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Improving the Accuracy of Cosmic-Ray Neutron Probe Estimate of Soil Water Content Using Multiple Detectors and Remote Sensing Estimates of Vegetation

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by

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The recently developed Cosmic-ray Neutron Probe (CRNP) for estimating soil water content (SWC) fills a critical measurement gap between point scale methods and large scale measurements collected from remote sensing. CRNP works by measuring the change in low-energy neutron intensity over time. However, the accuracy of CRNP to measure SWC is well known to be affected by other hydrogen sources (e.g. soil organic content, atmospheric water vapor, vegetation and surface water). This study focuses on the influence of rapidly growing vegetation in agricultural fields on the accuracy of the CRNP method.

Here we use data from three long-term CRNP study sites in central Nebraska (Paulman Farms, est. 2015), eastern Nebraska (US-Ne3, est. 2011), and central Iowa (IVS, est. 2010) that span a natural precipitation gradient of increasing precipitation from west to east. All three fields grow maize and soybean depending on rotation. At each CRNP site both hourly moderated and bare neutron counts are recorded. Previous research has shown that the bare to moderated ratio may be a good indicator of changing vegetation conditions and useful as a correction to estimating SWC. In addition, I use the MODIS remote sensing dataset to calculate a widely used index to monitor vegetation,

Green Wide Dynamic Range Vegetation Index (GrWDRVI or WDRVI). Finally, observed vegetation data from US-Ne3 was collected biweekly from 2003-2016 and used as a benchmark for the CRNP and remote sensing analyses.

My results indicate that biomass data determined from remote sensing (GrWDRVI) closely follows in-situ sampling of biomass (R^2=0.677 for Maize and R^2=0.567 for Soybean). The driest site (Paulman Farms) showed the best relationship between bare to moderated (B/M) ratios and GrWDRVI with an R^2 = 0.9188, while the wettest site (IVS) showed the worst relationship with R^2 = 0.09. I found that local correction factors using B/M ratio and moderated counts removing the influence of vegetation changes can be derived, thus removing bias in the CRNP SWC observations. The improved algorithm for estimating SWC from CRNP will be beneficial for long-term monitoring as well as validating remote sensing SWC products. More experiments with direct biomass observations and needed to fully understand the relationship between GrWDRVI, bare and moderated neutron counts, and in-situ biomass.

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Table of Contents

Table of Figures

Table of Tables

Chapter 1: Introduction

Hydrologic cycle plays a key role in water resources management. It will be beneficial to model and forecast hydrologic cycle in next decades (Vorosmarty, 2015). The rise of remote sensing, proximal sensing, citizen science, and opportunistic sensing have greatly increased our ability to observe the hydrologic balance (McCabe 2017). However, a critical gap remains in resolving the different spatial and temporal observation scales with scales at which decisions are made. For example, it is well known that estimating soil water content (SWC) at the appropriate spatial and temporal scale to make a management decision or compare with hydrological model output can be challenging (Vereecken 2008). There are many methods to measure SWC at point scale or large scale. However, these methods have well documented disadvantages. With respect to point measurements, we are not able to estimate SWC in surrounding areas due to spatially heterogeneous distribution of SWC over a range of length scales (Western, 1999). We can use satellite passive and active microwave sensor (i.e. SMOS and SMAP, Jackson, 1997, Kerr, 2010) to measure near-surface SWC over hundreds to thousands of square kilometers. But other influencing factors, such as vegetation cover, cloud cover, snow cover and surface roughness will affect the accuracy of satellite measurement (Njoku, 2003). Lastly the high initial cost of satellite data is of concern (Zreda, 2008, McCabe 2017 HESS).

Currently, most land surface models (LSM) aiming at characterizing the fluxes of water, energy, and nutrients, have relied on either sparse point scale SWC monitoring networks (Crow et al. 2012) or remote sensing products with large pixel sizes (~36 km) and shallow penetration depths (e.g., ~ 2-5 cm for SMOS/SMAP; Kerr et al., 2010 and SMAP Entekhabi et al., 2010). There is a critical scale gap between these methods requiring innovative monitoring strategies (Robinson et al., 2008). Moreover, as LSMs continue to move towards highly refined spatial resolutions of 1 km or less (Wood et al., 2011), the need for accurate and spatially exhaustive SWC datasets continues to grow (Beven and Cloke, 2012).

The recently-developed cosmic-ray method for measuring area-average soil moisture at the hectometer horizontal scale is being implemented in the COsmic-ray Soil Moisture Observing System and other complimentary networks around the globe (COSMOS, Zreda 2012, Andreasen 2017). The stationary cosmic-ray neutron probe measures the neutrons that are generated by cosmic rays within air and soil and other materials. The measured neutrons have been, moderated by mainly hydrogen atoms located primarily in soil water, and emitted to the atmosphere where they mix instantaneously at a scale of hundreds of meters; thus the density of neutrons is inversely correlated with SWC (Andreasen, 2016). Cosmic-ray Neutron Probe (CRNP) for estimating SWC fills a critical measurement gap between point scale methods and large scale measurements collected from remote sensing.

Atmospheric water vapor, surface liquid and solid water, vegetation liquid and solid water, soil water vapor and liquid and solid water, lattice water, plant tissue carbohydrates, and organic soil horizons are hydrogen pools existing at and near the land surface (Franz, 2012). When applying CRNP in complex ecosystems, uncertainty caused by other hydrogen sources should be accounted to improve the SWC measurement accuracy (Bogena, 2013). Based on previous research, hydrogen in biomass and organic matter in soil is usually small compared to the hydrogen in soil pore space and lattice water contained in the mineral grains. However, other researchers pointed out that neutron counts have been shown to be affected by fast growing vegetation, like maize or soybeans, and may require a correction factor for unbiased soil moisture measurements in time (Baatz, 2015).

In light of these challenges described above the main motivations for my thesis are the following:

1) Satellite estimates of SWC have large spatial footprints, are infrequent due to gaps in overpass times, and are constrained to near surface estimates.

2) Point scale soil water content observations are difficult to scale up to the landscape level where they are more relevant for decision making or model validation.

3) The CRNP contains both moderated and bare detectors that may be useful for detecting crop biomass and soil water content simultaneously at intermediate scales. To date minimal work has been explored using the bare and moderated detector (see Desilets 2010, Tian 2016, and Andreasen 2016, 2017 for preliminary work).

The overarching goal of this study is to explore the utility and accuracy of currently available remote sensing and vegetation datasets for use in the CRNP calibration function. To be more specific, my objectives are to explore the potential use of remote sensing products (i.e. MODIS) to determine what are the required cropping systems biomass information for integration in the standard CRNP calibration process, and investigate a strategy to simultaneously estimate crop biomass and soil water content using the CRNP moderated and bare detectors. The remainder of this thesis is organized as follows. Chapter 2 is summary of field experiments and remote sensing data at three existing study sites across the Midwest. This study specifically looked at MODIS satellite data and bare and moderated tubes for up to a 6-year period. Using the remote sensing data, neutron observations, and in-situ biomass data I explored statistical relationships to predict crop biomass information from neutron counts alone. Chapter 3 presents a summary of research and recommendations for future work.

Chapter 2: Incorporation of Multiple Detectors and Remote Sensing Estimates of Vegetation for Estimating Field Scale Soil Water Content

2.1. A Summary of the Cosmic-ray Neutron Probe (CRNP) Method

Instead of measuring soil moisture directly, CRNP monitors soil water content by measuring low energy neutron intensity (Zreda et al. 2008, 2012). Incoming higher level energy particles from out space will first interact with earth's atmospheric nuclei (Zreda et al., 2012 and Kohli et al., 2015, Andreasen 2017). After this process, fast neutrons are created. Then fast neutrons will continue to interact with nuclei in atmosphere and soil which resulting in more energy loss. Epithermal neutrons are the products of fast neutrons collision with nuclei (epithermal neutrons are measured by moderated neutron intensity, showing in Fig 2.1). The removal rate of epithermal neutrons are mainly controlled by hydrogen atoms in atmosphere and soil. (Zreda et al. 2012). Soil water content (SWC) is one of the largest sources of hydrogen present in terrestrial systems (McJannet et al. 2014). Thus, the changes in soil water content would cause the changes of epithermal neutron intensity. However, the shape of the calibration function is modified by local soil and vegetation parameters (Zreda et al. 2012) reflecting the variation of background hydrogen levels across landscapes.

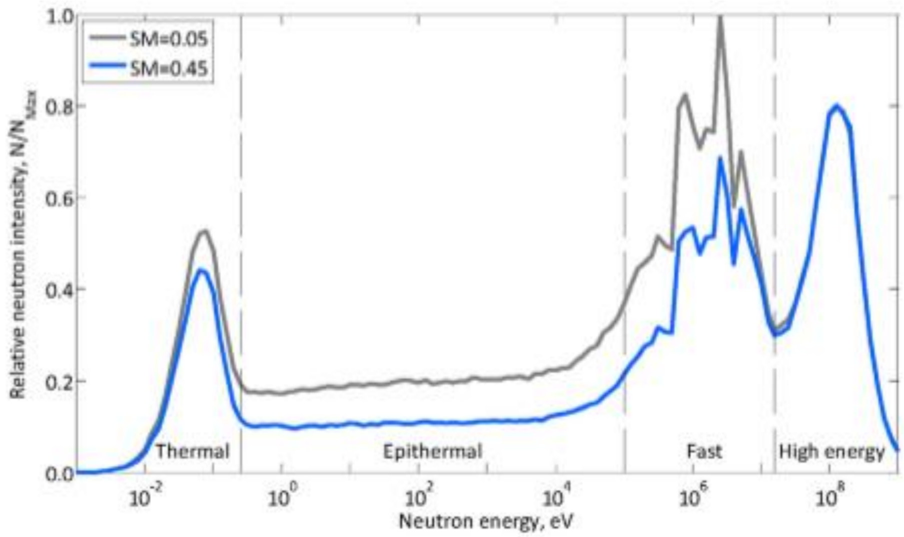


Figure 2.1: Ground level (1.5 m above the ground surface) energy spectra of cosmic-ray neutrons at volumetric soil moisture (SM) of 0.05 and 0.45 at an agricultural field site in western Denmark (bare ground conditions). The spectra are modeled using a modified model setup of Andreasen et al. (2016). The neutron transport model MCNP6 was used with the galactic cosmic-ray source option. Note the moderated detector primarily records epithermal neutrons while the bare detector records thermal neutrons. Figure was first published as Figure 2 in Andreasen et al. 2017.

