From:	Affonso, Jana
To:	Lee Corum; Ted Koch; Mary Grim
Subject:	Fwd: Revised Exhibit C
Date:	Tuesday, February 24, 2015 3:29:17 PM
Attachments:	image001.png Barrick BEA Exhibit C 2.24.15.docx

---------- Forwarded message ----------
From: **Sandi Snodgrass** <SSnodgrass@hollandhart.com>
Date: Tue, Feb 24, 2015 at 1:26 PM
Subject: RE: Revised Exhibit C
To: "Affonso, Jana" <jana_affonso@fws.gov>
Cc: Patrick Malone <pmalone@barrick.com>, Thomas Jensen <TCJensen@hollandhart.com>

Jana, please use the attached version instead of the version I sent earlier today. TNC caught a minor error in the table notes on page 8. The version I previously sent you included a management-threshold assumption of 100%, when it should have been 25%. My apologies for the inconvenience.

Sandi

From: Sandi Snodgrass
Sent: Tuesday, February 24, 2015 10:56 AM
To: 'Affonso, Jana'
Cc: Patrick Malone; Thomas Jensen
Subject: Revised Exhibit C

Jana, Patrick indicated you needed a revised version of Exhibit C that incorporates Lee's strikeout of the reference to the attached map. Here is that revised version.

Sandi

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Exhibit C

TNC Sage Grouse Conservation Forecasting Methodology

The Parties to the Barrick Mitigation Bank Enabling Agreement (BEA or Agreement) have agreed to use The Nature Conservancy's (TNC's) Sage Grouse Conservation Forecasting Methodology to calculate the credits attributable to the conservation measures that Barrick commits to undertake under the Agreement and the debits attributable to Barrick's plan of operations or other mining activities, once proposed. This Exhibit describes TNC's methodology and how it will be applied under the Agreement.

In brief, TNC's methodology uses six major steps to characterize greater sage-grouse (sage-grouse) habitat, including positive and negative changes in the habitat over time from specific causes, including temporary and permanent impacts from mining and conservation actions. The six methodological steps are:

1. Remote sensing and verification,
2. State-and-transition ecological departure modeling,
3. Integration of greater sage-grouse and other wildlife habitat suitability metrics,
4. Development of management scenarios,
5. Expert workshops to assess modeling and apply scenarios; and,
6. Calculation of return-on-investment from management actions.

Each of these steps is discussed below, including detailed descriptions of the different modeling tools used in TNC's methodology. This Exhibit concludes with a description of the work product that will be generated by TNC using the methodology, followed by citations to relevant literature.

I. Overview of TNC's Methodology

TNC's Sage Grouse Conservation Forecasting Methodology integrates state-and-transition ecological departure models with sage-grouse habitat suitability models. The approach uses uniform metrics to compare changes in habitat suitability (positive and negative) across locations and time. TNC's methodology uses well-established ecological modeling tools that have been developed or used widely by federal land and resource managers, including the Department of the Interior and U.S. Department of Agriculture's Natural Resources Conservation Service. TNC's methodology integrates those well-established models with the best information available today on sage-grouse habitat. The methodology will be applied in a collaborative manner, using a series of expert workshops and associated discussion processes.

TNC's methodology starts with remote sensing via Spot-6 satellite imagery (http://www.satimagingcorp.com/satellite-sensors/spot-6/) and fieldwork to collect site-specific habitat information. The satellite imagery is captured at a 1.5-meter resolution, meaning that each pixel covers an area of land 1.5 meters by 1.5 meters on a side (i.e., 2.25 square meters or 24.2 square feet). There are 1800 pixels of satellite imagery in each square acre, and 1.152 million pixels in each square mile. Each pixel is fine enough to capture one or two individual sagebrush plants.

The TNC methodology establishes the current value to sage-grouse of existing habitat in the study area using the metric of "Functional Acres," a term that takes into account vegetation classes and habitat suitability, as well as area (in acres or hectares) and location.[1] The methodology uses computer-based models to calculate the anticipated value of that same location in functional acres over a set time period as a result of natural processes and human-directed management actions. The models also calculate the expected increase or decrease in anticipated functional acres over the same period achieved by implementation of specifically identified alternative management scenarios, including both conservation actions and development projects. Any increases in functional acres are deemed to be "credits," and any decreases in functional acres are deemed to be "debits." This information will allow the Parties to the Agreement to determine reliably whether conservation actions achieve a "net benefit" to sage-grouse habitat as measured against impacts from mining activity.

The foundation of the methodology is high-resolution remote sensing to create maps of ecological systems and vegetation classes in the study area. TNC's Landscape Conservation Forecasting™ (LCF) platform applies computer-based state-and-transition models (described further below) to the maps to measure baseline ecological departure and to forecast changes to ecological departure that will result from particular management scenarios (including both conservation and development scenarios). Ecological departure is an index within the LCF platform that measures the difference between expected (pre-settlement) and observed vegetation for each ecological system in the study area. Low ecological departure is associated with healthy and resilient native vegetation.

The LCF modeling platform integrates the sage-grouse habitat suitability model developed by Dr. Jim Sedinger of the University of Nevada, Reno (UNR) to measure baseline sage-grouse habitat suitability and to forecast the effects of management scenarios on sage-grouse habitat suitability and population viability. In addition, the data acquired through this process could also be used to evaluate the effects of management scenarios on mule deer and golden eagle habitat suitability. The management scenarios evaluated by TNC through this process will specifically identify possible conservation measures in the BEA's Service Area (a geographic area defined in the BEA, and shown in Exhibit A), and the credits, measured in terms of functional acres, attributable to those conservation measures. Once Barrick has proposed a

[1] For purposes of achieving consistency with other policies, "acres" is being used as preferred unit of measure for spatial area under the BEA. At root, Functional Acres is a measure of Functional Area, and other units of area (e.g., square miles) would be equally valid.

mining plan of operations or other mining activity in the Service Area, TNC will use the same methodology to identify the debits, in terms of functional acres, attributed to the plan of operations or other activity.

