

CONCLUSIONS

Comparisons of habitat assessment outcomes showed agreement in most cases. When assessments did produce conflicting outcomes the average variation in plant cover estimates between standard sage-grouse methods and HAF methods was low at 3%. Though the specific plant functional group canopy estimates may differ this does not produce different assessment outcomes. The federal agencies responsible of assessing vast sagebrush landscapes can continue forward with confidence that the foundation of sage-grouse habitat objectives is in support of the current HAF methods being implemented.

The ability of the Piosphere tool to predict cattle distributions is very comparable with an RSF distribution model. This finding may support future use of the Piosphere tool to help managers determine cattle distributions or inform management decisions to improve cattle distributions in order to deal with some rangeland issues. The Piosphere tool presents advantages in its ability to produce visualizations of cattle distributions without relying on GPS collar units, however the Piosphere tool will likely need some additional testing to determine how effective the tool is in various regions. This tool may provide a simple option for resource managers to employ coupled with their own local knowledge of the range to better manage livestock distributions.
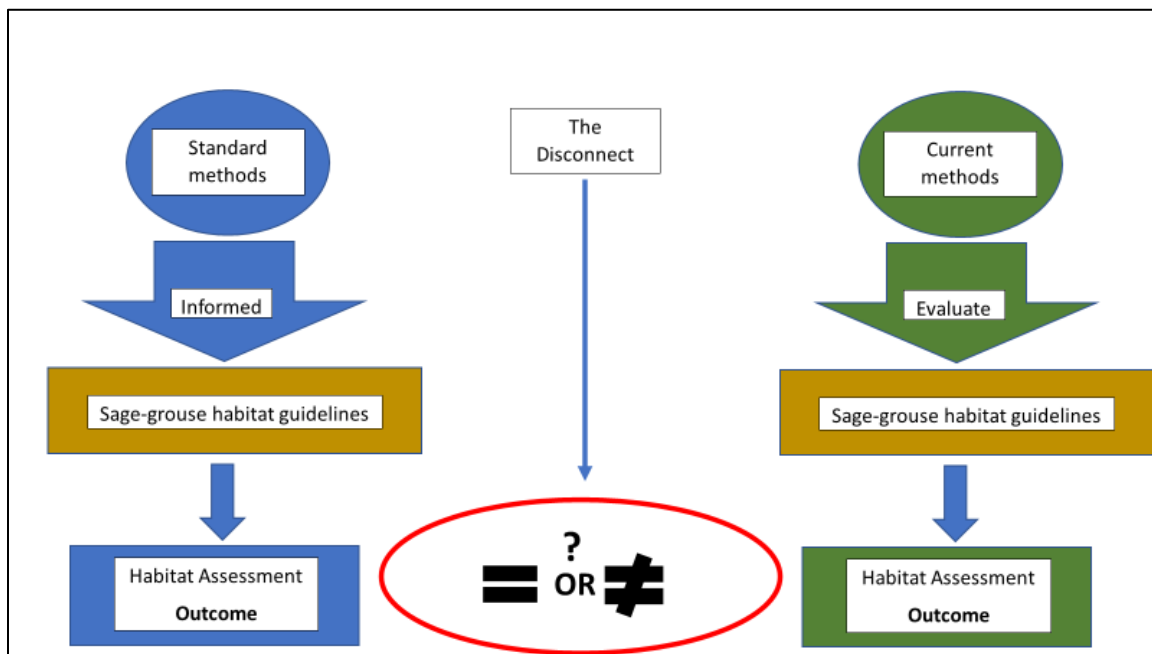
APPENDICES

APPENDIX A

ILLUSTRATION OF DISCONNECT BETWEEN STANDARD SAGE-GROUSE

BIOLOGIST METHODS AND HAF METHODS

Figure 5. Visual representation of how standard methods in blue and current HAF methods in green relate to sage-grouse habitat guidelines.

APPENDIX B

SIGNIFICANT LIMITATIONS TO CATTLE IN AN RSF AND VISUALIZATIONS

OF MODELED AND PREDICTED CATTLE DISTRIBUTIONS

Table 8. The Resource Selection Function (RSF) Generalized Linear Model (GLM) summary

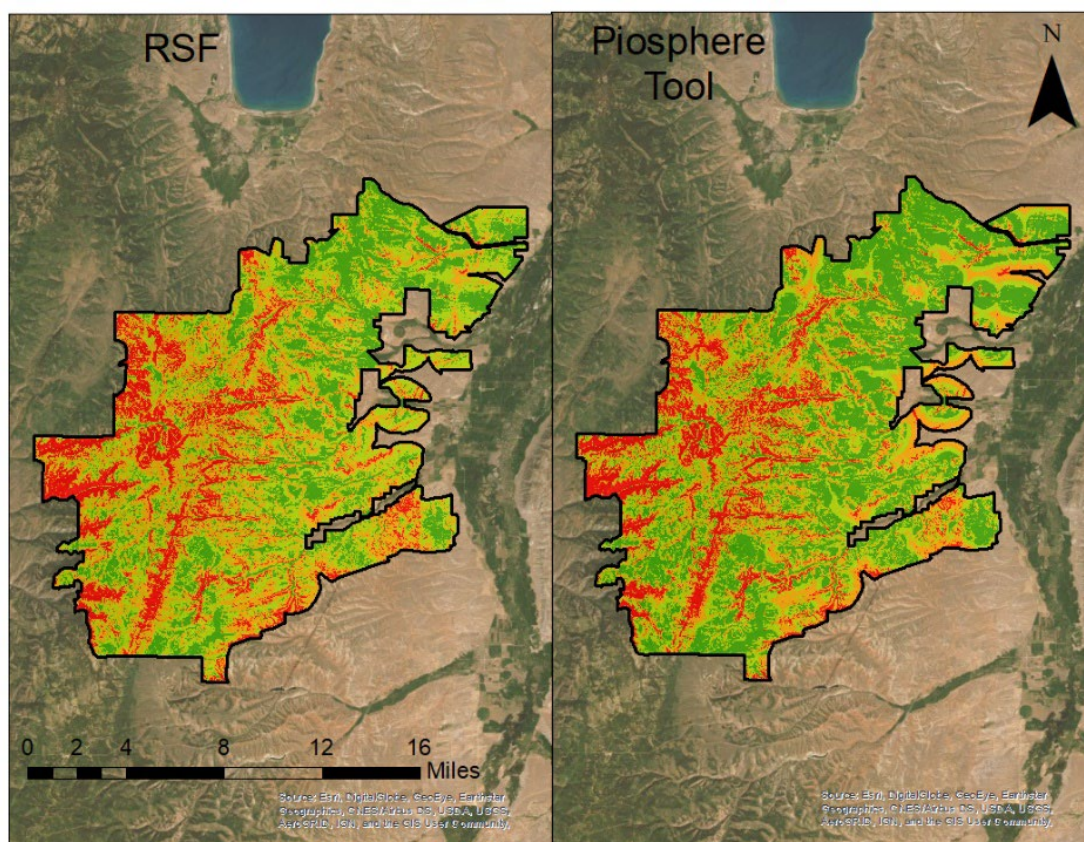|	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	-4.607553	0.005275	-873.39	<2e-16 ***
Slope	-0.424417	0.005990	-70.85	<2e-16 ***
Dist_Water	-0.264545	0.005499	-48.11	<2e-16 ***

Figure 6. Shows a visual comparison of the predicted outputs of the Piosphere tool and the Resource Selection Function (RSF).