The neutron detector of CRNP can measure up to ~300 m in radius with vertical penetration depths of 12 to 76 cm depending on soil water content (Zreda et al. 2008). Other researchers has proved that the footprint of CRNP is affected by atmospheric water vapor, elevation, surface heterogeneity, vegetation and soil water content (Desilets and Zreda, 2013, Kohli et al., 2015). With the large measurement footprint area up to tens of hectares, CRNP is an ideal new technology to monitor average field soil water content throughout the world. Over 200 fixed CRNP station are located in the United States of America, Australia, Germany, South Africa, China, and the United Kingdom currently (see Andreasen 2017 for recent review, Fig. 2.2).

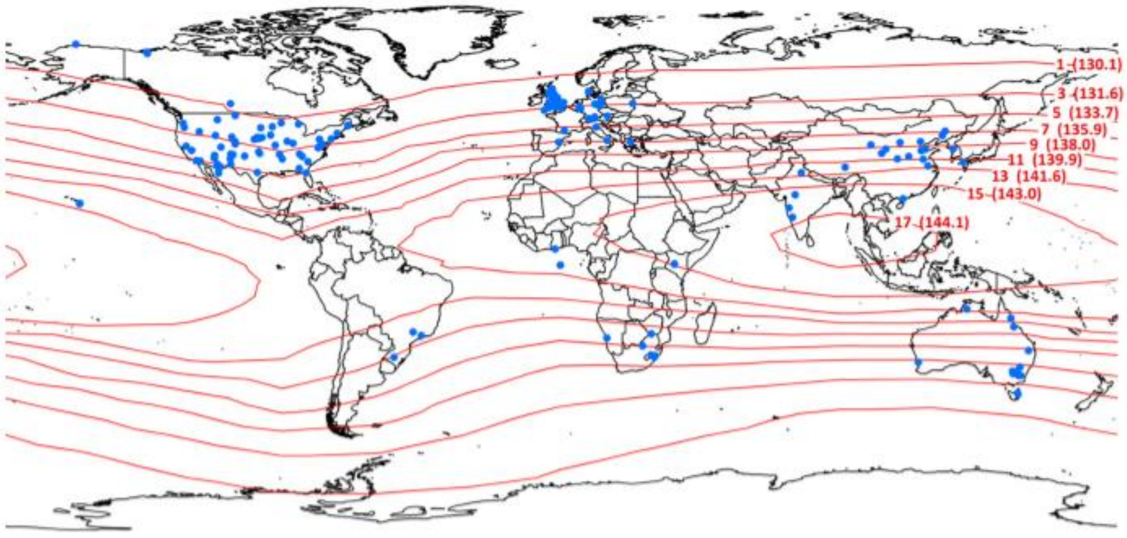


Figure 2.2: Current global distribution of cosmic-ray neutron stations (blue points), the cutoff rigidity of 2010 (in GeV, red lines; numbers in front of parentheses) and the attenuation length (in g/cm2, red lines; numbers in parentheses). Figure was first published as Figure 1 in Andreasen et al. 2017.

Additionally, roving version of CRNP or mobile CRNP has been applied to measure hourly soil water content. The temporal resolution is about 1 minute which can provide a reliable measurement over hundreds of square kilometers in a single day (Avery, 2016, see Fig. 2.3 and 2.4). Moreover, using fixed and mobile CRNP measurement, we can further obtain an accurate, real-time and multiscale soil water content monitoring network (Franz et al. 2015). With the increase of detector footprint, the traditional in-situ sampling is not practical in CRNP calibration functions. Avery, 2016 pointed out that global dataset (i.e. remote sensing dataset, global soil map et al.) can be used to correct CRNP calibration procedure. In this study, the capacity and reliability of remote sensing dataset was tested and in-situ biomass was used to explore the relationship between bare and moderated neutron intensity vs vegetation.

Figure 2.3: Cosmic-ray neutron probe at US-Ne3 site in Mead eastern Nebraska. The CRNP contains both bare and moderated detectors.

Figure 2.4: Mobile Cosmic-ray Neutron Probe Rover with moderated detectors only.

2.2. Methods

2.2.1 CRNP Calibration Function

A calibration function has been developed in order to convert moderated neutron counts to near surface SWC. The following set of equations (eqs 2.1-2.4) have been developed by Desilets et al. 2010, Zreda et al. 2012, and Franz et al. 2015 to account for various forms of hydrogen present in the CRNP footprint:

$$\left(\theta_p + \theta_{LW} + \theta_{SOC_{eq}}\right) = \frac{0.0808}{\frac{N}{N_0} - 0.372} - 0.115 \qquad (2.1)$$

Where θ_p is pore water content (g/g), θ_p (cm^3/cm^3) = $\theta_p * \frac{\rho_b}{\rho_w}$, θ_{LW} is lattice water content (g/g), $\theta_{SOC_{eq}}$ is soil organic carbon water content (g/g), ρ_{bd} is dry soil bulk density (g/cm^3), ρ_w is the density of water = 1 (g/cm^3), N is the corrected moderated neutron counts per hour (cph), and N_0 is an instrument specific calibrated parameter that represents the count rate over dry silica soils (cph). The three coefficients were determined by Desilets et al. 2010 from a semi-analytical solution of a neutron diffusion equation. Furthermore:

$$\theta_{SOC_{eq}} = \left(TC - \frac{12}{44}CO_2\right)0.494 \tag{2.2}$$

Where *TC* is the soil total carbon (g/g), CO_2 is the soil CO_2 (g/g), 12/44 is the stoichiometric ratio of carbon to CO_2, and 0.494 is the stoichiometric ratio of H_2O to organic carbon (assuming organic carbon is cellulose $C_6H_{10}O_5$).

Franz et al. (2015) corrected for variations between instruments and for changes in Biomass Water Equivalent (*BWE)* by scaling fixed probe observations against the rover:

$$N_{0,F}(BWE) = N_{0,F}(0)\left(\frac{m_R}{N_{0,R}(0)}BWE + 1\right) \tag{2.3}$$

Where $N_{0,F}(0)$ is the fixed probe estimate of N_0 with no standing biomass, $N_{0,R}(0)$ is the rover estimate of N_0 with no standing biomass, and m_R is the slope of the relationship between N_0 and *BWE* from the rover surveys and calibration datasets. The *BWE* was found from the calibration sampling as:

$$BWE = SWB - SDB + SDB * f_{WE} \tag{2.4}$$

Where SWB is the standing wet biomass per unit area (kg/m^2 ~ mm of water/m^2) and SDB is the standing dry biomass per unit area (kg/m^2 ~ mm of water/m^2) found by oven drying samples at 70^{o}C for 5 days. Note f_{WE} is = 0.494 like in Eq. [2.2] above. Franz et al. (2015) found the CRNP rover had a statistically significant linear relationship yielding the coefficients of $N_{0,R}(0) = 518.34$ cpm and $m_R = -4.9506$ with an R^2 = 0.515 and p value = 0.03. Here, I explore if there is a direct relationship between moderated neutron counts, bare neutron counts and BWE as a potential means of correcting for the influence from site specific vegetation.

2.2.2 Study sites

To achieve my objectives, data were used from three long-term CRNP study sites in central Nebraska (Paulman Farms, est. 2015), eastern Nebraska (US-Ne3, est. 2011), and central Iowa (IVS, est. 2010) that span a natural increasing precipitation gradient from west to east (Figure 2.5).

The eastern Nebraska site US-Ne3 is part of University of Nebraska Eastern Nebraska Research and Extension Center near Mead. The site is under a maize-soybean rotation and is not irrigated. This site continues to collect CRNP neutron data since 2011 that is part of Cosmic-ray Soil Moisture Observing System (COSMOS). The soil types of this site are mainly silt loam and silty clay loam (Web Soil Survey, 2016, http: //websoilsurvey.nrcs.usda.gov). Planting density, cultivars, and herbicide and pesticide applications and other crop managements has been applied in this site since 2001. According to data collected from High Plains Regional Climate Center (HPRCC) station Mead 6S, Average growing season precipitation for the recent 18 year period is about 22-inch with a maximum precipitation during this period is about 30-inch (2008) and the minimum precipitation is about 12-inch (2012). (Data from 2000-2016, High Plains Regional Climate Center, https://hprcc.unl.edu/). The approximate footprint of the CRNP measurement is up to 300m at all sites.

The central Iowa site, IVS, is located near Ames, Iowa. It consists of a square kilometer of gently rolling Des Moines Lobe soils in central Iowa. The site is under a maize-soybean rotation and is not irrigated. The crop is normally planted in late April to early May and is harvested in late September or early October. During the balance of the year the site is essentially bare with a small amount of crop residue. Nearly every aspect of the terrestrial hydrologic cycle is regularly observed, including soil moisture (at a variety of depths), depth to water table, net radiation, sensible and latent heat flux, and precipitation, all at multiple locations within the site (COSMOS, 2016, http://cosmos.hwr.arizona.edu/Probes/StationDat/016/index.php). According to HPRCC precipitation data collected from station AMES MUNICIPAL AP, the recent 18 year growing season average precipitation is 25.64 mm with the maximum precipitation during May-Oct is about 43-inch (2010) and the minimum precipitation is about 16-inch (2012) (Data from 2000-2016, High Plains Regional Climate Center, https://hprcc.unl.edu/).

The third site is at Paulman Farms, which is a 53 ha quarter section under variable rate center pivot irrigation near Sutherland, NE. The site is historically a maize-soybean rotation but was in maize production during 2015-2016. Significant topo-edaphic gradients make it an ideal crop field for variable rate irrigation. The field has a wide gradient in field capacity and wilting point values depending on soil classification (Soil Survey Staff, 2016). According to HPRCC precipitation data collected from station

HERSHEY 5 SSE, the maximum precipitation during growing season is about 21-inch in 2011 and the minimum precipitation is about 3-inch in 2012.