The four basic metrics used to characterize the predicted effects of management scenarios are:

i. **Unified ecological departure**. This metric accounts for the needs of major species and ecological processes.

ii-iii. **Habitat suitability and functional area (in acres)**. These metrics are used to calculate baseline and predicted future sage-grouse habitat functionality in the study area, whereby each mapped pixel is assigned a probability from zero (non-habitat) to one (excellent) for suitability. Functional area is derived from habitat suitability and equates to the sum of all pixel values multiplied by their area, yielding habitat values in terms of acres.

iv. **Return-on-investment**. This metric within the LCF platform calculates the relative cost effectiveness of alternative management scenarios in terms of the costs associated with their predicted future habitat improvements relative to a "no-action" scenario.

The information generated through application of TNC's methodology will allow the parties to identify the quantitative relationship between the functional acres of sage-grouse habitat impacted by mining and the functional acres of sage-grouse habitat affected by conservation actions as needed for the purpose of providing compensatory mitigation under the Agreement.

II. Detailed Discussion of TNC's Methodology

TNC's integrated methodology involves six steps. Each of these steps is described below.

1. Remote Sensing

TNC will use high-resolution, satellite-based remote sensing to develop maps of potential vegetation types, or ecological systems, and current vegetation classes within these ecological systems. All ecological systems will be mapped to allow conservation planning for not only sage-grouse, but also mule deer and golden eagles. The scope of this analysis will require consideration of many ecological systems at all elevations. Current vegetation classes will include those found in TNC's state-and-transition models (described further below) and new mappable classes specific to sage-grouse habitat use (e.g., denser nesting vegetation distinct from late-successional big sagebrush vegetation). The elements of the vegetation mapping include: (1) the distribution of ecological systems—i.e., the dominant potential vegetation types expected in the physical environment under natural disturbance regimes; and (2) current vegetation succession classes of each ecological system.

Prior to initiating remote sensing, all ecological systems and their vegetation classes in the study area will be described in a short field-friendly document. The inventory of ecological systems will be extracted from Natural Resources Conservation Services (NRCS) soil surveys, consultation with local experts, reconnaissance surveys (where available), and staff expertise. The inventory of systems will also include physical surfaces that are not ecological systems (for example, active mines). Descriptions of vegetation classes in each ecological system are based on staff and local expertise and existing state-and-transition models. TNC will then assign the appropriate already-defined ecological systems and vegetation classes to each pixel in the study area.

The vegetation will be mapped from interpreted 1.5-meter resolution multispectral Spot-6 satellite imagery. This remote-sensing approach is capable of capturing naturally small systems, such as wet meadows, pinyon-juniper encroaching shrublands, and variation among late-succession classes, including denser sage-grouse nesting habitat. TNC will subcontract the remote sensing and interpretation to Spatial Solutions (Provencher et al. 2008; Low et al. 2010). TNC will provide Spatial Solutions with a description of ecological systems and assist in remote-sensing field verification surveys. The imagery will be clipped to the boundary defined by Barrick. Spatial Solutions will use the software Imagine® from Leica Geosystems to conduct an "iterative" unsupervised classification of imagery supplemented with manual editing.[2] This approach has proven more appropriate and successful for complex vegetation than object-based interpretation.

To support interpretation of spectral classes (Lillesand and Kiefer 2000), Spatial Solutions and TNC will conduct two field trips separated by at least three months to establish rapid site observations. An important goal of field surveys is to visit at least five locations for each unique spectral class. However, this is not always possible if a unique spectral signature is found in fewer than five locations.[3] Field surveys will focus nearly exclusively on geo-referenced road, hiking, and helicopter observations allowing the collection of more than 3,000 data points per field trip per moderate to large property. TNC will record, at a minimum, the identities of each ecological system and its vegetation class including geo-referenced photographs.

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[2] In unsupervised classification, the image processing software classifies an image based on natural groupings of the spectral properties of the pixels, without the analyst specifying how to classify any portion of the image. This is in contrast to supervised classification, in which the analyst defines "training sites"—areas in the map that are known to be representative of a particular land cover type—for each land cover type of interest to guide the assignment of classes to each pixel.

[3] A spectral signature is another name for the plot of the variations of reflected or absorbed electromagnetic radiation as function of wavelengths for a given material. This important property of matter makes it possible to identify different substances or classes and separate them by their spectral signatures.

The products of remote sensing are two map layers, one for ecological systems and one for vegetation classes. As explained below under state-and-transition modeling, these layers are separately uploaded into the simulation software. These two layers are then combined to create the classes that are used in state-and-transition models. The combined layers are required for estimating various ecological metrics, including vegetation species composition, vegetation structure, and ecological disturbance regimes (e.g., fire, insect outbreaks, drought-induced mortality, and others).

At least one year after map delivery, TNC will conduct an accuracy assessment of the ecological system layer (performed while collecting observations on vegetation classes). A constrained randomized stratified sampling design will be used to record new observations. Each stratum will be one ecological system, and TNC will attempt to record at least 30 ecological system and vegetation class observations per stratum, although more effort might be devoted to larger ecological systems if they showed heterogeneous spectral characteristics during remote sensing.

