soil by physical forces generate homogeneity in the vertical axis through soil mixing and significant heterogeneity in the horizontal axis. The actual influences and the spatial patterns in which they occur, comprise a significant and poorly understood process in natural systems.

B31A MC: Hall D Wednesday 0830h

Global Terrestrial Vegetation Dynamics From the EOS MODIS and Other Remote Sensors

Presiding: **S W Running,** Univ. of Montana

B31A-0075 0830h POSTER

Annual Cycle of MODIS Albedo, Nadir BRDF-Adjusted Reflectance and BRDF Products

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The MODerate resolution Imaging Spectroradiometer (MODIS) BRDF/Albedo Products (MOD43B) have been available to the public since July 2000. For the first time, an annual phenological cycle of these MODIS products is available for use by climate and biogeochemical modelers. Model parameters describing the Bidirectional Reflectance Distribution Functions (BRDF), measures of the albedo, and Nadir BRDF-Adjusted Reflectances (NBAR) have all been upgraded to a provisional status (from November 2000 onward). The operational MODIS BRDF/Albedo algorithm relies on multidate, atmospherically corrected, cloud-free surface reflectances and a semiempirical kernel-driven bidirectional reflectance model (RossThickLiSparseReciprocal) to determine parameters describing the BRDF of the global land surface. These one kilometer gridded parameters (for seven spectral bands and three broad bands) are then used to determine the global directional hemispherical reflectance ("black-sky albedo") at local solar noon, and the bihemispherical reflectance ("white-sky albedo") for each 16-day period. Global spectral NBARs (at the mean solar zenith angle of the observing period) are also computed to provide surface reflectances that have been corrected for view angle effects. Due to the consistency of this product over time, NBARs are particularly useful in capturing the phenological signal of the underlying surface vegetation. Thus annual sequences of the NBAR Product serve as the primary input for the MODIS Land Cover Product (MOD12Q). The MODIS BRDF/Albedo products are currently globally available at 1km and 5km resolutions and a 1/4 degree resolution version will soon be released. The annual temporal sequences will be presented as well as a discussion of the evaluation and reprocessing efforts that are underway.

URL: http://geography.bu.edu/brdf/

B31A-0076 0830h POSTER

Mapping Global Vegetation and Land Cover Properties from MODIS

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Data from MODIS provide a rich source of information for vegetation and land cover mapping applications. In particular, the multispectral and multitemporal information supplied by MODIS allows a variety of vegetation properties to be mapped and monitored at global scales in a fashion that was not previously possible. In this paper, we describe the algorithms and databases being used to produce the MODIS global land cover parameter, focusing particular attention on a suite of vegetation properties that complement more traditional land cover maps derived from remote sensing. Specifically, we describe a set of internally consistent maps, each depicting different vegetation attributes that have wide utility for studies of ecosystem dynamics at continental to global scales. The set of parameters being mapped include permanence of above ground biomass, leaf longevity, leaf type, and phenologic dynamics, among others. The methodology used to create these maps exploits a database of site data that includes detailed information related to ecosystem properties at global scales. The relationship between these maps and more traditional maps based on conventional classification systems, such as the IGBP scheme, will also be discussed. To illustrate the utility and information content of the maps being produced by MODIS specific examples at regional scales that include a range of climate and ecosystem types are presented.

URL: http://geography.bu.edu/landcover/

B31A-0077 0830h POSTER

Vegetation Dynamics and Seasonal Responses of North and South America from EOS-MODIS Vegetation Indices

