Quantifying biomass fluctuations in Mitchell Grassland, Queensland, using multi-temporal MODIS data

○Kithsiri Perera[1] and Ryutaro Tateishi[2]

Abstract: The Mitchell grassland in northern Australia covers more than 335,300 sq km of land. The sustainability of this unique ecosystem is the key to efficient use of grassland in related economic activities. In this regard; satellite images provide the most effective data source to monitor, especially when consider its huge coverage and homogeneous land cover. The amount of greenery of the grassland is directly related to fluctuations of the rainfall which has greater variations from year to year. The present study links greenness changes of Mitchell grass with rainfall fluctuations within rainy months. We utilized temporal MODIS images to study greenness changes in a selected area in eastern region of the Mitchell grassland. After evaluating the use of Normalized Difference Vegetation Index (NDVI) and Enhanced Vegetation Index (EVI) in grassland and cropland studies, NDVI was used to extract greenness of the grassland. The mapping task was supported by field investigations already completed in the area and very high resolution image potions available in Google Image. Results clearly indicated a significant change in greenness, when the rainfall amount is changing within rainy months. The finding can be developed into a methodology that gives recommendations for the use of grassland, according to the productivity of the rainy season. Future research directions will include NDVI calculations for different dry months, and collecting field photo evidence under different rainfall conditions, to build a solid relationship between rainfall and sustainable use of the grassland.
Keywords **:** Mitchell Grassland, MODIS data, NDVI, Biomass fluctuations

1. Background

Mitchell Grass (*Astrebla spp*.), is a native grass species to Australia which covers a massive region (335, 332 square kilometers) in Queensland and Northern Territory. The bulk of Queensland's cattle and sheep farming is depending on Mitchell grass (Tropical Savannah CRC, 2009) and it is the primary feeding sources for about 12 million cattle in the state. Figure 1 shows the location of Mitchell Grassland.

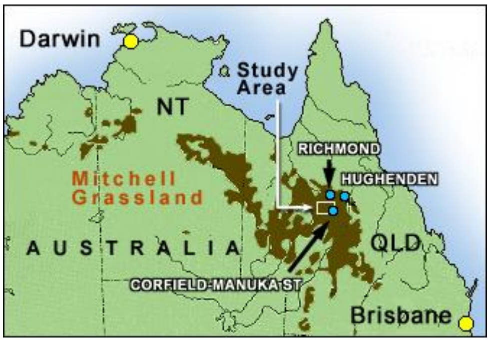

Fig. 1. Location of Mitchell Grassland and study area.

Figure 2 shows the general view of Mitchell grassland. Due to the economic and ecological importance of the grassland, regular monitoring of its various aspects is essential. For such monitoring purpose, application of satellite data is the practical approach, due to the widespread and homogeneous land cover character of Mitchell grassland.

MODIS (Moderate Resolution Imaging Spectrometer) medium resolution data became widely available for the scientific community since late 1990s (Barnes et al, 2003) to study various aspects of earth surface including land cover mapping and clarifying land cover status (Price, 2003; Perera and Tsuchiya, 2009, Xiong et al, 2009). For this study too, MODIS can be considered as the most suitable data source.

2. Data and study area

Extremely high rainfall (529.6 mm), recorded in north-east region of the grassland in Nov to Jan three months in 2008/2009 prompted the idea to examine the greenness of grassland against low records of same three months. Figure 03 shows last 100 year Nov-Jan three months rainfall data of Hughenden (No. 030024) in Queensland (Bureau of Meteorology, 2009). Rainfall pattern of another two stations were also analyzed and found a similar trend (see fig. 01 for locations). The lowest rainfall for Nov-Jan in recent years has recorded in 2003 (29.4mm). Yet, this amount is higher than the typical dry season (only 12.4 mm in Apr to Sept, 2009).

Fig. 2. Mitchell grassland, 200km west to Hughenden.

After observing daily MODIS data for the first 10 days of February (days followed by the three-month duration), images dated 05th February 2003 and 5th February 2009 were selected (WIST, 2009). NASA provides these data after correcting geometric and radiometric errors,

[1] Kithsiri Perera
(Faculty of Engineering and Surveying and Australian Centre for Sustainable Catchments, University of Southern Queensland, West Street, Toowoomba 4350 QLD Australia.)
(Contact: Tel; +61-7-4631-2543, E-mail; perera@usq.edu.au)
[2] Ryutaro Tateishi
(Center for Environmental Remote Sensing (CEReS), Chiba University, 1-33 Yayoi-cho, Inage-ku, Chiba 263-8522, Japan)
(Contact: Tel; 043-290-3850, E-mail; tateishi@faculty.chiba-u.jp)

making the data is suitable for scientific research. Based on rainfall data and field investigations conducted in 2007, a Mitchell grass dominant study plot of 800 by 400 pixels (20,000 sq km) was selected for the study.

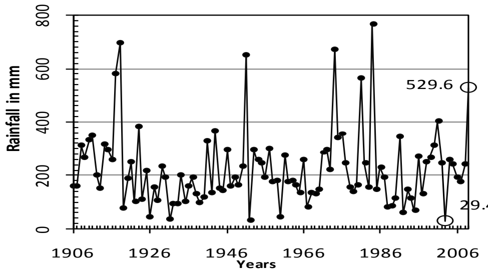

Fig. 3. Nov-Jan rainfall, Hughenden

3. Data processing and results

When the area is wide with homogenous land cover type (grass), and free of snow, sand dunes, and clouds, researchers have found both NDVI (Normalized Difference Vegetation Index) and EVI (Enhanced Vegetation Index) are producing similar seasonal variations (Wardlow et al., 2007). Therefore, NDVI was selected to extract plant biomass characters. Image processing was conducted using ENVI 4.4 software package, after installing MODIS HDF conversion toolkit. NDVI for both images were computed using MODIS Band 01 and Band 02 (Fig 4).