2. State-and-Transition Ecological Departure Modeling

Overview of Ecological Departure and Unified Ecological Departure

Conventional conservation planning methodologies often lack rigorous, consistent, and quantitative means for assessing: (1) current ecological conditions at a landscape scale; (2) likely future conditions under continuation of existing management actions; (3) the effectiveness of alternative management actions; and (4) the benefits and costs of alternative management actions.

TNC's Sage Grouse Conservation Forecasting Methodology uses ecological system condition and wildlife habitat suitability metrics that address the shortcomings associated with other methodologies. TNC's methodology uses "unified ecological departure" as the core metric to assess ecological systems.

An "**ecological system**" is similar to what the Natural Resources Conservation Service (NRCS) terms an "**ecological site,**" although multiple ecological sites with the same dominant indicator species can be grouped into one ecological system. The NRCS defines an ecological site as "a distinctive kind of land with specific physical characteristics that differs from other kinds of land in its ability to produce a distinctive kind and amount of vegetation."[4] For example, a site with loamy soil between 8 and 10 inches of precipitation and another site with gravelly loam between 8 and 10 inches of precipitation would both be grouped by TNC as a Wyoming big sagebrush ecological system as both sites are characterized by Wyoming big sagebrush. Ecological system is also synonymous with biophysical setting.

The ecological departure metric, described in greater detail below, was originally developed by the U.S. Forest Service (USFS) and then formalized under the auspices of the

[4] *National Forestry Manual*, www.nrcs.usda.gov/technical/ECS/forest/2002_nfm_complete.pdf.

national USFS-Department of the Interior-TNC program known as LANDFIRE.[5] Ecological departure is a broad-scale measure of ecological system "health"—an integrated, landscape-level estimate of the ecological condition of terrestrial and riparian ecological systems. For each ecological system, ecological departure considers vegetation species composition, vegetation structure, and ecological disturbance regimes (e.g., fire, insect outbreaks, drought-induced mortality, and others) to estimate an ecological system's departure from its reference**,** or historic, pre-European settlement condition (modeled reference conditions of natural disturbance regimes developed in the LANDFIRE program).

The "**reference**" condition, or "**natural range of variability (NRV)**," for a given ecological system is characterized by a modeled equilibrium distribution, or proportions, of all historic, or pre-European settlement vegetation classes with that system. "**Vegetation classes**" partly represent natural succession (i.e., differences in age), from early to mid to late succession, as well as open and closed canopy (i.e., differences in structure). As discussed further below, within a state-and-transition model succession classes for reference vegetation species are typically labeled as A, B, C, D, and E classes. Non-reference species, introduced as a result of post-settlement human causes, are known as "**uncharacteristic**" vegetation classes (typically termed "U classes"). Uncharacteristic vegetation includes, for example, invasive annual grasses and noxious weeds. Under reference conditions such uncharacteristic vegetation classes are absent. The presence of uncharacteristic vegetation indicates an ecological system has departed from its NRV, and is less than perfectly healthy.

"**Ecological departure**" calculates the difference between the estimated NRV of an ecological system and existing or current proportions of vegetation classes for that ecological system (or predicted future proportions). Ecological departure is scored on a scale of 0% to 100% departure from NRV: zero percent represents the NRV while 100% represents total departure.[6]

"**Unified ecological departure"** is a more generalized form of the traditional ecological departure metric, to which TNC recently added additional management elements that allow users to assign (a) special values to some very undesirable class of vegetation (for example, noxious weeds) and (b) thresholds to some desirable human-made vegetation classes that are created by restoration activities (for example, defining that at most 10% of the landscape seeded with introduced species, such as crested wheatgrass, will not result in ecological "penalties").

Whereas ecological departure considers all uncharacteristic classes as equally "bad," "unified ecological departure" allows for differential weighting of uncharacteristic vegetation

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[5] LANDFIRE originally referred to the metric, somewhat confusingly, as "Fire Regime Condition"; www.landfire.gov. The term has since been changed.

[6] A score of 33% or lower is typically considered to be low departure (i.e., close to reference status), moderate departure is found in the range from 34% to 66%, and high departure is a score of 67% or higher.

classes, as some may be worse than others, and some may even be desirable (e.g., non-native species that are intentionally introduced after a fire to prevent the spread of cheat-grass).

Example calculations of both ecological departure and unified ecological departure, for a simplified shrubland ecological system, are shown in the following table (equations are presented in footnotes). In the table, there are two reference classes (“younger” and “older”) and two uncharacteristic classes (“exotic species” and “introduced species seeding”) expressed by their current percentages in the landscape. Their respective NRVs are also shown. The first uncharacteristic class is undesirable and is expected to be expensive to restore. Therefore, the class has been assigned a “badness” level of 1, which resulted in a high-risk function value of -0.5 multiplying the observed percentage of the class to yield the effective observed percentage (see footnotes for formula). The other uncharacteristic vegetation class is an introduced species seeding that managers consider acceptable for wildlife management and for keeping cheatgrass to low levels. Managers in this hypothetical decided that no penalty will be incurred for an introduced species seeding if it does not exceed a 25% management threshold in the landscape. In this example, ecological departure and unified ecological departure are calculated, respectively, in the observed percentage and effective observed percentage columns. In the table, the presence of the introduced species seeding lowers unified ecological departure compared to the traditional ecological departure. The “bad” uncharacteristic class increases unified ecological departure (i.e., closer to 100% departure) beyond what is observed for ecological departure.