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Consistent and long-term measurements from satellite sensors are important in assessing the spatial and temporal variability of the earth's terrestrial vegetation and in studying how global ecosystems are changing and how the earth's vegetation is being transformed. In this paper we present and evaluate one year of vegetation index product availability from the Moderate Resolution Imaging Spectroradiometer (MODIS). Two MODIS vegetation indices (VI), the normalized difference vegetation index (NDVI) and enhanced vegetation index (EVI) are produced at 1 km, 500 m, and 250 m resolutions and 16-day compositing periods. Multitemporal, seasonal profiles of the MODIS VI's are presented for numerous biome types in North and South America which depicted quite well their respective phenologies. The dynamic range of the MODIS VI's are presented and their sensitivities in discriminating vegetation differences are evaluated over sparsely vegetated areas as well as high biomass, densely vegetated areas. We found the NDVI to asymptotically saturate in high biomass areas while the EVI remained sensitive to vegetation variations in higher biomass regions such as in the Amazon. Validation campaigns were made at test sites representing semi-arid grass and shrub, savanna, and tropical forest biomes. Results show a good correspondence between airborne-measured, top-of-canopy, reflectances and VI values with those from the MODIS sensor over the test sites. Simultaneously derived field biophysical measures also demonstrated the science utility of the VI's.

B31A-0078 0830h POSTER

MODIS Vegetation Cover Products for Estimating Tree Cover and Monitoring Change

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Accurate estimates of global and regional tree cover are crucial for the study of biogeochemical cycles, ecosystem assessment, and land management. Changes in tree cover are equally important as they represent perturbations of the earth system.

We present two new products derived from the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument onboard NASA's Earth Observing System Terra satellite. These products utilize the unique combination of spatial resolution (250m - 1km), daily global image acquisition, radiometric accuracy, and geolocation provided by MODIS.

The Vegetation Continuous Fields (VCF) product provides percent cover estimates at 500m spatial resolution for tree cover and vegetation life-form variables. This product is based on a time-series of data which captures the annual phenologic cycle. Prototype products for various regions of the world are presented and compared with other satellite-derived products as well as validation data sets collected on the ground.

The Vegetative Cover Conversion (VCC) product utilizes the 250m red and near-infrared bands on MODIS to detect changes in land cover. Changes of interest include flooding, burning, deforestation, urbanization and agricultural expansion. Various regional examples of dramatic land cover change are presented within the context of their impact on tree cover.

URL: http://glcf.umiacs.umd.edu/MODIS

B31A-0079 0830h POSTER

Siberian Landcover Analysis with MODIS and Landsat

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The Terra MODIS landcover product provides annual information on the type and extent of important cover classes. This product is useful for identifying change over large areas given the repeat observations of MODIS. It is important to know how well this product defines the landscape, especially in areas of rapid change. In Siberia, there is rapid change taking place form a host of factors including wildfire, insects, and logging. This paper reports on the results of a study to ascertain the relevance of the MODIS landcover product and its ability to detect change. In addition we evaluate the use of other products such as NDVI and EVI for our disturbance work in Siberia.

B31A-0080 0830h POSTER

The MODIS Land Rapid Response Project: A Comprehensive Suite of Products to Support U.S.D.A. Forest Service Fire Management

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The Moderate-resolution Imaging Spectroradiometer (MODIS) instrument on board the Terra satellite offers exceptional capabilities of observation for terrestrial surfaces. MODIS is viewing almost the entire Earth's surface every day, with a spatial resolution ranging from 1km to 250m, and covering a wide spectral range of observation, from visible to thermal infrared. The unprecedented combination of daily spatial coverage, 250m spatial resolution, and spectral characteristics makes MODIS ideal to observe a variety of rapid events: fires, floods, smoke transport, dust storms, severe storms, volcanic eruptions. A new processing system has been developed at NASA's Goddard Space Flight Center to provide a rapid response to those events, with initial emphasis on active fire detection and quasi-true-color 250m-resolution imagery. MODIS data of most of the Earth's land surface is processed within a few hours of data acquisition. A basic atmospheric correction is performed operationally to provide true-color imagery. An operational detection process retrieves the location of active fires. The perimeter of the fires are overlaid on true-color imagery and posted on a web site. A collaboration between NASA, the University of Maryland and the USDA Forest Service has been developed to provide fire information derived from MODIS to the fire managers. Active fire locations detected by MODIS in the conterminous United States are communicated to the USDA Forest Service within a few minutes of production. These active fire locations are used to generate cumulative fire maps, updated daily and made available to the fire managers. Active fire locations are also distributed through a web interface integrating MODIS active fire locations and Geographic Information System (GIS) datasets using GIS technology, as a contribution to the Global Observation of Forest Cover (GOFC) project. Burn severity maps derived from MODIS data are also being developed and will be made available within a few days after the fires to help burned area emergency rehabilitation teams. The design of the MODIS Rapid Response system is presented. The rapid atmospheric correction process and the active fire detection algorithm are described. Examples from the suite of MODIS Rapid Response fire products are presented. Results from the 2001 fire season in the United States are summarized and discussed. Products from the MODIS Rapid Response System can be obtained at http://rapidfire.sci.gsfc.nasa.gov.

