Topic & title: Use of LANDFIRE in Sage-Grouse Habitat Analysis: Western North America
Date: 2007 - 2009

Background: Greater Sage-Grouse (*Centrocercus urophasianus*) are endemic to western North America and are an obligate species dependent on sagebrush (*Artemisia* spp.) across their range. This paper primarily focuses on the application of LANDFIRE data products in support of a broader analysis and study evaluating the ecology and conservation interactions for sage-grouse and sagebrush spatial patterns. The material in this paper uses information found in the publication "Greater Sage-Grouse: Ecology and conservation of a landscape species and its habitats" edited by Steve Knick and John Connelly which outlines the effort conducted with teams of research and management from agency, academic, and private expertise.

Description of analysis: The historical distribution and amount of sagebrush habitat in pre-settlement times is not available. Therefore, the analysis estimated the difference between the potential vegetation type for pre-settlement times (Küchler's (1970) potential vegetation map (vegetation that would occur if there were no disturbances from man or nature (Küchler 1964)) and what currently is present based on LANDFIRE (LANDFIRE 2006). Comparisons between Küchler's sagebrush categories and LANDFIREs other vegetation categories were used in this analysis (Figure 1). The teams subtracted forested, water, marsh, and wetland habitats delineated in the map of current habitats (LANDFIRE 2006) from the total area for each sagebrush type in Küchler's (1970) map to partially correct for differences in thematic and spatial resolution.

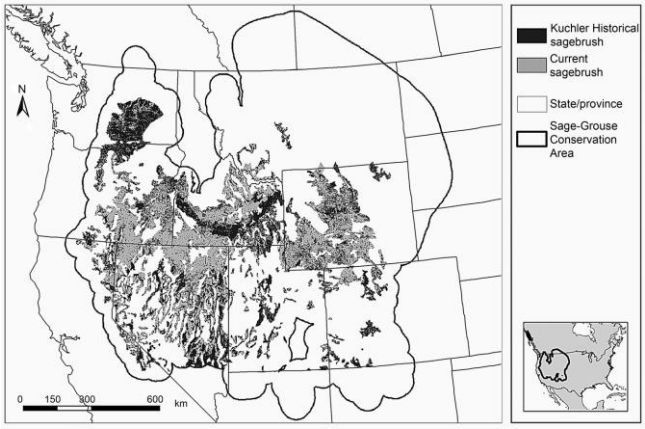

FIGURE 1. Difference between Küchler's map (1970) of potential sagebrush distribution and distribution of sagebrush (Fig. 1). Only the distribution of Küchler's categories for Great Basin sagebrush, sagebrush steppe, and wheatgrass-needlegrass shrubsteppe are used in this analysis. Sagebrush habitats also exist outside of the distribution of these habitat types.

The teams used connectivity analyses to: (1) delineate the dominant pattern of sagebrush landscapes (Figure 2), (2) identify regions of the current range-wide distribution of Greater Sage-Grouse important for conservation, (3) estimate distance thresholds that potentially isolate populations, and (4) understand how landscape pattern, environmental disturbance, or location within the spatial network influenced lek (breeding site) persistence during a population decline [Chapter 16 of the volume]. At least 11 species of sagebrush occur within the sage-grouse range, each differing in their specific plant community structure, productivity, resilience, and resistance to disturbance (West and Young 2000, Miller and Eddleman 2001, Miller et al. 2011).

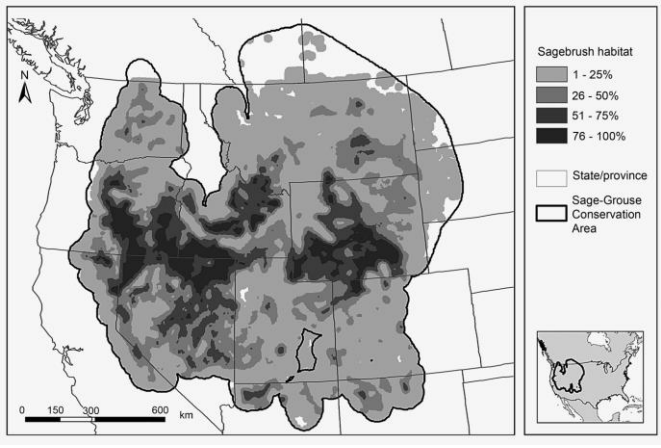

FIGURE 2. Distribution of sagebrush landcover within western North America. The map represents a general representation and percentage of the landscape dominated by sagebrush habitats and not site-specific values of ground cover.