Simplified Shrubland Ecological System With Two Reference and Two Uncharacteristic Classes

Vegetation Class	“Badness” level (B = 0 to 2)[&]	Mgmt Threshold %	Reference or NRV %	Observed in Class %	Effective Observed %
Reference: Young	na	na	20	1	1
Reference: Older	na	na	80	59	59
Uncharacteristic: Exotic species	1	0	0	16	HRF ×16 = -0.5 × 16 = -8
Uncharacteristic: Introduced Species Seeding	0	25 (no penalty if ≤25%)	0	24	Min[25, 24] = 24
Ecological Departure (%)[#]				100 – 1 – 59 = 40	
Unified Ecological Departure (%)[@]					100 – 1 – 59 – (-8) – 24 = 24

[&] 0= not a high risk vegetation class; 1 = undesirable vegetation class and/or expensive to restore; 2 = extremely undesirable vegetation class and expensive to restore.

[#] Ecological Departure (ED) = 100% $- \sum_{i=1}^{R} \min\{Observed\%_i, NRV\%_i\}$

[@] Unified Ecological Departure (UED) =

$$Min(100, Max[0, ED - \sum_{i=R+1}^{U_{No-Thresh}} \min\{HRF_i \times Observed\%_i, 0\} - \sum_{j=U_{No-Thresh}+1}^{N} \min\{Threshold\%_j, Observed\%_j\}])$$

where R, $U_{no\text{-}Thresh}$, and N are, respectively, the order number of reference, undesirable without threshold value, and total vegetation classes, $Threshold_j$ is a user-supplied management threshold for class *j* (here, assumed 25% for simplicity), and *HRF* is the high-risk function of class *j* for different levels of "badness" (see below).

[^] Uncharacteristic vegetation class with a badness level >0 are assigned a high risk value based on the arbitrary function *HRF* selected based on desirable curve fitting properties. We chose a negative sigmoid function for *HRF*:

$HRF_j = -e^{c(B-1)}/(1 + e^{c(B-1)})$

where *c* is an arbitrary fitted coefficient (here 10) and B is the badness level from the table. HRF = 0, -0.5, and -1 for, respectively, values of B = 0, 1, and 2.

Overview of State-and-Transition Models

Along with the ecological departure metric, ecological models are a foundational element of TNC's LCF platform. The LCF platform uses ecological models to represent the vegetation classes and dynamics of each major ecological system. The dynamics are captured by assumptions about the frequency, duration, and magnitude of natural ecological disturbances (e.g., fire and drought) for each system. The models can be programmed to also include dynamics related to non-natural or anthropogenic ecological stress (e.g., invasive weeds), as well as the effects of various management actions on those dynamics. These models are generally referred to as state-and-transition models.

The LCF platform uses ecological models to *forecast* likely future conditions. Actual future conditions are certain to be different than what is forecast because actual disturbance events will be different than assumed events. For example, the best available science might suggest the fire return interval for a given ecological system is 100 years. Yet, only time will tell whether a fire will actually occur on a particular landscape site. However, when considered across a large area, a fire-return interval of 100 years will result in a predictable mix of vegetation classes in various successional states. Thus, the forecasts can be used to identify the management actions needed to achieve a desired future condition. The modeling exercise results in an implementation-specific management plan for achieving and maintaining improved ecological health.

Thus, state-and-transition models are used to estimate baseline ecological departure for each ecological system, and to simulate the future ecological departure that will result from particular management scenarios. Conceptually, a state-and-transition model is a discrete, box-and-arrow representation of the continuous variation in vegetation composition and structure of an ecological system (Horn 1975; Westoby et al. 1989; Bestelmeyer et al. 2004; Provencher et al. 2007). The classification of an ecological system is important for framing each state-and-transition model. The NRCS has formalized the definition of conceptual state-and-transition models, whereas TNC's method uses computer-based state-and-transition simulation models run with specialized computer software.

Conceptual State-and-Transition Models

Within a NRCS state-and-transition model developed for an ecological site, boxes represent the possible vegetation conditions of a parcel of land within an ecological system as either different (a) states or (b) phases within a state (Fig. 1). "**States**" are formally defined in rangeland literature as: "recognizable, relatively resistant and resilient complex with attributes that include a characteristic climate, the soil resource including the soil biota, and the associated above-ground plant communities." The associated plant communities are "**phases**" of the same state that can be represented in a diagram with two or more boxes. Relatively reversible changes (e.g., succession, fire, flooding, drought, insect outbreaks, herbivory, and others) operate between phases within a state. Phases are most often recognizable steps of succession, which is a naturally continuous process. Phases can also occur among uncharacteristic vegetation classes as a result of succession.

Different states are separated by at least one threshold. A threshold is often caused by European post-settlement disturbance (at least in North America and Australia) or species invasion that initially occurs in the reference state. Thresholds are defined by conditions sufficient to modify ecosystem structure and function beyond the limits of ecological resilience, resulting in the formation of alternative states. Crossing of thresholds usually indicates that substantial management effort is required to restore ecosystem structure and function to another state.

The reference state represents the dynamic vegetation phases resulting from a natural disturbance regime, including disturbances caused by indigenous populations, or approximate pre-settlement vegetation. A threshold also implies the creation of uncharacteristic vegetation classes, which often exist because of European post-settlement disturbances, changes in climate, or species invasions. Moreover, thresholds can occur between different uncharacteristic states, usually signaling increasing degradation of the ecological system. A monoculture of cheatgrass in a sagebrush shrubland is an example of an uncharacteristic vegetation class, which could be a phase or a state depending on model structure. Uncharacteristic vegetation classes can be formed of entirely native species (native uncharacteristic) or contain non-native plant species (exotic uncharacteristic), such as invasive cheatgrass. The following figure illustrates a state-and-transition model:

Figure 1 is a subalpine low sagebrush steppe state-and-transition simulation model from northern Nevada created in the ST-Sim software.

