APPENDIX K
GREATER SAGE-GROUSE MITIGATION PLAN

DRAFT REPORT:
TransWest Express Transmission Line Project: Greater Sage-grouse Mitigation Plan

All numbers in this draft report are provisional and may be subject to change pending agency review and additional quality checks.

Prepared by:

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1. **Framework for Sage-grouse Impacts Analysis for the TransWest Express Transmission Project – January 2012**

2. **Draft Report: Greater Sage-grouse Habitat Equivalency Analysis for the TransWest Express Project, dated May 2014**

1. Introduction

This document presents the results of TransWest Express LLC's (TransWest) Habitat Equivalency Analysis (HEA) modeling and a framework for compensatory mitigation for greater sage-grouse (*Centrocercus urophasianus*) potentially impacted by the TransWest Express Transmission Line Project (TWE Project or Project). Changes to sage-grouse policies and guidance, analyses of effects, and final Project alignments continue to be developed and refined as the Project is reviewed by the Bureau of Land Management (BLM) and Western Area Power Administration (Western) pursuant to requirements of the National Environmental Policy Act (NEPA). TransWest will consider new information as it becomes available and revise this Mitigation Plan as appropriate.

1.1. Project Overview

The TWE Project is a proposed extra high voltage, direct current (DC) transmission system extending from south-central Wyoming to southern Nevada. The proposed transmission line would cross four states (Wyoming, Colorado, Utah, and Nevada) on lands owned or administered by the BLM, United States Forest Service (USFS), National Park Service (NPS), Bureau of Reclamation (BOR), Utah Reclamation Mitigation and Conservation Commission (URMCC), various state agencies, Native American tribes, municipalities, and private parties. The TWE Project would provide the transmission infrastructure and capacity necessary to deliver cost-effective renewable energy produced in Wyoming to the Desert Southwest region (California, Nevada, Arizona), ultimately helping contribute to a cleaner world, strengthen the electric grid, and provide much-needed electricity to millions of homes and businesses every year. The TWE Project will deliver enough clean, sustainable energy to power nearly 2 million homes and reduce greenhouse-gas emissions equivalent to taking 1.5 million cars from the road.

The ±600 kilovolt (kV) DC transmission line would be approximately 725 to 750 miles in length (depending upon the alternative selected), located within a 250-foot wide right-of-way (ROW). The TWE Project includes ground-disturbing activities associated with the construction of above-ground transmission lines and includes transmission tower locations, access roads, a ground electrode line, a ground electrode site, fly yards, material yards, two AC/DC converter stations (a northern terminal and a southern terminal), pulling/tensioning areas, and work areas. The TWE Project has been sited to avoid and minimize greater sage-grouse (*Centrocercus urophasianus*) lek buffers and occupied habitat. However, complete avoidance is unachievable and portions of the TWE Project cross designated habitat for greater sage-grouse (BLM's Preliminary General Habitat [PGH]) in Wyoming, Colorado, and Utah. As a result, TransWest has coordinated with the BLM, Western Area Power Administration (Western), U.S. Fish and Wildlife Service (USFWS), Wyoming Game and Fish Department (WGFD), Colorado Parks and Wildlife (CPW), and Utah Division of Wildlife Resources (UDWR) to develop a mitigation strategy to compensate for the unavoidable loss of sage-grouse habitat that would potentially occur as a result of the TWE Project construction, operation and maintenance in areas of greater sage-grouse habitat.

1.2. Sage-grouse Habitat

As described in the draft EIS (BLM 2013), greater sage-grouse use a variety of habitats throughout their life cycle. Breeding occurs on strutting grounds, or leks, that are located in flat, sparsely vegetated areas within large tracts of sagebrush (Connelly et al. 2004). Nesting habitat is typically located near active leks in medium to tall sagebrush with a perennial grass understory (Connelly et al. 2000). Studies have shown that taller sagebrush with larger canopies and more understory cover can lead to higher nesting success (Connelly et al. 2004, 2000). Hens and their broods are found in more lush habitats consisting of a high diversity of grasses and forbs that attract insects, such as wet meadows, riparian areas, and irrigated farmland within or near sagebrush. In winter, greater sage-grouse move to south- and west-facing slopes that maintain exposed sagebrush at least 10 to 12 inches above the snow. The quality and quantity of habitat and location within the landscape is key to the long-term survival and success of the greater sage-grouse.

1.3. Sage-grouse Conservation Strategies

In March 2010, the USFWS completed a status review for greater sage-grouse. After reviewing the five listing factors (habitat destruction, overutilization, disease and predation, inadequate regulatory mechanisms, and other natural or manmade factors) under section 4(a)(1) of the Endangered Species Act (ESA), the USFWS concluded that the greater sage-grouse warrants protection under the ESA. However, the USFWS determined that proposing the species for protection was precluded by the need to take action on other species facing more immediate and severe extinction threats. As a result, the sage-grouse was added to the list of species that are candidates for ESA protection.

In an effort to prevent federal listing of the greater sage-grouse, Wyoming, Colorado, Utah, and Nevada have developed greater sage-grouse management/conservation plans that outline goals and objectives for managing the species. In addition, the BLM and the State of Wyoming have issued several policies regarding management of the greater sage-grouse in Wyoming. BLM Instruction Memoranda IM) 2010-012, 2012-043, 2012-044, 2012-019, and State of Wyoming Executive Order 2011-5 include specific protection measures guiding development in greater sage-grouse habitat. The BLM is also currently completing resource management plan amendments in Wyoming, Colorado, Utah and Nevada specifically to address management of greater sage-grouse and their habitats on public lands.

1.3.1. BLM Sensitive Species

The principal greater sage-grouse regulatory mechanism for the BLM is conservation measures in Resource Management Plans (RMPs). In 2011, the BLM established the National Greater Sage-Grouse Planning Strategy to evaluate the adequacy of the RMPs and address revisions and amendments throughout the range of the greater sage-grouse. IM 2012-044 provides direction to the BLM for considering conservation measures identified in the Sage-Grouse National Technical Team's *A Report on National Greater Sage-Grouse Conservation Measures* during the RMP revisions that are now underway in accordance with the 2011 National Greater Sage-Grouse Planning Strategy.

1.3.2. Wyoming Sage-grouse Strategy

Wyoming Executive Order 2011-5 (preceded by Executive Orders 2008-8 and 2010-4) designated certain portions of Wyoming where viable greater sage-grouse populations are to be maintained at current levels, as core greater sage-grouse areas. The WGFD has developed a map of greater sage-grouse core population areas in Wyoming. The core areas contain important seasonal habitats and more than 80% of the state's greater sage-grouse population. Executive Order 2011-5 also identified corridors through several of Wyoming's core areas where large energy transmission projects were directed to be sited minimize impacts to greater sage-grouse. Generally, these transmission corridors were identified adjacent to previous disturbed corridors (highways, railroads, pipelines, transmission lines, etc.). The TWE Project is located in one such corridor that follows Interstate Highway 80.

The Wyoming Greater Sage-grouse Conservation Plan (Wyoming Sage-Grouse Working Group 2003) established the framework for local working groups to guide management efforts directed at halting long-term population declines and maintaining and improving greater sage-grouse habitats in Wyoming. The TWE Project falls within the South Central Wyoming Sage-grouse Conservation Plan (SC Working Group 2007) and Southwest Wyoming Local Sage-grouse Working Group.

1.3.3. Colorado Sage-grouse Strategy

CPW developed a comprehensive Colorado Greater Sage-Grouse Conservation Plan (2008) with a conservation strategy that identifies key issues facing sage-grouse conservation. For each issue, objectives were developed to help mitigate the issue; for each of these objectives, a number of specific strategies are described. The plan provides a statewide perspective to help ensure the long-term survival of greater sage-grouse and supplements local working groups. The TWE Project crosses land within the Northwest Colorado Greater Sage-grouse Conservation Plan (NWCGSGWG 2008).

1.3.4. Utah Sage-grouse Strategy

The Conservation Plan for Greater Sage-grouse in Utah (UDWR 2013) is designed to eliminate the threats facing greater sage-grouse while balancing the economic and social needs of the residents of Utah through coordination with local, state, and federal agencies, and local area working groups. The Plan states that transmission lines should be sited in existing corridors, or at a minimum, in concert with existing linear features in greater sage-grouse habitat and the direct effects of construction should be mitigated.

1.3.5. Nevada Sage-grouse Strategy

The TWE Project does not cross any greater sage-grouse habitat in Nevada.

1.4. Mitigation Purpose

The Draft Environmental Impact Statement for the TWE Project prepared by the BLM and Western (DEIS) (BLM 2013) analyzed potential impacts to sage-grouse from construction, operation and maintenance of the TWE Project. Known impacts would include direct mortality, permanent and temporary habitat loss, habitat fragmentation, and temporary displacement due to noise and human activity. The purpose of the TransWest mitigation strategy is to compensate for known and quantifiable

direct and indirect impacts to greater sage-grouse habitat that may occur as a result of Project construction, operation and maintenance.

Mitigation includes (a) avoiding the impact altogether; (b) minimizing impacts by limiting the degree or magnitude of the action; (c) rectifying the impact by repairing, rehabilitating, or restoring the affected environment; (d) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and (e) compensating for the impact by replacing or providing substitute resources or environments. This definition is consistent with National Environmental Policy Act (NEPA) regulations (40 CFR Part 1508.20(a-e)), USFWS Mitigation Policy (January 23, 1981 Federal Register, pp 7644-7663), and Wyoming Game and Fish Commission Mitigation Policy No. VII H.

In response to Secretarial Order Number 3330 entitled "Improving Mitigation Policies and Practices of the Department of the Interior," issued by the Secretary of the Interior Sally Jewel in October 2013, *"A Strategy for Improving Mitigation Policies and Practices of The Department of the Interior"* was released in April 2014 (Strategy). The Strategy highlights the challenges and opportunities associated with developing and implementing an effective mitigation policy, and describes the key principles and actions necessary to successfully shift from project-by-project management to consistent, landscape-scale, science-based management of the land and resources for which the Department is responsible. The Strategy concludes that taking a landscape-scale approach to mitigation can meet the Department's needs of accommodating both infrastructure development and conservation while improving permitting efficiencies, reducing conflicts, and better achieving development and conservation goals.

TransWest's greater sage-grouse mitigation plan is consistent with the Strategy by utilizing a landscape-scale, science-based approach to avoid, minimize and compensate for potential impacts to greater sage-grouse that may result from development of the TWE Project.

2. Mitigation Approach

The mitigation strategy will generally adhere to the following approach:

- BLM-identified spatial and temporal mitigation measures will be used to lessen the impacts to extent practicable.
- Greater sage-grouse habitat quality and quantity varies across the landscape. To ensure that habitat variability is fully captured, a quantitative habitat metric (i.e., the HEA) will be used to measure the potential loss of habitat that would result from construction, operation and maintenance of the TWE Project within currently occupied greater sage-grouse habitat.
- When possible, greater sage-grouse habitat that is directly lost or impacted during construction would be compensated for by replacing or enhancing habitats of similar quality and size. Mitigation siting would occur in the nearest suitable location in an effort to provide the greatest benefit to the local greater sage-grouse population being impacted by TWE Project construction, operation and maintenance.
- When possible, multiple mitigation measures will be coupled to maximize the benefit to greater sage-grouse populations.

- A maintenance and monitoring approach will be identified for each mitigation project type.

2.1. Mitigation Guidance

2.1.1. BLM Mitigation Policy

The mitigation approach TransWest will implement for the TWE Project will follow the guidance provided by BLM IMs IM 2013-142, 2012-043, and 2012-044 and Department of Interior Secretarial Order 3330 (Order 3330). Collectively, these provide guidance for greater sage-grouse habitat management and mitigation for pending transmission rights-of-way in Preliminary Priority Habitat (PPH) and Preliminary General Habitat (PGH). These policies state that transmission rights-of-ways having disturbances greater than 1 linear mile or 2 acres require cooperation between the BLM, project proponents, and other appropriate agencies to develop and consider implementation of appropriate regional mitigation to avoid or minimize habitat and population-level effects to greater sage-grouse.

Under these policies, offsite and onsite mitigation can include in-kind or out-of-kind mitigation. In-kind is defined as the replacement or substitution of resources that are of the same type and kind of those being impacted. Out-of-kind is defined as replacement or substitutions of resources that while related are of equal or greater overall value to public lands. IM 2013-142 also identifies that the BLM may accept monetary contributions, how they may be used, and that mitigation may be conducted on non-Federal lands.

2.1.2. Framework for Sage-grouse Impacts Analysis for Interstate Transmission Lines

The BLM, working in concert with the USFWS, has developed a *Framework for Sage-grouse Impacts Analysis for the TransWest Express Transmission Project* (Framework, Attached). The Framework addresses TWE Project-related impacts to greater sage-grouse habitat that bear directly on listing factors considered by the USFWS when evaluating the need to provide full listing protection under the ESA. The Framework specifies the use of HEA to scale mitigation and compensate for the loss of habitat services over the life of the TWE Project. HEA is a science-based, peer-reviewed method of scaling compensatory mitigation requirements to potential TWE Project-related effects, measured as a loss of habitat services from pre-disturbance conditions (Allen et al. 2005; Dunford et al. 2004; King 1997; Kohler and Dodge 2006; National Oceanic and Atmospheric Administration 2006, 2009). Habitat services include those ecosystem features (i.e., physical site-specific characteristics of an ecosystem) and ecosystem functions (i.e., biophysical processes that occur within an ecosystem) that support wildlife and human populations (King 1997).

In compliance with IM 2012-43, IM 2013-142, Order 3330, and the Framework, TransWest has completed an HEA to determine the amount of compensatory mitigation necessary to offset potential impacts to greater sage-grouse resulting from the construction, operation, and maintenance of the TWE Project. The HEA produced an estimate of the permanent and interim potential loss of greater sage-grouse habitat services as a result of vegetation loss, noise, and human presence anticipated with TWE Project construction and operation. The HEA also modeled mitigation measures that may be implemented to offset the potential lost habitat services.

2.1.3. U.S. Fish and Wildlife Service Mitigation Recommendations

The USFWS Wyoming Ecological Services Office has provided recommendations regarding the development and implementation of a mitigation plan to address Project impacts on greater sage-grouse and its habitat. Per these recommendations, TransWest will:

- Using results of the HEA, TransWest will allocate how much will be spent on mitigation in terms of specific actions or mitigation projects proposed for implementation. The selected mitigation project mix will be described providing a general breakdown regarding the amount of money going toward conservation easements, habitat enhancement projects, fence marking, etc.
- Focus the majority of mitigation on conservation of habitat, specifically on mitigation projects that protect habitat, enhance or maintain quality of habitat, and reduce fragmentation. Components of habitat conservation include preservation through easements, enhancements (such as juniper removal), and reclamation/restoration. These habitat conservation projects may then be supplemented by a smaller portion of mitigation projects such as fence-marking, focused research in designated areas following specific guidelines, improvement of mesic habitats important for brood-rearing and summer use, or others.
- Implement mitigation in a collaborative manner by working with members of an "Oversight Committee" composed of biologists working for BLM, Western, USFWS, WGFD, CPW, and UDWR. The role of this team is to provide guidance and biological advice concerning the accomplishment of successful mitigation on the ground.

Additionally, the USFWS provided specific recommendations to ensure successful completion of mitigation projects that contribute to greater sage-grouse habitat conservation. Within these recommendations, the USFWS emphasizes the need to consider each mitigation site individually and provide a clear justification regarding the value of the mitigation measure at that site.

2.2. Mitigation Siting Prioritization

Mitigation projects will be sited in the same state where the impact occurred and in a manner consistent with the priorities identified in the BLM's IM 2013-142 and Order 3330. As a baseline, mitigation project location will be prioritized according to following hierarchy to the extent practicable:

1. Mitigation will be located in Core Areas/Preliminary Priority Habitats that are intersected by the TWE Project or areas where habitat connectivity may be restored (i.e., local offsite mitigation).
2. Mitigation will be located within 18 kilometer (km) (11.2 mile [mi]) of the transmission line (i.e., onsite as defined in the DEIS) to benefit the impacted greater sage-grouse populations and their habitat.
3. Mitigation will be located within the region (e.g., Western Association of Fish and Wildlife Agencies' management zones) to benefit greater sage-grouse (i.e., regional offsite mitigation), particularly when onsite or nearby mitigation is deemed to offer less benefit to impacted greater sage-grouse populations or their habitat than offsite mitigation.

TransWest shall consider the above hierarchy and emphasize mitigation that benefits the populations that are impacted within each state; however, mitigation projects may be located elsewhere if the

Oversight Committee (see Section 2.4) identifies specific opportunities that will provide a greater benefit to greater sage-grouse than those in the impacted region.

2.3. Mitigation Schedule

Mitigation for the project is tied to the issuance of the BLM right-of-way grant or a specific notice-to-proceed. Mitigation funds would not be available for implementation until the right-of-way grant is issued or a specific notice-to-proceed for construction is issued although planning activities may take place earlier.

2.4. Oversight Committee

As described in the USFWS recommendations, an Oversight Committee consisting of agency biologists and other stakeholders/advisors, would be created to provide guidance on the mitigation approach for the TWE Project. As necessary, both local and landscape level perspectives would be represented on the Oversight Committee by involving local greater sage-grouse working groups, or other experts in the fields of mitigation, greater sage-grouse ecology, or other needed discipline. Committee members should have familiarity with the TWE Project area so that they can provide guidance on selection of mitigation locations. Committee participation may also be dependent upon the state in which the impact and mitigation occurs.

Primary objectives of the Oversight Committee would include recommendations for selection of mitigation projects, validation of the success of mitigation projects and their effectiveness at the local or landscape level, oversight of mitigation implementation, identification of alternate mitigation projects and strategies, and review of mitigation monitoring results. A selected committee member/entity would be responsible for facilitating communications among Oversight Committee members and would schedule necessary review meetings to discuss mitigation projects and monitoring results. The roles and responsibilities of Oversight Committee members will vary by mitigation project type and location. Once final mitigation projects are identified, participants, roles and responsibilities within the Oversight Committee will be determined and assigned.

2.5. Changes to the Plan

Changes to greater sage-grouse policies and guidance may be issued during the TWE Project ROW application review process. TransWest will consider new information as it becomes available and revise the Mitigation Plan as appropriate.

3. Types of Impacts to Sage-grouse

TransWest's mitigation strategy is to compensate for known impacts to greater sage-grouse habitat that may occur as a result of Project construction, operation and maintenance. Known and quantifiable impacts were modeled with a HEA.

3.1. HEA Modeled Impacts

The HEA for the TWE Project was completed using best-available scientific information regarding the primary indicators of quality greater sage-grouse habitat and the known anthropogenic impacts to that

habitat. The Draft Report for the HEA completed for the TWE Project is attached to this mitigation plan. Regulatory and resource agency staff, Non-Governmental Organizations (NGOs), and researchers generally agree on the potential direct impacts to greater sage-grouse and its habitat, and how to quantify these known impacts for the TWE Project. Direct loss of habitat resulting from ground-disturbing activities, construction related traffic and noise, and habitat loss associated with the footprint of the physical structures are the known potential impacts that can be accounted for in the HEA model. Compensatory mitigation, which may include mitigation projects undertaken by TransWest or in-lieu fees, will be applied to these potential direct impacts to ensure that there is no net loss of modeled habitat services as a result of TWE Project construction, operation and maintenance.

The total habitat service losses anticipated with the TWE Project construction, operation, and maintenance are provided in Table 1. Discounted service-acre-years (DSAYs) is the currency used by HEAs. The anticipated habitat service gains to be created with mitigation projects are also measured in DSAYs. Within the, the modeled impacts of the TWE project are considered to be fully offset when the DSAYs produced by the proposed mitigation project mix equal or exceed 3,733,029 DSAYs (the Total Habitat Services Lost from Table 1).

Table 1. Habitat Services Lost in the Analysis Area Over the Lifetime of the TWE Project (Modeled Years 1–104*).

State	Permanent Disturbances Modeled	Habitat Services in the Assessment Area at Baseline Condition (DSAYs over lifetime of the TWE Project assuming no development)	Habitat Services Lost in the Assessment Area (DSAYs lost over lifetime of the TWE Project)
Wyoming	AC/DC converter station and transmission tower pads	102,603,325	1,101,889
Colorado	transmission tower pads	71,739,071	1,374,208
Utah	transmission tower pads	73,696,032	1,256,932
Total	AC/DC converter station and transmission tower pads	248,038,428	3,733,029

* For the purposes of this analysis, the TWE Project lifetime is defined as the period between the TWE Project initiation and full recovery of vegetation. There are three years of construction and a year of reclamation, which is followed by a period of vegetation recovery. To be conservative, it was assumed that sagebrush will take 100 years to recover its full habitat service level after reclamation.

3.2. Other Potential Impacts

The HEA captures direct disturbances from the TWE Project construction, operation, and maintenance, and the indirect disturbance from noise and human presence during the years of construction. The effects of operating transmission lines on greater sage-grouse have not been established, are poorly understood, and require more research (Utah Wildlife in Need Cooperative [UWIN] 2010a, 2010b).

Literature, agency personnel, and the USFWS have identified the following potential impacts of transmission lines:

- Introduction and spread of invasive plant species in habitat;
- Collision and electrocution hazards;
- Decreased lek attendance near transmission corridors;
- Habitat fragmentation and habitat loss caused by behavioral avoidance of transmission corridors;
- Increased public access and associated impacts (e.g., noise, trash); and
- Increased predation by raptors and corvids due to the presence of transmission structures.