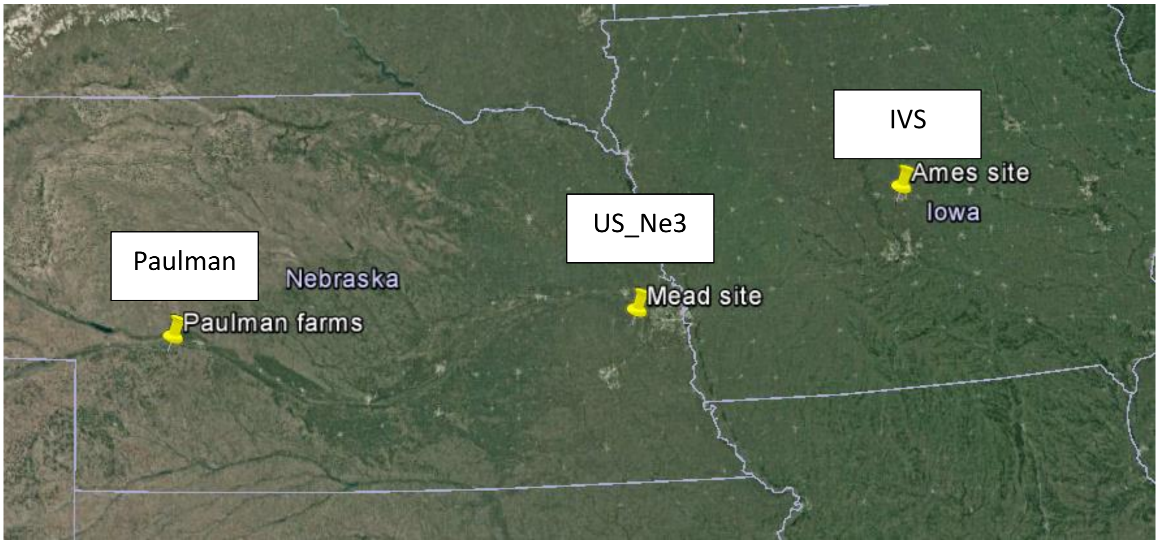


Figure 2.5: Location of three CRNP study sites in Central Nebraska (Paulman Farms, 41.058323,-101.102742 est. 2015), eastern Nebraska (US-Ne3, 41.179859,-96.441235, est. 2011), and central Iowa (IVS, 41.9832,-93.6837, est. 2010)

2.2.3 CRNP and MODIS data generation

All three fields grow maize and soybean depending on rotation. I evaluated growing season data (May to Oct) from 2011-2015 at the US-NE3 and IVS study sites. Since the Paulman Farms site was equipped with a CRNP in 2015, I only evaluated data from the 2015 and 2016 growing seasons. At each CRNP site both hourly moderated and bare neutron counts are recorded. Bare and moderated neutron counts data for the growing season (May-Oct) were obtained from Cosmic-ray Soil Moisture Observing System (COSMOS) publically available website (http://cosmos.hwr.arizona.edu/Probes/probemap.php).

Previous research has shown that the thermal to fast, or bare to moderated ratio (B/M) may be a good indicator of changing vegetation conditions and useful as a correction to estimating SWC (Tian, 2016). To document vegetation changes, MODIS data were used. Here I use the MODIS remote sensing dataset to calculate Green Wide Dynamic Range Vegetation Index (GrWDRVI or WDRVI). Compared with other vegetation indeices, GrWDRVI has more significant relationship with in-situ biomass. (Nguy-Robertson, 2015). Using the Python Integrated Development Environment built into ArcGIS a series of steps were taken to estimate GrWDRVI. (1) MODIS reflectance dataset was converted into green and near-infrared electromagnetic spectrum range (see Avery 2016). (2) Next, Any pixels that were skewed by incidental cloud cover were removed. (3) Using the following equation, green and near-infrared electromagnetic spectrum range were converted into the Green Wide Dynamic Range Vegetation Index (GrWDRVI):

$$GrWDRVI=(0.1*NIR-Green) /(0.1*NIR+Green) \quad (2.5)$$

Where NIR is near-infrared light that has a wavelength between 841 and 876 nm and green light has a wavelength between 545 and 565 nm (Gitelson, 2004).

2.2.4 Time-lapse Video

As mentioned in Chapter 1, fast growing vegetation has potential impact on the accuracy of CRNP. As an additional visual aid for understanding and interpreting the neutron observations, I used a time-lapse video to capture the diurnal growing process and dynamics (most in green-up stage) of maize at the US-Ne3 site during rapid green up. During June 2017, a camera (5Ds, Canon) located close to CRNP detector was used to take a series of time-lapse images. The time interval varied from 10s to 3min depending on the weather and growth status. I obtained more than 2000 raw images for evaluation.

Each image was inspected for quality assurance and quality control by first checking the availability of each image and resizing image quality. Using Photoshop and Lightroom software, I created a series of time-lapse video with 24fps and 29fps, which can show the growing condition within one day and within one month.

2.2.5 HPRCC Precipitation Data

Daily and monthly precipitation data from High Plains Regional Climate Center (HPRCC) from 2000 – 2017 near the US-Ne3, IVS and Paulman farm sites were obtained to investigate the influences of precipitation on the results.

US-Ne3 Monthly and total season precipitation (.in)							
Year	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Season**
2000	2.29	5.63	3.83	1.17	0.8	2.13	15.85
2001	8.84	1.82	0.87	2.5	2.9	2.4	19.33
2002	3.29	0.5	2.52	8.26	1.33	4.06	19.96
2003	5.17	4.05	0.95	1.7	3.58	1.72	17.17
2004	4.77	3.09	3	1.94	4.03	0.86	17.69
2005	2.74	3.47	3.97	0.77	0.99	1.69	13.63
2006	1.38	0.97	3.03	6.14	6.26	0.77	18.55
2007	6.87	2.45	1.65	10.15	2.99	4.75	28.86
2008	5.96	9.89	3.73	1.01	4.33	5.06	29.98
2009	M	6.49	2.62	7.27	1.55	4.34	Non
2010	2.66	9.82	7.22	2.51	5.84	0.23	28.28
2011	7.61	5.57	3.32	5.47	0.89	0.84	Non
2012	3.8	4.24	0.26	0.91	1.18	1.36	11.75
2013	6.42	4.68	0.62	1.8	3.79	3.86	21.17
2014	6.48	8.33	0.55	6.97	3.12	3.3	28.75
2015	7.8	6.04	3.54	7.69	4	0.51	29.58
2016	7.38	4.06	3.74	5.62	2.95	1.54	25.29
2017	7.87	2.91	3.28	4.42	5.05	4.35	27.88
Mean	5.37	4.67	2.71	4.24	3.09	2.43	22.11
Max	8.84	9.89	7.22	10.15	6.26	5.06	29.98
	2001	2008	2010	2007	2006	2008	2008
Min	1.38	0.5	0.26	0.77	0.8	0.23	11.75
	2006	2002	2012	2005	2000	2010	2012
Station	MEAD 6S, NE						

Table 2.1: 18-year precipitation data in US-Ne3 research site.

IVS Monthly and total season precipitation (.in)							
Year	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Season**
2000	3.86	4.8	3.12	2.3	1.1	1.9	17.08
2001	6.21	2.58	1.7	2.87	5.99	2.46	21.81
2002	3.86	3.03	4.7	3.37	1.13	3.55	19.64
2003	4.42	4.65	6.51	1.2	1.11	0.89	18.78
2004	8.42	3.55	4.58	4.42	2.57	1.45	24.99
2005	3.86	4.77	2.6	6.77	3.83	0.46	22.29
2006	1.08	1.38	4.75	6.56	5.92	2.08	21.77
2007	7.1	2.64	4.08	6.1	2.2	5.81	27.93
2008	8.27	10.54	7.98	1.64	3.51	2.98	34.92
2009	5.59	3.17	2.36	3.99	1.19	7.87	24.17
2010	3.5	12.27	4.79	15.6	4.98	1.5	42.64
2011	5.61	6.31	2.95	2.99	1.71	0.95	20.52
2012	2.83	3.12	2.44	2.98	2.51	2.35	16.23
2013	11.64	3.26	1.45	0.79	1.92	3.81	22.87
2014	5.1	11.27	2.98	8.14	3.47	4.2	35.16
2015	4.41	7.3	7.99	9.57	4.67	1.84	35.78
2016	3.55	1.71	5.59	9.89	8.94	0.78	30.46
2017	5.4	2.85	2.82	4.06	2.9	6.48	24.51
Mean	5.26	4.96	4.08	5.18	3.31	2.85	25.64
Max	11.64	12.27	7.99	15.6	8.94	7.87	42.64
	2013	2010	2015	2010	2016	2009	2010
Min	1.08	1.38	1.45	0.79	1.1	0.46	16.23
	2006	2006	2013	2013	2000	2005	2012
Station	AMES MUNICIPAL AP, IA						

Table 2.2: 18-year precipitation data in IVS research site.

Paulman Farm Monthly and total season precipitation (.in)							
Year	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Season**
2000	2.05	1.34	1.68	0.49	2.73	3.41	11.7
2001	2.73	Non	3.41	2.12	2.58	0.98	Non
2002	1.38	1.16	0.64	1.75	1.15	1.57	7.65
2003	1.62	3.71	1.12	0.8	0.84	0.41	8.5
2004	2.31	Non	6.09	1.29	2.06	Non	Non
2005	Non	Non	Non	Non	Non	Non	Non
2006	Non	Non	3.52	2.26	2.64	0.96	Non
2007	Non	3.78	3.29	0.93	0.98	0.99	Non
2008	Non	3.86	Non	2.01	2	6.23	Non
2009	2.39	Non	Non	1.69	1.73	3.64	Non
2010	3.3	8.25	3.72	2.09	2.59	0.51	20.46
2011	5.92	6.45	3.14	1.81	1.05	2.5	20.87
2012	0.73	0.59	0.71	0.3	0.17	0.28	2.78
2013	3.53	Non	1.72	0.8	1.46	1.23	Non
2014	1.68	8.05	1.96	2.36	1.42	0.58	16.05
2015	4.69	3.63	1.16	1.96	0.94	3.9	16.28
2016	3.34	Non	5.02	1.11	0.25	4.69	Non
2017	3.66	0.81	1.83	2.6	3.65	2.16	14.71
Mean	2.81	3.78	2.6	1.55	1.66	2.13	13.22
Max	5.92	8.25	6.09	2.6	3.65	6.23	20.87
	2011	2010	2004	2017	2017	2008	2011
Min	0.73	0.59	0.64	0.3	0.17	0.28	2.78
	2012	2012	2002	2012	2012	2012	2012
Station	HERSHEY 5 SSE, NE						

Table 2.3: 18-year precipitation data near Paulman farm research site.

2.2.6 Standing Biomass

Among the three study sites, US-Ne3 site is our most familiar and well sampled study site. In-situ biomass data from previous researchers is made available through the Carbon Sequestration Program and Ameriflux programs. Here I used two separate biomass data. One is collected by Nguy-Robertson A, 2013 (from 2003-2013) and further generated and published by Avery, 2016. This dataset was used as a benchmark for the neutron and remote sensing analyses to investigate if any linear relationships existed between

GrWDRVI and moderated neutron counts and bare to moderated (B/M) ratio during each growing season for each site.