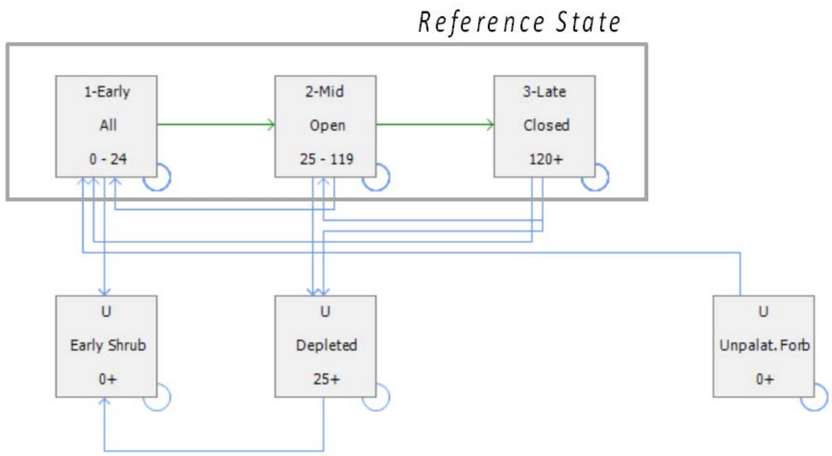

Figure 1. Subalpine low sagebrush steppe state-and-transition simulation model from northern Nevada created in the ST-Sim software. Class legend: Early = early-succession, Mid = mid-succession, Late = late-development, ESH = early-succession shrubs, Depleted = shrubland with an understory with <5% grass cover, Unpalat. Forb = Shrubland with a dominant herbaceous cover of unpalatable forbs, such as mule-ears). Structural legend: All = a variety of open to closed canopy, Open = open canopy, and Closed = closed canopy. Arrows originating from the side of boxes are successional pathways, whereas boxes originating from the top, bottom, or corner of boxes are disturbances, including management actions. The numbers in each box represents its range of succession ages. The upper row of three phases (i.e., states starting with Early, Mid, and Late) represent the reference condition (outlined by the rectangle). All other vegetation classes are uncharacteristic.

The other fundamental component of conceptual state-and-transition models is **"transitions"** representing either succession between phases or disturbances that alter the structure or composition of phases and, eventually, states. Transitions can be natural (e.g., fire, flooding) or managed (e.g., prescribed burning). Furthermore, natural disturbances can represent pre-settlement (e.g., surface fire) and European post-settlement (e.g., cheatgrass invasion) events. Most transitions are reversible given succession, natural disturbances, or management actions; however, some transitions can result in crossing of biotic or abiotic thresholds that irreversibly change either the diagnostic species composition of an ecological system (e.g., loss of aspen clones caused by prolonged fire exclusion or excessive herbivory) or the potential of a soil to support the ecological system due, primarily, to soil loss. Cheatgrass invasion is a good example of an irreversible transition and hence both conceptual state-and-transition models and corresponding state-and-transition simulation models are well suited to exploring related management questions.

Conceptual state-and-transition models are familiar to many students of natural resources because graphical, quantitative, and written models can all be represented by boxes and arrows or a written description. Graphical representation of states and transitions for different ecological systems are common not only in rangelands, but also in other systems such as reclaimed mine sites. These conceptual models provide a flexible approach for describing and documenting the vegetation dynamics associated with a particular ecosystem.

The NRCS has been nationally revising their ecological site descriptions to include conceptual state-and-transition models. This revision is on-going, including in Nevada, but incomplete. One benefit of the work under this Agreement would be to provide detailed state-and-transition models for the subject areas. These models can be graphical (box-and-arrow models with larger boxes for states and smaller nested boxes for phases), written descriptions of reference and uncharacteristic states, plus disturbances causing transitions between thresholds or a combination of both. The initial state depicted in NRCS models is the historic plant community (i.e., reference state) from which all other states are derived through natural and managed transitions. The reference state is based on the natural range of conditions associated with natural disturbance regimes and often includes several plant communities (phases) that differ in dominant plant species relative to type and time since disturbance.

NRCS ecological site descriptions are frequently used by Department of the Interior staff, in Nevada and elsewhere, for restoration project prescriptions (e.g., native seed mix) and National Environmental Policy Act documentation. Conceptual state-and-transition models generate non-quantitative general predictions about desirable and undesirable processes causing transitions between states at a site-specific level. A recent criticism of purely conceptual state-and-transition models is that they lack the ability to project state transitions that will be important in the future and link these to levels of conservation funding for management and restoration actions. By contrast, the TNC methodology models the specific effects of management and restoration actions.

State-and-Transition Simulation Models

State-and-transition simulation models begin with conceptual models, such as the ones described above. Before the models are applied, the landscape being simulated is subdivided into simulation cells, which can be non-spatial or spatially represented using a map. These models can be quantified with the following additional information: (1) an inventory, either spatial or non-spatial, of the vegetation conditions of the landscape at the start of the simulation, which describes the ecological system, and state class (state and phase) of each simulation cell in the landscape, and (2) a rate associated with each possible transition between state classes. Then, these transition rates can be further quantified using three general approaches: (1) probabilistic, with a specified probability at any point in time; (2) deterministic, occurring after a specified period of time in a state class has elapsed; or (3) with target areas assigned to occur on the landscape over time. The former two approaches are typically used to emulate natural processes such as disturbances and succession, whereas the latter is typically applied for management actions such as herbicide application. Computer software then uses the inventory of starting vegetation conditions and rates associated with each transition (and as affected by management actions) to project future vegetation conditions of the landscape, as well as occurrence of transitions over time.