The HEA does not model indirect disturbance caused by the transmission line after construction is complete because insufficient information is available to characterize and quantify these effects. No "peer-reviewed" manuscripts have reported results from experimental studies that document greater sage-grouse avoidance of tall structures, increased predation related to avian predators using tall structures as perches, increased mortality attributed to collisions, or habitat degradation and/or fragmentation attributed to tall structures (UWIN 2010). Steenhof et al. 1993 and Lammers and Collopy 2007 provide substantial evidence on the use of transmission lines for nesting raptors and the effectiveness (or lack thereof) of perch deterrents, respectively; however, they provide very little insight on effects of transmission lines on greater sage-grouse. Lammers and Collopy (2007) discuss that perch deterrents did not have an effect on the observed number of greater sage-grouse predators and sagebrush conservation may better serve greater sage-grouse populations. Furthermore, ongoing research performed by Dr. James Sedinger of the University of Nevada – Reno and his colleagues, studying the Falcon to Gondor transmission line in eastern Nevada, has resulted in over ten years of data indicating that impacts to greater sage-grouse are more attributed to natural predation, wildfire impacts-habitat impacts from cheatgrass invasion, habitat fragmentation, and fitness of females (Nonne et al. 2013). The presence of the power line itself does not directly or indirectly result in increased mortality or a reduction in overall breeding success (Nonne et al 2013).

TransWest has addressed these potential impacts through adherence to the BLM spatial and timing stipulations identified in the DEIS as well as the development of effective reclamation and maintenance procedures, efficient and timely construction, environmental protection measures, traffic and access management, and avoidance of leks as discussed in Section 4.3.

4. Mitigation Measures

4.1. Avoidance and Minimization

TransWest has avoided and minimized both direct and indirect potential impacts to greater sage-grouse to the maximum extent practicable through the routing and siting process, adhering to buffers, and utilizing existing corridors and establishing environmental protection measures (EPMs) for construction, operation and maintenance activities. During the routing and siting process, TransWest has identified and will adhere to the appropriate spatial and timing stipulations surrounding leks and other greater

sage-grouse habitat to the extent practicable. TransWest has also worked with state and federal agencies, local governments, and local working groups and NGOs to avoid and minimize impacts to greater sage-grouse habitats.

To minimize potential direct and indirect impacts, the transmission line and ancillary facilities were located following existing linear corridors (e.g., other transmission lines, pipelines, roads, designated west-wide energy corridor) where possible. For instance, in Colorado TransWest's proposed action is to co-locate with the existing Craig-Bonanza 345 kV transmission line. In Utah, TransWest's proposed action is to co-locate with the existing Mona-Bonanza 345 kV transmission line. Co-location with existing transmission lines would minimize potential incremental impacts.

4.1.1. Environmental protection measures

The TWE Project includes EPMs to maintain environmental quality during construction, operation, and maintenance activities. Implementation of the EPMs will help TransWest to avoid and/or minimize impacts to greater sage-grouse and its habitat. The EPMs are listed the following appendices to the Preliminary Plan of Development (May 2014):

Avian Protection Plan, addresses measures to minimize risk to avian species, including greater sage-grouse, during construction and operation of the TWE Project. The Avian Protection Plan follows the guidance of the Avian Power Line Interaction Committee (APLIC).

Traffic and Transportation Plan, includes measures that limit roads to the minimum distance and width necessary for construction and operation of the transmission line, limit non-approved use and introduction of weeds by unauthorized vehicles, and control dust from roads and other surface disturbances. These measures minimize the potential for direct mortality of greater sage-grouse by vehicles, substantially reduce the potential for degradation of greater sage-grouse habitat from weeds and dust.

Fire Prevention Plan, addresses fire preventative measures to minimize fire risk during construction of the TWE Project.

Reclamation Plan, includes measures to reduce the impact of construction on greater sage-grouse habitat by re-establishing vegetation and reducing habitat degradation, including the use of seed mixes compatible with greater sage-grouse habitat and monitoring to ensure successful reclamation.

Noxious Weed Plan, includes measures to prevent the introduction or transport of noxious or invasive weeds and control thereof, thus reducing potential habitat degradation.

Stormwater Pollution Prevention Plan, includes measures to reduce erosion and sedimentation, thus reducing potential habitat degradation both on and off-site.

Spill Prevention, Containment, and Countermeasures Plan, includes measures that reduce the chance of contamination from spills affecting habitat adjacent to the construction area.

Dust Control and Air Quality Plan, includes measures to minimize fugitive dust and air quality impacts that could affect sage-grouse habitat.

Operation and Maintenance Plan, includes measures to avoid and minimize potential impacts during operation and maintenance.

4.2. HEA Modeled Mitigation

The avoidance and minimization measures discussed above substantially avoid known impacts to greater sage-grouse and minimize impact to their habitat. However, even with these measures in place, there are unavoidable potential impacts to habitat from the construction and operation of the TWE Project.

The HEA quantified the long-term and interim loss of habitat services (measured in DSAYs) resulting from unavoidable potential impacts (Table 1). The HEA used the same habitat services metric to quantify the habitat services to be gained by implementing habitat improvement measures selected by the interagency HEA Technical Advisory Team (See Table 2 in the Draft HEA Report, Attached). These measures include fence marking and removal, sagebrush restoration and enhancement, juniper removal, and purchase of conservation easements. The estimated DSAYs returned per one acre or one mile of each mitigation measure is provided in Table 2. The analysis also produced a cost per DSAY gained for each habitat improvement measure based on the average cost of mitigation project implementation (See Tables 6 and 8 in the Draft HEA Report, Attached).

Table 2. Mean Discounted Service-Acre-Years Gained for Each Mitigation Measure Modeled in the HEA.

Conservation Measure	General Method	Mean Habitat Services Gained (present value service-acre-years per unit)
Fence removal and marking with flight diverters*	Fence marking within 3 km of leks and in other high risk areas (e.g., winter concentration areas, movement corridors)	3,597 per mile of fence marked
	Fence removal within 3 km of leks and in other high risk areas	3,597 per mile of fence removed
Sagebrush restoration and improvement projects	Seeding sagebrush and bunchgrass understory	1,751 per acre of disturbance treated
	Transplanting containerized sagebrush stems and seeding bunchgrass understory	4,556 per acre of disturbance treated
	Planting seedlings and seeding bunchgrass understory	1,935 per acre of disturbance treated
Juniper/conifer removal	Lop and scatter Phase I† juniper	480 per acre treated
	Cut-pile-cover or mastication of Phase II2 juniper	328 per acre treated
	Mastication of Phase III† juniper and seeding bunchgrass understory	197 per acre treated
Conservation easements	Land purchase (baseline value service credit) applying the annual maintenance and monitoring fee to every 5,000 acres of easement.	650 per acre purchased§

* Although fence removal is more effective at removing the threat of sage-grouse collision than fence marking, both measures were modeled as having the same benefit due to a limitation in the model.
† Phases of juniper describe the dominance of this vegetation on the landscape. Phase I is a sagebrush-dominated landscape with scattered juniper, Phase II is a landscape comprising a 50:50 mixture of sagebrush and juniper, and Phase III is a landscape dominated by juniper.
§Estimated using the average habitat services value per acre in the Assessment Area, because no specific easements have been proposed.

A mitigation package will be developed that describes a mitigation project mix that will produce a net balance of habitat services over the lifetime of the TWE Project. The mitigation package will consist of conservation easements (at 100% baseline habitat service level credit), sagebrush restoration and enhancement (including juniper removal), fence marking and removal, and other mitigation projects not modeled in the HEA where justified (e.g., understory seeding and enhancement of mesic habitats).

4.2.1. Mitigation Project Types

Descriptions of the mitigation project types modeled in the HEA are provided below. These mitigation projects are consistent with recommendations provided by the USFWS. TransWest is not limited to these mitigation project types for mitigation credit.

Fence Marking and Removal

Based on Christiansen (2009) it has been demonstrated that each mile of fence within 2 miles of leks kills up to 53 greater sage-grouse per year. This threat can be eliminated by removing fences or significantly reduced by increasing the visibility of fences. Christiansen (2009) estimated a 70% reduction

in mortalities could be expected along marked sections of fence. Stevens (2011) similarly predicted that marking fences with vinyl reflectors (flight diverters) reduced collision rates by up to 74%.

To eliminate the threat of collisions, fences would be removed or marked with flight diverters similar to those used in the Christiansen (2009), Wolfe (2007), and Stevens (2011) studies to increase fence visibility to greater sage-grouse. Fences will be removed where possible. Where removal is not possible, two flight diverters would be installed between each fence span (4 m post-to-post). Priority areas for fence removal and marking would be:

- Sections of fence known to cause sage-grouse collisions,
- Fences within 2 km (1.2 mi) of leks (Braun 2006; Stevens 2011) or other high risk area,
- Fences in areas with low slope and terrain ruggedness (Stevens 2011), and
- Fence segments bounded by steel t-posts with spans greater than 4 m (Stevens 2011).

Once fences have been removed or marked, local annual mortality due to fence collisions will be substantially reduced. This mitigation project type will be used on a limited site-specific basis per recommendations from the USFWS. As described in Section 2.2, all mitigation projects will be sited in the same state where the impact occurred and in a manner consistent with the priorities identified in the BLM's IM 2013-142 and Order 3330.

The HEA calculated that 3,597 service-acre-years would be created for every mile of fence marked (with annual maintenance) or fence removed over the lifetime of the TWE Project.

Sagebrush Restoration and Enhancement

Sagebrush restoration and enhancement creates new habitat for greater sage-grouse and can be used to create corridors between existing sagebrush patches to produce contiguous habitat. Habitat for greater sage-grouse consists of a mosaic of plant communities dominated by sagebrush and a diverse grass and forb understory. This conservation measure increases the quality and quantity of habitat within the landscape, contributing to the long-term survival and success of the greater sage-grouse.

New habitat for greater sage-grouse will be created by establishing sagebrush and understory grasses and forbs in disturbed areas (e.g., roads, unreclaimed pipeline corridors, well pads, burned areas). These mitigation areas are in pre-existing areas of surface disturbance, not areas disturbed by the TWE Project. Vegetation disturbance from the TWE Project will be restored as described in the Plan of Development. All mitigation projects will be sited in the same state where the impact occurred and in a manner consistent with the priorities identified in the BLM's IM 2013-142 and Order 3330. Where possible, mitigation projects will be placed strategically to decrease habitat fragmentation by connecting existing habitats. All treatments will have monitoring plans and funding to conduct monitoring until the treatment is determined to be successful.

Sagebrush can be seeded, planted as seedlings, or transplanted (i.e., containerized stems). Because seeded sagebrush can take several decades to grow to a size that provides habitat for greater sage-grouse, the HEA determined that planting containerized stems can be the most economical and

successful option in many cases. Sagebrush restoration and enhancement projects will include understory (grass and forb) treatments.

The value of sagebrush restoration depends on the method used; methods that result in faster plant establishment have higher value. For every acre of disturbance planted with sagebrush seedlings and seeded with bunchgrass, 1,935 service-acre-years would be created. For every acre of disturbance planted with containerized sagebrush stems and seeded with bunchgrass, 4,556 service-acre-years would be created.

Juniper Removal

Fire suppression and other post-settlement conditions have allowed western juniper to spread into areas previously dominated by grasses, forbs, and shrubs. Many areas have experienced an estimated 10-fold increase in juniper over the last 130 years (Miller et al. 2005). The expansion of juniper and other conifer species reduces habitat for greater sage-grouse and other sagebrush obligate species that depend on large patches of sagebrush-dominated vegetation. Sagebrush cover decreases with juniper encroachment as the vegetation transitions into woodland.

Most juniper communities are still in a state of transition. Miller et al. (2005) characterized three stages of woodland succession:

- Phase I (early) – trees are present but shrubs and herbs are the dominant vegetation that influence ecological processes (hydrologic, nutrient, and energy cycles) on the site;
- Phase II (mid) – trees are codominant with shrubs and herbs and all three vegetation layers influence ecological processes on the site;
- Phase III (late) – trees are the dominant vegetation and the primary plant layer influencing ecological processes on the site.

Sites in Phase I or II successional stages often retain a significant understory of grasses and forbs, so removal of Phase I or II can produce immediate habitat benefits for greater sage-grouse (NRCS 2010; USFWS recommendations). Therefore juniper/conifer removal projects used for mitigation will focus primarily on areas in the early to mid stages of succession (i.e., Phase I or Phase II) with no cheatgrass component. Removal of juniper/conifer will be done by mechanical means without the use of fire or chemicals. Phase I juniper/conifer will be treated by having a field crew walk from tree-to-tree, cutting them into pieces and scattering them on-site (lop and scatter). Phase II juniper/conifer will be treated by using a masticator, a large mechanical device that goes from tree-to-tree and demolishes the tree with whirling blades; debris is then left on site (mastication).

All juniper/conifer removal projects will include understory treatment, where needed, and vegetation monitoring until the understory vegetation is established. Locations of removal projects will be selected with guidance from the Oversight Committee so that each treatment site provides value to the local greater sage-grouse population. Mitigation projects will be located in the same state where the impact occurred and in a manner consistent with the priorities identified in the BLM's IM 2013-142 and Order 3330 (Section 2.2).

The value of juniper/conifer removal in the HEA depended on the density of juniper removed (i.e., Phase I, Phase II, or Phase III juniper). The HEA calculated that 480 service-acre-years are created for every acre of Phase I juniper removed, 328 service-acre-years for every acre of Phase II juniper removed, and 197 service-acre-years for every acre of Phase III juniper removed with understory seeding over the lifetime of the TWE Project.

Bunchgrass and Forb Seeding

Bunchgrasses, as opposed to rhizomatous grasses, are recognized as an important component of greater sage-grouse nesting and brood-rearing habitats (Connelly et al. 2000; Crawford et al. 2004). The structure and abundance of bunchgrasses influence the quality of a site for nesting greater sage-grouse. Tall, dense, residual grass in nesting habitat improves hatching success by providing cover for incubating females (Cagney et al. 2010). Herbaceous cover may provide scent, visual, and physical barriers to potential predators (DeLong et al. 1995, as cited in Connelly et al. 2000). In addition to providing cover from predators, forbs are an important food source for greater sage-grouse broods.

Greater sage-grouse nesting and brood-rearing habitat will be improved by seeding native bunchgrasses and forbs into existing sagebrush stands or into adjacent disturbance. Understory seeding project sites will be selected in coordination with the Oversight Committee to maximize the benefit of these mitigation projects for greater sage-grouse. Objectives for these mitigation projects and criteria for success will be developed in coordination with the Oversight Committee.

While not captured in the TransWest HEA because of lack of available data, using results from other similar HEA models that contained bunchgrass variables, including the model for the Energy Gateway West transmission project, overseeding bunchgrass in 1-acre of sagebrush habitat is approximately 5% of the services returned by removing 1-acre of Phase I juniper. As a result, it is estimated 24 service-acre-years would be returned for each acre of overseeding. A greater number of service-acre-years are created when areas of disturbance (i.e., no vegetation) are seeded with bunchgrass. Using results from other similar HEA models indicates that overseeding bunchgrass in 1-acre of disturbed habitat is equivalent to approximately 25% of the services returned by removing 1-acre of Phase I juniper. As a result, it is estimated 120 service-acre-years would be returned for each acre of seeding in disturbed areas over the life of the TWE Project.

Conservation Easements

Conservation easements may be purchased and managed to remove or reduce threats to greater sage-grouse. The purchase of easements can prevent future greater sage-grouse habitat destruction or degradation near urban areas or other industrial developments.

Conservation easements purchased for mitigation would focus on areas or locations that demonstrate the highest need for protection and potential for reducing habitat fragmentation. Conservation easements would be purchased and managed in coordination with the Oversight Committee. Specific locations of conservation easements would depend on availability of easements for purchase, but would generally follow the priorities identified in the BLM's IM 2013-142 and Order 3330.

The HEA calculated that, on average, 650 service-acre-years would be created per acre of conservation easement purchased, assuming the easement is maintained over the life of the TWE Project. Greater credit could be possible if the easement was maintained in perpetuity. This total does not include the value of any subsequent habitat improvements to the property and assumes the proponent receives 100% credit for the baseline habitat-service level of the property.

4.2.2. Specific Mitigation Projects

In the final mitigation plan, TransWest will include viable mitigation projects/opportunities which meet mitigation goals and strategy. Specific mitigation projects will be selected in coordination with the Oversight Committee following the recommendations and guidelines provided by the states, BLM, Western, and USFWS. Mitigation projects may be located on either public or private land. Although only five mitigation measures are modeled, TransWest is not bound to only those project types. If other project types are recognized by the Oversight Committee as providing greater sage-grouse population or habitat benefits similar to those modeled in the HEA, then these mitigation projects may be included in future updates of this Plan.

Potential mitigation sites would be evaluated to determine their current state, the type of mitigation that would be most beneficial, and the potential for that mitigation project to meet the success criteria defined by the Oversight Committee. Mitigation projects that confer the greatest potential benefit to greater sage-grouse and have a high probability of success will be given priority.

4.2.3. In lieu fees

For all or a portion of the compensatory mitigation, TransWest may employ an in-lieu fee approach that considers the cost of purchasing or implementing a mitigation project and monitoring and managing that project over the life of the TWE Project. TransWest may pay mitigation fees into accounts that will fund mitigation projects that benefit greater sage-grouse and their habitats. Refer to Section 2.2 for general/minimum criteria for selection of mitigation projects that would utilize in-lieu fees. TransWest will work with the Oversight Committee to identify the appropriate organizations to receive and manage in-lieu fees in each state, as well as to set standards for the mitigation projects funded by those fees.

Mitigation may include programs that are currently being pursued by other entities where there is opportunity for TransWest to provide financial support. Support of such identified mitigation projects would be in the form of direct funding or in-lieu fees to assist the entity proposing the mitigation project with implementation. The balance of the mitigation dollars owed (the total dollar cost estimated by the HEA minus the costs of the specific mitigation projects) may be provided through in-lieu fees.

In Wyoming, the Wyoming Wildlife and Natural Resource Trust (WWNRT) has been identified as a potential organization that could receive and manage in-lieu fees for the TWE Project. The WWNRT is an independent state agency governed by a nine-member citizen board appointed by the Governor and works closely with the WGFD and Wyoming state government.

4.2.4. Monitoring and maintenance

Monitoring the success of mitigation measures and maintaining each measure to ensure continued success are important elements the mitigation strategy. TransWest and the Oversight Committee will identify a monitoring and maintenance approach for each mitigation project or project type in the mitigation package. Each mitigation project will require a monitoring and mitigation facilitator role that could be filled by agencies, private landowners, NGOs, environmental or reclamation contractors, or TransWest.

The final monitoring and maintenance approach for each mitigation project will be formalized in a monitoring and maintenance strategy that will be reviewed by the Oversight Committee annually, or as necessary. The duration of monitoring may vary for each mitigation project type. The strategy will also include success criteria for each mitigation project, such as:

- Measurable increase in desired vegetation structure and composition in a restoration area when compared to a suitable control area
- Adherence to conservation easement contract terms
- Removal of stated acreage of encroaching juniper stands

5. Conclusion

Reliable, cost-effective electricity is a basic necessity for Americans' quality of life and for the health and prosperity of American industry. The TWE Project not only will ensure delivery of a vital renewable wind-energy resource for a growing America but also will create jobs, support environmental protection, enhance tax revenues, and further strengthen the nation's energy foundation for the future. TransWest is committed to developing the TWE Project in an environmentally responsible manner using best available science and best management practices from the electric transmission industry. TransWest's greater sage-grouse mitigation plan is consistent with Order 3330 and *"A Strategy for Improving Mitigation Policies and Practices of The Department of the Interior"* by utilizing a landscape-scale, science-based approach to avoid, minimize and compensate for potential impacts to greater sage-grouse that may result from development of the TWE Project.

6. References

Braun, C.E. 2006. A Blueprint for Sage-Grouse Conservation and Recovery. Tucson: Grouse Inc.

Bureau of Land Management. 2013. TransWest Express Transmission Project. Draft Environmental Impact Statement. BLM Wyoming State Office and Western Area Power Administration. June 2013.

Cagney, J., E. Bainter, B. Budd, T. Christiansen, V. Herren, M. Holloran, B. Rashford, M. Smith, and J. Williams. 2010. Grazing influence, objective development, and management in Wyoming's greater sage-grouse habitat with emphasis on nesting and early brood rearing. University of Wyoming Cooperative Extension Service. B-1203, March 2010.

Christiansen, T. 2009. Fence Marking to Reduce Greater Sage-grouse (Centrocercus urophasianus) Collisions and Mortality near Farson, Wyoming – Summary of Interim Results. Wyoming Game and Fish Department. Available at: http://pbadupws.nrc.gov/docs/ML1108/ML110830116.pdf. Accessed March 2014.

Connelly, J.W., M.A. Schroeder, A.R. Sands, and C.E. Braun. 2000. Guidelines to manage sage grouse populations and their habitats. Wildlife Society Bulletin 28:967–985.

Connelly, J. W., S. T. Knick, M. A. Schroeder, and S. J. Stiver. 2004. Conservation assessment of greater sage-grouse and sagebrush habitats. Western Association of Fish and Wildlife Agencies. Unpublished Report. Cheyenne, WY, USA.

Crawford, J.A., R.A. Olson, N.E. West, J.C. Mosely, M.A. Schroeder, T.D. Whitson, R.F. Miller, M.A. Gregg, and C.S. Boyd. 2004. Synthesis paper: ecology and management of sage-grouse and sage-grouse habitat. Journal of Range Management 57:2–19.

