New Alternatives for Monitoring Rangelands

by Neil West and Ben Wu

Many interested in rangelands assume they will have to learn how to identify all the plants that grow on a piece of rangeland they love, if they ever hope to understand trends and what condition it is in. While this is still desirable, such hard won traditional knowledge of plant names and enumeration of species abundances in small plots is no longer the only way that rangelands can be monitored.

Several alternatives for monitoring rangelands are emerging, and many of these innovative methods were presented in a symposium at the annual SRM meeting in Kansas City on February 15, 2002 (see Table 1 for a list of the presentations that were made). Here, we offer an overview of that symposium:

When managers ask the questions: What is the current condition of this pasture, allotment or ranch and how are they changing (trend), plant composition data from a few small plots isn't really going to give the complete answer. See Peter Sundt's article in the April 2002 issue of *Rangelands* for why this is so. It is really status and changes over landscapes that are involved in the above questions. While we have long looked at landscapes and intuitively and qualitatively evaluated them, we have, until now, lacked both concepts and techniques to quantify what can happen across landscapes. Those interested in learning more about the relevant concepts can find them introduced in the landscape ecology book by Turner and others (2001) and a review on quantifying landscape spatial pattern by Gustafson (1998). The technology that has made the concepts useful is becoming known as geomatics (Kavanagh 2003).

Geomatics involves the combined usage of remote sensing (RS), global positioning systems (GPS), geographic information systems (GIS), and spatial statistics. What the recent SRM symposium did is demonstrate how these ideas and technology can apply to assessment and monitoring of rangelands.

Title and authors of papers presented at the Symposium on "Landscape Analyses for Rangelands Assessment and Monitoring".

Talk #	Title	Authors & Affiliations
1	Detection of non-lineanty and critical thresholds in the response of a semi-arid landscape to herbivore diversity	Washington-Allen, R.A., (Oak Ridge Nat. Lab), N.E. West (Utah St. Univ.), R.D. Ramsey (Utah St. Univ.) And C.T. Hunsaker (U.S. Forest Service)
2	Landscape changes in Lesser Prairie Chicken habitat in the Texas Panhandle	X.B. Wu, F.E. Smeins, N.J. Silvy, M.J. Peterson and P. Rho (all Texas A&M)
3	Exploring spatial and temporal pattern of Northern Bobwhite abundance and land use	X.B. Wu, M.J. Peterson and P. Rho (all Texas A&M)
4	Juniper encroachment effects on landscape cover type and pattern dynamics in fragmented Southern Great Plains grasslands	B.R. Coppedge, D.M. Engle, S.D. Fuhlendorf, R.E. Masters and M.S. Gregory (all Oklahoma St. Univ.)
5	Geostatistical sampling design for analysis of vegetation patterns in tundra rangelands.	M.K. Owens (Texas Agr. Exp. Sta.) and D.E. Spalinger (Alaska Dept. of Fish & Game)
6	Cokriging of biophysical model output and NDVI to create forage production maps for livestock early warning systems.	J.P. Angerer, J.W. Stuth, W.N. Mnene, F.P. Wandera, R.J. Kaitho, and A.A. Jama (all Texas A&M).
7	Light distribution in mesic grasslands: spatial patterns and temporal dynamics.	J.D. Derner (USDA-ARS) and X.B. Wu (Texas A&M)
8	Appropriate scales and metrics for measurement of change in shrubland landscapes.	S.T. Knick and T.W. Loveland (both USGS)

Talk #1 demonstrated how changes in patches, dominated by either various dominant plant life forms or bare soil, could be related to variations in climate, fire and livestock grazing over about 100,000 acres of mostly privately owned rangeland in northern Utah since 1972. A 28 year sequence of cover class data were derived from LANDSAT satellite imagery, combined with ground truthing at selected times and locations, as well as animal management and fire records maintained by the ranch were analyzed for relationships.

Satellite imagery yields numbers for cover classes across all of very large areas at instances in time, not just for a few small plots, often collected over considerable a period within a year. Changes in plant growth form were more strongly correlated with cattle grazing than climatic variations or fire. Grassland cover was dominant until shrub cover crossed a threshold of rapid increase in 1991.

More and smaller patches of brush were seen after 1991, as well as in increase in bare ground. This rapid change toward a more complex landscape was coincident with concomitant high stocking rates of cows and widespread drought in the early 1990's. The very strong El Nino associated wet period of 1997, however, led to a major recovery of perennial grass cover more recently.

Talk #2 employed landscape analyses and GIS modeling to determine the landscape patterns and changes associated with lesser prairie chicken habitat in the High Plains and Rolling Plains of the Texas Panhandle. By comparing aerial photos from 1940's and 1990's landscapes where this bird has disappeared with those where it remains, the contraction of lesser prairie chicken range was related to conversions of rangelands to croplands in the High Plains and fragmentation of formerly herbaceous rangelands by increased invasion by woody plants in the Rolling Plains.

It was also demonstrated that spatial characteristics of landscapes obtained through remote sensing can be used to delineate habitat areas with different levels of suitability for lesser prairie chicken. This work provides new approaches for monitoring habitat change over large areas and information for prioritization of proactive efforts to slow down loss of these birds where they now exist and to mount restoration elsewhere.

Talk #3 explored the spatial and temporal patterns of Northern Bobwhite abundance in relation to land use across the entire eastern and central US. Bird abundance data from the North American Breeding Bird Survey and county level land use data from the U.S. Census of Agriculture were used to evaluate the relationship between Northern Bobwhite abundance and landuse pattern. Although there was an overall decline in average bobwhite abundance, the most serious declines were in the east, with many western populations showing no decline and even some increases at the western-most fringe of the species range. No consistent range wide relationships between land use variables and bobwhite abundance were found.