Sage-Grouse Management Zones (SMZ) were used as assessment boundaries and the relative human-footprint activities and their connection to sagebrush habitats evaluated using LANDFIRE Existing Vegetation data to evaluate the human intensity on sagebrush land-cover types. LANDFIRE data products were re-sampled from 30-m to 180-m cell size to match human-footprint model (Leu et al. 2008) and further resampled to 540-m grid cells evaluating landscape patterns and habitat coverage. LANDFIRE sagebrush land-cover classes were collapsed to a sub-set of land-cover classes. The configuration of sagebrush land cover was investigated across the landscape, a critical determinant of sagebrush land-cover connectivity, in relation to human-footprint intensity by examining landscape patterns and patch metrics across SMZ. Sagebrush landscape patterns differed in human-footprint intensity and sagebrush landscapes were more clumped with the increasing human-footprint. For the teams analysis, the knowledge of how sagebrush landscape patterns influence ecological processes stems from studies which were based on land cover spatial data sets such as Sagestitch (Comer et al. 2002), LANDFIRE (LANDFIRE 2006) and Shrubmap (United States Geological Survey 2005) which delineate only part of the physical human footprint, limited to large-scale anthropogenic features. The teams' analysis sought to determine if lek persistence during long-term population declines was related to their connectivity within the sage-grouse network, structure of sagebrush landscapes, or environmental and human disturbance. The distribution of sage-grouse is closely aligned with the distribution of sagebrush dominated landscapes (Schroeder et al. 2004). The teams found that trends were correlated with several habitat features, but not always similarly throughout the range. Lek trends were positively associated with the proportion of sagebrush (*Artemisia* spp.) cover, within 5 km and 18 km. Lek trends had negative associations or tended to be lower with the coverage of agriculture, exotic plant species, and proportion of surrounding burned landscape. Few leks were located within 5 km of developed land and trends were lower for those leks with more developed land within 5 km or 18 km. Because sagebrush landscape fragmentation is inherently complex and the degree of fragmentation varies spatially throughout the sage-grouse range (Knick et al. 2003; Knick and Hanser 2011), the team chose a landscape metric that assessed complexity of sagebrush landscapes at various scales to mimic how sagebrush obligate vertebrate species might perceive landscape patterns (Leu and Hanser 2011, Knick and Hanser 2011).

Methods: A large number of geospatial variables potentially could explain sage-grouse trends at each lek location. Certain variables were measured at the lek site itself; others reflected conditions in circles of 5- and 18-km radii centered at the lek. These two radii were selected because they correspond to the distances around lek locations recommended for management of non-migratory (5 km) and migratory (18 km) populations of Greater Sage-Grouse (Connelly et al. 2000). Among these variables were measures of physical attributes, vegetation (land cover), fire history, and anthropogenic features. Land cover information was derived from the LANDFIRE "Existing Vegetation Type" Map (LANDFIRE 2006) and was used as the base GIS layer of land cover types for describing spatial structure of sagebrush landscapes. Vegetation in LANDFIRE was classified from Landsat Thematic Mapper satellite imagery [circa 2001]. The teams collapsed the original 210 ecological systems mapped by LANDFIRE into two, five, and eight land-cover classes for habitat coverage analysis, patch metrics, and proportional area assessments. Sagebrush taxa have different environmental optima (West and Young 2000) and are not used equally by Greater Sage-Grouse (Crawford et al. 2004, Connelly et al. 2011). The teams grouped sagebrush into collapsed classes because of map inaccuracies in delineating different *Artemisia* species. These inaccuracies are a result of limited available field plot data and difficulties distinguishing *Artemisia* species from the Landsat imagery. Sagebrush range-wide similarities in spatial structure may offset site-specific preferences in taxa used by Greater Sage-Grouse (Johnson et al. 2011, Knick and Hanser 2011).

Results: Different patterns of clustering within a landscape emerged with changes in the analysis radii (Fig. 3). Local patterns of sagebrush landcover, when mapped using a 5-km radius, were widely distributed and present across the Greater Sage-Grouse range. However, when using the larger 54-km radii, four primary regions with landscapes dominated by sagebrush land cover were evident: south central Oregon and northwest Nevada; the Owyhee region of southeast Oregon, southwest Idaho, and northern Nevada; southwest Wyoming; and south central Wyoming.