DeLong, A.K., J.A. Crawford, and D.C. DeLong, Jr. 1995. Relationships between vegetational structure and predation of artificial sage grouse nests. Journal of Wildlife Management 59:88–92.

Department of the Interior. 2013. Improving Mitigation Policies and Practices of the Department of the Interior, Department of the Interior Secretarial Order 3330. October 31, 2013. Washington D.C.

Idaho Sage-grouse Advisory Committee. 2006. Conservation Plan for the Greater Sage-grouse in Idaho. July 2006. 477 pp.

Lammers, W.M. and M.W. Collopy. 2007. Effectiveness of avian predator perch deterrents on electric transmission lines. Journal of Wildlife Management 71:2752-2758.

Miller, R.F., J.D. Bates, T.J. Svejcar, F.B. Pierson, and L.E. Eddleman. 2005. Biology, ecology, and management of western juniper. Oregon State University, Technical Bulletin 152. June 2005. 77 pp.

Natural Resources Conservation Service (NRCS). 2010. Oregon sage-grouse habitat improvement initiative: a strategic approach to Farm Bill conservation program delivery. Oregon Implementation Plan, March 2010. Available at:

http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_041539.pdf Accessed March 2014.

Nonne, D., E. Blomberg, and J. Sedinger. 2013. Dynamics of greater sage-grouse (*Centrocercus urophasianus*) populations in response to transmission lines in central Nevada. Progress Report – Year 10. University of Nevada – Reno, Department of Natural Resources and Environmental Sciences. Reno, NV. February 2013.

Stevens, B. 2011. Impacts of fences on greater sage-grouse in Idaho: collision, mitigation, and spatial ecology. M.S. thesis, University of Idaho, Moscow.

Stiver, S.J., A.D. Apa, J.R. Bohne, S.D. Bunnell, P.A. Deibert, S.C. Gardner, M.A. Hilliard, C.W. McCarthy, and M.A. Schroeder. 2006. Greater Sage-grouse Comprehensive Conservation Strategy. Western Association of Fish and Wildlife Agencies. Unpublished Report. Cheyenne, Wyoming.

Utah Wildlife in Need Cooperative (UWIN). 2010a. Contemporary knowledge and research needs regarding the potential effects of tall structures on sage-grouse (*Centrocercus urophasianus* and *C. minimus*). UWIN Cooperative: Utah Wildlife in Need, Rocky Mountain Power, and Utah Department of Natural Resources. September 2010. Available online at http://utahcbcp.org/files/uploads/TallStructuresReportSeptember202010.pdf. Accessed May 2014.

UWIN. 2010b. Contemporary knowledge regarding the potential effects of tall structures on sage-grouse (*Centrocercus* spp.) and other wildlife in the Western United States. UWIN Cooperative: Utah Wildlife in Need, Rocky Mountain Power, and Utah Department of Natural Resources. September 2010. Available online at http://utahcbcp.org/files/uploads/TallStructureLitReview28July.pdf. Accessed May 2014.

UWIN. 2011. Protocol for Investigating the Effects of Tall Structures on Sage-grouse (*Centrocercus* spp.) within Designated or Proposed Energy Corridors. http://www.utahcbcp.org/htm/tall-structure-info. Accessed March 2014.

Wolfe, D.H., M.A. Patten, E. Shochat, C.L. Pruett, and S.K. Sherrod. 2007. Causes and patterns of mortality in lesser prairie-chickens (Tympanuchus pallidicinctus) and implications for management. Wildlife Biology 13 (Suppl. 1):95–104.

ATTACHMENT

DRAFT REPORT: Greater Sage-grouse Habitat Equivalency Analysis for the TransWest Express Project

All numbers in this draft report are provisional and may be subject to change pending agency review and additional quality checks.

Prepared by:

TRANSWEST EXPRESS LLC

May 2014

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TransWest Express LLC's (TransWest) **TransWest Express Project** (TWE Project) is a proposed extra high voltage, direct current (DC) transmission system extending from south-central Wyoming to southern Nevada. The proposed transmission line would cross four states (Wyoming, Colorado, Utah, and Nevada) on lands owned or administered by the BLM, United States Forest Service (USFS), National Park Service (NPS), Bureau of Reclamation (BOR), Utah Reclamation Mitigation and Conservation Commission (URMCC), various state agencies, Native American tribes, municipalities, and private parties. The TWE Project would provide the transmission infrastructure and capacity necessary to deliver cost-effective renewable energy produced in Wyoming to the Desert Southwest region (California, Nevada, Arizona), ultimately helping contribute to a cleaner world, strengthen the electric grid, and provide much-needed electricity to millions of homes and businesses every year. The TWE Project will deliver enough clean, sustainable energy to power nearly 2 million homes and reduce greenhouse-gas emissions equivalent to taking 1.5 million cars from the road.

The ±600 kilovolt (kV) DC transmission line would be approximately 725 to 750 miles in length (depending upon the alternative selected), located within a 250-foot wide right-of-way (ROW). The TWE Project includes ground-disturbing activities associated with the construction of above-ground transmission lines and includes transmission tower locations, access roads, a ground electrode line, a ground electrode site, fly yards, material yards, two AC/DC converter stations (a northern terminal and a southern terminal), pulling/tensioning areas, and work areas. The TWE Project has been sited to avoid and minimize greater sage-grouse (*Centrocercus urophasianus*) lek buffers and occupied habitat. However, complete avoidance is unachievable and portions of the TWE Project cross designated habitat for greater sage-grouse (BLM's Preliminary General Habitat [PGH]) in Wyoming, Colorado, and Utah. As a result, TransWest has coordinated with the BLM, Western Area Power Administration (Western), U.S. Fish and Wildlife Service (USFWS), Wyoming Game and Fish Department (WGFD), and Colorado Parks and Wildlife (CPW), and Utah Division of Wildlife Resources (UDWR) to develop a mitigation strategy to compensate for the unavoidable loss of greater sage-grouse habitat that would potentially occur as a result of the TWE Project construction, operation and maintenance in areas of greater sage-grouse habitat.

The mitigation approach TransWest will implement for the TWE Project will follow the guidance provided by BLM IMs IM 2013-142, 2012-043, and 2012-044 and Department of Interior Secretarial Order 3330 (Order 3330). Collectively, these provide guidance for greater sage-grouse habitat management and mitigation for pending transmission rights-of-way in Preliminary Priority Habitat (PPH) and Preliminary General Habitat (PGH). These policies state that transmission rights-of-ways having disturbances greater than 1 linear mile or 2 acres require cooperation between the BLM, project proponents, and other appropriate agencies to develop and consider implementation of appropriate regional mitigation to avoid or minimize habitat and population-level effects to greater sage-grouse.

Under these policies, offsite and onsite mitigation can include in-kind or out-of-kind mitigation. In-kind is defined as the replacement or substitution of resources that are of the same type and kind of those

being impacted. Out-of-kind is defined as replacement or substitutions of resources that while related are of equal or greater overall value to public lands. IM 2013-142 also identifies that the BLM may accept monetary contributions, how they may be used, and that mitigation may be conducted on non-Federal lands.

The BLM, working in concert with the USFWS, has developed a *Framework for Sage-grouse Impacts Analysis for the TransWest Express Transmission Project* (Framework). The Framework addresses TWE Project-related impacts to greater sage-grouse habitat that bear directly on listing factors considered by the USFWS when evaluating the need to provide full listing protection under the ESA. The Framework specifies the use of HEA to scale mitigation and compensate for the loss of habitat services over the life of the TWE Project. HEA is a science-based, peer-reviewed method of scaling compensatory mitigation requirements to potential TWE Project-related effects, measured as a loss of habitat services from pre-disturbance conditions (Allen et al. 2005; Dunford et al. 2004; King 1997; Kohler and Dodge 2006; National Oceanic and Atmospheric Administration 2006, 2009). Habitat services include those ecosystem features (i.e., physical site-specific characteristics of an ecosystem) and ecosystem functions (i.e., biophysical processes that occur within an ecosystem) that support wildlife and human populations (King 1997).

In compliance with IM 2012-43, IM 2013-142, Order 3330, and the Framework, TransWest has completed an HEA to determine the amount of compensatory mitigation necessary to offset potential impacts to greater sage-grouse resulting from the construction, operation, and maintenance of the TWE Project. The HEA produced an estimate of the permanent and interim potential loss of greater sage-grouse habitat services as a result of vegetation loss, noise, and human presence anticipated with TWE Project construction and operation. The HEA also modeled mitigation measures that may be implemented to offset the potential lost habitat services.

The following sections provide overviews of HEA, the HEA process for the TWE Project, the methods used for the HEA, the results of the HEA, and potential types of mitigation measures that could be used to compensate for habitat loss. Detailed methods excerpt from the TWE Project's HEA Plan are provided in the appendices to this report.

Overview of Habitat Equivalency Analysis

HEA is a science-based, peer-reviewed method of quantifying interim and permanent habitat injuries, measured as a loss of habitat services from pre-disturbance conditions, and scaling compensatory habitat requirements to those injuries (King 1997; Dunford et al. 2004; Allen et al. 2005; Kohler and Dodge 2006; National Oceanic and Atmospheric Administration [NOAA] 2006, 2009). Habitat services include those ecosystem features (i.e., physical site-specific characteristics of an ecosystem) and ecosystem functions (i.e., biophysical processes that occur within an ecosystem) that support wildlife and human populations (King 1997).

Habitat services are generally quantified using a metric that represents the functionality or quality of habitat (i.e., the ability of that habitat to provide wildlife "services" such as nest sites, forage, cover from predators, etc.). When wildlife habitat is the primary service of interest, areas with the highest habitat service levels are those areas with highest habitat quality. Interim (or short-term) habitat injuries are those services that are absent during certain phases of the project that would have been available if that disturbance had not occurred (e.g., temporary vegetation losses, temporary soil partitioning, temporary displacement of wildlife populations). Permanent habitat injuries are those habitat injuries remaining after project completion and interim reclamation and recovery are complete (e.g., permanent vegetation loss, permanent loss of wildlife or fisheries populations, irrecoverable impacts to soils or water as a result of contamination).

HEA uses a service-to-service approach to scaling. HEA does not assume a one-to-one trade-off in resources (e.g., number of acres). Rather, HEA balances the number of services lost with those that are gained as a result of conservation activities (NOAA 2006). For example, one acre of land with a diverse vegetative structure and abundant tree canopy can support higher numbers of nesting songbirds (the habitat service of interest) than one acre of land with few trees and little vegetative diversity. The two land parcels, although equal in size, provide unequal habitat services.

What Does Habitat Equivalency Analysis Do?

HEA is an economics model that:

- Quantifies current habitat services provided in a project area or landscape (commonly referred to as the baseline habitat service level)
- Quantifies the interim and permanent injuries to the baseline habitat service level
- Determines appropriately scaled restoration and conservation activities to offset habitat services lost as a result of project impacts

Benefits of Habitat Equivalency Analysis

The benefits of HEA include:

- High credibility – the approach has been evaluated and documented in scientific peer-reviewed literature and has held up in numerous court cases
- Quantitative rather than qualitative in nature
- Equations are straightforward, but have enough input variables to allow flexibility in project design

- Provides a replicable method for negotiation of mitigation ratios, acceptable compensatory restoration, and/or fines
- Valuable planning tool; can be used to evaluate the cost of multiple compensatory mitigation measures
- Applicable to any ecosystem type where an appropriate habitat services metric can be defined
- Currently the most commonly used method by natural resource trustees to assess damages to ecosystems
- Used by federal regulatory agencies, such as the U.S. Fish and Wildlife Service, NOAA, BLM, Environmental Protection Agency, Department of Interior, U.S. Army Corps of Engineers

When Habitat Equivalency Analysis Should Be Used (Chapman 2004)

HEA is an appropriate tool for scaling mitigation:

- When habitat services can be defined or modeled
- When quantification of project impacts is possible
- When replacement of services lost is feasible
- When conservation methods are sufficiently known

Compensation Components

Compensation for impacts includes two components: (1) recovery of the injured area (primary restoration; Figure 1), and (2) compensation for the interim loss of habitat services occurring prior to full recovery (compensatory restoration; Figure 2).

HEA quantifies the habitat services lost during the lifetime of a project compared to baseline (Area X in Figure 1) and scales the compensatory project (mitigation project) so that it provides services that are equal to that loss (Area Y in Figure 2). Baseline refers to the condition of the resources and quantity of habitat services that would have existed had the disturbance not occurred. The quantity of services lost (Area X) depends on the extent of the injury and the time required for restoration; actions taken to accelerate the rate of primary restoration would decrease the interim loss of habitat services, requiring less compensatory restoration. In some cases, full restoration of the lost services may not be feasible, in which case the area required for compensation (Area Y) would be larger. Compensatory restoration may occur off-site (e.g., the purchase of additional habitat), or on-site through habitat improvements

that increase habitat services above baseline (e.g., non-native vegetation removal, shrub thinning, or understory planting).

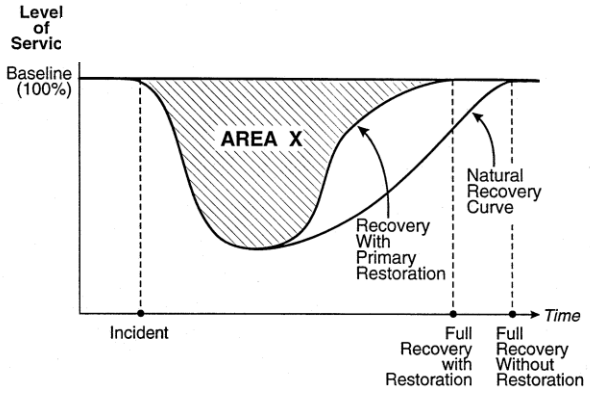

Figure 1. Changes in habitat service level compared to the baseline service level during construction and restoration (copied from King 1997). Area X represents the services lost at an injury site with Primary Restoration expressed as percent of baseline.

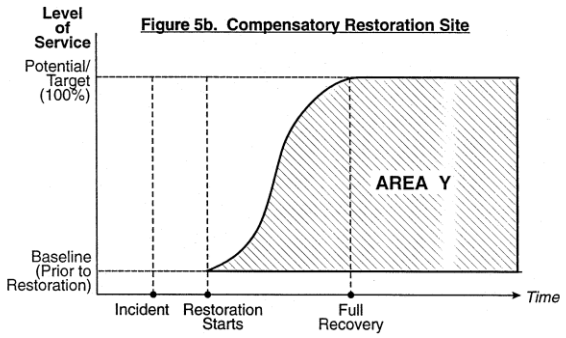

Figure 2. Changes in habitat service level with compensatory restoration (copied from King 1997). Area Y represents the services gained at the compensatory restoration site expressed as percent of potential/target level less baseline (pre-restoration) percent.

Measuring Habitat Services (Ecological Economics)

Quantifying the services provided by an ecosystem is a complex task. This complexity can be reduced through the use of an attribute, or metric, that provides a measure of the services of interest. The metric must be able to capture the relative differences in the quality and quantity of services being provided before and after restoration and between primary and compensatory sites (NOAA 2009).

Measurements of habitat services over the lifetime and area of a project are used in the HEA. These measurements have three components: land area, service level, and time. The relative service level can be quantified using a metric that measures or scores one or more key habitat elements for a species or wildlife community of interest (e.g., vegetation stem density, vegetation type, nest density, percentage of canopy cover, proximity to critical habitat, etc.). Habitat services are commonly expressed in service-acres (one year) or service-acre-years (multiple years).

Overview of the Habitat Equivalency Analysis Process for the TWE Project

Completion of the HEA process for the TWE Project Agency Preferred Alternative required close coordination with the BLM, Western, and other appropriate agencies and stakeholders (the HEA Technical Advisory Team, hereafter). Such coordination ensures that the best available scientific data were used, the habitat service metric was appropriate for resources in the TWE Project area, the results of the HEA are understood, and the compensation offsets the interim and permanent loss of habitat services modeled. The following steps will be completed as part of the development of the HEA for the TWE Project:

1. **Establishing baseline habitat services prior to disturbance.**

   TransWest has worked closely with the HEA Technical Advisory Team to finalize a habitat services metric that will quantified the baseline greater sage-grouse habitat services available prior to TWE Project construction. Appendix A provides information related to the development of the habitat services metric that served as the basis for quantifying baseline habitat services and determining TWE Project impacts and appropriate mitigation. Appendix B presents information related to how this metric was applied to establish baselines habitat services for the TWE Project area. Development of the baseline habitat service metric presented in Appendix A considered the best available scientific information regarding greater sage-grouse habitat and response to disturbance.

2. **Quantifying the permanent and interim losses to the baseline service level that result from the TWE Project disturbance.**

   Permanent and interim losses of habitat services caused by the construction and operation of the TWE Project were subtracted from the baseline habitat services. Direct and indirect losses that remain following reclamation efforts and vegetation recovery in the ROW over the life of the TWE Project will provide the basis for assessing the adequacy of mitigation proffered by TransWest. Appendix C describes the approach that was used to assess the direct and indirect losses that will occur as a result of TWE Project construction and operations.

3. **Identifying appropriate mitigation measures that may be used to compensate for lost services.**

TransWest worked the HEA Technical Advisory Team to identify mitigation measures that may be used to compensate for the permanent and interim losses of habitat services. All mitigation measures would be subject to appropriate land management agency or landowner approval, permits, and planning. Appendix D describes the methods that were used to quantify habitat service gains resulting from mitigation measures.

In the HEA process, the benefits of mitigation measures must be quantifiable using the habitat services metric. Additional mitigation measures with benefits that cannot be quantified in the HEA (e.g., brood rearing habitat improvement and understory improvement measures) will be considered separately in TransWest's Mitigation Plan and their compensatory value determined in coordination with the lead agencies and other stakeholders.

4. **Quantifying the amount of mitigation necessary to compensate for the losses to baseline services that remain after the TWE Project implementation.**

   Once final mitigation measures have been identified and approved by TransWest, the lead agencies and involved stakeholders, the average habitat service gain and cost per service returned were quantified for each mitigation measure. The resulting values will be balanced with the services lost to determine the compensatory mitigation appropriate to offset the permanent and interim loss of greater sage-grouse habitat services resulting from development of the TWE Project. This balancing will occur in TransWest's Mitigation Plan with a proposed mitigation project mix. TransWest's Mitigation Plan that documents the scaled compensatory mitigation will be provided to BLM and Western as a voluntary applicant-committed mitigation measure for greater sage-grouse.

Overview of the Habitat Equivalency Analysis Methods Used

The following sections provide an overview of methods used to develop the HEA models that were applied to assess the loss of greater sage-grouse habitat services associated with the TWE Project development and the benefits of various conservation project types that may be proposed for mitigation.

Development of Habitat Service Metric

To quantify the habitat services (e.g., greater sage-grouse habitat functionality) provided by an ecosystem, a habitat service metric is developed that scores key habitat elements for the species. Scoring habitat services is a critical step in the HEA process because it provides a way to quantitatively measure the quality of specific habitat functions in a specific area. The habitat metrics used in the HEA must be able to capture the relative differences in the quantity of services provided before and after construction and conservation-focused activities. Habitat services often have three components—land

area, service level, and time—and are commonly expressed in service-acres (one year) or service-acre-years (service-acres summed over multiple years).

The greater sage-grouse habitat services metric for the TWE Project was developed collaboratively by the HEA Technical Advisory Team. The focus of the metric was to capture changes in greater sage-grouse habitat services over time with vegetation removal and recovery. Using this approach, lost habitat services (decreases in habitat quality) must be replaced with like services. The HEA does not assume a one-to-one trade-off in resources (e.g., number of acres of greater sage-grouse habitat affected), but instead determines compensation based on the habitat services those acres provide (e.g., development in high-quality greater sage-grouse habitat would have higher compensation levels than development in lower-quality habitat that provides fewer services).

The habitat service metric developed for the TWE Project included variables identified by the peer-reviewed literature as having influence on the quality of greater sage-grouse habitat, including dominant vegetative components and anthropogenic influences (Table 1). The variables included were limited to those for which reliable and consistent data were available across the TWE Project area. For each of the variables, a habitat service score ranging from 0 to 3 (zero to high services) was assigned for categories like those defined in the Sage-Grouse Habitat Assessment Framework Multi-scale Habitat Assessment Tool (Stiver et al. 2010). Categorical variables were more appropriate than continuous variables due to the resolution of the remotely sensed vegetation data available for the length of the TWE Project. The breaks between scores were primarily based on information contained in the literature regarding greater sage-grouse habitat use and selection. When literature did not allow for direct quantification of the HEA scores, professional judgments of the HEA Technical Advisory Team informed by the available peer-reviewed literature were used. When a particular variable matched literature-based optimal conditions, that variable was given a service score of 3.

The metric for greater sage-grouse habitat services used in this HEA is an additive model (Table 1) with a score adjustment for the presence of fences posing a high collision risk to greater sage-grouse during the lekking season. Each cell in the analysis area is scored separately by summing the scores of Variables 01 through 08. The summed score is then multiplied by a factor that reduces the score where high risk fences are present. Each of the variables and the fence collision score adjustment is described in detail in Appendix A.