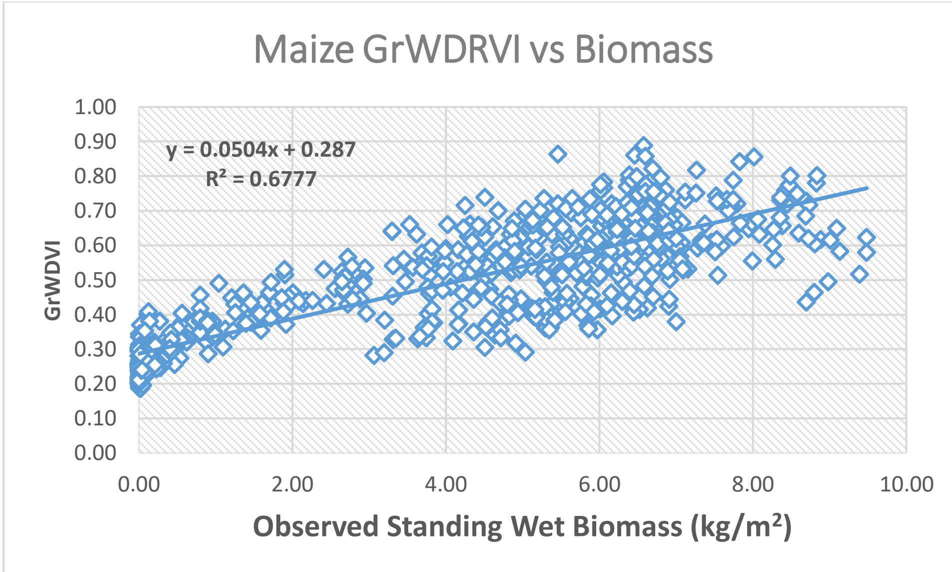
The other observed vegetation data from US-Ne3 was collected biweekly from 2003-2016 by Prof. T. Arkebaur of the University of Nebraska-Lincoln. Data from 2011 to 2016 was used to investigate the relationship between in-situ biomass and bare and moderated neutron counts.

2.3. Results

2.3.1 Comparison of GrWDRVI and In-situ Biomass Data

Figure 2.6 shows the relationship between observed standing wet biomass and GrWDRVI at US-Ne3 site during growing seasons between 2003-2016. The data show a linear correlation coeffcient (R^2) of 0.677 for maize and 0.5672 for soybean for all years. Avery et al. (2016) found that GrWDRVI from CSP3 and two other fields was dependent not only on vegetation type (maize vs. soybean), but also on irrigation vs. rainfed, and green-up vs. senescence periods of crop development. The influence of different crop development stage will be discussed in following sections.

On one hand this result underscores that remote sensing estimates of biomass are useful but also contain a large amount of variation. On the other hand, direct observations of biomass are limited given the large amount of effort and time such observations require. Therefore, a note of caution is warranted for comparison between remote sensing data, neutron data, and observed biomass.



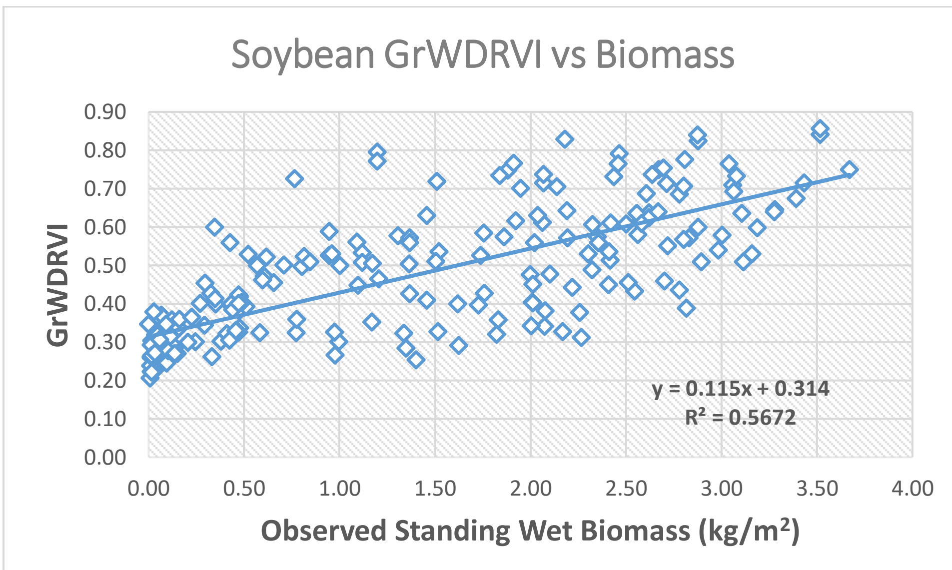


Figure 2.6: Comparison of in-situ standing wet biomass data for maize and soybean at US-Ne3 vs. MODIS derived GrWDRVI. The data shows biweekly growing season observations between 2003 and 2016.

2.3.2 Comparison of GrWDRVI, B/M Ratio and Moderated Neutron Intensity

Time series are presented for moderated neutron counts for each site between 2011 and 2016 (Fig. 2.7), the B/M ratio (Fig. 2.8), and the GrWDRVI (Fig. 2.9). Table 2.4

summarizes the linear and multivariate liner regression analysis for each site and each year. The western irrigated site (Paulman Farms) showed the best relationship (R^2 = 0.9188) while the eastern site (IVS site) showed one of the worst relationship (R^2 is always not significant). Also US-Ne3 2014 had the lowest R^2 value.

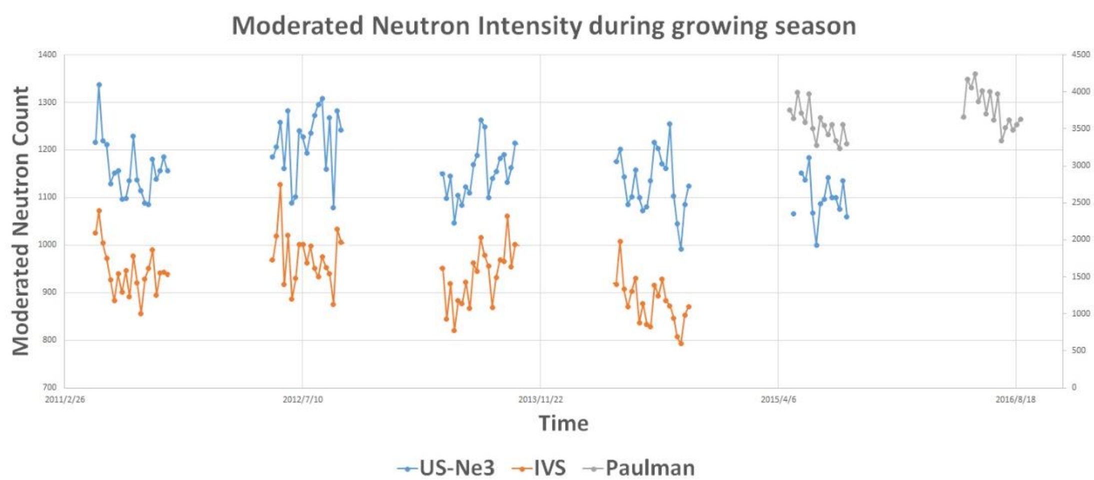


Figure 2.7: Time series of moderated neutron counts between 2011 and 2017 for three study sites. Note a second axis represents Paulman Farm moderated neutron intensity given the higher count rates.

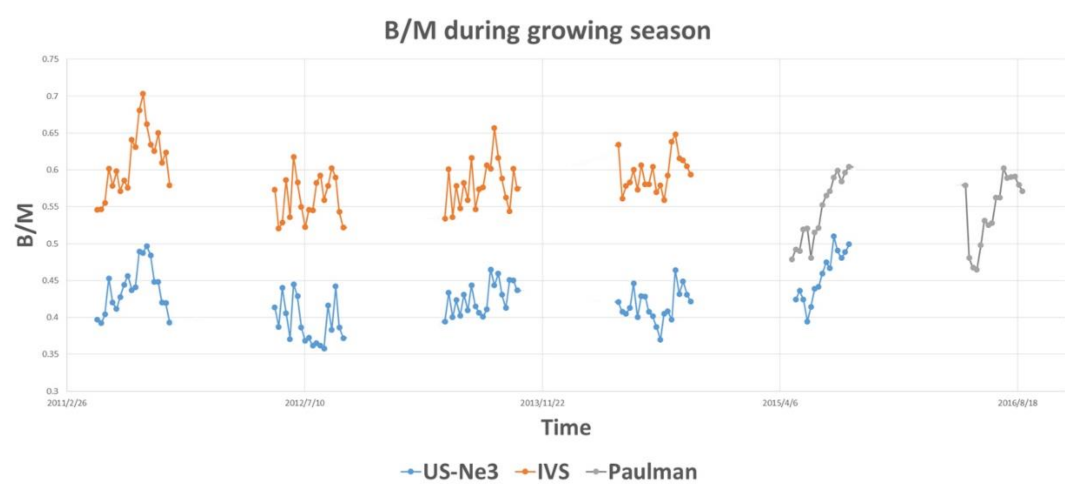


Figure 2.8: Time series of daily B/M ratio between 2011 and 2016 for three study sites.

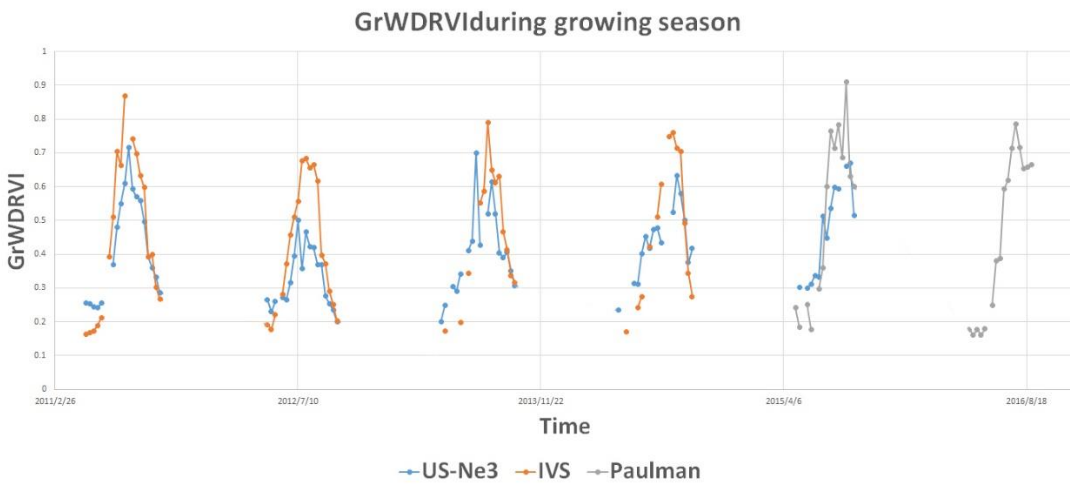
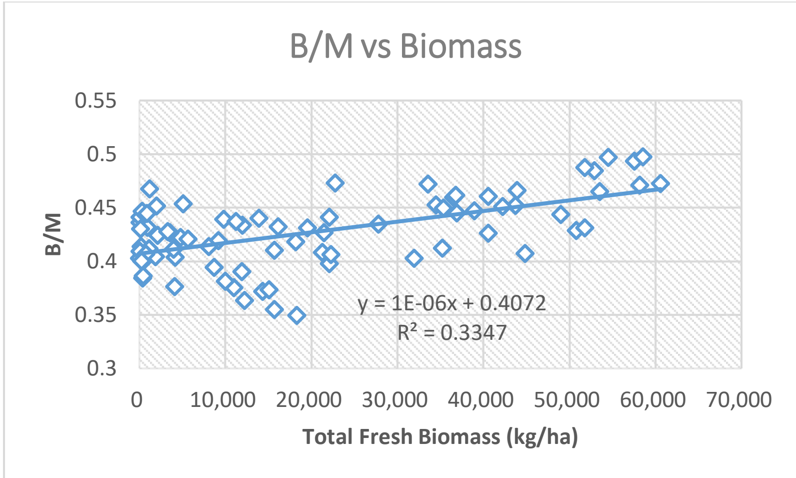


Figure 2.9: Time series of daily (MODIS overpass) GrWDRVI calculated values between 2011 and 2016 for three study sites.