URL: http://rapidfire.sci.gsfc.nasa.gov

B31A-0081 0830h POSTER

Independent Confirmation of the MODIS LAI/fPAR Algorithm

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The Leaf Canopy Model (LCM)-2 is a nested model that combines leaf radiative transfer with a full canopy reflectance model through the phase function (Ganapol et al. 1999). The basic components of the model include inversion for a leaf scattering coefficient, construction of a representative absorption coefficient and the determination of canopy reflectance given leaf area index (LAI) values and information on canopy type and structure. It can also be used to calculate the fraction of absorbed photosynthetically active radiation (fPAR) for the canopy. It therefore serves as an independent means of confirming the results of the MOD15 algorithm (Knyazikhin et al. 1998) that produces LAI and fPAR fields from reflectance measured by the Moderate Resolution Imaging Spectrometer (MODIS). In LCM2, relatively simple first principles of radiative transfer are used whereas in the MOD15 algorithm, scene variability is accounted for by specifying distributions and a response surface in a table-lookup procedure. The distributions are generated by various radiative transfer models with a host of underlying assumptions. The attempt to compare results from these two models is a useful means of addressing the structural uncertainty in the Earth Observing System prediction problem.

We compared LCM2 results with those from the MOD15 algorithm for fPAR calculation. 100 pixels for an EOS Core Validation Site where there were coincident reflectance, vegetation index, fPAR and LAI products were chosen. The 8-day 500 m reflectance product was spatially degraded to coincide with 8-day 1 km LAI and fPAR products and LAI and land cover products were used to parameterize LCM2. Most fPAR results agreed to within 10 percent, though a bias was observed. Poor agreement was seen with vegetation index products.

Ganapol, B.D., L.F. Johnson, C.A. Hlavka, D.L. Peterson, and B. Bond, LCM2: A coupled leaf/canopy radiative transfer model, Remote Sensing of Environment, 70:153-166, 1999.

Knyazikhin, Y., J.V. Martonchik, R.B. Myneni, D.J. Diner, and S.W. Running (1998) Synergistic algorithm for estimating vegetation canopy leaf area index and fraction of absorbed photosynthetically active radiation from MODIS and MISR data, Journal of Geophysical Research, 103:32257-32276.

B31A-0082 0830h POSTER

Remote sensing of vegetation and fire dynamics during SAFARI 2000

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Remote sensing of vegetation dynamics during the SAFARI 2000 campaign shows an increase in vegetation greenness south of 15S over the Southern Africa region as inferred from vegetation index measurements made by the NOAA satellite system. Specifically, during the 1999/2000 growing season, most of the region showed anomalous positive departures to in vegetation on the order of 40 % above the 1981-2000 mean, especially over the shrub and grassland areas of Namibia and Botswana. This increase in the vegetation index is related to above normal rainfall during this period associated with the cold phase of the ENSO phenomena, which exerts a major influence on the interannual climate dynamics of this region. An extended growing season and above normal green biomass accumulation increased the amount of fuel available during seasonal burning between May-October 2000. There was a noted increase in the number of fires over the bush grassland areas during this period, compared to the previous SAFARI campaign in 1992, when this region received below normal rainfall associated with the 1991/1992 warm ENSO event. Comparison of data from in-situ airborne measurements of trace gases and aerosols from these two campaigns will need to take into consideration the very different vegetation and fire conditions

B31A-0083 0830h POSTER

Use of EO-1 Hyperion Data for the Inter-Sensor VI Translations to Minimize Differences in Spectral Band-Pass Filters