The metric is only applied to areas that contain occupied greater sage-grouse habitat. The assessment area was first clipped to the BLM's Priority General Habitat (PGH). Then, land cover types typically avoided by greater sage-grouse are assigned a metric score of 0 (provides no habitat services) before the metric was applied to the remaining areas. Disturbances of these lands require no mitigation in the HEA. These avoided land cover types include all forest types, urban areas, open water, some introduced vegetation types, roadways, well pads, mine footprints, areas <100 meters (m) from roadways with >6,000 annual average daily traffic (AADT), and <25 m of paved roads with <6,000 AADT and heavily

traveled gravel roads (multiple sources per U.S. Fish and Wildlife listing decision in Federal Register; Johnson et al. 2011). The specific GAP vegetation classifications that were included in these avoided land cover types are listed in Appendix E.

All variables were weighted evenly. Weights were not applied because there was not adequate information in the literature to support the use of one specific weight over another. The importance of sagebrush was already intrinsically weighted higher than other vegetation types due to the number of variables that measured an aspect of sagebrush vegetation (for which non-sagebrush vegetation types would score low). Comparisons of the final baseline maps to maps of known greater sage-grouse use indicated that the metric performed well to distinguish between high-quality and low-quality greater sage-grouse habitat across the length of the TWE Project without adjusting the variable weights.

Greater sage-grouse habitat suitability publications vary in their baseline environmental conditions affecting a particular study site. Even studies within a single state may describe different suitable habitat conditions depending on elevation, precipitation zone, and other geographic or climatic factors affecting each study site. The habitat metric relied on generalizations presented in BLM et al. (2000), Cagney et al. (2009), Connelly et al. (2011), Connelly et al. (2000), Stiver et al. (2010), and other summary publications. Specific citations are given to support these generalizations when applicable. The same metric of habitat services was applied to the entire TWE Project area.

The HEA metric was used to score habitat service level for all areas on and within 2 kilometers (km) of the TWE Project footprint, including access roads and other infrastructure (Assessment Area). None of the habitat service losses modeled (vegetation loss, noise, and human presence) extended outside the Assessment Area. The Assessment Area was clipped to the greater sage-grouse PGH and partitioned by state (Wyoming, Colorado, and Utah). The final Assessment Area centerline length varied by state.

Table 1. Anthropogenic and Habitat Variables Used as a Metric of Greater Sage-grouse Habitat Services.

Variable Number	Variables	3	2	1	0	Primary Citations
VAR01	Distance to high-traffic (>6,000 AADT) road, such as an interstate, federal, or state highway (meters)	>1,000	650–1,000	100–650	N/A*	Craighead Beringia South (2008); Johnson et al. (2011); Pruett et al. (2009)
VAR02	Distance to low-traffic (<6,000 AADT) paved roads, heavily travelled gravel roads, well pads, mine footprints, transmission substations (meters)	>200	50–200	25–50	N/A*	Connelly et al. (2004); Craighead Beringia South (2008); Johnson et al. (2011); Pruett et al. (2009)
VAR03	Percent slope	<10	10–30	30–40	>40	Beck (1977); Lincoln County Sage Grouse Technical Review Team (2004)
VAR04	Distance to occupied lek† (kilometers)	0–6.4	6.4–8.5	>8.5	N/A	Cagney et al. (2009); Connelly et al. (2000); Connelly et al. (2011); Holloran and Anderson (2005)
VAR05	Sagebrush abundance index (% of vegetation that is sagebrush within a 1 km^2 moving window)	50–95	30–50 or >95	10–30	0–10	Carpenter et al. (2010); Walker et al. (2007); Aldridge and Boyce (2007); Aldridge et al. 2008; Wisdom et al. (2011)
VAR06	Percent sagebrush canopy cover	15–35	5–15 or >35	1–5	<1	Cagney et al. (2009); Connelly et al. (2000); Stiver et al. (2010)
VAR07	Sagebrush canopy height (centimeters)	30–80	20 to <30 or >80	5–20	<5	Crawford et al. (2004); Connelly et al. (2000); Stiver et al. (2010)
VAR08	Distance of habitat to sage or shrub dominant (meters)	<90	90–275	275–1,000	>1,000	BLM et al. (2000); Connelly et al. (2000); Lincoln County Sage Grouse Technical Review Team (2004)

* Lands less than 100 m from a high traffic road and less than 25 m from a low traffic paved road or high traffic gravel road were given a total metric score of 0 (provides no habitat services), not just a score of 0 for these individual variables.
† Leks were classified as active if their 10-year attendance average was greater than 0.

Quantification of Habitat Service Losses

The following sections describe the losses of habitat services that would likely occur as a result of the TWE Project construction and operation. These changes in the habitat service level were simulated in a GIS platform to produce data inputs for the HEA.

The HEA model calculates the present value of future changes to the baseline habitat service level with time caused by losses of habitat services with TWE Project development and gains of habitat services with mitigation projects. Economists call this process *discounting* and it is a standard part of the HEA model. Discounting converts services being provided in different time periods into current time period equivalents (Allen et al. 2005). Discounting results in a gradual increase in the service-acres provided by injured habitats over time, and the same rate of decrease in service-acres gained by habitat conservation over time. Consequently, credit for mitigation in the form of habitat conservation (increase in discounted service-acre-years) is greater when implemented early in the lifetime of the TWE Project than when implemented late in the lifetime of the TWE Project. This encourages early mitigation to offset habitat service losses, to ensure that long-term adverse effects to the resource are minimal. Likewise, the injury (i.e., loss of discounted service-acre-years) due to construction and operation of the TWE Project is greater when it occurs early in the project lifetime than when it occurs later in the project lifetime.

Ideally, the baseline habitat service level would account for all habitat service losses associated with existing environmental disturbances. This was done to the extent possible with the existing data for the Assessment Area. In some cases, existing habitat disturbances were not mapped in the baseline service level because they were not detected by the chosen habitat services metric, or because the data were unavailable for use in the baseline analysis. Omission of these disturbances is a conservative approach to the analysis of the TWE Project-related habitat service losses. When baseline disturbances are omitted, the analysis assumes that the habitats affected by the TWE Project are of higher-quality than they actually are, and thus require a greater amount of mitigation to offset the TWE Project-related habitat service losses.

Description of Changing Habitat Service Level by Project Milestone

The habitat services provided by the Assessment Area were calculated at TWE Project milestones that reflected varying levels of disturbance. The TWE Project milestones modeled with GIS data for the HEA are listed below.

1. **Baseline**—the baseline milestone quantifies habitat services available to greater sage-grouse before disturbance. The calculation of Baseline is described above and in Appendix B.
2. **Construction—**the construction milestone quantifies habitat services available to greater sage-grouse during the construction or operation of the AC/DC converter station proposed as part of the TWE Project and the construction of the transmission line and electrode grid. Magnitude of the loss of habitat services during construction is dependent on proximity to the TWE Project and the amount of new surface disturbance.
3. **Restoration**—the restoration milestone quantifies habitat services available to greater sage-grouse after substation and transmission line construction is complete and some services return with the reduction in noise and human presence.
4. **Recovery**—the recovery milestone quantifies habitat services available to greater sage-grouse after a vegetation type has recovered to the greatest extent expected after the TWE Project restoration is complete. Habitat services return to baseline conditions in restored areas with the time to recovery being dependent on the vegetation type.

Quantifying Habitat Service Losses during Construction

Snapshots of the changing habitat services over time are modeled using GIS-based tools for each of the milestones identified above for incorporation into the HEA. The HEA calculates the total interim and permanent habitat injuries associated with the TWE Project. Specifics of the GIS and HEA methods are provided in Appendix C.

Timing

A conceptual substation, transmission structure, and infrastructure layout was provided by TransWest from which all habitat service losses were calculated (Table 2). The transmission line is planned to be constructed over a period of 3 years in each state, which is concurrent for all states.

Direct Disturbance

The footprint of the TWE Project was provided electronically by TransWest. The footprint files specified the anticipated locations of and direct disturbance associated with access roads, the ground electrode grid and line, transmission towers, pulling/tensioning areas, an AC/DC converter station (the northern terminal), mid spans, material yards, and fly yards.

During the three Construction years, direct disturbance was defined as the loss of all habitat services within the entire construction footprint for the segment modeled (Table 3). Access roads were assumed to have a width of 10 m. The model did not capture temporal restrictions on the TWE Project construction required by the BLM, which may have resulted in high estimates of service losses in the three Construction years. In the Restoration year following construction, direct disturbance was still

defined as the loss of all habitat services in the construction footprint, because the vegetation had not regrown sufficiently to provide habitat. In the Recovery years, direct disturbance was defined as the loss of all habitat services in the footprint of permanent facilities (i.e., the AC/DC converter station and transmission structure pads). The direct disturbance in restored areas was returned at different rates depending on baseline vegetation type. There were four vegetation-based recovery endpoints: 1) agriculture and wetland (1 year after Restoration); 2) grassland and riparian (5 years after Restoration), 3) shrubs other than sagebrush (20 years after restoration); and 4) sagebrush (100 years after Restoration). The assignment of the GAP vegetation types to these four recovery endpoints is described in Appendix E.

Table 2. TWE Project Milestone Years

Project Year	Project Milestone
0	Baseline
1	Construction
2	Construction
3	Construction
4	Restoration
5	Recovery 1
6	--
7	--
8	--
9	Recovery 2
10	--
11	--
12	--
13–23	--
24	Recovery 3
25	--
26	--
27	--
28–103	--
104	Recovery 4; End of Analysis

Table 3. Direct Disturbance Levels Modeled by TWE Project Year and Disturbance Type

Project Milestones	Project Year Applied	Percent Baseline Services Present at each Milestone by Direct Disturbance Type		
		AC/DC Converter Station	Transmission Towers*	Access Roads, Transmission Lines, Ground Electrode Line, Ground Electrode Grid, and Temporary Infrastructure
Baseline	0	100%	100%	100%
Construction	1, 2, 3	0%	0%	0%
Restoration	4	0%	0%	0%
Progressive Vegetation Recovery	5 (Recovery 1)	0%	• 0% in tower pad† (500 ft^2) Elsewhere ‡: • 100% of agricultural and wetland baseline services • 20% of grassland and riparian baseline services • 5% shrub baseline services • 1% of sagebrush baseline services	• 100% of agricultural and wetland baseline services • 20% of grassland and riparian baseline services • 5% shrub baseline services • 1% of sagebrush baseline services
	9 (Recovery 2)	0%	• 0% in tower pad (0.06 acre) Elsewhere: • 100% of agricultural, wetland, grassland, and riparian baseline services • 25% shrub baseline services • 5% of sagebrush baseline services	• 100% of agricultural, wetland, grassland, and riparian baseline services • 25% shrub baseline services • 5% of sagebrush baseline services
	24 (Recovery 3)	0%	• 0% in tower pad (0.06 acre) Elsewhere: • 100% of agricultural, wetland, grassland, riparian, and shrub baseline services • 20% of sagebrush baseline services	• 100% of agricultural, wetland, grassland, riparian, and shrub baseline services • 20% of sagebrush baseline services
	104 (Recovery 4)	0%	• 0% in tower pad (0.06 acre) Elsewhere: • 100% of agricultural, wetland, grassland, riparian, shrub, and sagebrush baseline services	• 100% of agricultural, wetland, grassland, riparian, shrub, and sagebrush baseline services

* The guide lattice tower type is assumed for this analysis.
† Tower pad in this table refers to the permanent tower footprint.
‡ Elsewhere refers to construction roads that were reduced to two-track roads, or any areas where vegetation was cleared for Project construction that were subsequently revegetated during Restoration (e.g., staging areas).

Indirect Disturbance

In addition to the actual surface disturbance, indirect disturbance buffers were applied to reduce habitat services around the Project Footprint during active construction (Table 4). Within these buffers (>200 meters [m], 50–200 m, 25–50 m, or <25 m), the habitat services were scored by the metric as if they were in the same proximity to a secondary road (a paved road with <6,000 AADT or heavily travelled gravel road) to account for the disturbance associated with noise and human presence (see Appendix C,

Quantifying Loss of Habitat Services Due to Indirect Disturbances During Construction for additional detail).

After construction, the indirect disturbance buffers were dropped from everything except the AC/DC converter station. The noise associated with the operation of this station was characterized as a permanent indirect disturbance in the model. Little information has been published on greater sage-grouse habitat use near transmission lines. TransWest decided not to model disturbance due to transmission lines after construction is complete, because insufficient information was available to characterize and quantify these effects. Potential indirect impacts associated with transmission lines are discussed in detail in the TWE Project's DEIS.

Table 4. Indirect Disturbance Levels Modeled by TWE Project Year and Disturbance Type

Project Milestones	Project Year Applied	Indirect Disturbance Buffers* Applied by Disturbance Type		
		AC/DC Converter Station	Transmission Towers	Access Roads, Transmission Lines, Ground Electrode Line, Ground Electrode Grid, and Temporary Infrastructure
Baseline	0	None	None	None
Construction	1, 2, 3	Secondary Road	Secondary Road	Secondary Road†
Restoration	4	Secondary Road	None	None
Progressive Vegetation Recovery	5	Secondary Road	None	None
	9	Secondary Road	None	None
	24	Secondary Road	None	None
	104	Secondary Road	None	None

* "Secondary Road" indicates that the footprint of the disturbance was classified as having the same indirect disturbance as a secondary road in the GIS model and the scores of the surrounding vegetation decreased as defined by the habitat services metric.

† Construction of the ground electrode grid will be completed in the first year. No indirect disturbances were modeled for the ground electrode grid after Construction Year 1.

Quantification of conservation Benefit to Habitat Services

Habitat conservation measures (Table 5) were selected by the HEA Technical Advisory Team to be modeled in the HEA. These measures have been identified to improve greater sage-grouse habitat services and produced a benefit that could be measured by the habitat service metric used in this HEA. These conservation measures serve as a "toolbox" from which mitigation options may be selected by

TransWest for inclusion in a mitigation package.[1] The benefit (in service-acres) for each habitat conservation measure was calculated with GIS technology, using the same habitat service metric as was used to calculate habitat service losses.

The same conservative vegetation growth rates that were used to model vegetation recovery in the TWE Project footprint were applied to the habitat conservation measures proposed for mitigation. Conservative growth rates offset the potential for mitigation project failure in the model.

Three to five hypothetical mitigation project areas were selected to model each conservation measure. The variable scores were manipulated using GIS technology to approximate the change expected with implementation of the measure. The benefit of the measure was the difference in the service score before and after implementation. The mean benefit among the hypothetical mitigation project areas was entered into the HEA, where estimated time until full benefit and discount rate was applied to estimate the discounted service-acre-years gained per mitigation project area. The HEA assumed that the mitigation projects would be funded in the first year of the TWE Project construction.

The cost of the modeled habitat conservation measures was estimated by averaging the known cost of similar conservation projects previously implemented in Idaho and Wyoming—cost estimates from the Gateway West HEA (BLM 2013) were adjusted using a 3% annual inflation rate (equal to the discount rate used in this HEA) to bring the costs up to 2014 dollars. These cost estimates were used to calculate the price per service-acre-year. An HEA scales the mitigation package (i.e., funding to create habitat services) to offset the loss of habitat services over the lifetime of the TWE Project. Appendix D describes the calculation used to quantify the benefit of the mitigation projects compared to baseline.

[1] Proposed mitigation may not be limited to the modeled conservation measures. The benefit of some measures could not be measured using the habitat service metric (e.g., improvement of brood rearing habitat, improvement of understory vegetation).

Table 5. Potential Mitigation Projects Modeled in the HEA

Mitigation Project Type	Brief Project Description	Anticipated Benefits	Average Cost of Implementation*,§
Fence removal and marking with flight diverters	Fences would be removed or marked in: 1) Sections of fence known to cause greater sage-grouse collisions, 2) Within 3 km (1.2 mi) of leks (Stevens et al. 2013) or other high risk areas, 3) In areas with low slope and terrain ruggedness (Stevens 2011), and 4) Where segments are bounded by steel t-posts with spans greater than 4 m (Stevens 2011).	• Reduce mortality due to greater sage-grouse collisions • Increase visibility of fences, where diverters are used • Increase contiguous patches of shrub-steppe habitat • Remove localized grazing pressure where fences are removed, thereby increasing local habitat quality (e.g., bunchgrass cover)	• $1,485 per mile ($920 per km) for fence removal or initial installation of flight diverters, and $320 per mile per year ($200 per km per year) for maintenance on flight diverters†
Sagebrush restoration and improvement projects	Seeding, planting seedlings, or transplanting containerized sagebrush plants (one plant per 5 m^2) and seeding a bunchgrass understory	• Create contiguous patches of shrub-steppe habitat with optimal sagebrush cover and height and a bunchgrass understory • Increase availability of high-quality nesting, brood rearing, and winter habitats	• $3,975 to $7,320 per acre ($9,820 to $18,090 per hectare), depending on method used
Juniper/conifer removal	Mechanical removal (lop and scatter, cut-pile-cover, or mastication) of juniper/confer adjacent to areas with optimal sagebrush cover and height	• Reverse juniper/conifer encroachment on shrub-steppe habitat to increase contiguous patches of greater sage-grouse habitat • Increase light penetration to support a forb and grass understory	• $180 to $2,120 per acre ($445 to $5,240 per hectare), depending on density of vegetation removed.‡
Conservation easements	Removes threat of specific land uses to sensitive wildlife populations	• Prevent greater sage-grouse habitat destruction or degradation near urban areas and oil and gas development • Reduce future fragmentation of shrub-steppe habitat	• $615 per acre ($1,515 per hectare) average purchase price • $2650 per year for each easement for maintenance and monitoring

* Cost of implementation includes a 50% markup for indirect costs, which include contract writing, supervision, clearances, monitoring, inspections, and vehicle costs.
† The cost of maintenance for the lifetime of the project is included in the HEA model and the resulting estimated cost per service-acre-year in Table 7.
‡ The cost of this treatment varies widely depending on the baseline vegetation. The lower end cost includes lop and scatter of Phase I juniper with no understory treatment. The upper end cost includes mastication of Phase III juniper and seeding a bunchgrass understory.
§ Costs were estimated for the Gateway West Transmission Line HEA (BLM 2013) and then adjusted using a 3% inflation rate to bring them up to 2012 to 2014 dollars. Mitigation funds provided in years after 2014 should be further adjusted for inflation.

HABITAT EQUIVALENCY ANALYSIS RESULTS

The following sections describe the results of the HEA for habitat service losses over the lifetime of the TWE Project and the results of the HEA for conservation measure benefits. These results are expressed as the discounted service-acre-years (DSAYs) lost or gained, which is the sum of the permanent and interim losses gains over the lifetime of the TWE Project with the economic discount rate applied. These results may be used to scale mitigation.

HEA Habitat Service loss Results

A separate HEA was run for each state where the TWE Project intersected greater sage-grouse habitat (Wyoming, Colorado, and Utah). The modeled habitat service level at each of the TWE Project milestones was entered into the HEA to calculate the present value of the habitat services lost over the lifetime of the TWE Project. A linear change in service level was assumed between modeled milestones. A summary of the estimated habitat service losses due to the TWE Project's construction, operation, and maintenance are provided in Table 6 for the full Analysis Area (i.e., 2-km buffer around Project footprint). These are the habitat service totals that need to be offset with mitigation. Service losses varied among states with differences in the buffered TWE Project centerline that intersected greater sage-grouse PGH, differences in baseline habitat quality, and the type of development.

Table 6. Habitat Services Lost in the Analysis Area Over the Lifetime of the TWE Project (Modeled Years 1–104).

State	Permanent Disturbances Modeled	Habitat Services in the Assessment Area at Baseline Condition (DSAYs over lifetime of the TWE Project assuming no development)	Habitat Services Lost in the Assessment Area (DSAYs lost over lifetime of the TWE Project)
Wyoming	AC/DC converter station and transmission tower pads	102,603,325	1,101,889
Colorado	transmission tower pads	71,739,071	1,374,208
Utah	transmission tower pads	73,696,032	1,256,932
Total	AC/DC converter station and transmission tower pads	248,038,428	3,733,029

HEA Conservation Benefit Results

A separate HEA was run for each habitat conservation measure. The habitat service increases modeled using GIS-based tools were entered into the HEA, along with estimates of time between receipt of funding and implementation of the measure, and time between implementation of the measure and full service benefit from the measure. The habitat service gains per unit area treated summed over the lifetime of the TWE Project are provided for each conservation measure in Table 7.

New habitat services (measured in DSAYs) and cost per services gained varied among conservation measures (Table 7). Conservation easements preserve existing habitat services in areas of potential development and can create new habitat services if existing land practices that are damaging to greater sage-grouse habitat are restricted.

Application of Results to a Mitigation Package

TransWest, BLM, and agencies will evaluate the services returned per habitat conservation measure, compare those services gained to the services lost as a result of the TWE Project, and develop an appropriate mitigation plan to compensate for services lost. This analysis is a decision-making support tool for the development of the mitigation plan.

To accomplish a 1:1 trade-off in habitat service-acre-years over the lifetime of the TWE Project per a traditional HEA, habitat conservation measures from Table 7 should be selected to offset 100% of the habitat service losses quantified for each segment in Table 6. The recommended approach to this process is outlined in the steps below.

1. Select the habitat conservation measures most appropriate for each segment from Table 5 and define the proportion of each measure to be used as mitigation (e.g., mitigation in Segment A will be composed of w% fence modification, x% sagebrush restoration, y% juniper removal, and z% conservation easements).
2. Calculate the habitat services to be replaced using each habitat conservation measure. The total of the habitat services replaced using each measure should equal the total services lost in Table 6.
3. Calculate the cost to implement each habitat conservation measure in each segment. Multiply the habitat services to be replaced using a measure by the cost per habitat services gained for that measure from Table 7.
4. Sum the costs of the habitat conservation projects separately for each segment. The total would be the mitigation for the modeled habitat service losses in that segment.