In recent years there has been a proliferation of applications of quantitative state-and-transition simulation models to a diverse set of natural resource management problems in shrublands, forests, and grasslands in the United States, Australia, and Canada (Daniel and Frid 2012). This development has been driven in part by the model development, training, and awareness created by LANDFIRE in the U.S. and the need for improved management decision support tools. The TNC methodology builds on LANDFIRE, but is tailored to the specific sagebrush ecosystem.

The popularity of quantitative state-and-transition simulation models has also been facilitated by the availability of flexible software tools, beginning with VDDT (Vegetation Dynamics Development Model by ESSA, Technologies, Ltd.) in the early 1990s for the Interior Columbia Basin Ecosystem Management Project. The most recent of these tools, ST-Sim (by ApexRMS Ltd.; www.syncrosim.com), has both non-spatial and spatially explicit capabilities.[7] As discussed below, TNC's modeling relies substantially on the ST-Sim tool.

TNC has created a library of computer-based state-and-transition management models for all ecological systems in Nevada and western Utah (including for the Great Basin, Utah High Plateau, Mojave Desert, and Sierra Nevada ecoregions). These models have been updated and improved during multiple recent projects for, among others, the Bureau of Land Management, USFS, and Nevada's Wildlife Action Plan (Provencher et al. 2009, 2010, 2012, 2013; Abele et al. 2010; Low et al. 2010; Tuhy et al. 2010a, b; Provencher and Anderson 2012). TNC has incorporated into these models assumptions regarding temporal variability for fire, drought, flooding, insect/disease, snow deposition, and other correlated disturbances. For example, the year-to-year variability in fires in a project area can be simulated into the future using past fire occurrence time series data from the same area.

One state-and-transition simulation model will be built or updated for each major potential ecological system (e.g., Wyoming big sagebrush, low sagebrush, wet meadow) found in the study area. Each model contains reference and management vegetation classes. Models will be incorporated in the raster-based state-and-transition St-Sim software (www.apexrms.com, www.syncrosim.com, ApexRMS 2012, Daniel and Frid 2012; the latest generation started 15 years ago with the VDDT software by ESSA Technologies –Barrett [2001]).

3. Integration of Greater Sage-Grouse and Other Wildlife Habitat Suitability Metrics

TNC's state-and-transition models are useful for estimating the health, or ecological departure, of any given ecological system. Healthier vegetation usually is good for sage-grouse population viability. However, sage-grouse have particular and complex habitat requirements beyond just vegetation health. The relative "habitat suitability" of a particular area of vegetation needs to be assessed through understanding of the entire suite of factors that

[7] Non-spatial simulations do not directly use a map for data input, although data may have been ultimately obtained from a map, and each "virtual pixel" behaves completely independently of others (i.e., disturbances do not spread from virtual pixel to virtual pixel). Spatial simulations directly use maps for input and disturbances spread to adjacent pixels based on their characteristics.

influence sage-grouse population viability. A sage-grouse habitat suitability model is based on observations and measurements of key habitat features of particular places that are actively supporting viable sage-grouse populations, and of how variations of those measurable features are associated with variations in levels of population viability.

The sage-grouse habitat model in this study was developed by Dr. Jim Sedinger's group at UNR and uses field observations of occupied sage-grouse habitat taken over 10 years in the Falcon-Gondor study area, a zone of about 1.25 million acres that overlaps and is adjacent to and in the immediate vicinity of the Barrick study area. UNR's study has been published in a final report (Gibson et al. 2013) and in the peer-reviewed literature (Blomberg et al. *in press,* 2013a, b, c; Nonne et al. 2013). The field data have enabled the generation of three seasonal suitability metrics that quantitatively describe the habitat requirements for: (1) nest selection, (2) nest success, and (3) chick survival.[8] Each pixel of the Barrick study area will receive a 0-1 score for each of these metrics. Taken together for any given pixel, these three distinct metrics can be further interpreted statistically to yield a fourth metric for the per capita population growth rate. This fourth metric shows for each pixel the likelihood that it will support a growing, stable, or declining population. This fourth metric—per capita growth rate—is the basis for the Functional Area calculation.

The model is built on field observations of occupied habitat. Population and demographic data (including nest success and chick survival) and movement data were collected for existing populations in the Falcon-Gondor study area. Measurements were taken of physical vegetation features in areas where actual nests were selected and brood-rearing occurred. In addition, observed variations in the nest-success rates and chick-survival rates from one location to another were accompanied by notations of how habitat features also varied from location to location. Specific habitat features that were measured included:

- Vegetation composition (e.g., which types of vegetation are present) and structure (e.g., cover and biomass);
- The distance between habitat types, and more generally the spatial distribution, patterns, and sizes of ecological systems; and
- Anthropogenic factors, such as roads, infrastructure, and noise.

From this analysis, this sage-grouse habitat suitability model can specify habitat suitability based on:

1. The relative importance of certain ecological systems;
2. Seasonal variations in the importance of ecological systems;

[8] Winter habitat is not calculated because there were no data on this seasonal phase. However, typical winter survival is greater than 90% for sage-grouse, and winter habitat represented by tall sagebrush cover is generally not limiting.

3. The tolerance of sage-grouse to variations in vegetation composition and structure within ecological systems (including ecological departure); and

4. How variations in the spatial distribution of habitat types affect population viability, including the effect of:

    a. The distance between habitat types. In general, it is better to have the distinct habitat types (e.g., nesting and brood rearing) closer to each other to lessen the distances sage-grouse need to travel between seasons or life stages.

    b. Variations in the relative sizes, shapes, and patterns of habitat patches.

    c. Proximal human disturbances, such as towers that host predators, or human-caused noise.