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Spectral calibration of remote sensors have been a major effort for many satellite programs, and the continuity and compatibility of derived data products such as spectral vegetation index among different sensors have been paid attention in these days. Those efforts are also needed to increase accuracy in land surface observations by different optical sensors onbord multiple satellites that have differences in spatial, spectral and temporal resolutions. This is particularly true with the recent advancement of satellite technology involving autonomous formation flying, e.g., ALI on board the EO-1 platform with Landsat-7 ETM+ and Terra MODIS/MISR/ASTER sensors. This study is to use the hyperspectral data from EO-1 Hyperion sensor to rectify NDVI products in spectral sense by accounting the differences in band-pass filters of various sensors. The technique first designs a sensor specific vegetation index (VI) and background brightness index (BI) for each sensor. Those VIs and BIs are then used to estimate the common parameters (sensor independent parameters) attributed to vegetation amount and background brightness. Finally, these common parameters are used for the translation of VI among sensors. This algorithm will be demonstrated using hyperspectral satellite data from the Hyperion sensor onboard the EO-1 platform simulating various sensorsf spectra over several land cover types.

B31A-0084 0830h POSTER

Study of Aggregation Errors of the MODIS Landcover Image Using Analytical Equations and Spatial Pattern Metrics

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The scale of a study is an interaction of resolution (grain) and extent. Domians of scale appear to exist in which a relationship established at a particular scale may be reliably extrapolated at similar scales, but may break down when applied at very different scales. Pattern assessment based upon remote sensing data can therefore be considered as a hierarchical process, involving structural measurements at various scales.

Spatial aggregation of data is required because patterns (and processes) have to be studied at the exact scale, and because high resolution data requires more processing and storage capacity. Data scale can be adjusted by aggregation of sub-pixels into pixels that represent a larger actual area, resulting in a smaller data set. Generally, the majority rule is applied to aggregate data, in which the pixel is assigned to the class represented by a majority of sub-pixels.

The reliability of image analysis is assessed by analyzing the errors present in spatial data as the result of aggregation. Two main features are focused on: landcover class area and landcover pattern. Rare land cover types are lost when grain becomes coarser. Patchy arrangements dissappear more rapidly with decreasing resolution than contagious ones. Problems with grain arise when spatial elements at the sub-pixel level are scattered and are as small or smaller than the pixel. The spatial structure of the data sets at different scale (aggregation) levels is analyzed using patch statistics (area, perimeter, shape) and by calculation of pattern metrics (e.g. contiguity, clustering, class area evenness).

Next to pattern analysis, analytical equations and relationships are developed to quantify aggregation effects. This will include the consideration of aggregation procedures different from the majority rule. Because the change -and the concomitant loss- of information with change of resolution is determined by the aggregation rule, insights provided by these analytical equations allows alternative aggregation schemes to be evaluated.

The study is executed using aggregated images generated from the MODIS landcover image representing North America (original resolution 1 km) and containing 18 landcover classes (15 biomes, urban and built-up, water bodies, and open space related to image projection).

URL: http://cybele.bu.edu

B31A-0085 0830h POSTER

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The recent availability of quasi-simultaneous multispectral and multidirectional measurements from space, as provided by the Multiangle Imaging SpectroRadiometer (MISR) on board the Terra platform, offers new and unique opportunities to document the anisotropy of land surfaces at critical solar wavelengths. This contribution outlines simple physical principles supporting the interpretation of the anisotropy of spectral radiances exiting terrestrial surfaces in terms of a signature of surface heterogeneity. The shape of the anisotropy function is represented with two model parameter values which may

be mapped and interpreted in their own right. Beyond the information about the heterogeneity of the surface, the value of one of these parameters also permits identifying geophysical conditions where the surface heterogeneity becomes significant. Structure functions and singularity measures can be employed to describe the non-stationary and intermittent behaviour of geophysical fields. This approach is applied on synthetic height field measurements of a large variety of vegetation canopies. The joint analysis of the shape of the anisotropy function together with the height fields yields remarkable patterns of organization: It is possible for multiangular instruments, like MISR, to deliver information about the type of surface heterogeneity at the subpixel scale, that is in agreement with canopy structure characterizations obtained by other means.