Table 7. Mean Present Value Habitat-Service-Acre Gained and Average Cost for Each Habitat Conservation Measure

Conservation Measure	General Method	Mean Habitat Services Gained (DSAYs per unit)	Cost per Services Gained (U.S. dollars per DSAY) ‡
Fence removal and marking with flight diverters*	Fence marking within 3 km of leks and in other high risk areas (e.g., winter concentration areas, movement corridors)	3,597 per mile of fence marked	$9.57
	Fence removal within 2 km of leks and in other high risk areas	3,597 per mile of fence removed	$0.41
Sagebrush restoration and improvement projects	Seeding sagebrush and bunchgrass understory	1,751 per acre of disturbance treated	$2.27
	Transplanting containerized sagebrush stems and seeding bunchgrass understory	4,556 per acre of disturbance treated	$1.61
	Planting seedlings and seeding bunchgrass understory	1,935 per acre of disturbance treated	$2.30
Juniper/conifer removal	Lop and scatter Phase I† juniper	480 per acre treated	$0.38
	Cut-pile-cover or mastication of Phase II† juniper	328 per acre treated	$2.11
	Mastication of Phase III† juniper and seeding bunchgrass understory	197 per acre treated	$10.76
Conservation easements	Land purchase (baseline value service credit) applying the annual maintenance and monitoring fee to every 5,000 acres of easement.	650 per acre purchased§	$1.03

* Although fence removal is more effective at removing the threat of greater sage-grouse collision than fence marking, both measures were modeled as having the same benefit due to a limitation in the model. The cost of fence removal is much lower than marking because no ongoing maintenance is required.

† Phases of juniper describe the dominance of this vegetation on the landscape. Phase I is a sagebrush-dominated landscape with scattered juniper, Phase II is a landscape comprising a 50:50 mixture of sagebrush and juniper, and Phase III is a landscape dominated by juniper.

‡ Cost estimates include permitting and maintenance as described in Table 5.

§ Estimated using the average habitat services value per acre in the Assessment Area excluding scores of 0, because no specific easements have been proposed.

LITERATURE CITED

Allen, P.D. II, D.J. Chapman, and D. Lane. 2005. Scaling environmental restoration to offset injury using habitat equivalency analysis. In Economics and Ecological Risk Assessment: Applications to Watershed Management, edited by R.F. Bruins and M.T. Heberling, pp. 165–184. Boca Raton, Florida: CRC Press.

Beck, T.D.I. 1977. Sage grouse flock characteristics and habitat selection during winter. Journal of Wildlife Management 41:18–26.

Bureau of Land Management (BLM), U.S. Fish and Wildlife Service, U.S. Forest Service, Oregon Department of Fish and Wildlife, and Oregon Division of State Lands. 2000. Greater Sage-grouse and Sagebrush-steppe Ecosystem: Management Guidelines.

Bureau of Land Management (BLM). 2011. Draft Environmental Impact Statement for the Gateway West Transmission Line Project, Wyoming, Idaho, and Nevada. Cheyenne, Wyoming: U.S. Department of the Interior, Bureau of Land Management, Wyoming State Office. July 2011.

Bureau of Land Management. 2013. TransWest Express Transmission Project. Draft Environmental Impact Statement. BLM Wyoming State Office and Western Area Power Administration. June 2013.

Cagney, J., E. Bainter, B. Budd, T. Christiansen, V. Herren, M. Holloran, B. Rashford, M. Smith, and J. Williams. 2009. Grazing influence, management and objective development in Wyoming greater sage-grouse habitat with emphasis on nesting and early brood rearing. Unpublished report. Available at: http://gf.state.wy.us/wildlife/wildlife_management/sagegrouse/index.asp. Accessed December 2009.

Chapman, D.J. 2004. Habitat Equivalency Analysis: Overview and Case Example. Presentation to: EPA Science Advisory Board Committee on Valuing the Protection of Ecological Systems and Services

Christiansen, T. 2009. Fence Marking to Reduce Greater Sage-grouse (*Centrocercus urophasianus*) Collisions and Mortality near Farson, Wyoming – Summary of Interim Results. Wyoming Game and Fish Department. Available at: http://pbadupws.nrc.gov/docs/ML1108/ML110830116.pdf. Accessed January 2012.

Connelly, J.W., E T. Rinkes, and C.E. Braun. 2011. Characteristics of greater sage-grouse habitats. In Greater Sage-grouse Ecology and Conservation of a Landscape Species and its Habitats, edited by S.T. Knick and J.W. Connelly, pp. 69–83. Berkeley: University of California Press.

Connelly, J.W., M.A. Schroeder, A.R. Sands, and C.E. Braun. 2000. Guidelines to manage sage grouse populations and their habitats. Wildlife Society Bulletin 28:967–985.

Connelly, J.W., S.T. Knick, M.A. Schroeder, and S.J. Stiver. 2004. Conservation Assessment of Greater Sage-grouse and Sagebrush Habitats. Unpublished Report. Cheyenne, Wyoming: Western Association of Fish and Wildlife Agencies.

Craighead Beringia South. 2008. Monitoring Sage Grouse with GPS Transmitters, Implications for Home Range and Small Scale Analysis: A Preliminary Look. Jonah Interagency Mitigation and Reclamation Office. 2008 Wildlife Workshop.

Crawford, J.A., R.A. Olson, N.E. West, J.C. Mosely, M.A. Schroeder, T.D. Whitson, R.F. Miller, M.A. Gregg, and C.S. Boyd. 2004. Synthesis paper: ecology and management of sage-grouse and sage-grouse habitat. Journal of Range Management 57:2–19.

Dunford, R.W., T.C. Ginn, W.H. Desvousges. 2004. The use of habitat equivalency analysis in natural resource damage assessments. Ecological Economics 48(2004):49–70.

Gregg, M.A., J.A. Crawford, M.S. Drut, and A.K. DeLong. 1994. Vegetative cover and predation of sage-grouse nests in Oregon. Journal of Wildlife Management 58:162–166.

Holloran, M.T., and S.H. Anderson. 2005. Spatial distribution of greater sage-grouse nests in relatively contiguous sagebrush habitats. The Condor 107:742–752.

Johnson, D.H., M.J. Holloran, J.W. Connely, S.E. Hanser, C.L. Amundson, and S.T. Knick. 2011. Influences of environmental and anthropogenic features on greater sage-grouse populations, 1997–2007. In Greater Sage-grouse Ecology and Conservation of a Landscape Species and its Habitats, edited by S.T. Knick and J.W. Connelly, pp. 407–450. Berkeley: University of California Press.

King, D.M. 1997. Comparing ecosystem services and values, with illustrations for performing habitat equivalency analysis. Prepared by King and Associates, Inc., Washington, D.C., for U.S. Department of Commerce, Silvery Spring, MD.

Kohler, K.E., and R.E. Dodge. 2006. Visual_HEA: Habitat equivalency analysis software to calculate compensatory restoration following natural resource injury. Proceedings of 10th International Coral Reef Symposium, pp. 1611–1616.

Lincoln County Sage Grouse Technical Review Team. 2004. Lincoln County Sage Grouse Conservation Plan. Nevada. Available at: http://www.ndow.org/wild/conservation/sg/plan/SGPlan063004_R.pdf. Accessed January 2012.

Miller, R.F., J.D. Bates, T.J. Svejcar, F.B. Pierson, and L.E. Eddleman. 2005. Biology, ecology, and management of western juniper. Oregon State University, Technical Bulletin 152. June 2005. 77 pp.

National Oceanic and Atmospheric Administration (NOAA). 2006. Habitat equivalency analysis: an overview. Available at: www.darrp.noaa.gov/library/pdf/heaoverv.pdf. Accessed July 2009.

NOAA. 2009. Restoration economics, habitat equivalency analysis. Available online at: http://www.csc.noaa.gov/coastal/economics/habitatequ.htm. Accessed on 7-6-2009.

Pruett, C.L., M.A. Patten, and D.H. Wolfe. 2009. Avoidance behavior by prairie grouse: implications for development of wind energy. Conservation Biology 23:5, 1253–1259.

Rogers, G.E. 1964. Sage grouse investigations in Colorado. Technical Bulletin No. 16. Denver: Colorado Game, Fish and Parks Department, Game Research Division.

Stevens, B. 2011. Impacts of fences on greater sage-grouse in Idaho: Collision, mitigation, and spatial ecology. Master's Thesis. University of Idaho, Moscow.

Stiver, S.J., E.T. Rinkes, and D.E. Naugle. 2010. Sage-grouse Habitat Assessment Framework. Unpublished report. Boise, Idaho: Bureau of Land Management, Idaho State Office.

Wallestad, R.O. 1971. Summer movements and habitat use by sage grouse broods in central Montana. Journal of Wildlife Management 35:129–136.

APPENDIX A

Greater Sage-Grouse Habitat Service Metric for the TransWest Express Project

Text is excerpt from the TWE Project HEA Plan.

DEVELOPMENT OF HABITAT SERVICE METRIC FOR HABITAT EQUIVALENCY ANALYSIS

A habitat service metric was developed for the greater sage-grouse (*Centrocercus urophasianus*) using variables identified in the peer-reviewed literature as representative of greater sage-grouse habitat. Habitat service levels are intended to reflect both the quality of the habitat and the ability of the birds to use the habitat. For each of the metric variables, a habitat service score ranging from 0 to 3 (no services [contributing no value to habitat] to high services [optimal habitat]) was assigned, similar to the greater sage-grouse habitat assessment framework developed by Stiver et al. (2010) and the greater sage-grouse habitat suitability index developed by LaGory et al. (2012). Scoring habitat services is a critical step in the HEA process, because it provides a way to measure the relative quality of specific habitat functions in a specific area.

The scores for this HEA are primarily based on information contained in the literature regarding greater sage-grouse habitat use and selection. When literature did not allow for direct assignment of value ranges for HEA scores, professional judgments, which were based on peer-reviewed literature, were used. Professional judgments are associated with specific literature references when possible and/or confirmed with academic and agency biologists.

When a basic life requisite of greater sage-grouse is absent (vegetation is absent, the area is forested, or high levels of disturbance are present), the cell being scored is assigned a total service value of 0. When a measurements for particular variable within the metric (e.g., % sagebrush cover) matches literature-based descriptions of sub-optimal conditions, that variable is given a service score of 0 (contributing no value to habitat), 1 (poor habitat), or 2 (moderate habitat). For example, sagebrush cover <1% would score a 0, cover of 1%–5% would score a 1, and cover of 5%–15% or >35% would score a 2 for that variable. When measurements for a particular variable match literature-based recommended conditions, that variable is given a service score of 3 (optimal habitat). For example, sagebrush cover of 15%–35% would score a 3 for that variable.

Scoring of the variables is categorical and each variable is given the same weight in the model. This approach is based on the best available data and is consistent with the general approach of LaGory et al. (2012). LaGory et al. (2012) describe their approach as follows:

> In general, there was insufficient information in existing studies to determine relationships among variables and habitat suitability or relative contributions between variables/components. Therefore, for simplicity, we developed piecewise linear functions of suitability based on the assumption that all variables are of equal weight and applied these functions to geospatial layers to generate indices ranging from 0 (poor) to 100 (optimal). This approach is similar to that used for many of the U.S. Fish and Wildlife Service (USFWS) Habitat Suitability Index models in their Habitat Evaluation Procedure, (available at http://www.fws.gov/policy/ESMindex.html).

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While the individual variables are not weighted, the number of variables relating to a habitat attribute (e.g., six for vegetation vs. one for slope) and the size of the buffers (e.g., 1,000 m for high traffic roads vs. 200 m for low traffic roads) give some attribute categories more influence than others. In the metric, there are three variables that score sagebrush characteristics (sagebrush abundance index, sagebrush % cover, and sagebrush canopy height), so areas that are not dominated by sagebrush will score low for these three variables, resulting in a lower overall score.

Greater sage-grouse habitat suitability publications vary in their baseline environmental conditions affecting a particular study site. Even studies within the same state may describe different suitable habitat conditions depending on elevation, precipitation zone, and other geographic or climatic factors affecting each study site.

No specific habitat studies have been conducted on the TWE Project's transmission line corridor alternatives, therefore the habitat metrics described below mostly rely on information presented in BLM et al. (2000), Cagney et al. (2009), Connelly et al. (2000), Connelly et al. (2011), and other summary publications. Specific citations are given to support the habitat model framework when applicable.

A single habitat service metric is applied to the entire TWE Project corridor in order to standardize results. This approach assumes that optimal habitat or poor habitat for greater sage-grouse looks the same (that is, measures the same for the variables in the metric) regardless of its location, despite regional differences in habitat features and availability.

As a result, the best available habitat at the edge of the species' range may not score as high as the best available habitat in the center of the species' range, unless they have the same measurements for the variables in the metric. The following sections describe the development of the habitat service model variables.

METRIC OF GREATER SAGE-GROUSE HABITAT SERVICES

The metric is only applied to areas that contain greater sage-grouse habitat. The assessment area was first clipped to the BLM's Priority General Habitat (PGH). Then, land cover types typically avoided by greater sage-grouse are assigned a metric score of 0 before the metric is applied to the remaining areas. Disturbances of these lands require no mitigation in the HEA. These land cover types include all forest types, urban areas, open water, some introduced vegetation types, roadways, well pads, mine footprints, areas <100 meters (m) from roadways with >6,000 annual average daily traffic (AADT), and <25 m of paved roads with <6,000 AADT and heavily traveled gravel roads (multiple sources per U.S. Fish and Wildlife listing decision in Federal Register; Johnson et al. 2011).

The metric for greater sage-grouse habitat services used in this HEA is an additive model (Table A1) with a score adjustment for the presence of fences posing a high collision risk to greater sage-grouse during the lekking season. Each cell in the analysis area is scored separately by summing the

scores of Variables 01 through 08. The summed score is then multiplied by a factor that reduces the score where high risk fences are present. Each of the variables and the fence score adjustment is described in detail below.

Descriptions of Additive Metric Variables

After areas of non-habitat (i.e., areas not suitable for greater sage-grouse or areas located outside the BLM's PGH boundaries) are assigned a metric score of 0, the remaining habitats are scored by adding the individual scores for the eight following variables.

VAR01 and VAR02 Distance to Roads and Highways

Research into the effects of roads on greater sage-grouse is varied. For instance in Colorado, Rogers (1964) mapped 120 leks with regard to distance from roads and found that 42% of leks were over 1.6 km (1 mile) from the nearest improved road, but that 26% of leks were within about 90 m (about 100 yards) of a county or state highway, and two leks were on a road. Connelly et al. (2004) also note the use of roads for lek sites. In contrast, Craighead Beringia South (2008) reported results from a 2007 to 2009 study of greater sage-grouse seasonal habitat use in Jackson Hole, Wyoming. Results indicate that greater sage-grouse avoid areas within approximately 100 m of paved roads. Similarly, Pruett et al. (2009) found that lesser prairie-chickens avoided one of the two highways in the study by 100 m; however, some prairie-chickens crossed roads and had home ranges that overlapped the highways, thus roads did not completely exclude them from neighboring habitat. Johnson et al. (2011) examined the correlation between trends in lek attendance and the environmental and anthropogenic features within 5- and 18-km buffers around leks. They found that lek attendance declined over time with length of interstate highway within 5 km, although the authors note that this trend was based on relatively few data points and no pre-highway data were available for comparison. Interstate highways >5 km away and smaller state and federal highways had little or no effect on trends in lek attendance. Thresholds less than 5 km were not examined.

In the habitat services metric, those habitats located within 100 m of a high-traffic (>6,000 AADT) paved road (an interstate highway or high-traffic federal or state highway, for example), or within 25 m of a low-traffic (<6,000 AADT) paved road (a low-traffic federal or state highway, for example) were considered to provide no services to greater sage-grouse due to traffic and associated noise/human disturbance and were given a full metric score of 0 (no services). Unpaved roads with high traffic loads (for example, oil and gas service roads, mine service roads, etc.) provide similar disturbance levels as paved roads with similar traffic loads (e.g., low-traffic state highway). To characterize this disturbance in the model, mine footprints and well pad footprints were classified and scored as if they were low-traffic roads, so that there are no habitat services within 25 m of these disturbances. The AC/DC converter station will also classified and scored as if it is a low-traffic road in the model to account for the noise and human presence associated with this facility.

Those habitats located farther than 200 m and 1,000 m, respectively, of a low-traffic road or high-traffic road were considered the most serviceable to greater sage-grouse (that is, exhibited no decrease in lek attendance) and given a score of 3. A logarithmic curve was fit between the highest

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and lowest categories so that score increased with distance from the road to estimate the distance breaks associated with scores 1 and 2. A logarithmic rate of change simulates sound attenuation rates better than a linear rate of change (Crocker 2007). Conflicting research results regarding greater sage-grouse use near and on unpaved resource/collector roads (e.g., two-track roads) did not allow for quantification of the disturbance caused by these roads in the model.

While the application of distances to all scores (0–3) is not perfectly supported in the peer-reviewed literature, our approach places a penalty upon habitats that are bisected by all types of large roadways. Penalties are higher for roads that typically have higher traffic levels and risk to greater sage-grouse (e.g., mortality from collision, noise disturbance) than less-utilized secondary roads that generally have less traffic and implied risk.

VAR03 Slope

Slope was used to refine greater sage-grouse habitat potential. Greater sage-grouse generally use flat or gently sloping terrain (Connelly et al. 2011; Eng and Schladweiler 1972; Nisbet et al. 1983; Rogers 1964). Beck (1977) plotted the distribution of 199 greater sage-grouse flocks in Colorado and found that 66% of flocks were on slopes less than 5% and only 13% of flocks were on slopes greater than 10%. Areas with slopes greater than 40% are unsuitable for nesting habitat (Lincoln County Sage Grouse Technical Review Team 2004), but still have some value to greater sage-grouse and should be retained in the model (professional judgment of the agency biologists). Therefore, areas with less than 5% slope were assigned a habitat service score of 3, and those exceeding 10% subjectively received incrementally lower habitat service scores. Slopes >40% did not add value to the habitat and received a score of 0 for this variable, but these areas may provide habitat services depending on the scores for the other variables.

A terrain roughness index (TRI) was evaluated for use in place of the slope variable, as some studies have shown that it is a better indicator of greater sage-grouse use (Carpenter et al. 2010; Doherty et al. 2008; Doherty et al. 2010; Dzialak et al. 2011). However, there was substantial variation in the methods used to calculate TRI (e.g., measure of roughness used and analysis window size) and region evaluated (e.g., Alberta, Canada, vs. Powder River Basin, Wyoming) by these studies. Given this variation, it was not possible to identify literature-supported cutoffs between scores for use in the model.

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Table A1. Additive Variables in the Metric of Greater Sage-grouse Habitat Services

Variable Number	Variables	3	2	1	0	Primary Citations
VAR01	Distance to high-traffic (>6,000 AADT) road, such as an interstate, federal, or state highway (meters)	>1,000	650–1,000	100–650	N/A*	Craighead Beringia South (2008); Johnson et al. (2011); Pruett et al. (2009)
VAR02	Distance to low-traffic (<6,000 AADT) paved roads, heavily travelled gravel roads, well pads, mine footprints, transmission substations (meters)	>200	50–200	25–50	N/A*	Connelly et al. (2004); Craighead Beringia South (2008); Johnson et al. (2011); Pruett et al. (2009)
VAR03	Percent slope	<10	10–30	30–40	>40	Beck (1977); Lincoln County Sage Grouse Technical Review Team (2004)
VAR04	Distance to occupied lek† (kilometers)	0–6.4	6.4–8.5	>8.5	N/A	Cagney et al. (2009); Connelly et al. (2000); Connelly et al. (2011); Holloran and Anderson (2005)
VAR05	Sagebrush abundance index (% of vegetation that is sagebrush within a 1 km^2 moving window)	50–95	30–50 or >95	10–30	0–10	Carpenter et al. (2010); Walker et al. (2007); Aldridge and Boyce (2007); Aldridge et al. 2008; Wisdom et al. (2011)
VAR06	Percent sagebrush canopy cover	15–35	5–15 or >35	1–5	<1	Cagney et al. (2009); Connelly et al. (2000); Stiver et al. (2010)
VAR07	Sagebrush canopy height (centimeters)	30–80	20 to <30 or >80	5–20	<5	Crawford et al. (2004); Connelly et al. (2000); Stiver et al. (2010)
VAR08	Distance of habitat to sage or shrub dominant (meters)	<90	90–275	275–1,000	>1,000	BLM et al. (2000); Connelly et al. (2000); Lincoln County Sage Grouse Technical Review Team (2004)

* Lands less than 100 m from a high traffic road and less than 25 m from a low traffic paved road or high traffic gravel road were given a total metric score of 0 (provides no habitat services), not just a score of 0 for these individual variables.
† Leks were classified as active if their 10-year attendance average was greater than 0.

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VAR04 Distance to Lek (10-year Average Count >0 Males)

Current greater sage-grouse habitat management guidance uses occupied leks as focal points for nesting habitat management (Connelly et al. 2000; Connelly et al. 2011); therefore, distance to lek was used as a variable in the habitat services metric. These guidelines recommend protecting sagebrush communities within 3.2 km of a lek in uniformly distributed habitats and 5.0 km in non-uniformly distributed habitats. Holloran and Anderson (2005) studied nesting greater sage-grouse at 30 leks in central and western Wyoming and determined that 45% and 64% of female greater sage-grouse nested within 3.2 km and 5.0 km, respectively, of the lek where the hen was radio-collared. Moreover, statistical analyses suggested that the area of interest for nesting greater sage-grouse should be truncated at 8.5 km from a lek. Similar frequencies are reported in Cagney et al. (2009)—66% within 5.0 km and 75% within 6.4 km of a lek where the female bred.