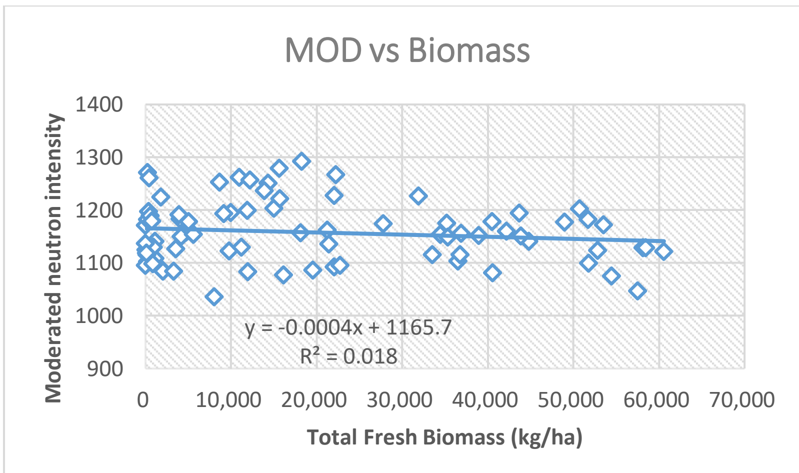


Figure 2.10: Linear correlation between growing season in-situ biomass data and B/M and Moderated neutron intensity for US-Ne3 site from 2011 to 2016.

Results in Table 2.4 indicate that B/M ratio is a reasonable predictor of vegetation changes (i.e. GrWDRVI), however the results vary considerably between sites. The western site (Paulman Farms) showed the best relationship as more hydrogen is contained in the vegetation instead of the soil as compared to the eastern sites. This likely improves the signal to noise ratio of detecting vegetation with the method. There is a fair linear relationship between B/M and biomass. As expected the relationship between moderated neutron intensity and biomass is weak. Thus, a multivariate analysis using B/M and moderated neutron intensity differed little from that with B/M alone.

Also note that 2012, 2013 and 2014, the relationship was not very strong at US-Ne3 and IVS sites, which was probably caused by drought and limitations of GrWDRVI. In the following section I will discuss the potential reasons and how it affects the results.

Site	Year	Crop	Precipitation (seasonal)	GRWDVI vs B/M		GrWDVI vs Mod		GRWDVI vs B/M vs Mod	
				R^2	RMSE	R^2	RMSE	R^2	RMSE
US-Ne3	2011	Maize	Non	0.6345	0.09538	0.2254	0.1389	0.6378	0.09807
	2012	Soybean	11.75	0.2269	0.08023	0.02271	0.0902	0.2391	0.08219
	2013	Maize	21.17	0.0616	0.1287	0.05978	0.1289	0.1593	0.1261
	2014	Soybean	28.75	0.0111	0.1129	0.008338	0.113	0.01434	0.117
	2015	Maize	29.58	0.7116	0.07861	0.02898	0.1442	0.7134	0.08219
IVS	2011	Soybean	20.52	0.4869	0.1701	0.2156	0.1695	0.4869	0.1753
	2012	Maize	16.23	0.03885	0.1875	0.07851	0.1836	0.08136	0.1893
	2013	Soybean	22.87	0.09129	0.187	0.08862	0.1873	0.5657	0.1356
	2014	Maize	35.16	0.2892	0.1854	0.06424	0.2127	0.2938	0.1938
	2015	Soybean	35.78	0.4181	0.09881	0.2685	0.1108	0.421	0.108
Paulman Farms	2015	Maize	16.28	0.7442	0.1327	0.2757	0.2234	0.7453	0.1384
	2016	Maize	Non	0.9188	0.06945	0.7567	0.1203	0.9673	0.04623

Table 2.4: Multivariate linear regression of moderate, B/M and GrWDRVI of each study site for each year.

2.3.3 Comparison of in-situ biomass, B/M and Moderated neutron intensity

Based on a previous study conducted by Avery (2016), different crop development stages have significant influence on GrWDRVI estimating crop condition. Because during August and September, crop will dry out and leaves lose their chlorophyll and leaf structure beings to collapse. This process will result in increasing reflected green and reducing near-infrared radiation (Avery, 2016). Similarly, I compared the relationship between B/M and in-situ biomass in green-up vs senescence (Figure 2.11). From previous research by Tian (2016), I expected the comparison to have a positive relationship. Figure 2.11 indicates that in years 2012, 2013 and 2014 there is no significant relationship or even negative relationship between B/M and biomass in both green-up and senescence stage. In 2011and 2015 there is strong relationship for both green-up and senescence. No consistent linear relationship between B/M and fresh biomass is observed between years, crop stage, and vegetation type.

Using a multivariate linear analysis I found significant improvement by using both B/M and moderated neutron counts. Table 2.5 summarizes the univariate and multivariate results. I found that the R^2 increased for both the green-up and senescence crop stages. In addition the multivariate R^2 values made the largest gains in the drought years of 2012 and 2013. Smaller to minimal R^2 gains were seen in the multivariate analysis during the non-drought periods. This analysis shows that both B/M and moderated counts could be used to predict fresh biomass, especially under non-drought conditions. I suspect the Tian (2016) results using just B/M ratios vs. fresh biomass had non-limiting soil moisture conditions and did not experience the same level of water stress conditions as was experienced in 2012 and 2013 at US-Ne3 and IVS sites. Future work should explore this finding more explicitly.

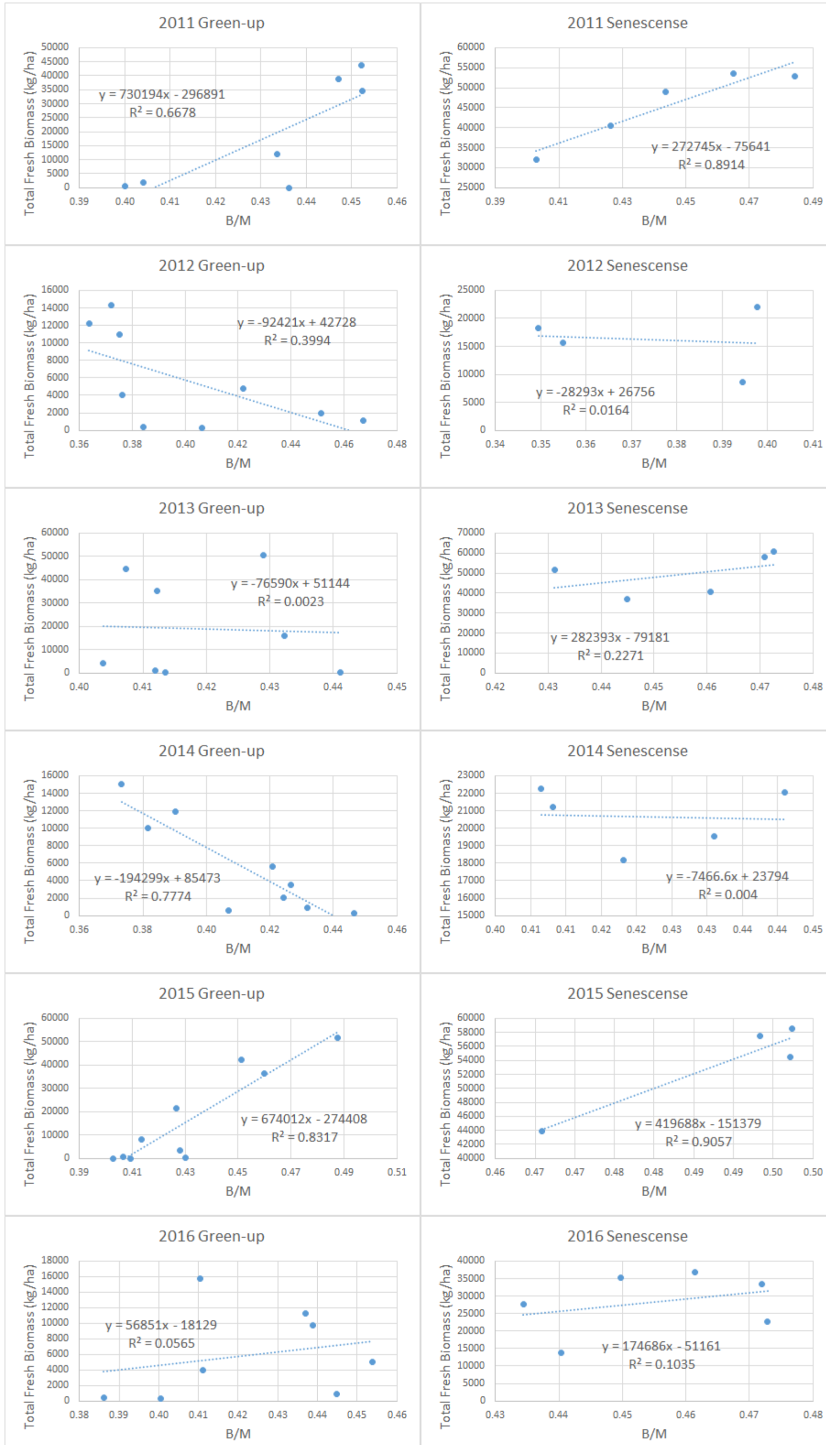


Figure 2.11: Linear relationship between B/M and total fresh biomass from 2011 to 2016 in green-up and senescence.

Year	R^2			
	Green-up		Senesense	
	B/M vs Biomass	B/M vs Biomass vs Mod	B/M vs Biomass	B/M vs Biomass vs Mod
2011	0.5035	0.6678	0.8914	0.9083
2012	0.3994	0.5832	0.0164	0.302
2013	0.0023	0.3612	0.2271	0.6194
2014	0.7774	0.7836	0.004	0.2648
2015	0.8317	0.8408	0.9057	0.9065
2016	0.0565	0.06526	0.1035	0.552

Table 2.5: Multivariate linear regression of moderate, B/M and biomass of US-Ne3 site for each year.