Analyses by physiographic provinces yielded more interpretable results than those based on state political boundaries but in order to be able to relate specific land use to bird abundance, even finer scale analyses became necessary.

Talk #4 focused on landscape effects of juniper encroachment into remnant native grasslands of northwestern Oklahoma a region that has been fragmented by agricultural activities. By analyzing 3 sets of sequential aerial photos from 1965, 1981, and 1995, they discovered how land cover and pattern has changed, especially in regard to juniper invasion into grasslands and expansion of juniper woodlands and mixed juniper-deciduous woodlands.

It was concluded that juniper expansion, related to human activities (excessive livestock use, declining tillage, and fire prevention), is exacerbating the fragmentation process initiated by previous human activity (land use alteration), and represents a serious threat to the conservation of remaining grasslands.

Talk #5 examined different sampling designs for monitoring vast areas of tundra rangelands in the Seward Peninsula and the Bering Land Bridge National Preserve of Alaska based on principles of geostatistics (see Rossi et al. 1992 and Goovaerts 1999 for an introduction to the concepts and applications of geostatistics). It was found that the classical design of sampling in a simple grid pattern was not only the most time-consuming technique but also the least effective one in accounting for the spatial variations in plant distribution.

A sampling design with transects radiating from a central point within key areas improved the effectiveness but was inefficient for sampling large areas, whereas a design using linear transects with clustered subsamples increased time efficiency but provided poor estimates of the spatial structure. A sampling design was developed that had sampling stations distributed along a zigzagging transect and nested subsamples at each sampling station, which effectively and efficiently portrayed the spatial pattern of plant species distribution across landscapes and was still able to detect patterns at fine scales.

Talk #6 dealt with the applications of geostatistical approaches in the development of a real-time livestock early warning system for drought mitigation in the Sahel Region on the southern edge of the Sahara Desert across Africa. The geostatistical technique of cokriging was used to determine if biophysical simulation model (PHYGROW) output and real-time Normalized Difference Vegetation Index (NDVI) data from satellite remote sensing can be used to create forage availability maps to pinpoint areas of drought vulnerability in southern Kenya. It was found that cokriging generally did a good job of estimating forage production. Maps generated from the analysis successfully identified areas of drought vulnerability and their dynamics over time.

Talk #7 investigated the use of a spatial analysis approach, lacunarity analysis (Plotnick et al. 1993), to characterize the spatial pattern and seasonal dynamics of light distribution in tallgrass prairie rangelands with contrasting vegetation composition resulting from combinations of different disturbance regimes (annual haying) and past land use (cultivation). Results showed that disturbance (annual haying) had a stronger influence on light distribution pattern than did species composition, and growth and development of species in these rangelands contributed to the different seasonal variation in light distribution patterns.

These differences in spatial pattern and seasonal dynamics of light distribution may result in differential susceptibilities of these rangelands to various invasive species. Integrating spatial analysis with the more traditional assessment monitoring measurements of rangelands may be an effective way to assess functional changes in rangelands.

The **final talk (#8)** argued that the mosaic of habitats within a landscape is the result of multiscale spatial and temporal dynamics. In order to determine the response of bird populations to the spatial and temporal changes in shrubland regions in the Intermountain West that were impacted by agriculture, fire, livestock grazing, mining, and urbanization, a series of satellite imagery taken over the past 30 years was used to determine the influence of these disturbances on the composition, configuration, and rate of change of the landscape.

A research design has been developed that incorporates a hierarchical approach to estimating composition, configuration, and change at multiple scales in space and time. The response of breeding birds will be determined by coupling Breeding Bird Survey and field estimates of population trends with multiscale estimates of spatial and temporal changes in landscapes.

In conclusion, these groups of researchers have shown other researchers that there are indeed new ways to approach both old and new unanswered questions regarding rangelands. Furthermore, they have shown that while these spatial concepts and tools can involve long runs of data over vast areas in synoptic data coverage, they can also be employed to better organize and analyze short runs of data over small spaces.

The majority of the presentations had aspects that should appeal to managers. What remains to be done is to explore shortcuts to the procedures so that the costs of applying these new approaches can be brought into routine practice. We believe we have provided sufficient demonstrations that these approaches are worth further encouragement by both scientists and managers.

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References

Goovaerts, P. 1999. Geostatistics in soil science: state-of-the-art and perspectives. Geoderma 89:1-45.

Gustafson E J. 1998. Quantifying landscape spatial pattern: What is the state of the art? Ecosystems 1(2):143-156.

Isaaks, E.H. and R.M. Srivastava. 1989. An Introduction to Applied Geostatistics. Oxford University Press, New York, N.Y..

Kavanagh, B.F. 2002. Geomatics. Prentice Hall, Upper Saddle River, N.J..

Klopatek, J.M. and R.H. Gardner (eds.). 1999. Landscape Ecological Analysis: Issues and Applications. Springer-Verlag, New York, N.Y..

Plotnick, R.E., R.H. Gardner, and R.V. O'Neill. 1993. Lacunarity indices as measures of landscape texture. Landscape Ecol. 8(3):201-211.

Rossi, R.E., D.J. Mulla, A.G. Journel, and E.H. Franz. 1992. Geostatistical tools for modeling and interpreting ecological spatial dependence. Ecol. Monogr. 62(2):277-314.

Sundt, P. 2002. The statistical power of rangeland monitoring data. Rangelands 24(2):16-20.

Turner, M.G., R.H. Gardner, and R.V. O'Neill. 2001. Landscape Ecology in Theory and Practice: Pattern and Process. Springer-Verlag, New York, N.Y.