Female greater sage-grouse do nest at distances greater than 8.5 km (farthest distance reported in Holloran and Anderson [2005] was 27.4 km), so all distances >8.5 km from occupied leks were given a service score of 1 to reflect some potential use by nesting greater sage-grouse. Areas within 6.4 km of a lek provide the highest service level, because they provide female grouse with forage, roost sites, and cover from predators or inclement weather during the lekking season, in addition to containing lekking habitat and nesting habitat (Cagney et al. 2009). Therefore, areas within 6.4 km of an occupied lek were assigned a service score of 3 for this variable. Between these distances (6.4–8.5 km), areas were assigned a score of 2 for this variable.

VAR05 Sagebrush Abundance Index

Walker et al. (2007) found that the proportion of habitat that was sagebrush within a 6.4-km moving window was a strong predictor of lek persistence in the Powder River Basin of Wyoming. The moving window is an analysis area that is larger than and centered on the cell being scored; in this case, the window is a 6.4-km buffer that moves as the cell being scored is changed. Areas with less than 30% of sagebrush within 6.4 km of the lek center had a lower probability of lek persistence. Aldridge and Boyce (2007) also used a moving window (1 km^2) to measure sagebrush cover and abundance. Their resource selection function found that greater sage-grouse selected nesting habitat that contained large patches (1 km2) of sagebrush with moderate canopy cover and moderate sagebrush abundance (i.e., heterogeneous distribution of sagebrush). Carpenter et al. (2010) found similar results in Alberta, Canada. Their top resource selection functions included a quadratic function for sagebrush abundance, which indicates that areas of moderate sagebrush abundance were selected more frequently than areas of homogenous sagebrush.

Aldridge et al. (2008) [per Wisdom et al. (2011)] found that at least 25% of the landscape in a 30.77-km analysis area needed to be dominated by sagebrush for greater sage-grouse persistence, with 65% being preferred. Wisdom et al. (2011) found that landscapes with less than 27% sagebrush were not different from landscapes from which greater sage-grouse have been extirpated. Similar to Aldridge et al. (2008), Wisdom et al. (2011) found that 50% sagebrush across a landscape was a good indicator of greater sage-grouse persistence.

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The agency biologists indicated that greater sage-grouse prefer higher sagebrush abundance in the southern part of their range than is indicated by these studies. For example, the Colorado Parks and Wildlife Avian Research Center has generally found a positive linear relationship between sagebrush abundance and measures of habitat selection (Brian Holmes, Colorado Parks and Wildlife, personal communication with Jon Kehmeier, SWCA, on February 13, 2013). Colorado Parks and Wildlife has not observed an upper inflection point in the proportion of the landscape covered in sagebrush where use or selection begins to drop, and suggest that the difference may be due to the structure and composition of the sagebrush community (that is, silver sagebrush mixed grassland rangelands of Alberta [Aldridge and Boyce 2007; Carpenter et al. 2010] vs. big sagebrush steppe [TWE Project Area]).

Sagebrush covering 50% to 95% of the landscape scored a 3 for this variable (Aldridge et al. 2008; Wisdom et al. 2011; professional judgment of the agency biologists). Sagebrush covering 30% to 50% or >95% scored a 2 for this variable (Aldridge et al. 2008). Sagebrush covering 10% to 30% scored a 1 (Walker et al. 2007; Wisdom et al. 2011) and sagebrush covering less than 10% scored a 0 for this variable.

VAR06 Sagebrush Canopy Cover

Recommended sagebrush canopy cover for greater sage-grouse habitat varies seasonally. Seasonal habitats were not modeled, but seasonal differences in the selection for sagebrush cover was considered when developing habitat services metrics. The seasonal habitat needs of greater sage-grouse are described below, followed by scoring of percent sagebrush cover in the habitat services metric.

Seasonal Habitat Use

Nesting

Connelly et al. (2000) cite 13 references to sagebrush coverage that range from 15% to 38% mean canopy cover surrounding the nest. Citations contained within Crawford et al. (2004) reported 12% to 20% cover and 41% cover in nesting habitat. In their species assessment, Connelly et al. (2000) conclude that 15% to 25% canopy cover is the recommended range for productive greater sage-grouse nesting habitat. This is also the range identified in the greater sage-grouse habitat assessment framework (Stiver et al. 2010) as providing the highest service level for greater sage-grouse based on a review of the available literature. Wallestad and Pyrah (1974) reported that successful nests were in stands where sagebrush cover approximated 27%. This cover range is used as a goal in some greater sage-grouse management guidelines (Bohne et al. 2007; BLM et al. 2000). Cagney et al. (2009) guidelines for grazing in grouse habitat, which use information synthesized from over 300 sources, state that hens tend to select an average 23% live sagebrush canopy cover when selecting nesting sites.

Greater sage-grouse in Utah use habitats with higher sagebrush canopy cover than is observed in the northern and eastern portions of the species range, possibly due to the relative scarcity of understory grasses in Utah (Renee Chi, BLM, personal communication with Ann Widmer, SWCA, on March 22, 2013). Nest sites in Wildcat Knoll (part of the Emery-Sanpete population of Utah) were located in areas

with an average of 33% shrub canopy cover for successful nests and 22% for unsuccessful nests (Perkins 2010). Nests (n = 50) in Parker Mountain were located at sites with an average canopy cover of 35.5% for big sagebrush and 32% for big sagebrush mixed with black sagebrush (Chi 2004; Renee Chi, BLM, personal communication with Ann Widmer, SWCA, on March 22, 2013). In the Sheeprock greater sage-grouse population, nest site shrub canopy cover measured an average of 62% in 2005 and 83.5% in 2006 (Robinson 2007).

Brood Rearing

Connelly et al. (2000) found that productive brood-rearing habitat should include 10% to 25% cover of sagebrush. This is the range used as a goal in greater sage-grouse management guidelines (Bohne et al. 2007; BLM et al. 2000). While sagebrush is a vital component of greater sage-grouse habitat, very thick shrub cover may inhibit understory vegetation growth and reduce the birds' ability to detect predators (Wiebe and Martin 1998).

Again, greater sage-grouse in Utah may use areas with higher canopy cover than is typical throughout the northern and eastern parts of their range. Grouse in the Sheeprock population were documented using areas with an average shrub canopy cover of 73% during brood rearing in 2005 and 2006 (Robinson 2007).

Winter

Connelly et al. (2000) cite 10 references to sagebrush coverage in winter-use areas that range from 15% to 43% mean canopy cover (Crawford et al. [2004] also cite two of these references in their assessment); however, they considered a canopy of 10% to 30% cover (above the snow) as a characteristic of sagebrush needed for productive greater sage-grouse winter habitat. This is the cover range used as a goal in greater sage-grouse management guidelines (Bohne et al. 2007; BLM et al. 2000). Greater sage-grouse in Utah may prefer higher cover in winter. In Emma Park, areas of high sagebrush cover were used disproportionally to their availability on the landscape, with an average of 38.3% sagebrush canopy cover in winter-use areas (Crompton and Mitchell 2005).

Scoring in Habitat Services Metric

In general, the recommended sagebrush cover for nesting habitats was intermediate to, and overlapped that of, brood-rearing and winter habitats. Thus, favorable conditions for nesting were given the highest scores for percent sagebrush cover in the greater sage-grouse habitat services metric.

This variable used the scores assigned by Stiver et al. (2010) for sagebrush cover categories in greater sage-grouse nesting habitat, with a slight adjustment to account for use of higher canopy cover in Utah. This adjustment is also consistent with the Colorado Greater Sage-Grouse Conservation Plan (Colorado Division of Wildlife et al. 2008). Sagebrush percent canopy cover of 15% to 35% was assumed to provide the highest level of services (score of 3) to nesting greater sage-grouse. This includes canopy covers that are 10% higher than the average ranges provided in Connelly et al. (2000) and Cagney et al. (2009). Areas with slightly less or more cover than this (55–15 or >35) were given a habitat services score of 2. Habitats with <5% cover received a score of 1.

VAR07 Sagebrush Canopy Height

Sagebrush canopy height is an important aspect of all greater sage-grouse seasonal habitats. As described above, seasonal habitat models will not be developed for the TWE Project. However, seasonal habitat requirements were considered when developing habitat metric values. The seasonal habitat needs of greater sage-grouse are described below, followed by scoring of percent sagebrush cover in the habitat services metric.

Seasonal Habitat Use

Nesting

Gregg et al. (1994, cited in Crawford et al. 2004) found that the area surrounding successful nests in Oregon consisted of medium-height (40 to 80 centimeters [cm]) sagebrush. Connelly et al. (2000) cite 11 references to sagebrush height that range from 29 to 79 cm mean height. In their assessment, Connelly et al. (2000) conclude that sagebrush with a height of 30 to 80 cm is needed for productive greater sage-grouse nesting habitat in arid sites and 40 to 80 cm in mesic sites. These ranges are supported by Stiver et al. (2010), who recommend a range of 30 to 80 cm, and BLM et al. (2000), which state that optimum greater sage-grouse nesting habitat consists of sagebrush stands containing plants 40 to 80 cm tall.

Winter

Important structural components in winter habitat include medium to tall (25–80 cm) sagebrush stands (Crawford et al. 2004). Connelly et al. (2000) cite 10 references to sagebrush height in winter habitat that range from 20 to 46 cm above the snow. Two studies measured the entire plant height and provided a range from 41 to 56 cm. In their assessment, Connelly et al. (2000) conclude that characteristics of productive winter habitat include sagebrush that is 25 to 35 cm in height above the snow. This is the height range used as a goal in greater sage-grouse management guidelines (Bohne et al. 2007; BLM et al. 2000).

Scoring in Habitat Services Metric

Sagebrush canopy heights that provided high-quality nesting habitat generally also provided high-quality winter habitat for greater sage-grouse. Thus, favorable conditions for nesting were given the highest scores for sagebrush canopy height in the greater sage-grouse habitat services metric.

The sagebrush cover scores assigned for nesting habitat in the greater sage-grouse habitat assessment framework by Stiver et al. (2010) to different sagebrush cover categories were assigned to this variable. Areas of sagebrush with a height of 30 to 80 cm were assigned a habitat services score of 3. As sagebrush canopy height decreases, the value of a sagebrush plant to provide cover for nesting females and their nests is diminished. Additionally, low-lying sagebrush is less available to greater sage-grouse during the winter due to snow cover. Areas with canopy heights greater than 80 cm provided intermediate levels of services because they may provide relatively poor cover for nesting greater sage-grouse and have foliage that is difficult for greater sage-grouse to access during mild and moderate winters. Sites with lower and higher sagebrush canopy heights were scored lower (sagebrush 12 to <30 cm or >80 cm in height received a score of 2). Areas with minimal sagebrush

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canopy heights were considered to have the lowest habitat service value (sagebrush <20 cm received a score of 1).

VAR08 Distance to Vegetation Dominated by Sagebrush or Shrub

Greater sage-grouse use shrubby habitats including sagebrush during the brood-rearing season (Connelly et al. 2000) and for grouse movement and dispersal (Stiver et al. 2010). Close proximity to shrubby vegetation increases the service value of all vegetation types modeled because shrubby vegetation provides cover from predators, facilitates grouse movement, and supports population connectivity.

The Lincoln County Sage Grouse Technical Review Team (2004) identified proximity to sagebrush cover as an important component in habitat suitability of non-sagebrush, brood-rearing habitats (e.g., mesic lowland habitats, hay meadows). The Team considered brood-rearing areas within <100 yards, 100 to 300 yards, and >300 yards of sagebrush cover as suitable, marginal, and unsuitable habitat, respectively. Similarly, Stiver et al. (2010) considered mesic habitats <90 m, 90 to 275 m, and >275 m of sagebrush to be suitable, marginal, and unsuitable late brood-rearing/summer habitat, respectively. These categorizations support the concept of increasing service level with proximity to shrubs, particularly sagebrush.

The distance to vegetation dominated by sagebrush or shrub variable (VAR09) measured the distance of the cell being scored (regardless of its vegetation type) to the next nearest cell that was dominated by sagebrush or a shrub species, including willows. For this variable, cells <90 m, 20 to 275 m, and >275 m to a cell dominated by a shrub species were assigned scores of 3, 2, and 1, respectively. The scoring was applied to all vegetation types, because this variable is relevant to bird movement and dispersal from all habitat types.

Score Adjustment for Fences that Pose a High Risk for Collision

Habitat within and surrounding the TWE Project transmission line corridor is currently influenced by fences used for livestock management. These fences are typically constructed from barbed wire and are used to control livestock movements and vegetation use within grazing allotments and pastures, to delineate or protect private property and agricultural croplands, and to restrict livestock from improved and unimproved roadways.

Fence collisions have been reported as a cause of significant injury and mortality to grouse species (greater sage-grouse [Braun 2006; Call and Maser 1985; Connelly et al. 2004; Christiansen 2009; Danvir 2002; Stevens et al. 2012]; lesser prairie-chicken [Wolfe et al. 2007]; ptarmigan [Bevanger and Broseth 2000]; and red grouse, black grouse, and capercaillie [Baines and Summers 1997; Catt et al. 1994; Petty 1995]). In addition to direct mortality, fences provide corridors for mammalian predators increasing the opportunity for predation of hens and broods (Braun 1998). Unlike the additive variables in the metric, which are primarily meant to characterize use and avoidance of habitat by greater sage-grouse, the distance to high risk fences was added to account for the potential direct loss of greater sage-grouse (not greater sage-grouse avoidance of fences).

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In Wyoming, Christiansen (2009) reported preliminary results of a multiple-year study (2005–ongoing) near Farson on greater sage-grouse fence strikes and mortalities and the utility of fence markers on reducing collisions. After installation of fence markers on portions of high-risk fences, grouse mortality decreased by 70%. Although the study did not compare the number of strikes with regard to distance to lek, the author recommends that fences should not be located within 0.25 mile (0.4 km) of leks.

In Idaho, Stevens (2011) and Stevens et al. (2012a; 2012b) evaluated the environmental features associated with greater sage-grouse fence collision risk, and tested the efficacy of reflective vinyl fence markers to reduce collision rates at eight study sites. Modeling of these data predicted marking reduced collision rates by 74% to 83% at the mean lek size and fence distance from the lek during the breeding season. Collision probability varied by region, topography, fence type, fence density, and lek proximity. Areas with high slope or terrain ruggedness generally showed lower collision risk than flat areas. Collisions were more common on fence segments bound by steel t-posts with spans between posts exceeding 4 m. Collision probability increased with fence length per km^2 and proximity to nearest active lek.

For this variable, fences segments having a high risk for collision were identified using the model by Stevens et al. (2013), which is determines the fence-collision risk from proximity to lek and a terrain roughness index (Equation 1).

Equation 1: $$\hat{y} = 78 * \quad (\beta_0 + \beta_1 * TRI + \beta_2 * distance)$$

Where:

$\hat{y}$ is an estimate of the total number of greater sage-grouse collisions over a 78-day lekking season for each 30-m pixel if a fence is present;

β_0 = -3.325 (per Bryan Stevens, personal communication with Ann Widmer, SWCA, on February 14, 2014);

β_1= -0.25;

β_2 = -0.0006;

TRI is a terrain roughness index calculated using ArcInfo; and

$distance$ is the distance from each 30-m pixel to the nearest greater sage-grouse lek in GIS using the Euclidean distance function (up to 3 km).

The additive metric score (the sum of VAR01 through VAR08) for a cell was multiplied by an adjustment factor that reduced the score if the cell was located within 3 km of a greater sage-grouse lek (i.e., it was scored by the Stevens et al. 2013 model) and there was a fence present in that cell. The adjustment factor for each probability of collision is provided in Table A2. Allotment boundaries were used as a surrogate for fence lines. Following the convention established by Stevens et al. 2013, the arbitrary threshold of 1 grouse collision per lekking season was used as the breaking point between our

score adjustment categories. The other category break was established based on a natural break in the data distribution.

Table A2. Cell score adjustment for the presence of fences posing a high collision risk.

$\hat{y}$ (prediction of the total number of greater sage-grouse collisions per lekking season)	Score adjustment factor
0.00-0.40	0.75
0.40-1.00	0.50
≥1.00	0

Here are three examples of the application of the fence score adjustment factor. In the first, there is a cell with an additive score of 10 (the sum of VAR01-VAR08) that is located within 3 km of a lek and has a fence running through it. The Stevens et al. 2013 model predicts 0.2 collisions per lekking season for a fence in that cell, so the additive score of 10 is multiplied by 0.75 for a final metric score of 7.5 for that cell. In the second example, there is another cell with an additive score of 10 that is located within 3 km of a lek and has a fence running through it. The Stevens et al. 2013 model predicts 1.4 collisions per year a fence in this cell, so the additive score of 10 is multiplied by 0 to produce a final metric score of 0 (no habitat services). In the third example, there is a cell with an additive score of 10 that has a fence running through it, but the cell is located >3 km from a lek. Stevens et al. 2013 model does not produce an estimated number of collisions for this cell, because it is located more than 3 km from a lek. This fence is considered to have a relatively low collision risk during the lekking season, so the cell retains its full value (no adjustment).

Collisions with fences may occur outside of the lekking season. Marking of fences located more than 3 km of a fence may be considered for mitigation. If so, they will be treated as if they have the lowest fence risk collision (0.00-0.39 collisions/year) for the purposes of modeling.

LITERATURE CITED

Aldridge, C.L., and M.S. Boyce. 2007. Linking occurrence and fitness to persistence: Habitat based approach for endangered Greater Sage Grouse. *Ecological Applications* 17(2)508–526.

Aldridge C.L., S.E. Nielsen, H.L. Beyer, M.S. Boyce, J.W. Connelly, S.T. Knick, and M.A. Schroeder. 2008. Range-wide patterns of greater sage-grouse persistence. *Diversity and Distributions* 17:983–994.

Baines, D., and R.W. Summers. 1997. Assessment of bird collisions with deer fences in Scottish forests. *Journal of Applied Ecology* 34:941–948.

Beck, T.D.I. 1977. Sage grouse flock characteristics and habitat selection during winter. *Journal of Wildlife Management* 41:18–26.

Bevanger, K., and H. Broseth. 2000. Reindeer *Rangifer tarandus* fences as a mortality factor for ptarmigan *Lagopus* spp. *Wildlife Biology* 6:121–127.

Bohne, J., T. Rinkes, and S. Kilpatrick. 2007. *Sage-Grouse Habitat Management Guidelines for Wyoming*. Wyoming Game and Fish Publication. July 24.

Braun, C.E. 1998. Sage-grouse declines in western North America: what are the problems. Proceedings of the Western Association of State Fish and Wildlife Agencies 78:139–156.

———. 2006. A Blueprint for Sage-Grouse Conservation and Recovery. Tucson: Grouse Inc.

Bureau of Land Management (BLM), U.S. Fish and Wildlife Service, U.S. Forest Service, Oregon Department of Fish and Wildlife, and Oregon Division of State Lands. 2000. *Greater Sage-grouse and Sagebrush-steppe Ecosystem: Management Guidelines*.

Cagney, J., E. Bainter, B. Budd, T. Christiansen, V. Herren, M. Holloran, B. Rashford, M. Smith, and J. Williams. 2009. Grazing influence, management and objective development in Wyoming greater sage-grouse habitat with emphasis on nesting and early brood rearing. Unpublished report. Available online at http://gf.state.wy.us/wildlife/wildlife_management/sagegrouse/index.asp. Accessed December 2009.

Call, M.W., and C. Maser. 1985. *Wildlife Habitats in Managed Rangelands – The Great Basin of Southeastern Oregon: Sage Grouse.* General Technical Report PNW-187. USDA Forest Service, Pacific Northwest Forest and Range Experiment Station.

Carpenter, J., C. Aldridge, and M.S. Boyce. 2010. Sage-grouse habitat selection during winter in Alberta. *Journal of Wildlife Management* 74(8):1806–1814.

Catt, D.C., D. Dugan, R.E. Green, R. Moncrieff, R. Moss, N. Picozzi, R.W. Summers, and G.A. Tyler. 1994. Collisions against fences by woodland grouse in Scotland. *Forestry* 67:105–118.

Chi, R.Y. 2004. Greater sage-grouse reproductive ecology and tebuthiuron manipulation of dense big sagebrush on Parker Mountain. M.S. thesis, Utah State University, Logan.

Christiansen, T. 2009. Fence Marking to Reduce Greater Sage-grouse (*Centrocercus urophasianus*) Collisions and Mortality near Farson, Wyoming – Summary of Interim Results. Wyoming Game and Fish Department. Available online at http://pbadupws.nrc.gov/docs/ML1108/ML110830116.pdf. Accessed January 2012.

Colorado Division of Wildlife, USDA Forest Service, USDA Natural Resource Conservation Service, U.S. Bureau of Land Management, and U.S. Fish and Wildlife Service. 2008. Colorado Greater Sage-Grouse Conservation Plan. January 2008. Available online at http://wildlife.state.co.us/WildlifeSpecies/SpeciesOfConcern/Birds/Pages/GreaterSageGrouseConsPlan2.aspx. Accessed March 2013.