2.3.4. Influence of Precipitation and Drought at US-Ne3

According to Table 2.1, precipitation of US-Ne3 site in 2012, 2013 and 2014 growing season are less than the 18-year average. So the influence of drought should be taken into account.

Among the three sites chosen for this study, US-Ne3 (Mead) is our most familiar and well instrumented site to do further analysis. This is done by comparing GrWDRVI, B/M, vegetation and precipitation. According to the precipitation data note in 2012, 2013 and 2014 US-Ne3 site experienced drought during the growing season. The seasonal precipitation in 2014 was similar to other years which did not experience drought. But in early grow-up stage (July), maize only received 0.55 in precipitation. The GrWDRVI and B/M still responded to biomass changes (Figure 2.12) but crop water stress may affect our ability to accurately use remote sensing tools to detect biomass changes.

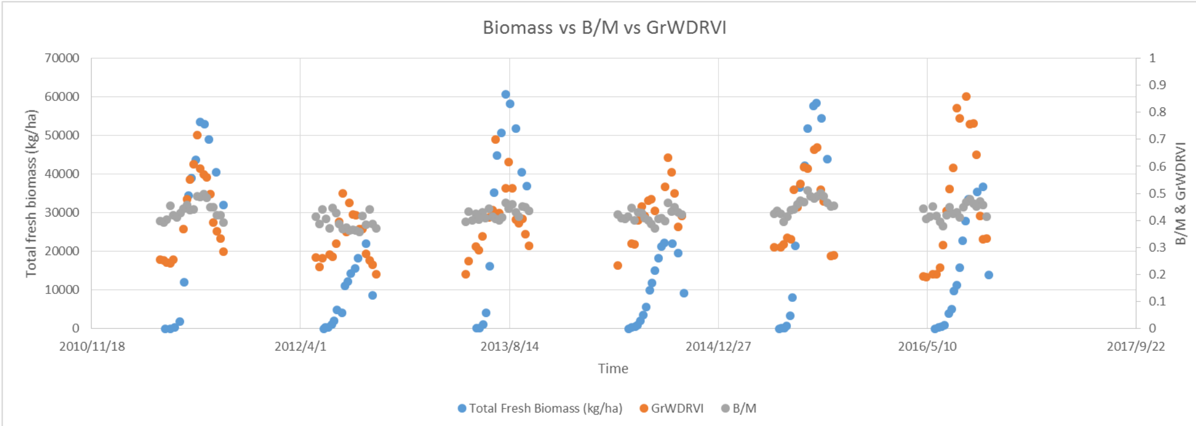


Figure 2.12: Comparison of in-situ biomass, B/M and GrWDRVI in US-Ne3 site.

Figure 2.13 illustrates the relationship between B/M, Moderated neutron intensity and in-situ biomass using data from average rainfall conditions (2011 and 2015-2016) at the US-Ne3 site. Without drought, I found a better relationship between B/M and Biomass (R^2= 0.56 in green-up and 0.34 in senescence). Using B/M I found the ability to monitor crop growth is reasonable when there is sufficient water supply. At US-Ne3 site in 2012-2014 the linear correlation was decreased due to the lack of precipitation. During that period of time the maize and soybean experienced drought and water stress conditions. I found that GrWDRVI still showed a good relationship with in-situ biomass during those same conditions. Lastly, the seasonal precipitation in 2014 was similar to other years which did not experience drought. But in early grow-up stage (July), maize only received 0.55 in precipitation. Thus resulted in a poor relationship between GrWDRVI and B/M ratio. Again, Table 2.5 illustrates reasonable multivariate relationships between fresh biomass and B/M and moderated neutron counts.

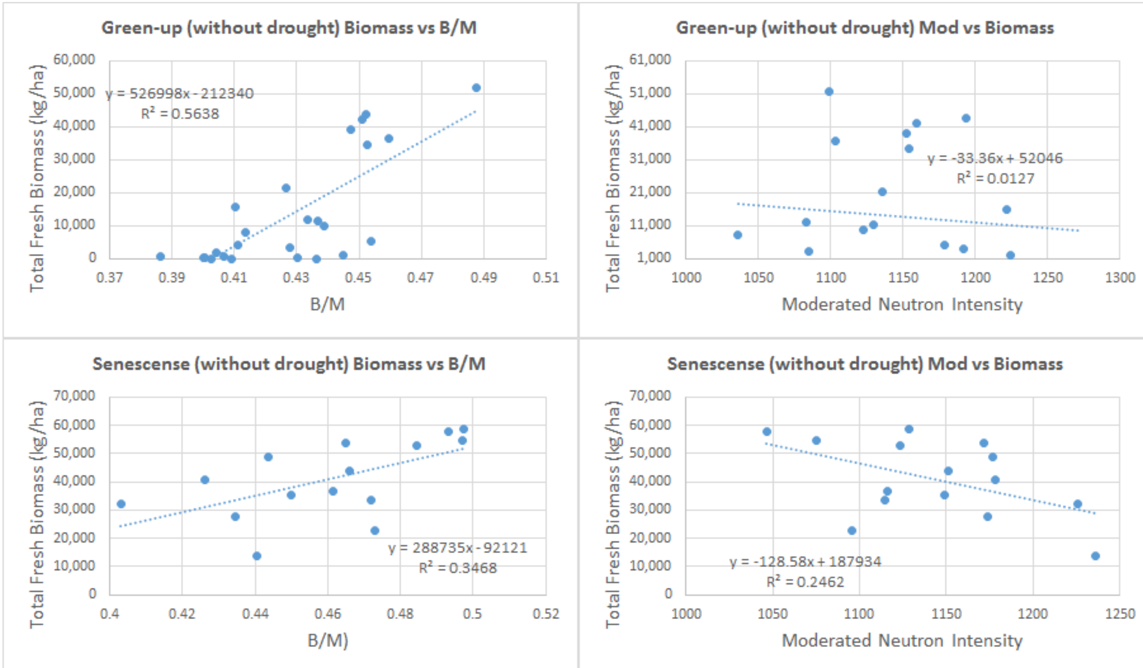


Figure 2.13: Comparison of B/M, Moderated Neutron and In-situ Biomass data of year 2011 and 2015-2016 without influence of drought.

2.4 Discussion and Conclusions

In this section I discuss the advantages and disadvantages of the Cosmic-ray Neutron Probe for soil water content monitoring. The main disadvantage of the CRNP method is the dependence of changing vegetation on the SWC observations. Therefore, my objectives were to: 1) investigate strategies to incorporate remote sensing products (i.e. MODIS) to determine the required cropping systems biomass information for integration in the standard CRNP calibration process, and 2) investigate a strategy to simultaneously estimate crop biomass and soil water content using the CRNP moderated and bare detectors.

My work showed that there is unlikely a general linear relationship that exist for all sites between fresh biomass and GrWDRVI. Besides the well-known influencing factors, crop type, drought, or the timing of dry conditions may have impacts on the accuracy of GrWDRVI. Like previous work (Avery 2016) my results also showed that fresh biomass (SWB) is correlated to GrWDRVI. However the relationship is noisy with R^2= 0.6 for maize and 0.55 for soybean for US-Ne3. There are some opportunities to use MODIS data but are limited by MODIS time collection (~8 day product) and pixel size (250 to 500 m). More importantly, note the relationship between GrWDRVI and SWB is dependent on crop type, irrigated vs. rainfed and green up vs. senescence. In this study, I used MODIS data to obtain GrWDRVI which is used as reference to estimate the crop growth condition. In that case, soil water content measured by CRNP could be corrected using GrWDRVI and equations presented in Chapter 2. The comparison of 2003-2016 of in-situ vegetation samples from maize and soybeans at US-Ne3 site in eastern Nebraska indicated that the GrWDRVI was able to predict biomass in agricultural fields. I believe GrWDRVI shows a reliable relationship with in-situ biomass data, especially if we partition GrWDRVI into green-up vs senescence and irrigated vs. rainfed (Avery, 2016). However, this method still has some limitations. The difference of time interval between in-situ measurement and satellite MODIS overpass may have potential effect on the accuracy of our measurement. Low resolution of MODIS image is another problem. GrWDRVI obtained from MODIS image data may not represent the true surface conditions. Only 2-4 pixels cover for whole research site, which made it hard to get accurate values due to edge effects. In addition, MODIS data are influenced by weather where it is not available on cloudy days. This results in missing MODIS data during critical summer time growth periods.

With respect to the CRNP, I found at US-Ne3 that a multivariate linear relationship between fresh biomass and B/M and moderated counts was reasonable (R^2>0.6, Table 2.4) in most years. However, in dry years (2012 and 2013) this relationship behaved more poorly with $R^2 < 0.3$. Overall, my results indict that correcting in-situ biomass measurements using B/M and moderated counts is reasonable when locally calibrated with biomass data. Including moderated counts as well as B/M is an improvement over previous research that only considered B/M ratios to predict biomass changes (Tian 2016). Additional work is needed to further generalize these relationships and make the methodology more practical and transferrable between sites.

Based on previous research, CRNP can accurately measure average soil moisture in the field particularly when correcting for local biomass changes using remotely sensed vegetation indices (Coopersmith, 2014). Another study showed that B/M ratios can be used to estimate aboveground biomass and make further adjustment (Tian, 2016). In our study, I investigated the relationship between fresh biomass changes in crops with GrWDRVI and bare and moderated neutron counts. I found that the relationship between biomass changes and neutron counts was improved by including both moderated counts and B/M ratios in a multivariate linear regression. In addition, I also found evidence that rainfall and irrigation (non-limiting soil moisture conditions) affected the relationships between neutron counts and fresh biomass changes. When comparing remotely sensed GrWDRVI and B/M ratios from the three study sites from western Nebraska to central Iowa, western study sites under irrigation showed a stronger linear relationship (R^2= 0.92

vs $R^2 < 0.2$). This is likely due to the fact that CRNP is a hydrogen mass detector and more hydrogen is contained in the vegetation instead of the soil at the non-limiting soil moisture sites. I note that the western site is irrigated as opposed to rainfed for the other two sites. While the irrigation is additional pmoisture it is likely to be contained in the top 0.3 m of soil. The CRNP is more sensitive in the top soil and likely responding to the water and vegetation changes. Unfortunately given the lack of in-situ biomass data at all sites the robustness of this conclusion will need to be further evaluated in future work. Clearly the B/M and GrWDRVI both reflect changes in crop biomass albeit with their own local calibration issues. I suggest more research is needed before a biomass fix can be included in the CRNP SWC calibration equations. A clear first step is resolving a more robust statistical relationship between in-situ biomass data, B/M and moderated neutron count data across a diverse set of sites with varying crops, soil, and soil moisture conditions.