Sagebrush was common in all management zones however, the types of sagebrush cover varied by management zone. Of note is that the average percentage cover of sagebrush within 5 km exceeded the average within 18 km suggesting that sage-grouse leks are preferentially located within sagebrush. Lek trends across all management zones increased modestly but steadily with the cover of all sagebrush (combined categories for tall sage and low sagebrush).

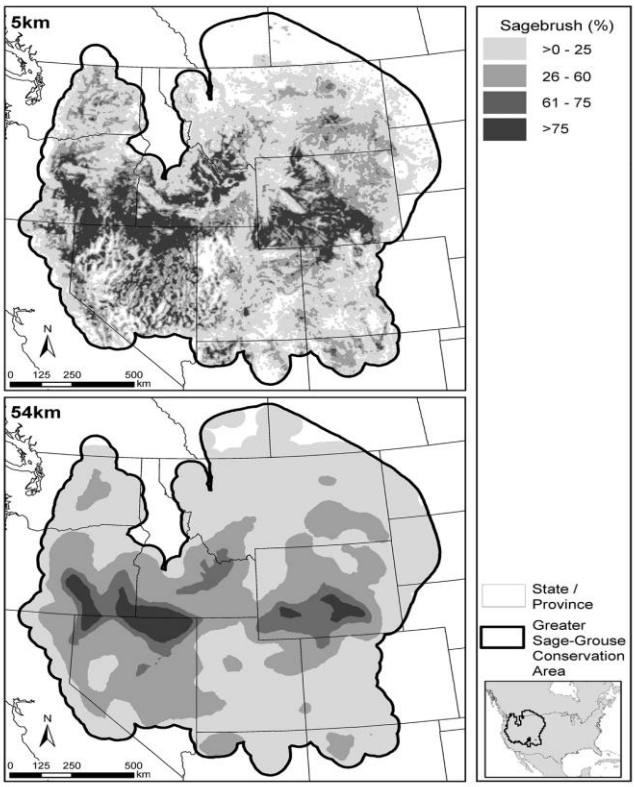

FIGURE 3. Percent of the landscape dominated by sagebrush within a 5-km (top) and 54-km (bottom) radius of each 0.5 km grid cell.

Key points: Accurate estimates of the amount of sagebrush habitat that has been lost from what was present during pre-settlement are not possible because of our inability to map the historical distribution with an accuracy or resolution comparable to that in modern satellite image data. The teams estimated the difference between the area that could be dominated by sagebrush in Küchler's (1970) potential vegetation map to the current distribution of sagebrush habitats (Fig. 1). Differences between potential and current are partially a function of the coarse resolution in the Küchler's map compared to the finer resolution in the sagebrush map. The analysis identified broad-scale differences between current and potential distribution in sagebrush and was not intended to identify specific locations where sage-grouse habitat had been lost. The proportion of the landscape dominated by sagebrush and amount of habitat edge were similar between leks at which sage-grouse were present in 1998–2007 compared to those that had been abandoned. Amount of burned area and the human footprint was higher for leks that were abandoned by 1998–2007. The most significant spatial scales for environmental predictors were proportion of sagebrush within 54 km of the lek ($P < 0.05$), proportion of burned area within 54 km of the lek ($P < 0.01$) and level of human footprint within 5 km ($P < 0.01$) (Knick and Hanser 2011).

Management Considerations: Connectivity analysis provided a framework for quantifying the range-wide pattern of sage-grouse populations that integrated landscape arrangement of habitat and populations, population dynamics within components, and exchange of sage-grouse individuals among leks and components. The analysis of spatial patterns in sage-grouse populations reflects processes such as dispersal and response to changes in their environment that can be incorporated into range-wide and regional conservation strategies.

- Sagebrush (*Artemisia* spp.) habitats necessary to support sage-grouse are being burned by large wildfires, invaded by nonnative plants, and developed for energy resources (gas, oil, and wind). Management on public lands, which contain 70% of sagebrush habitats, has changed over the last 30 years from large sagebrush control projects directed at enhancing livestock grazing to a greater emphasis on projects that often attempt to improve or restore ecological integrity.
- Proximate reasons for population declines differ across the sage-grouse distribution, but ultimately, the underlying cause is loss of suitable sagebrush habitat.
- Maintaining landscapes dominated by sagebrush is a major challenge because changes in fire regimes, widespread invasion by non-native plants, and increases in destructive land use are likely to accelerate the trajectory of fragmentation and loss.