Connelly, J.W., S.T. Knick, M.A. Schroeder, and S.J. Stiver. 2004. Conservation assessment of greater sage-grouse and sagebrush habitats. Unpublished report. Cheyenne, Wyoming: Western Association of Fish and Wildlife Agencies.

DRAFT

Connelly, J.W., E T. Rinkes, and C.E. Braun. 2011. Characteristics of greater sage-grouse habitats: a landscape species at micro- and macroscales. In *Greater Sage-grouse Ecology and Conservation of a Landscape Species and its Habitats*, edited by S.T. Knick and J.W. Connelly, pp. 69–83. Berkeley: University of California Press.

Connelly, J.W., M.A. Schroeder, A.R. Sands, and C.E. Braun. 2000. Guidelines to manage sage grouse populations and their habitats. *Wildlife Society Bulletin* 28:967–985.

Craighead Beringia South. 2008. Monitoring Sage Grouse with GPS Transmitters, Implications for Home Range and Small Scale Analysis: A Preliminary Look. Jonah Interagency Mitigation and Reclamation Office. 2008 Wildlife Workshop.

Crawford, J.A., R.A. Olson, N.E. West, J.C. Mosely, M.A. Schroeder, T.D. Whitson, R.F. Miller, M.A. Gregg, and C.S. Boyd. 2004. Synthesis paper: ecology and management of sage-grouse and sage-grouse habitat. *Journal of Range Management* 57:2–19.

Crocker, M.J. 2007. *Handbook of Noise and Vibration Control*. Hoboken, New Jersey: John Wiley and Sons, Inc.

Crompton, B., and D. Mitchell. 2005. The sage-grouse of Emma Park—survival, production, and habitat use in relation to coalbed methane development. Utah Division of Wildlife Resources. December 2005.

Danvir, R.E. 2002. Sage grouse ecology and management in northern Utah sagebrush-steppe. Woodruff, Utah: Deseret Land and Livestock Ranch and the Foundation for Quality Resource Management.

Doherty, K.E., D.E. Naugle, B.L. Walker. 2010. Greater sage-grouse nesting habitat: the importance of managing at multiple scales. *Journal of Wildlife Management* 74(7):1544–1553.

Doherty, K.E., D.E. Naugle, B.L. Walker, and J.M. Graham. 2008. Greater sage-grouse winter habitat selection and energy development. *Journal of Wildlife Management* 72(1):187–195

Dzialak, M.R., C.V. Olsen, S.M. Harju, S.S. Webb, J.P. Mudd, J.B. Winstead, and L.D. Hayden-Wing. 2011. Indentifying and prioritizing greater sage-grouse nesting and brood-rearing habitat for conservation in human-modified landscapes. PLoS ONE 6(10): e26273. doi:10.1371/journal.pone.0026273.

Eng, R.L., and P. Schladweiler. 1972. Sage grouse winter movements and habitat use in central Montana. *Journal of Wildlife Management* 36:141–146.

Gregg, M.A., J.A. Crawford, M.S. Drut, and A.K. DeLong. 1994. Vegetative cover and predation of sage-grouse nests in Oregon. *Journal of Wildlife Management* 58:162–166.

Holloran, M.T., and S.H. Anderson. 2005. Spatial distribution of greater sage-grouse nests in relatively contiguous sagebrush habitats. *The Condor* 107:742–752.

Johnson, D.H., M.J. Holloran, J.W. Connely, S.E. Hanser, C.L. Amundson, and S.T. Knick. 2011. Influences of environmental and anthropogenic features on greater sage-grouse populations, 1997–2007. In *Greater Sage-grouse Ecology and Conservation of a Landscape Species and its Habitats*, edited by S.T. Knick and J.W. Connelly, pp. 407–450. Berkeley: University of California Press.

DRAFT

LaGory, K.E., Y. Hamada, P.F. Tarpey, E.B. Levine, C.C. Weber, L.J. Walston, and D.J. LePoire. 2012. *A Spatially Explicit Individual-Based Modeling Approach to Evaluate the Cumulative Effects of Wind Energy Development on the Greater Sage-grouse*. Prepared by Argonne National Laboratory, Argonne, IL, for the U.S. Department of Energy, Washington, D.C. September 2012. 56 pp.

Lincoln County Sage Grouse Technical Review Team. 2004. *Lincoln County Sage Grouse Conservation Plan*. Nevada. Available online at http://www.ndow.org/wild/conservation/sg/plan/SGPlan063004_R.pdf. Accessed January 2012.

Nisbet, R.A., S.H. Berwick, and K.L. Reed. 1983. A spatial model of sage grouse habitat quality. *Developments in Environmental Modeling* 5:267–276.

Perkins, C.J. 2010. Ecology of isolated greater sage-grouse populations inhabiting the Wildcat Knolls and Horn Mountain, Southcentral Utah. M.S. thesis, Utah State University, Logan.

Petty, S.J. 1995. Assessment of fence collisions by grouse species in Scotland. Forestry Commission Research Information Note 264.

Pruett, C.L., M.A. Patten, and D.H. Wolfe. 2009. Avoidance behavior by prairie grouse: implications for development of wind energy. *Conservation Biology* 23:5:1253–1259.

Robinson, J.D. 2007. Ecology of two geographically distinct greater sage-grouse populations inhabiting Utah's West Desert. M.S. thesis, Utah State University, Logan.

Rogers, G.E. 1964. *Sage Grouse Investigations in Colorado*. Technical Bulletin No. 16. Denver: Colorado Game, Fish and Parks Department.

Stevens, B. 2011. Impacts of fences on greater sage-grouse in Idaho: collision, mitigation, and spatial ecology. M.S. thesis, University of Idaho, Moscow.

Stevens, B.S., J.W. Connelly, and K.P. Reese. 2012a. Multi-scale assessment of greater sage-grouse fence collision as a function of site and broad scale factors. *Journal of Wildlife Management* 76(7):1370–1380.

Stevens, B.S., K.P. Reese, J.W. Connelly, and D.D. Musil. 2102b. Greater sage-grouse and fences: does marking reduce collisions? Wildlife Society Bulletin 36:297-303.

Stevens, B.S., D.E. Naugle, B. Dennis, J.W. Connelly, T. Griffiths, and K.P. Reese. 2013. Mapping sage-grouse fence-collision risk: Spatially-explicit models to target conservation implementation. *Wildlife Society Bulletin* 37(2):409-415.

Stiver, S.J., E.T. Rinkes, and D.E. Naugle. 2010. Sage-grouse habitat assessment framework. Unpublished report. Boise, Idaho: Bureau of Land Management, Idaho State Office.

Wallestad, R.O., and D.B. Pyrah. 1974. Movement and nesting of sage grouse hens in central Montana. *Journal of Wildlife Management* 38:630–633.

Walker, B.L., D.E. Naugle, and K.E. Doherty. 2007. Greater sage-grouse population response to energy development and habitat loss. *Journal of Wildlife Management* 71:2644–2654.

DRAFT

Wiebe, K.L., and K. Martin. 1998. Costs and benefits of nestcover for ptarmigan: changes within and between years. *Animal Behaviour* 56:1137–1144.

Wisdom M.J., C.W. Meinke, S.T. Knick, and M.A. Schroeder. 2011. Factors associated with extirpation of sage-grouse. In *Greater Sage-grouse Ecology and Conservation of a Landscape Species and its Habitats*, edited by S.T. Knick and J.W. Connelly, pp. 451–474. Berkeley: University of California Press.

Wolfe, D.H., M.A. Patten, E. Shochat, C.L. Pruett, and S.K. Sherrod. 2007. Causes and patterns of mortality in lesser prairie-chickens (*Tympanuchus pallidicinctus*) and implications for management. *Wildlife Biology* 13 (Suppl. 1):95–104.

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APPENDIX B

Quantification of Baseline Habitat Service Level

Text is excerpt from the TWE Project HEA Plan.

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QUANTIFICATION OF BASELINE HABITAT SERVICE LEVEL

The pre-construction baseline of the habitat services will be based on existing datasets to the extent possible. It is not anticipated that additional data collection will be necessary to complete the HEA. The baseline service level will be determined by applying the habitat service metrics described in Appendix A to the Assessment Area that is identified for the TWE Project. The Assessment Area will include the footprint of the project and a buffer around the footprint, because greater sage-grouse (*Centrocercus urophasianus*) habitat service losses are expected to extend beyond the area of direct disturbance. For the TWE Project, this buffer will be clipped to the Bureau of Land Management's (BLM) Priority General Habitat (PGH) boundaries.

ESRI ArcGIS ArcInfo 10.X, Spatial Analyst, and ModelBuilder software and tools will be used to conduct analyses. To facilitate calculations across the entire assessment area, it is anticipated that all data will be converted to a raster/grid format. Raster or grid algebra processing is significantly faster for an analysis of this size.

PREPARATION OF GIS MODEL INPUT LAYERS

Habitats within and surrounding the corridor for the preferred alternative will be summarized in a series of representative raster layers for the eight additive metric variables (see Appendix A). These eight variables consist of data representations within the TWE Project Area for human disturbance, landscape characteristics, proximity to greater sage-grouse lek locations, and vegetation characteristics that may influence the use of habitat by greater sage-grouse. A spatial resolution of 30-meters is anticipated to be sufficient to capture a 'landscape level' perspective of habitat across the Assessment Area.

Representative raster data will be created for each additive variable in the HEA metric (Appendix A). Scores for each cell in each raster will be assigned per the variable scores listed in Table A1 of Appendix A. In addition, a raster layer will be developed that locates fences and their relative collision risk during the lekking season. The following sections describe the datasets anticipated to be necessary to describe each of these variables:

Lands Assigned No Habitat Value

As described in Appendix A, land cover types and terrain features that do not provide suitable habitat for greater sage-grouse will be removed from the HEA model. All vegetation types and landforms that potentially provide habitat for greater sage-grouse will remain in the model.

Distance to Roads (VAR01 and VAR02)

Road layers used in developing the baseline HEA model are available from the BLM, Forest Service, state agencies, or from readily available standard road and infrastructure layers (e.g., TIGER data from the U.S. Census Bureau). Road layers will be compared between states to ensure consistency in classification

prior to using them in the HEA model development. HEA model scores will be applied to 30-meter raster cells according to the process described in Table A1, Appendix A. For example, all cells that are more than 1,000 meters from interstate highways or high traffic volume state and federal highways (>6,000 AADT) will be given a score of 3, those between 650 and 1,000 meters will be given a score of 2, those between 100 and 650 meters will be given a score of 1, and those cells within 100 meters will be assigned a value of 0 habitat services (no habitat value) in the model per the description provided Appendix A (Metric of Greater Sage-grouse Habitat Services).

Percent Slope (VAR03)

Slope will be calculated using 30-meter digital elevation models and scored according to the process described in Appendix A.

Distance to Lek (10-year Average Count >0 Males) (VAR04)

Lek data will be obtained from the wildlife management agencies in each state. Lek status will be determined for all leks. Leks that have been active in the past 10 years or that have an unknown status will be included in the HEA model. Those that are labeled as unoccupied or inactive will not be included. Cells surrounding leks will be scored according to the methods described in Appendix A with cells closest to leks receiving the highest scores.

Sagebrush Abundance Index (VAR05)

A sagebrush abundance index will be determined from available vegetation layers by calculating the proportion of sagebrush in a 1-km^2 area surrounding each 30-meter cell in the assessment area. Scores will be applied using the methods described in Appendix A. Areas with a high proportion of sagebrush in the landscape and some habitat heterogeneity will be score higher than areas with little habitat heterogeneity or areas with little or no sagebrush.

Sagebrush Cover, Sagebrush Canopy Height (VAR06 and VAR07)

When possible, percent cover and height will be determined directly from the vegetation attribute data included in the GAP and Landfire vegetation datasets. Where data are not available, attributes for percent cover and height will be determined using other data sources. Sampling data from GAP/Landfire datasets as well as datasets obtained from BLM and the state agencies will be used to attribute vegetation percent cover and height for segments of the landscape with the most similar characteristics. Once vegetation values have been applied to the 30-meter grid, HEA scores will be applied using the methods described in Appendix A.

Distance to Vegetation Dominated by Sagebrush or Shrub (VAR08)

The distance from each cell to the nearest sagebrush or shrub dominated cell will be calculated. Cells within or closest to sagebrush or shrub landscapes will be scored higher than those that are distant from shrub-dominated cells.

Fences that Pose a High Risk for Collision (Adjustment Factor)

A raster file will be produced by running the Stevens et al. 2013 model as described in Appendix A to estimate the greater sage-grouse collision risk during the lekking season within 3 km of leks. The Stevens et al. 2013 model does not consider actual fence locations, so a separate fence location dataset will be intersected with the results of the model to identify actual locations of high collision risk.

Fence locations will be used if the data are available for the entire assessment area. In the event that fence data are not available, grazing allotment boundaries will be used as surrogates for fence layers in the HEA baseline model development.

After the model results and fence layer are intersected, cells in the resulting raster file will be assigned to different score adjustment factors as described in Appendix A. Every cell with a fence running through it that is located within 3 km of a lek will have an estimated number of collisions per lekking seasons. If the estimate is between 0 and 0.39, the adjustment factor will be 0.75. If the estimate is between 0.40 and 0.99, the adjustment factor will be 0.50. If the estimate is 1.0 or above, the adjustment factor will be 0 (i.e., cells containing the highest risk fences have no habitat value).

SUMMATION OF BASELINE SERVICES IN THE HEA MODEL

Spatial grids representing the above HEA variables will be combined through additive and multiplicative raster calculations to create a final raster layer. A simple additive overlay process will be used to calculate the HEA metric value for each cell. The value of each cell will be the sum of VAR01 through VAR08. The resulting value will be multiplied by 0 or 1 to remove all vegetation types that do not provide habitat for greater sage-grouse (e.g., urban areas, roadways, forests) and to retain those habitats that do provide value for greater sage-grouse. This value will be multiplied by the Fence Collision Adjustment Factor if it is located within 3 km of a lek. The final numeric value for each cell is the habitat services provided to greater sage-grouse by that cell.

The resulting habitat service values and the number of acres associated with each of the habitat service values will be multiplied together and summed across the assessment area to calculate the total habitat services (expressed in service acres) (Equation 1). The total habitat services provided by the Assessment Area will be calculated and will serve as the pre-construction baseline for the TWE Project.

Equation 1.

$$VJ = \sum_{1}^{i} (V_i * J_{V_i})$$

where:

VJ is the habitat services (service-acres) provided by the Assessment Area,

V is the habitat service score (i.e., the sum of the variable scores in the habitat service metric),

i is the number of possible unique values for *V*, and

J_{V_i} is the number of acres for each value of V_i , where $\sum_1^i J_{V_i}$ would equal the total acreage of the Assessment Area (*J*).

LITERATURE CITED

Stevens, B.S., D.E. Naugle, B. Dennis, J.W. Connelly, T. Griffiths, and K.P. Reese. 2013. Mapping sage-grouse fence-collision risk: Spatially-explicit models to target conservation implementation. *Wildlife Society Bulletin* 37(2):409-415.

APPENDIX C

Quantification of Habitat Service Losses

Text is excerpt from the TWE Project HEA Plan.

QUANTIFICATION OF HABITAT SERVICE LOSSES

Habitat service losses caused by the TWE Project will be modeled using geographic information system (GIS) technology for important TWE Project milestones by decreasing the variable scores for the habitat services metric below the Baseline level in the footprint of the TWE Project (direct disturbances) and in buffers around the footprint (indirect disturbances). The habitat service scores for each milestone will be summed across the Assessment Area to calculate the estimated interim and permanent habitat service losses associated with the TWE Project.

DESCRIPTION OF DISTURBANCES BY TWE PROJECT MILESTONE

The habitat services provided by the Assessment Area will be measured at several different TWE Project milestones that reflected varying levels of disturbance.

The TWE Project milestones modeled for the HEA will be:

1. **Baseline**—the baseline milestone quantifies habitat services available to greater sage-grouse before disturbance. The calculation of the habitat services available to greater sage-grouse at Baseline is described in Appendix B.
2. **Construction—**the transmission line construction milestone quantifies habitat services available to greater sage-grouse during the construction of the TWE Project.
3. **Restoration**—the restoration milestone quantifies habitat services available to greater sage-grouse after TWE Project construction is complete and some services return with the reduction in noise and human presence.
4. **Recovery**—the recovery milestone quantifies habitat services available to greater sage-grouse after a vegetation type has recovered to the greatest extent expected after TWE Project restoration is complete. Habitat services return to baseline conditions in restored areas with the time to recovery being dependent on the vegetation type. It is anticipated that there will be multiple vegetation-based recovery endpoints. Vegetation recovery endpoints will be determined upon identification of the vegetation communities impacted by the TWE Project.

QUANTIFYING LOSS OF HABITAT SERVICES DUE TO SURFACE DISTURBANCE DURING CONSTRUCTION

For the Construction milestone, direct disturbances will be defined as the loss of habitat services associated with vegetation removal and ground disturbing activities within the construction footprint (Table C1). The habitat service scores for all 30-m^2 raster cells in the TWE Project footprint where vegetation removal or ground disturbance occur will be changed from the Baseline service scores to 0 in the GIS model for this milestone. Recovery from the disturbed state will be applied per the vegetation-specific recovery curves for the TWE Project.

Table C1. Direct Disturbance Levels Modeled by TWE Project Milestone and Disturbance Type

Project Milestones	Percent Baseline Services Present by Direct Disturbance Type		
	AC/DC Converter Station	**Transmission Towers**	**Access Roads, Transmission Lines, and Temporary Infrastructure**
Baseline	100%	100%	100%
Construction	0%	0%	0%
Restoration	0%	0%	0%
Progressive Vegetation Recovery	0%	0% within permanent tower footprint (500 ft^2 for a guide lattice tower, which is 5.2% of a 30-m cell) Elsewhere baseline services will be retuned per the vegetation-specific recovery curves developed for the Project.	Baseline services will be retuned per the vegetation-specific recovery curves developed for the Project.

QUANTIFYING LOSS OF HABITAT SERVICES DUE TO INDIRECT DISTURBANCES DURING CONSTRUCTION

Indirect disturbances will be simulated by applying buffers to the construction footprint and decreasing the habitat service scores below the Baseline habitat service scores within the buffers. Because of uncertainties in the indirect impacts of transmission on greater sage-grouse, at this time, noise and human presence will be the only indirect disturbance modeled in the HEA.

Use of construction equipment such as backhoes, cranes, front-end loaders, bulldozers, graders, excavators, compressors, generators, and various trucks would be needed for mobilizing crew, transportation and use of materials, line work, site clearing, and preparation during the construction phase of the TWE Project. Construction of and improvements to access roads would require use of earthmoving equipment such as bulldozers and graders. Table C2 provides the typical noise levels for the construction equipment that could potentially be used during the construction phase of the TWE Project (ranging 80 to 90 A-weighted decibels [dBA] at 50 feet [15 meters (m)] from any work site).[2]

Table C2. Typical Noise Levels from Construction Equipment

Equipment Type	Noise Level at 50 feet (dBA)
Crane	88
Backhoe	85
Pan loader	87
Bulldozer	89

[2] Construction noise values taken from Energy Gateway West HEA report.

Fuel truck	88
Water truck	88
Grader	85
Roller	80
Mechanic truck	88
Flatbed truck	88
Dump truck	88
Tractor	80
Concrete truck	86
Concrete pump	82
Front end loader	83
Scraper	87
Air compressor	82
Average construction site	85

Noise during the construction phase of the TWE Project would be similar in magnitude to noise produced by vehicles using secondary roads (county highways, state highways, and heavily travelled gravel roads [e.g., access roads for oil and gas development, mining, etc.]). Passenger vehicles, medium trucks, and heavy trucks going 55 miles per hour (mph) produce typical noise levels of 72 to 74 dBA, 80 to 82 dBA, and 84 to 86 dBA, respectively, from a distance of 50 feet. Therefore, the noise disturbance associated with construction will be modeled as if the construction area was a secondary road (Table C3).

In the model, buffers will be placed around active construction areas in a manner that is identical to the methods used for secondary roads. The cells that fall within these buffers will be scored in a manner identical to a secondary road (i.e., the score for VAR02 decreased).

Table C3. Indirect Disturbance Levels Modeled by TWE Project Year and Disturbance Type

Project Milestones	Indirect Disturbance Buffers Applied by Disturbance Type		
	AC/DC Converter Station	**Transmission Towers**	**Access Roads, Transmission Lines, and Temporary Infrastructure**
Baseline	None	None	None
Construction	Secondary Road	Secondary Road	Secondary Road
Restoration	Secondary Road	None	None
Progressive Vegetation Recovery	Secondary Road	None	None
	Secondary Road	None	None
	Secondary Road	None	None
	Secondary Road	None	None

QUANTIFYING HABITAT SERVICES LOSSES DURING RESTORATION AND RECOVERY

TWE Project-related habitat service losses are anticipated to decrease once construction is complete. Although still below baseline levels, the habitat service scores rise during restoration and recovery with vegetation regrowth (direct disturbances) and decreased levels of noise and human presence (indirect disturbances).

Restoration Milestone

For the Restoration milestone, direct disturbances will be defined as the loss of all habitat services in the construction footprint where vegetation clearing and ground disturbance occurs because the vegetation has not regrown sufficiently to provide habitat (see Table C1).

The indirect disturbance buffers that are applied to the power conversion terminal during construction will remain during the restoration milestone and for the life of the TWE Project because of the noise human activity associated with operation of the facility. No indirect disturbances will be modeled for the rest of the TWE Project because little vehicle traffic or human presence is anticipated in these areas after construction of the line is complete.