URL: http://www.gvm.sai.jrc.it/stars

B31B MC: Hall D Wednesday 0830h

Land Use and Land Cover Change: Observations and Consequences II

(joint with GC)

Presiding: **N Ramunkutty,** University of Wisconsin**; R Leemans,** National Institute for Public Health the Environment (RIVM)

B31B-0086 0830h POSTER

Controls on Early Rates of Succession in a Virginia Piedmont Old-Field.

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There are many factors that influence plant community production and structure during succession on temperate old-fields. To investigate the effects of proximity to forest edge and method of abandonment on ecosystem properties and community structure during succession, field measurements of leaf area index (LAI), species composition, and soil carbon were collected along four transects within a 14 year old temperate successional field over the 2000 growing season. Additionally, normalized difference vegetation index (NDVI) was calculated from Landsat 7 satellite data at a resolution of 30 m for the entire field. Values of LAI and NDVI were used to examine spatial variations in vegetative biomass and foliar production, while relative frequencies of trees were used to provide information regarding rates of succession. Results show a significant positive relationship between proximity to forest edge and peak season LAI ($r = 0.55$, $p < 0.001$) and NDVI ($r = 0.84$, $p < 0.001$). Additionally, the presence of several key plant species, such as Celastrus orbiculatus (Japanese bittersweet), exhibited a strong control on the variability of LAI. Values of vegetative biomass (LAI and NDVI) taken in mid-August were significantly higher (ANCOVA, $p < 0.05$) in the section of the field plowed at the time of abandonment. In general, frequencies of trees increased with proximity to forest edge suggesting greater rates of succession at these locations. However, soil carbon levels do not show a significant increase at sites in later successional states, suggesting that the recovery period for soil carbon in these systems is greater than 14 years.

B31B-0087 0830h POSTER

Land Cover, Rainfall and Land Surface Albedo in West Africa

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Land surface albedo is an important variable in General Circulation Models (GCMs). When land cover is modified through anthropogenic land use, changes in land-surface albedo may give rise to atmospheric subsidence and reduction of rainfall. In this study we examined albedo time series, derived from AVHRR Pathfinder data, and their relationships with rainfall, land cover, and population in West Africa. This particular region was selected because it has become a focal point in debates over biophysical impacts of desertification and deforestation. Our analyses revealed that albedo and rainfall were related only modestly at short time scales (monthly and annual) and that mean annual albedo values remained relatively stable from 1982-1989 over a wide range of climatic and vegetation zones in West Africa. The relationship between long-term mean rainfall and mean albedo was strong and curvilinear ($r2 = 0.802$). The same was true for the relationship between percent tree cover and mean albedo ($r2 = 0.659$). These results suggest that long-term climate patterns, which control vegetation type and canopy structure, have greater influence on albedo than short-term fluctuations in rainfall. Our results reinforce other recent studies based on satellite data that have questioned the extent and pervasiveness of desertification in West Africa.

URL: http://www.gwu.edu/~geog

B31B-0088 0830h POSTER

Spatial and Temporal Drivers of Fire Dynamics in the Amazon/Tocantins Basin

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This study examines factors and processes explaining the current spatial and temporal distribution of fires in the Amazon/Tocantins basin. It combines mid-1990s observations of agricultural land-use and fires derived from the GOES-8 satellite with natural burned areas simulated using climatic and fuel load limitations. The spatial distributions of observed fires in 1995 and 1997 are generally similar, 1995 having significantly more fires (+10%). In several subregions, we find a significant correlation between spatial distributions of observed fires and land-use. Nevertheless, when considering the entire basin this relationship is not as pronounced due to land-use data set biases, as in Amazonas, or to inadequate spatial and temporal resolution needed to detect all fires, as in Tocantins and along the Andes. When comparing the spatial distributions of fires in 1995 to the different land-use types maps, planted pasture shows the best agreement with fire occurrence; cropland is often not a significant predictor, and natural pasture has an intermediate behavior. The main features of the 1997 minus 1995 differences of fire distribution can be explained by climatic anomalies. The strong 1997 El Niño event has a significant impact on the numbers and patterns of fire, especially in Bolivia and around Manaus where the associated precipitation changes are large. The 1997 minus 1995 differences in fire dynamics in regions with small changes in climate are probably the result of some anthropogenic factors. Interannual differences in climate factors, coupled with maps of land use, provide a strong basis for understanding and potentially predicting fire dynamics in this rapidly changing region.