References:

For the volume:
KNICK, S. T., AND J.W. CONNELLY (editors). 2011. Greater Sage-Grouse: Ecology and conservation of a landscape species and its habitats. Studies in Avian Biology Series (vol. 38), University of California Press, Berkeley, CA.

For individual chapters: Chapters 3, 10, 13, 16, and 17 where LANDFIRE is discussed.
CONNELLY, J.W., C.A. HAGEN, AND M.A. SCHROEDER. 2011. Characteristics and dynamics of Greater Sage-Grouse populations. In S. T. Knick and J. W. Connelly (editors). Greater Sage-Grouse: Ecology and conservation of a landscape species and its habitats. Studies in Avian Biology Series (vol. 38), University of California Press, Berkeley, CA.

JOHNSON, D. H., M. J. HOLLORAN, J. W. CONNELLY, S. E. HANSER, C. L. AMUNDSON, AND S. T. KNICK. 2011. Influences of environmental and anthropogenic features on Greater Sage-Grouse populations, 1997-2007. Pp. 407-450. *In* S. T. Knick and J. W. Connelly (editors). Greater Sage-Grouse: ecology and conservation of a landscape species and its habitats. Studies in Avian Biology (vol. 38), University of California Press, Berkeley, CA.

LEU, M., AND S. E. HANSER. 2011. Influences of the human footprint on sagebrush landscape patterns: implications for Sage-Grouse conservation. Pp. 253-272. *In* S. T. Knick and J. W. Connelly (editors). Greater Sage-Grouse: ecology and conservation of a landscape species and its habitats. Studies in Avian Biology (vol. 38), University of California Press, Berkeley, CA.

KNICK, S. T., AND S. E. HANSER. 2011. Connecting pattern and process in Greater Sage-Grouse populations and sagebrush landscapes. Studies in Avian Biology Pp. 383-406. *In* S. T. Knick and J. W. Connelly (editors). Greater Sage-Grouse: ecology and conservation of a landscape species and its habitats. Studies in Avian Biology (vol. 38), University of California Press, Berkeley, CA.

MILLER, R. F., S. T. KNICK, D. A. PYKE, C. W. MEINKE, S. E. HANSER, M. J. WISDOM, AND A. L. HILD. 2011. Characteristics of sagebrush habitats and limitations to long-term conservation. Pp. 145-184. *In* S. T. Knick and J. W. Connelly (editors). Greater Sage-Grouse: ecology and conservation of a landscape species and its habitats. Studies in Avian Biology (vol. 38), University of California Press, Berkeley, CA.

From Material in the chapters and volume:

CRAWFORD, J. A., R. A. OLSON, N. E.WEST, J. C.MOSLEY, 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.

COMER, P, J. KAGAN, M. HEINER, AND C. TOBALSKE. 2002. Current distribution of sagebrush and associated vegetation in the western United States (excluding NM and AZ). Interagency Sagebrush Working Group. <http://sagemap.wr.usgs.gov> (18 June, 2009).

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 28:1–19.

KNICK, S. T., D. S. DOBKIN, J. T. ROTENBERRY, M. A. SCHROEDER, W. M. VANDER HAEGEN, AND C. VAN RIPER III. 2003. Teetering on the edge or too late? Conservation and research issues for avifauna of sagebrush habitats. Condor 105:611–634.

KÜCHLER, A.W. 1970. Potential natural vegetation. USDI Geological Survey. The national atlas of the United States of America. U.S. Government Printing Office 89–92. Washington DC.

LANDFIRE. 2006. National existing vegetation type layer. USDI Geological Survey. <http://gisdata.usgs.net/website/landfire/> (13 July 2008).

MILLER, R. F., AND L. EDDLEMAN. 2001. Spatial and temporal changes of sage grouse habitat in the sagebrush biome. Oregon State University, Agricultural Experiment Station Technical Bulletin 151, Corvallis, OR.

UNITED STATES GEOLOGICAL SURVEY. 2005. Current distribution of sagebrush and associated vegetation in the Columbia Basin and southwestern regions. <http://sagemap.wr.usgs.gov> (18 June 2009).

WEST, N. E., AND J. A. YOUNG. 2000. Intermountain valleys and lower mountain slopes. Pp. 255– 284 *in* M. G. Barbour, and W. D. Billings (editors). North American terrestrial vegetation. 2nd Edition. Cambridge University Press, Cambridge, UK.