Progressive Recovery Milestone

For the Recovery milestone, direct disturbances will be defined as the loss of all habitat services in the footprint of the transmission structure pads and the partial loss of services in areas of vegetation regrowth (see Table C1). Indirect disturbances will be applied in a manner identical to the Construction milestone (see Table C3).

Habitat services in areas where the vegetation is reclaimed (i.e., outside the footprint of permanent facilities) will gradually return to baseline conditions at a rate dependent on the vegetation type. Services will return more rapidly for vegetation having rapid recovery rates (e.g., agriculture, wetland, grassland, or riparian) than for those with slower recovery times (e.g., shrub-dominated including sagebrush). Vegetation recovery curves will be developed for the vegetation communities that are impacted by TWE Project activities.

To calculate the progressive return of services, the percentage of the baseline service value for a cell will be calculated based on the appropriate vegetation recovery curve. For example, in those vegetation types with rapid restoration potential (agricultural areas, some grasslands, etc.), habitat services could be returned to 100% of Baseline in the first year following construction. Those with longer recovery times may only achieve partial service returns per year until achieving their maximum value. For example, a vegetation community with a 50 year recovery period might achieve 10% value in year 5 after restoration, 20% in year 10, 30% in year 15, etc. until all services are returned in year 50.

HEA TO QUANTIFY INTERIM AND PERMANENT HABITAT INJURIES

The approach described above will produce a measure of habitat services (in service-acres) for each of the TWE Project milestones for each of the modeled project segments. The HEA is a stepwise model which quantifies the habitat injury separately in each year (Figure C1) and each of the milestones will be assigned to a calendar year per the schedule provided by TransWest after the preferred alternative is identified. It is likely that a linear change in habitat services will be used to estimate annual service-acre increases between restoration and recovery and between the vegetation-specific recovery times. The total number of service-acres lost per year will be summed across the analysis period and expressed as service-acre-years. This value is the estimated sum of the interim and permanent losses to greater sage-grouse habitat that would occur as a result of the TWE project construction, operation, and maintenance.

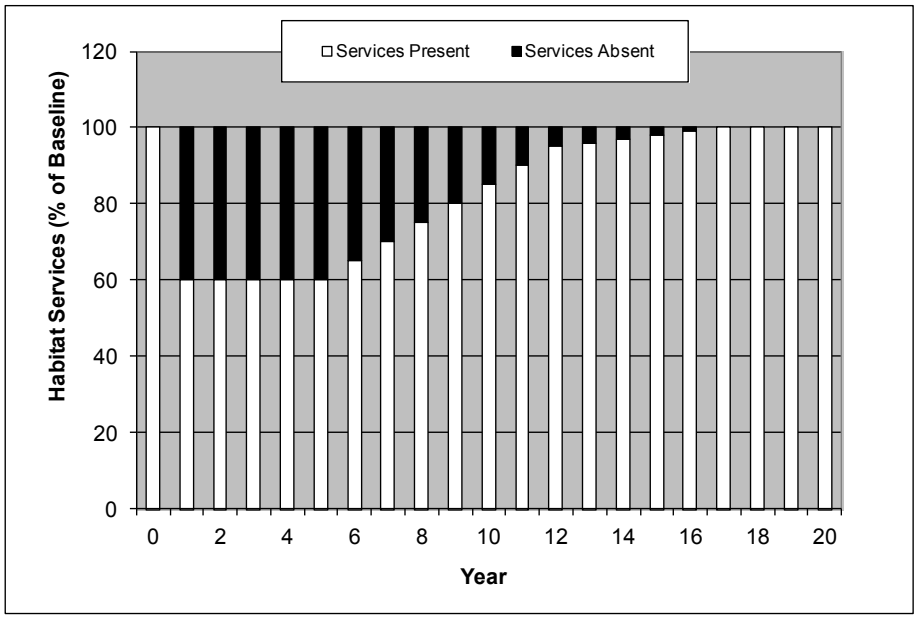

Figure C1. Hypothetical example of how the HEA model considers habitat services absent and habitat services present in each year to calculate the total services lost over the Project period (i.e., sum of the black bars).

The HEA model balances the cumulative injury (*I*, service-acre-years) over the lifetime of the TWE Project with the cumulative benefit of habitat restoration and mitigation (*R*, service-acre-years), so that the services returned by habitat restoration and mitigation are greater than or equal to the cumulative injury ($R \geq I$). The habitat injury (*I*, service-acre-years) will be quantified for the life of the TWE Project using Equation 2. Equation 2 was adapted from Equation 8.1 in Allen et al. (2005). The discount rate (*r*) is anticipated to be set to 3%, which is standard for this type of analysis. The discount rate converts services being provided in different time periods into current time period equivalents (Allen et al. 2005). The discount rate effectively weighs the habitat service losses so that losses occurring early in the TWE Project result in a greater overall injury than losses occurring later

in the project. Likewise, habitat restoration and mitigation occurring early in the TWE Project would result in a greater benefit than habitat restoration and mitigation occurring late in the project.

Equation 2. $$I = \sum_{t=0}^{y} JV^{j} * \rho_{t} * \left[(b^{j} - x_{t}^{j}) / b^{j} \right]$$

where:

I is the present value of the service-acre-years lost over *y* due to interim and permanent injury,

t = 0 is the year the TWE Project begins,

y is the analysis period, in years (e.g., 107),

JV^j is the value of the habitat services provided by the injured habitat (service-acres) before injury (i.e., at the Baseline milestone),

b^j is the mean service score provided by the Assessment Area (JV^j/J, where J is the injury Assessment Area in acres) at the Baseline milestone (time [*t*] = 0),

ρ_t is the discount factor, where $\rho_t = 1/(1+r)^{t-C}$, where *r* is the discount rate for the time period and *C* is the time the claim is presented (*C* = Project Year 1), and

x_t^j is the mean service score provided by the Assessment Area at the end of year *t* if TWE Project disturbances are applied.

LITERATURE CITED

Allen, P.D. II, D.J. Chapman, and D. Lane. 2005. Scaling environmental restoration to offset injury using habitat equivalency analysis. In *Economics and Ecological Risk Assessment: Applications to Watershed Management*, edited by R.F. Bruins and M.T. Heberling, pp. 165–184. Boca Raton, Florida: CRC Press.

Baker, W.L. 2006. Fire and restoration of sagebrush ecosystems. *Wildlife Society Bulletin* 34:177–185.

Bunting S.C. 2002. Natural and prescribed fires in big sagebrush steppe – response of individual species and implications to burning practices. Restoration and Management of Sagebrush/Grass Communities. Elko, Nevada.

Bureau of Land Management (BLM). 2011. *Draft Environmental Impact Statement for the Gateway West Transmission Line Project, Wyoming, Idaho, and Nevada*. Cheyenne, Wyoming: U.S. Department of the Interior, Bureau of Land Management, Wyoming State Office. July 2011.

Cooper, S.V., P. Lesica, and G.M. Kudray. 2007. *Post-Fire Recovery of Wyoming Big Sagebrush Shrub-Steppe in Central and Southeast Montana*. Prepared for U.S. Department of the Interior Bureau of Land Management. Helena, Montana: Montana Natural Heritage Program.

U.S. Geological Survey. 2007. The National Map LANDFIRE: LANDFIRE National Fire Regime Condition Class layer. Last updated 2007. U.S. Department of the Interior, Geological Survey. Available at http://gisdata.usgs.net/website/landfire/. Accessed August 2009.

Wambolt, C.L., K.S. Walhof, and M.R. Frisina. 2001. Recovery of big sagebrush communities after burning in south-western Montana. *Journal of Environmental Management* 61:243–252.

APPENDIX D

Quantification of Habitat Service Gains Produced by Habitat Restoration and Mitigation Measures

Text is excerpt from the TWE Project HEA Plan.

MODELING MITIGATION PROJECT HABITAT SERVICE GAINS

Habitat restoration and conservation measures are intended to create new, or protect existing, greater greater sage-grouse habitat services (Table D1). These measures serve as a "toolbox" from which mitigation projects may be selected by TransWest for inclusion in a mitigation package once the BLM has identified the preferred alternative and final HEA results are available for that alternative. The purpose of the mitigation projects is to offset the cumulative greater sage-grouse habitat service losses in the Assessment Area over the TWE Project lifetime (i.e., *I* in Equation 2 from Appendix C). The HEA will used to evaluate the benefit of a sample of conservation measures in the Assessment Area.

Table D1. Potential Habitat Restoration and Conservation Measures for Inclusion in the HEA.

Measure	Brief Conservation Measure Description	Anticipated Benefits
Fence removal and marking with flight diverters	Fences would be removed or marked in: 1) Sections of fence known to cause greater sage-grouse collisions, 2) Fences within 2 km (1.2 mi) of leks (Braun 2006; Stevens 2011) or other high risk area, 3) Fences in areas with low slope and terrain ruggedness (Stevens 2011), and 4) Fence segments bounded by steel t-posts with spans greater than 4 m (Stevens 2011).	• Reduce mortality due to greater sage-grouse collisions • Increase visibility of fences • Increase contiguous patches of shrub-steppe habitat • Remove localized grazing pressure and increase habitat
Sagebrush restoration and improvement projects	Seeding, planting seedlings, or transplanting containerized sagebrush plants (one plant per 5 m^2) and seeding a bunchgrass understory.	• Create contiguous patches of shrub-steppe habitat with optimal sagebrush cover and height and a bunchgrass understory • Increase availability of high quality nesting, brood rearing, and winter habitats
Juniper/conifer removal	Mechanical removal (lop and scatter, cut-pile-cover, or mastication) of juniper/confer adjacent to areas with optimal sagebrush cover and height	• Reverse juniper/conifer encroachment on shrub-steppe habitat to increase contiguous patches of greater sage-grouse habitat • Increase light penetration to support a forb and grass understory
Conservation easements	Removes threat of specific land uses to sensitive wildlife populations	• Prevent greater sage-grouse habitat destruction or degradation near urban areas and oil and gas development • Reduce future fragmentation of shrub-steppe habitat

GIS MODELING OF CONSERVATION BENEFITS

The analysis of habitat service benefits produced by each habitat restoration or mitigation measure in Table D1 will be completed using an approach similar to that described or quantifying habitat losses. It is necessary that both analyses (i.e., quantification of habitat service losses and habitat service gains) use the same habitat services metric (see Appendix A), the same unit of measure (service-acres and service-acre-years), the same analysis period, and the same discount rate. Figure D1 illustrates a hypothetical example of how mitigation would be added to the baseline service metric over time to derive an estimate of the service-acre-years provided by the mitigation measures that will be modeled for the TWE Project.

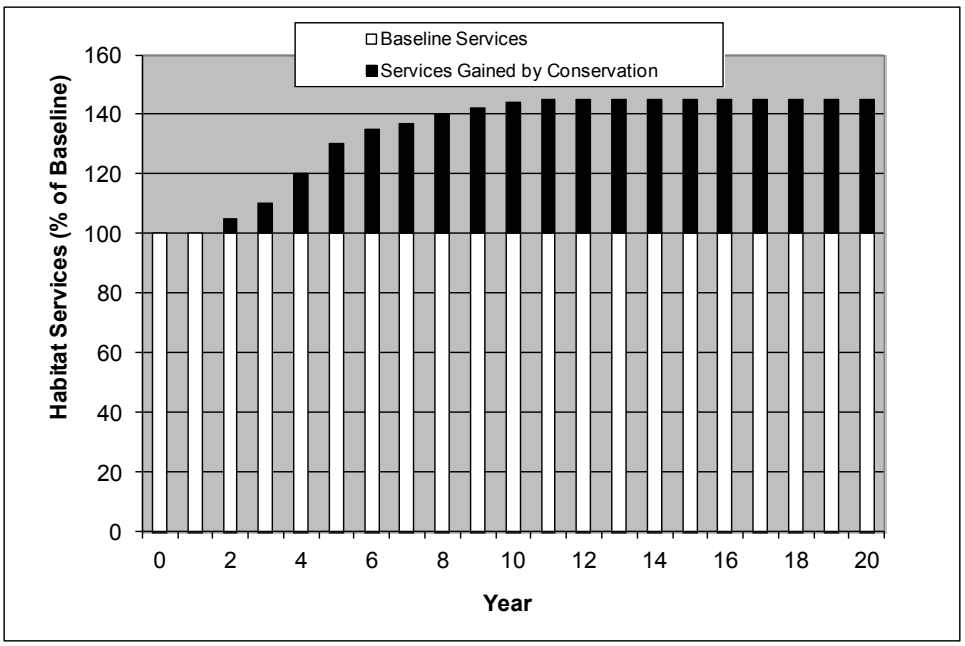

Figure D1. Hypothetical example of how the HEA model considers habitat services gained by habitat restoration and mitigation to calculate the total services gained over the project period (i.e., sum of the black bars).

Modeling Habitat Restoration and Mitigation Measures

Ideally, locations of possible habitat restoration and mitigation projects will be identified prior to finalization of the HEA process. In the event that these locations are not known, hypothetical habitat restoration and mitigation project areas will be used to estimate average habitat service gain.

Once actual or hypothetical habitat restoration and mitigation project locations are identified, variable scores in the HEA model will be changed to approximate the change in habitat services expected with implementation of the measure. The new habitat service score will be calculated for each cell in the Assessment Area using the same habitat services metric used to quantify baseline and impacts (see Appendix A). The habitat service benefit of a modeled mitigation project will be calculated by determining the difference in the habitat services provided at baseline and after implementation of the habitat restoration or mitigation measure.

For each habitat restoration/mitigation project, the time to full benefit and project initiation timing will be determined and accounted for in the HEA model to estimate of the present value habitat service gain that would be created. The present value habitat service gain (*R*, service-acre-years) will be quantified for the life of the TWE Project using Equation 3 (adapted from Equation 8.1 in Allen et al. 2005).

Equation 3.
$$R = \sum_{t=0}^{y} PV^{p} * \rho_{t} * \left[(x_{t}^{p} - b^{p}) / b^{p} \right]$$

where:

R is the present value of the service-acre-years gained by the habitat restoration or mitigation measure,

t = 0 is the year the transmission line TWE Project begins,

y is the analysis period, in years (i.e., 107),

PV^p is the value of the habitat services provided by the improved habitat (service-acres) before habitat restoration or mitigation measure (i.e., at the Baseline milestone),

b^p is the mean service score provided by the Assessment Area (PV^p/P, where *P* is the injury Assessment Area in acres) at the Baseline milestone (time [*t*] = 0),

ρ_t is the discount factor, where $\rho_t = 1/(1+r)^{t-C}$, where *r* is the discount rate for the time period and *C* is the time the claim is presented (*C* = Project Year 1), and

x_t^p is the mean service score provided by the Assessment Area at the end of year *t* if habitat restoration or mitigation measure benefits are applied.

The present value habitat service gain (*R*) will be standardized among mitigation project types by dividing by size of mitigation project (units in acres or linear mile depending on the conservation measure modeled) and averaged among hypothetical projects applying the same conservation measure to produce the service-years gained per unit of treatment ($\overline{R}^m$). This value will be used in mitigation calculations.

ESTIMATING COST TO IMPLEMENT MODELED HABITAT RESTORATION AND MITIGATION MEASURES

The cost of the modeled habitat conservation measures will be estimated by averaging the known cost of similar mitigation projects previously implemented (in current year U.S. dollars). The cost per unit treated will be divided by the average service-acre-years per unit area treated (calculated in the previous section), to estimate the price per service-acre-year gained for each of the habitat restoration and mitigation measures. This is the currency that will be used to offset the permanent and interim habitat service losses associated with the TWE Project's construction, operation, and maintenance for the lifetime of the TWE Project.

APPROACH TO OFFSET HABITAT SERVICE LOSSES WITH HABITAT SERVICE GAINS

An HEA scales the mitigation package (i.e., funding to create habitat services) to offset the loss of habitat services over the lifetime of the TWE Project. The injury is offset by planned habitat restoration and mitigation projects in Equation 4, where the mitigation project size (P^m) can be solved for each habitat restoration or mitigation measure type (*m*).

Equation 4 $$I = \sum_{m1}^{i} P^m * \overline{R}^m$$

where:

I is the present value of the service-acre-years lost over y due to interim and permanent injury,

i is the number of habitat restoration and mitigation measures modeled,

Pm is the size of the habitat restoration or mitigation project of type m (in units of acres or miles), and

$\overline{R}^m$ is mean service-years gained per unit (acres or miles) of treatment.

Once the P^m is defined for each habitat improvement and mitigation measure, the costs per unit can be applied. Mitigation due is the sum of the costs to implement each of the habitat improvement and mitigation projects needed to offset the TWE Project

APPENDIX E

Assignment of National Gap Analysis Program (GAP) Vegetation Classifications to Categories for HEA Modeling

VEGETATION CATEGORIZATION FOR HEA MODELING

Vegetation and other landcover types in the USGS GAP Land Cover Dataset were classified as providing habitat for greater sage-grouse or not providing habitat for greater sage-grouse. Vegetation types providing no habitat services to greater sage-grouse (Non-Habitat in Table E1) were assumed to require no mitigation in the HEA. Those vegetation types that are used by greater sage-grouse (Habitat in Table E1) were assigned to one of four modeled vegetation categories. Each of the modeled vegetation categories had a different vegetation recovery time in the HEA model.

Table E1. Vegetation categorization based on GAP landcover types

Vegetation Categories	GAP Vegetation: ECOLSYS_LU
Non-Habitat: Anthropogenic Disturbance and Open Water	Developed, High Intensity
	Developed, Low Intensity
	Developed, Medium Intensity
	Developed, Open Space
	Disturbed/Successional - Recently Chained Pinyon-Juniper
	Open Water (Fresh)
	Quarries, Mines, Gravel Pits and Oil Wells
Non-Habitat: Natural Vegetation	Colorado Plateau Mixed Bedrock Canyon and Tableland
	Colorado Plateau Pinyon-Juniper Shrubland
	Colorado Plateau Pinyon-Juniper Woodland
	Great Basin Pinyon-Juniper Woodland
	Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland
	Inter-Mountain Basins Cliff and Canyon
	Inter-Mountain Basins Juniper Savanna
	Inter-Mountain Basins Shale Badland
	Introduced Riparian and Wetland Vegetation
	Introduced Upland Vegetation - Annual Grassland
	Introduced Upland Vegetation - Perennial Grassland and Forbland
	Introduced Upland Vegetation - Treed
	North American Warm Desert Bedrock Cliff and Outcrop
	North American Warm Desert Lower Montane Riparian Woodland and Shrubland
	Recently Burned
	Rocky Mountain Alpine Bedrock and Scree
	Rocky Mountain Aspen Forest and Woodland
	Rocky Mountain Bigtooth Maple Ravine Woodland
	Rocky Mountain Cliff, Canyon and Massive Bedrock
	Rocky Mountain Foothill Limber Pine-Juniper Woodland
	Rocky Mountain Gambel Oak-Mixed Montane Shrubland

	Rocky Mountain Lodgepole Pine Forest
	Rocky Mountain Lower Montane Riparian Woodland and Shrubland
	Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland
	Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland
	Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland
	Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland
	Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland
	Western Great Plains Cliff and Outcrop
Habitat: Agriculture and Wetland (HEA assumed 1 year recovery time)	Cultivated Cropland
	Inter-Mountain Basins Playa
	North American Arid West Emergent Marsh
	North American Warm Desert Playa
	Pasture/Hay
	Rocky Mountain Alpine-Montane Wet Meadow
	Rocky Mountain Subalpine-Montane Mesic Meadow
	Western Great Plains Closed Depression Wetland
	Western Great Plains Open Freshwater Depression Wetland
	Western Great Plains Saline Depression Wetland
Habitat: Grassland and Riparian (HEA assumed 5 years recovery time)	Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland
	Inter-Mountain Basins Semi-Desert Grassland
	North American Warm Desert Riparian Mesquite Bosque
	North American Warm Desert Wash
	Northwestern Great Plains Mixedgrass Prairie
	Rocky Mountain Subalpine-Montane Riparian Shrubland
	Southern Rocky Mountain Montane-Subalpine Grassland
	Western Great Plains Riparian Woodland and Shrubland
Habitat: Sagebrush (HEA assumed 20 years recovery time)	Colorado Plateau Mixed Low Sagebrush Shrubland
	Great Basin Xeric Mixed Sagebrush Shrubland
	Inter-Mountain Basins Big Sagebrush Shrubland
	Inter-Mountain Basins Big Sagebrush Steppe
	Inter-Mountain Basins Montane Sagebrush Steppe
Habitat: Shrub Steppe (HEA assumed 100 years recovery time)	Great Basin Semi-Desert Chaparral
	Inter-Mountain Basins Active and Stabilized Dune
	Inter-Mountain Basins Curl-leaf Mountain Mahogany Woodland and Shrubland
	Inter-Mountain Basins Greasewood Flat

	Inter-Mountain Basins Mat Saltbush Shrubland
	Inter-Mountain Basins Mixed Salt Desert Scrub
	Inter-Mountain Basins Semi-Desert Shrub Steppe
	Mogollon Chaparral
	Mojave Mid-Elevation Mixed Desert Scrub
	Rocky Mountain Lower Montane-Foothill Shrubland
	Sonora-Mojave Creosotebush-White Bursage Desert Scrub
	Sonora-Mojave Mixed Salt Desert Scrub
	Wyoming Basins Dwarf Sagebrush Shrubland and Steppe