In TNC's methodology, these habitat suitability statistical relationships are applied to TNC's high-resolution vegetation maps and to maps of leks, elevation, precipitation (from PRISM geodata), and human-made features. Each pixel gets four different suitability scores, one each for nest site selection, nest success, chick survival, and per capita population growth rate. For the first three categories, the metric is on a 0-1 scale, where zero equals no suitability and one equals the highest possible suitability. For example, a pixel at 7,000 feet of elevation within two miles of an active lek and five miles from a wet meadow complex surrounded by sagebrush might have a score of 0.9 (90%) for nest site selection, 0.7 (70%) for nest success, 0.75 (75%) for chick survival, and 1.28 for per capita population growth rate (growing population at that location). Using the same hypothetical example, the presence of pinyon and juniper around the wet meadows could drop chick survival to 0.1 (10%) and the per capita population growth rate to 0.9 (declining population at that location).

When initially calculated, the fourth of these metrics—per capita population growth rate—may range between zero and a value greater than one, where a value of one translates into a stable population, a value of less than one represents a declining population, and a value greater than one indicates a growing population at that location. To standardize the population growth metric to a 0-1 scale, all individual pixel values will be divided by the maximum value observed, which creates an upper boundary of 1.0 (e.g. 1.15/1.15 = 1.0).

The **Functional Acre** estimate will be based on this fourth, per capita population growth metric, and is premised on a 0-1 scale. Functional area is calculated as the sum of all the standardized individual pixel scores multiplied by the area of each pixel.

The relative importance of each habitat type takes into consideration the proximity or distance calculations. For example, the field observations of the Falcon-Gondor study will have recognized the fact that a healthy stand of middle-aged sagebrush with no nearby accessible wet meadows might have half the suitability scores of a similar stand of sagebrush with a nearby accessible wet meadow (in this case, the nest success metric might be high for both areas but the chick survival metric would be lower in the area without a meadow). In this example, it can be inferred from the data that summer brood-rearing habitat is the most limiting (and important) type of habitat. Or, put differently, restoration of brood-rearing habitat would be a high-leverage conservation action.

These habitat suitability metrics also identify what habitat type can least afford to be adversely impacted for a given area. Consider an area where a small wet meadow exists surrounded by a large extent of healthy middle-aged sagebrush, and there are no other wet meadows for many miles. The wet meadow is what cannot afford to be lost, and this is captured in the habitat suitability scores of the entire area around the meadow. That is, the per capita growth metric for the pixels of sagebrush will be much higher if the meadow is close by. If that meadow were adversely affected, not only would the suitability scores of the meadow area itself go down, but all the suitability scores of the surrounding sagebrush would go down as well. In this way, the habitat suitability model reveals both what is the limiting habitat type in any area, and captures the indirect effects of how changes to one area of habitat impact the suitability of adjoining habitat.

In the presence of the newly created sagebrush habitat, the suitability scores of both the adjoining wet meadow and the sagebrush pixels would increase. The spatial interdependence of the habitat types, and the importance of the relative proximity to each other, is embedded in the statistical relationships, and is used to reveal relative importance (or potential importance) of a given area of habitat. Thus, it is important to recognize that the unique habitat suitability score for any given pixel or area of vegetation is determined in part by the health and suitability of other adjoining areas of habitat. Thus, by virtue of how habitat suitability is estimated, an increase/decrease in habitat suitability in one area of functional habitat will automatically increase/decrease the habitat suitability of adjoining areas of functional habitat.

A great deal of the policy and technical literature around sage-grouse uses habitat categories of “core, priority, and general.” These terms are useful and necessary for statewide-scale habitat designations and analysis and to inform high level policy-making. But these very general designations are based on much less detailed and precise data and measurements of habitat quality than are supported by TNC’s methodology. The combination of high-resolution vegetation maps with the Falcon-Gondor suitability measurements and statistical relationships supports data-driven analysis of the limiting habitat types in a geographically precise, site-specific manner (i.e., in any given spot within the Barrick study area, one can discern the most limiting habitat type). The TNC methodology informs ways to improve spatial distribution of sage-grouse habitat, vegetation composition and structure, and reduction of anthropogenic influences. It also informs which of these types of improvements are most helpful.

Although the UNR study provides quantitative relationships for sage-grouse to build a habitat suitability/population viability raster, similar demographic and movement data and statistical relationships for mule deer and golden eagle are not available for the study area. Moreover, the rules of restoration in simulations will be dictated by benefits to sage-grouse. Therefore, metrics for mule deer and golden eagle habitat suitability will measure change to these species' habitats as a consequence of sage-grouse management. No additional mule deer or golden eagle specific studies will be performed. As a result, TNC and wildlife experts will explore alternative, less data-rich metrics of mule deer and golden eagle habitat suitability or population viability; metrics that calculate for each ecological system the departure between current and reference pseudo-habitat suitability (possibly also population viability) based on the current percentage of each vegetation class relative to the natural range of variability in the project area (i.e., ecological departure), where an expert/data-derived species-specific "weight" is assigned to each vegetation class.

4. Management Scenarios

Representatives from TNC, Barrick, public agencies, and other wildlife, habitat, and land-management experts will develop a reasonable range of management scenarios. These scenarios are themes formed of consistent management actions similar to alternatives developed as part of an environmental impact assessment, including a minimum management (or "no action" alternative) to serve as a control. For example, one narrow scenario might consist of strategically placed green strips to prevent the extensive loss of sagebrush canopy from fire spreading over areas greater than 5,000 acres below an elevation of 9,000 feet. On the other hand, a broader scenario in higher elevation sagebrush might combine prescribed fire and mastication of trees encroaching into shrublands, thinning of small areas of shrub cover to increase brood-rearing habitat, seeding herbaceous and shrub species into invasive annual grassland previously sprayed with the herbicide Plateau®, and changing the livestock grazing system. The full suite of possible management actions that will be considered within scenarios (and their likely impacts on states and transitions, success rates and costs) will be determined through the expert workshops.