Chapter 3: Conclusions and Future Directions

In this thesis I investigated using remotely sensed or neutron observations to correct for biomass changes to improve the use of the Cosmic-ray neutron probe for soil water content observations. By combining both bare and moderated detectors with remote sensing MODIS data I found evidence that a local relationship may be derived to estimate vegetation biomass changes and thus improve the accuracy of this new technology. The comparison of remote sensing MODIS data and in-situ biomass from US-Ne3 (2003-2016), show a linear relationship between GrWDRVI and fresh biomass could be used to correct the CRNP observations via the calibration procedure. Other work has shown that there is unlikely a general relationship or set of coefficients that exist for all sites. It is known that influencing factors such as crop type, irrigation type and drought conditions impact the accuracy of the GrWDRVI to fresh biomass observations. Lastly, a remaining challenge of using MODIS/GrWDRVI biomass correction for CRNP are the 8-day repeat overpass time and large band sizes of 250 to 500m to fully capture hourly and daily vegetation changes.

With respect to the CRNP, I found the B/M ratio and moderated counts are good predictors to capture crop growth at US-Ne3 albeit with some dependency on crop growth stage and local rainfall. However, the in-situ biomass data was limited to a single site and only a few times during the growing season. Taking samples every 10-14 days is actually quite frequent, but more samples are needed to make more reliable linear regression. The data was collected by a different research group for another study thus limiting its full usefulness to this study. I would encourage future work to collect more in-situ biomass data and corresponding SWC datasets focused on better deriving local and potentially general relationships between biomass changes and neutron observations. This work is encouraging on the future use of bare and moderated neutron counts to estimate fresh biomass changes directly and improve the accuracy of the CRNP calibration function for estimating SWC. Given the wide range of 200+ CRNP sites globally, bare and moderated neutron counts offer an interesting dataset to investigate both SWC and vegetation changes simultaneously at large scales.

Moreover, the influence of vegetation changes on CRNP SWC monitoring is still unresolved in this study. In-situ SWC samples are needed to investigate the relationship between vegetation changes and accuracy of the CRNP observations. I would suggest a dedicated study with weekly biomass and SWC sampling at US-Ne3 to resolve this issue following Franz (2015). Additionally, a field campaign coordinating sampling efforts across the three long-term CRNP monitoring sites would be preferred. This will be a time and labor intensive effort but needed to fully understand the potential of using both moderated and bare neutron counts to monitor vegetation and SWC simultaneously.

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Appendix

Table A.1: Summary of GrWDRVI, B/M, and moderated neutron counts by date and study site.

	US-Ne3				IVS				Paulman			
Time	GrWDVI	B/M	MOD	STD	GrWDVI	MOD	B/M	STD	GrWDVI	MOD	B/M	STD
2011/5/1	0.255588	0.397144	1215.208	0.018545	0.162738	1024.958	0.545672	0.029761				
2011/5/9	0.253115	0.392197	1336.417	0.015303	0.168975	1071.917	0.546851	0.036934				
2011/5/17	0.245205	0.40439	1218.458	0.019431	0.173197	1004.042	0.55529	0.030852				
2011/5/25	0.241449	0.453213	1211.542	0.026897	0.188179	972.875	0.601719	0.023771				
2011/6/2	0.255028	0.420257	1129.583	0.026818	0.21244	927.625	0.578274	0.0331				
2011/6/10		0.411607	1151	0.01779		883.0833	0.598288	0.024406				
2011/6/18		0.427781	1156.125	0.028025	0.392048	939.4583	0.571194	0.031363				
2011/6/26	0.369175	0.444507	1095.958	0.022855	0.510062	901	0.585886	0.02924				
2011/7/4	0.479846	0.456405	1097.958	0.024693	0.704212	946.0417	0.57598	0.027269				
2011/7/12	0.550327	0.437078	1135.583	0.021456	0.662538	891.4167	0.640772	0.031824				
2011/7/20	0.608466	0.441001	1228.583	0.022329	0.868619	976.7083	0.630922	0.041967				
2011/7/28	0.716101	0.489179	1136.292	0.034019		920.1667	0.680528	0.027538				
2011/8/5	0.592378	0.487759	1114.25	0.024963	0.740797	856	0.703219	0.037808				
2011/8/13	0.569212	0.496894	1089.083	0.027749	0.697771	929.3333	0.66196	0.032089				
2011/8/21	0.559597	0.484457	1085.125	0.026543	0.631837	952.0417	0.634478	0.030346				
2011/8/29	0.496925	0.448091	1180.833	0.02256	0.597281	989.625	0.62549	0.023709				
2011/9/6	0.391174	0.448228	1137.875	0.021135	0.393017	894.9167	0.650183	0.029893				
2011/9/14	0.360746	0.420258	1156.583	0.022462	0.400212	941.7917	0.609745	0.027595				
2011/9/22	0.33283	0.419478	1184.917	0.025209	0.302774	943.5	0.623359	0.034623				

2011/9/30	0.285596	0.392922	1156.5	0.020479	0.266905	938.2083	0.579077	0.025811				
2012/5/8	0.264288	0.413728	1185	0.030124	0.192346	968.5	0.573128	0.029756				
2012/5/16	0.229458	0.387362	1205.75	0.021639	0.178399	1018.417	0.520496	0.026836				
2012/5/24	0.261624	0.440369	1258.167	0.024696	0.222241	1126.958	0.528602	0.032923				
2012/6/1		0.405946	1161.333	0.021214		916.875	0.586103	0.030103				
2012/6/9	0.272771	0.370832	1281.542	0.018434	0.281234	1020.208	0.535845	0.030764				
2012/6/17	0.265541	0.445082	1088.75	0.024701	0.370408	887.2917	0.617775	0.030556				
2012/6/25	0.314965	0.428763	1100.583	0.028691	0.456796	930.875	0.583068	0.038645				
2012/7/3	0.395078	0.386267	1240.292	0.022645	0.510956	1001.583	0.550175	0.02237				
2012/7/11	0.500065	0.368452	1226.917	0.021804	0.557011	1002.042	0.522374	0.029885				
2012/7/19	0.357104	0.372524	1193.375	0.01846	0.677061	963.2083	0.546124	0.027344				
2012/7/27	0.466171	0.361623	1234.708	0.019584	0.68337	997.4583	0.544973	0.026275				
2012/8/4	0.422826	0.36548	1271.875	0.021119	0.656089	950.9167	0.582738	0.046736				
2012/8/12	0.419141	0.361661	1295.875	0.016496	0.666051	932.8333	0.592683	0.037217				
2012/8/20	0.368891	0.358194	1307.25	0.018656	0.616285	975.6667	0.559211	0.029429				
2012/8/28	0.369519	0.416266	1160.042	0.01667	0.397157	953.25	0.578278	0.027402				
2012/9/5	0.27615	0.383369	1268.375	0.021576	0.371999	939.875	0.602364	0.037715				
2012/9/13	0.253685	0.442108	1079.375	0.0277	0.291176	875.625	0.589605	0.035655				
2012/9/21	0.23509	0.386604	1282.208	0.01444	0.251144	1033.167	0.542971	0.036725				
2012/9/29	0.20005	0.372149	1242.125	0.028567	0.201691	1006	0.521707	0.032008				
2013/5/1	0.200881	0.394765	1150.417	0.024955		950.7917	0.534043	0.027473				
2013/5/9	0.24897	0.43375	1098.458	0.027701	0.171942	844.5833	0.600929	0.0357				
2013/5/17		0.400304	1144.167	0.024097		918.4167	0.535987	0.029949				
2013/5/25	0.303557	0.423537	1047	0.02966		820.5	0.578671	0.032438				

2013/6/2	0.291194	0.402504	1105.125	0.022766		883.4583	0.547776	0.023299				
2013/6/10	0.342067	0.430871	1084.375	0.023784	0.198835	876.7917	0.582148	0.029649				
2013/6/18		0.409655	1123.042	0.019418		922.3333	0.559267	0.035101				
2013/6/26	0.411544	0.443476	1109.917	0.02878	0.343722	866.7917	0.615968	0.036512				
2013/7/4	0.439345	0.415272	1169.833	0.023609		962.4583	0.546613	0.029522				
2013/7/12	0.69955	0.406126	1188	0.023022		945.0417	0.573638	0.022277				
2013/7/20	0.427801	0.401051	1263.417	0.017429	0.551675	1015.125	0.576491	0.02752				
2013/7/28		0.410965	1248.792	0.018446	0.587053	978.375	0.606207	0.033936				
2013/8/5	0.519459	0.464986	1099.792	0.026031	0.790463	956.875	0.601724	0.033667				
2013/8/13	0.614945	0.443405	1139.875	0.034522	0.647834	869.4583	0.656953	0.04047				
2013/8/21	0.520205	0.459301	1154.208	0.019709	0.612226	931.4167	0.616537	0.032819				
2013/8/29	0.402913	0.431168	1182.458	0.027433	0.630929	969.7917	0.588089	0.0259				
2013/9/6	0.390547	0.412856	1190.208	0.024992	0.465967	966.2917	0.562765	0.02599				
2013/9/14	0.406006	0.450823	1131.833	0.021554	0.412932	1061.042	0.543792	0.035067				
2013/9/22	0.350604	0.450062	1162.292	0.018408	0.337375	954.7917	0.601834	0.036624				
2013/9/30	0.30701	0.436922	1213.625	0.019291	0.316877	1002.042	0.574193	0.028872				
2014/5/1	0.234301	0.420923	1175.292	0.017109		917.5	0.634529	0.083992				
2014/5/9		0.407511	1200.75	0.022469		1007.583	0.561341	0.036887				
2014/5/17		0.404831	1143.792	0.023794	0.169576	907.4583	0.578558	0.030486				
2014/5/25		0.41329	1085.875	0.030551		869.8333	0.58312	0.040613				
2014/6/2	0.313582	0.44643	1101.917	0.027375		902.7917	0.600184	0.034013				
2014/6/10	0.311784	0.400462	1157.292	0.01306	0.241774	930.5417	0.573289	0.035296				
2014/6/18	0.400735	0.429234	1099.458	0.024115	0.274872	837.0833	0.606365	0.036029				
2014/6/26	0.452716	0.42845	1072.25	0.028971		877.0833	0.580294	0.039676				