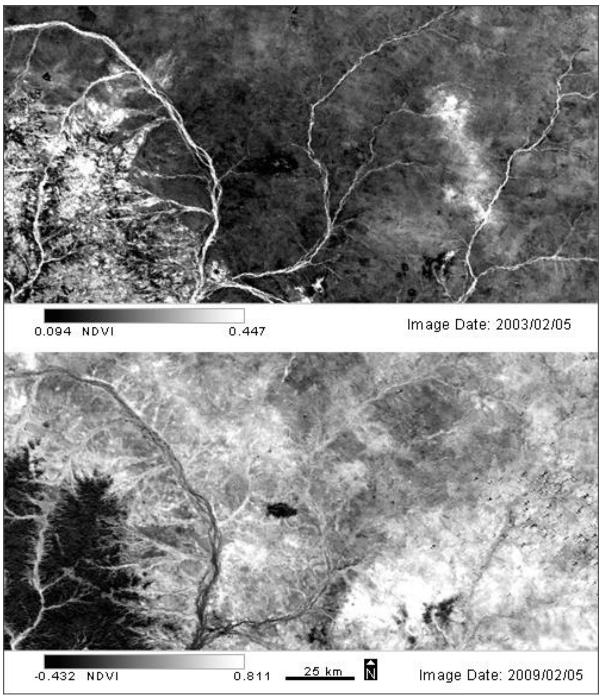

Fig. 4. NDVI of 2003(top) and 2009.

A clear improvement in greenness can be observed even visually. White to gray represents greener pixels. In 2003, white linear shape riparian vegetation along the rivers is clearly visible among dry Mitchell grass but disappeared in 2009 heavy rainy season, among greener grasses. All NDVI values were less than 0.447 in 2003 image while 2009 image recorded values as high as 0.81 ($-1 <$ NDVI < 1 and closer to 1 is greener). Also, mean NDVI values showed the different clearly, i.e., 0.21 in 2003 and 0.43 in 2009. Changes of the greenness is directly related to the precipitation, hence, quantitative relationship between precipitation and greenness has examined. Figure 5 presents histograms of NDVI at lowest (2003) and highest precipitation (2009) events. Under the assumption of bulk of area covered by grass, the biomass increase can be explained by the rightward shift of the curve, as a result of heavy rains. The noise around 2003 NDVI 0.20 presents the impact of open soil within grassland in weak wet season.

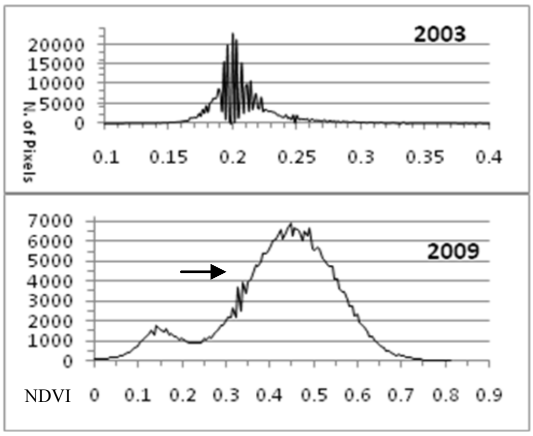

Fig. 5. Comparison of NDVI values.

4. Conclusions

MODIS data based NDVI values were successfully analyzed to confirm the biomass changes in Mitchell grass. Future research steps will examine greenness in intermediate rainy seasons and comparison with dry seasons. Also, field investigations are important to link rain and grass growth rates. A successful link between rain amounts and grass conditions will help for sustainable management of Mitchell grassland.

References

Barnes, W. L., Xiong, X., Salomonson. V. V., (2003), Status of TERRA and Aqua. Adv.Space Res., 32(11) ,2099-2108, 2003.

Bureau of Meteorology (2009), Weather station data, http://www.bom.gov.au/climate/data/weather-data.shtml

NASA, MODIS Rapid Response Systems (2009), http://rapidfire.sci.gsfc.nasa.gov/, 2009.

Perera, K., Tsuchiya, K., (2009) Experiment for mapping land cover and its change in south eastern Sri Lanka utilizing 250 m resolution MODIS, Advances in Space Research 43 (2009) 1349–1355

Price, J.C.,(2003) Comparing MODIS and ETM+ data for regional and global land classification. R Sensing of Environment, 86, 491-499, 2003.

Wardlow, B.D., Egbert S.L., Kastens H.J.,(2007) Analysis of time-series MODIS 250 m vegetation index data for crop classification in the U.S. Central Great Plains, Remote Sensing of Environment 108 (2007) 290–310.

WIST (2009), Warehouse Inventory Search Tool (WIST), https://wist.echo.nasa.gov/~wist/api/imswelcome/

Xiong, X, Chiang, K., Sun J., Barnes, W.L., Guenther, B., Salomonson, V.V., (2009), NASA EOS Terra and Aqua MODIS on-orbit performance, Ad. in Space Research, Volume 43, Issue 3, 2 February 2009, Pages 413-422

Acknowledgements: Thankful to CEReS, Chiba University, Japan, for partly funding this work under cooperative research grant, 2009. Also, special gratitude is due to Dr K. MacDougal and Dr. A. Apan, Southern Queensland University, Australia, for institutional facilities and encouragements.