For simulation of potential future conditions, the models will require a characterization of current management for both public and private lands, as well as characterization of alternative management scenarios, which can be differentiated by land ownership. The model can incorporate different assumptions about how different areas of land, whether public or private, will be managed over time.

Given proposed management scenarios, TNC and other experts will design the vegetation-based and spatial "rules of restoration" that will guide ST-Sim's yearly treatment of vegetation classes as mapped in raster format given: (1) the constraints imposed by the sage-grouse habitat suitability or population viability layer; (2) known habitat relationships for golden eagle and mule deer; (3) Barrick and agency implementation cost rates and budget limits; and (4) regulatory constraints decided by experts. The resulting vegetation map, which will show where various treatments were implemented during the entire simulation period, will allow calculation of sage-grouse habitat suitability or population viability (by pixel and at landscape-scale), the ecological departure of each ecological system, and the cost of restoration. The forecasted results of the management scenarios will also include a calculation of the functional acres anticipated to be conserved, restored, or enhanced for each proposed scenario.

Once Barrick has proposed a mining plan of operations or other mining activity, TNC will apply the same methodology to determine the debits, in terms of functional acres, attributable to that plan of operations or other activity. To accomplish this, TNC will input the proposed footprint of infrastructure as a raster and cause all vegetation classes at the direct impact site to transition to "mine" vegetation classes. The type of "mine" classes included in the state-and-transition simulation models will be determined by the immediate and future fate of the class for the period of simulation based on Barrick expertise. These classes will account for variations in intensity and duration. For example, the analysis of mine vegetation class for an open pit mine will be different than the analysis of mine vegetation class for an area that may only be temporarily disturbed or subject to less intense use, such as a stock pile.

Habitat suitability will be re-estimated with the infrastructure footprint, and the scenario will then proceed until the end of the simulation period. Because of the anticipated timing of Barrick's submittal of a proposed plan of operations, this effort will likely be completed after TNC has produced its Final Plan regarding the management scenarios on Barrick's ranch properties and allotments, described below. However, to be clear, the analysis of habitat in the area impacted by mining will be conducted using the same tools in the same way as the analysis of habitat in the mitigation areas.

5. Expert Workshops

Three expert workshops will be conducted with participation of 5 or more participants, including representatives of Barrick, BLM, FWS, and others who may be uniquely qualified to contribute. Barrick and TNC jointly will select invitees. BLM and FWS will be invited to all workshops. Other experts will be invited based on local knowledge and technical expertise. The experts will be responsible for designing management scenarios for testing by the models. The experts will be required to take the following steps:

1. Review ecological system and vegetation class descriptions.
2. Review/update existing state-and-transition models.
3. Review vegetation maps.
4. Set management objectives.
5. Design minimum and alternative active management scenarios.
6. Provide unit cost estimates of restoration treatments and policy actions.
7. Estimate failure percentages associated with treatment application.

TNC will conduct pre- and post-workshop model runs, but many management simulations will be completed during expert workshops. Experts will provide advice on the duration of simulations. Barrick has options in choosing the length of time over which management actions will be modeled to determine the habitat values achieved by those actions. TNC recommends that management actions be modeled for 25 years. This time period is long enough that the consequences of management actions will be evident and measurable.

6. Return-On-Investment

Because TNC will run a minimum management scenario (i.e., business-as-usual or an agency's no-action scenario), both ecological departure and sage-grouse metrics will allow a calculation of return-on-investment, which is the change in one or jointly more than one metric between the minimum and active management, multiplied by the size of the ecological system, and divided by the cumulative cost of the scenario (Low et al. 2010). The different management scenarios will be modeled and presented in a way that allows comparisons and contrasts to be drawn among the variables: sage-grouse habitat suitability/population viability, vegetation ecological departure, and return-on-investment.

III. TNC's Initial Work Product

Once the six steps described above have been completed, TNC will prepare a Final Plan that summarizes the application of its methodology and the results of that application. Specifically, the Final Plan will include the following sections.

1. Executive summary.

2. Introduction, including background and objectives.

3. Methods, including descriptions of the project area, expert workshop process, remote sensing, state-and-transition modeling, vegetation metrics, sage-grouse habitat suitability and/or population viability estimation, other habitat-suitability metrics, management scenarios, spatial modeling, and analysis tools.

4. Results, including both non-spatial and spatial for vegetation, metrics, and return-on-investment.

5. Discussion focused on management scenarios, regulatory conclusions, and next steps.

6. Literature Cited.

7. Technical Appendices.

The results section of the Final Plan will include a range of management scenarios that Barrick could implement on in the Service Area, as appropriate. For each management scenario, TNC will identify the functional acres that are anticipated to be conserved, enhanced, or restored. If Barrick has proposed a plan of operations or other mining activities before TNC issues its Final Plan, the Final Plan will also include an analysis of the impacts, in terms of functional acres, anticipated as a result of the plan of operations. If Barrick has not proposed a plan of operations or other activities before TNC issues its Final Plan, TNC will undertake a separate analysis of the impacts of the plan of operations, using Steps 1 through 4 described above, once Barrick has proposed that plan. TNC will provide the results of that analysis in a separate report.

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