B31B-0089 0830h POSTER

Detection and Mapping of Desertification

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The extent and severity of desertification is an important issue that affects economic development, and is significant in the context of global climate change and the global carbon cycle. The need for a measure of desertification that can also be used to map the extent and severity of the problem has long been recognized, but there is a lack of any readily measured, objective indicators applicable at a regional. Amongst the definitions of desertification many make clear the central role of the carbon cycle. Satellite remote sensing has partly supplied the need for data by providing techniques that can detect variables related to net primary production (NPP). We have developed procedures for mapping desertification using satellite data and a carbon cycle model (GLO-PEM) that allows monitoring the actual and potential NPP. We will discuss work in southern Africa where we have shown that negative deviations from the potential (undesertified) NPP provide an effective indicator of desertification. Three approaches to measurement using reduced NPP will be presented. The first is the Rain Use Efficiency, the ratio of NPP to rainfall over a five-year period. Deviations from the conservative value of RUE provides a useful index of degradation, independent of the rainfall. A second, more mechanistic technique using a comprehensive biogeochemical model to estimate potential NPP is used to overcome the limitations of estimating potential NPP with rainfall alone. The index of degradation in this case is the difference between potential and actual NPP. One problem with both RUE and Potential-Actual NPP is a limitation on spatial resolution caused by data; meteorological stations are sparsely distributed and local rainfall can be spatially highly variable in semi-arid regions. To avert this problem, a third technique has been developed, Local NPP Scaling (LNS), in which the NPP of each pixel is expressed as a proportion of the maximum observed in all land falling into the same terrain type. Stratification by terrain type allows climate, soil and land cover differences to be normalized and degradation to be detected relative to the maximum observed NPP. Cultural factors can also be included, such as commercial or communal land tenure. The results suggest that the deviation of NPP was quite variable throughout the region during the period of study. Thus, in parts of the region, NPP seems to be significantly less than the potential productivity, and it is these that we have identified as desertified.

B31B-0090 0830h POSTER

Closing the System: Carbon Storage and Cation Uptake to 10 m Depth Along a Gradient of Precipitation and Vegetation Change

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Shifts of woody and herbaceous vegetation with deforestation, afforestation, and woody plant encroachment alter above- and belowground allocation of plants and the depth and distribution of roots, in turn influencing soil nutrient distributions, net primary production, and carbon storage. This study compared adjacent grassland and shrubland communities along a precipitation gradient in the central United States (230-1100 mm mean annual precipitation). Paired fenceline comparisons at six sites were used to compare differences in carbon storage and cation uptake as a consequence of woody plant encroachment to 10 m depth in the soil. Along the gradient there was a clear negative relationship between precipitation and the amount of SOC stored in the top 3 m of soil after conversion to woody vegetation. Woody plant encroachment increased soil organic carbon (SOC) content at the three drier sites and decreased SOC at the wetter sites, with a crossover point for this linear decline of 500 mm precipitation (approximately the point of canopy closure). While none of the three desert sites gained more than 1.3 kg m-2 of SOC, the three wetter sites lost =1, 4, and 6 kg m-2. Sr signatures of the grasses matched the signatures in the shallowest soil layers almost perfectly at sites with more than 300 mm precipitation, but the integrated depth of Sr uptake was a surprisingly deep 2 to 3 m for the two driest grasslands. Overall, desertification and woody plant encroachment altered the depth of Sr uptake substantially at all sites except Vernon, most prominently a dramatic 2.5 m shift at Riesel.

URL: http://www.biology.duke.edu/jackson

B31B-0091 0830h POSTER

The Use of Biofilter to Reduce Atmospheric Global Warming Gas (CH4) Eemissions from Landfills

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