2014/7/4	0.417075	0.407497	1079.792	0.020045	0.422816	833.7917	0.580291	0.040063				
2014/7/12	0.47253	0.401671	1134.833	0.018153		828.7917	0.604359	0.034348				
2014/7/20	0.478047	0.387088	1216.083	0.020536	0.511107	915.75	0.569552	0.023785				
2014/7/28	0.434895	0.369691	1202.875	0.019772	0.608138	893.5	0.579253	0.032846				
2014/8/5		0.405164	1170.75	0.024628		928.12	0.55905	0.028717				
2014/8/13		0.408181	1161.875	0.023759	0.748175	883.0833	0.592232	0.031963				
2014/8/21	0.52492	0.396917	1255.375	0.026363	0.76003	872.1667	0.638252	0.039421				
2014/8/29	0.632811	0.464273	1102.833	0.026984	0.71473	846.5833	0.648475	0.036575				
2014/9/6	0.579392	0.431954	1045.292	0.028112	0.703575	808.3333	0.615705	0.023028				
2014/9/14	0.501074	0.448801	992	0.029574	0.490848	792.7083	0.613197	0.027475				
2014/9/22	0.375099	0.431048	1085.792	0.022333	0.344493	852.4583	0.604799	0.030948				
2014/9/30	0.416798	0.421734	1123.792	0.028575	0.27513	871.0833	0.593802	0.024055				
2015/5/1				0.019945					0.241471	3750.737	0.478931	0.011819
2015/5/9	0.301843	0.424334	1065.75	0.028521					0.183875	3641.333	0.492361	0.01618
2015/5/17		0.436094		0.024362						3993.958	0.490361	0.013869
2015/5/25	0.300646	0.424024	1151.708	0.018348					0.250615	3707.125	0.519374	0.018473
2015/6/2	0.311616	0.394738	1136.875	0.018819					0.177889	3585.773	0.520449	0.013637
2015/6/10	0.337082	0.414503	1182.917	0.019733						3973	0.480829	0.013019
2015/6/18	0.331307	0.439164	1067.583	0.028403					0.298183	3504.381	0.515133	0.014231
2015/6/26	0.513266	0.441576	1000.083	0.019579					0.359544	3277.625	0.521284	0.020551
2015/7/4	0.448527	0.459514	1086.042	0.023857					0.600869	3647.261	0.55221	0.015374
2015/7/12	0.536482	0.474503	1096.208	0.028235					0.764175	3542.458	0.565209	0.017668
2015/7/20	0.598179	0.46678	1141.583	0.0227					0.714614	3419.208	0.570819	0.017381
2015/7/28	0.59282	0.50997	1100.333	0.033778					0.783895	3558.125	0.589808	0.028961

2015/8/5		0.490666	1100.375	0.027477					0.685524	3338.75	0.599272	0.017786
2015/8/13	0.661594	0.480705	1074.833	0.030449					0.910008	3236	0.584615	0.016816
2015/8/21	0.669501	0.488653	1134.625	0.022485					0.630928	3557.792	0.596457	0.014559
2015/8/29	0.513982	0.49907	1059.708	0.023367					0.600256	3294.125	0.604645	0.015296
2016/4/30									0.162081	3656	0.578899	0.02873
2016/5/8									0.176237	4172.917	0.480537	0.014377
2016/5/16									0.161456	4052.833	0.467272	0.015467
2016/5/24									0.178996	4237.208	0.464616	0.015051
2016/6/1										3863.435	0.49778	0.014004
2016/6/9									0.249556	4013.5	0.531514	0.017193
2016/6/17									0.381005	3704.708	0.525118	0.019149
2016/6/25									0.388466	4004.417	0.527662	0.010301
2016/7/3									0.592321	3616.792	0.562285	0.01334
2016/7/11									0.618537	3966.042	0.562285	0.016233
2016/7/19									0.714505	3332.708	0.602367	0.015914
2016/7/27									0.785921	3513.875	0.589133	0.017298
2016/8/4									0.716258	3622.458	0.590263	0.019702
2016/8/12									0.652918	3482.625	0.591302	0.017607
2016/8/20									0.659126	3551.833	0.57974	0.016328
2016/8/28									0.665553	3632.042	0.57104	0.015239

Table A.2: Multi-year fresh and dry weight summary data of US-Ne3 site

CSP 2011 Maize
Site 3

Year	Sample Taken (DOY)	Growth Stage	Plant Population per m2 from POPULATION DATA SHEET	Number of plants in sample	Height (cm)	Green Leaf LAI (m2 m2)	Est. Dead Leaf LAI (m2 m2)	Total LAI (m2 m2)	Total Dry Above Ground Biomass (kg/ha)	Pct. Biomass in Green Leaves	Pct. Biomass in Dead Leaves	Pct. Biomass in Stem	Pct. Biomass in Repro	Dry Green Leaf Biomass (kh/ha)	Dry Dead Leaf Biomass (kg/ha)	Dry Stem Biomass (kg/ha)	Dry Repro Biomass (kg/ha)	Total Fresh Above Ground Biomass (kg/ha)
2011	133				0.0	0.00	0.00	0.00	-					-	-	-	-	0
2011	146	V2	5.018	26	13.0	0.01	0.00	0.01	4	67.46%	0.00%	32.54%	0.00%	3	0	1	0	31
2011	158	V5	5.018	29	33.7	0.10	0.00	0.10	55	61.22%	0.15%	38.63%	0.00%	34	0	21	0	398
2011	168	V7	5.018	26	58.7	0.34	0.00	0.34	209	59.62%	0.19%	40.19%	0.00%	125	0	84	0	1,824
2011	179	V10	5.018	25	109.8	1.47	0.02	1.49	1,215	53.33%	0.80%	45.87%	0.00%	648	10	557	0	11,960
2011	189	V15	5.018	25	189.2	3.28	0.02	3.31	3,766	44.40%	0.30%	54.89%	0.40%	1,672	11	2,067	15	34,462
2011	196	VT	5.018	28	237.0	3.44	0.01	3.46	5,090	35.45%	0.14%	55.54%	8.87%	1,804	7	2,827	452	38,936
2011	207	R2	5.018	25	255.8	3.28	0.07	3.35	7,859	24.71%	0.50%	49.84%	24.95%	1,942	39	3,917	1,961	43,678
2011	216	R3	5.018	25	260.1	3.49	0.07	3.56	11,194	18.45%	0.38%	39.45%	41.72%	2,065	43	4,416	4,670	53,530
2011	227	R5	5.018	24		3.32	0.05	3.37	14,265	14.83%	0.23%	33.25%	51.69%	2,116	32	4,744	7,374	52,871
2011	237	R5	5.018	24		2.95	0.24	3.18	15,020	11.35%	0.87%	28.30%	59.48%	1,705	130	4,251	8,935	48,985
2011	256	R5	5.018	26		0.93	1.41	2.34	17,127	4.13%	6.50%	25.31%	64.06%	707	1,113	4,335	10,971	40,537
2011	272	R6	5.018	60		0.03	1.50	1.52	16,672	0.17%	9.95%	25.42%	64.46%	29	1,659	4,238	10,746	31,936

CSP 2012 Soybeans
Site 3

Year	Sample Taken (DOY)	Growth Stage Index	Plant Population per m2 from POPULATION DATA SHEET	Number of plants in sample	Height (cm)	Green Leaf LAI (m2 m2)	Est. Dead Leaf LAI (m2 m2)	Total LAI (m2 m2)	Total Dry Above Ground Biomass (kg/ha)	Pct. Biomass in Green Leaves	Pct. Biomass in Dead Leaves	Pct. Biomass in Stem	Pct. Biomass in Repro	Green Leaf Biomass	Dead Leaf Biomass	Stem Biomass	Repro Biomass	Total Fresh Above Ground Biomass (kg/ha)
2012	147	0.00	30.745		0.0	0.000	0.000	0.000	0	0.0%	0.0%	0.0%	0.0%	0	0	0	0	0
2012	151	0.50	29.479	23.8	6.2	0.051	0.000	0.051	42	73.8%	0.0%	26.2%	0.0%	31	0	11	0	288
2012	158	0.92	29.479	22.5	11.5	0.091	0.001	0.093	80	70.0%	0.7%	29.3%	0.0%	56	1	23	0	385
2012	167	2.83	29.479	22.5	19.0	0.218	0.005	0.223	244	62.3%	0.8%	36.9%	0.0%	152	2	90	0	1,161
2012	173	4.17	29.479	23.7	25.8	0.501	0.008	0.508	360	57.5%	0.9%	41.6%	0.0%	207	3	150	0	1,972
2012	180	6.96	29.479	23.0	41.8	1.081	0.031	1.112	815	51.8%	1.8%	46.4%	0.0%	422	15	378	0	4,770
2012	191	9.96	29.479	24.2	54.2	1.834	0.114	1.947	1518	43.8%	3.3%	53.0%	0.0%	664	50	804	0	4,085
2012	199	11.00	29.479	23.2	73.7	2.599	0.167	2.766	2284	38.3%	3.2%	58.5%	0.1%	876	72	1335	1	10,977
2012	206	11.46	29.479	24.3	77.0	3.073	0.062	3.135	2767	37.5%	0.9%	61.1%	0.5%	1037	26	1689	15	12,200
2012	213	12.63	29.479	22.7	86.0	3.201	0.054	3.254	3486	36.6%	0.7%	61.1%	0.5%	1277	23	2129	19	14,320
2012	222	12.96	29.479	21.7	90.3	3.190	0.091	3.280	3972	32.0%	1.0%	57.7%	9.3%	1271	39	2290	371	15,652
2012	230	13.31	29.479	23.7	93.0	3.313	0.049	3.362	4756	28.1%	0.5%	51.1%	20.3%	1338	22	2432	965	18,268
2012	248	14.00	29.479	22.0	81.5	2.661	0.289	2.951	6800	15.6%	2.0%	37.7%	44.7%	1060	136	2565	3039	22,066
2012	264	14.96	29.479	24.2	82.5	0.146	0.147	0.293	4737	1.3%	1.4%	34.3%	62.9%	61	68	1627	2981	8,690

CSP 2013 Maize
Site 3

Year	Sample Taken (DOY)	Growth Stage Index	Plant Population per m2 from POPULATION DATA SHEET	Number of plants in sample	Height (cm)	Green Leaf LAI (m2 m2)	Est. Dead Leaf LAI (m2 m2)	Total LAI (m2 m2)	Total Dry Above Ground Biomass (kg/ha)	Pct. Biomass in Green Leaves	Pct. Biomass in Dead Leaves	Pct. Biomass in Stem	Pct. Biomass in Repro	Green Leaf Biomass	Dead Leaf Biomass	Stem Biomass	Repro Biomass	Total Fresh Above Ground Biomass (kg/ha)
2013	141	0			0	0	0	0	-					-	-	-	-	
2013	148	1.56	5.819	28	14.3	0.015	0.000	0.015	6	66.40%	0.00%	33.60%	0.00%	4	0	2	0	50
2013	155	3.05	5.819	29	24.1	0.057	0.000	0.057	23	64.64%	0.00%	35.36%	0.00%	15	0	8	0	204
2013	163	4.83	5.819	28	43.9	0.212	0.000	0.212	116	64.06%	0.00%	35.94%	0.00%	74	0	42	0	1,135
2013	171	6.64	5.819	28	73.6	0.602	0.002	0.604	447	55.22%	0.18%	44.60%	0.00%	247	1	199	0	4,164
2013	179	9.18	5.819	27	121.1	1.901	0.012	1.913	1,395	58.85%	0.31%	40.84%	0.00%	821	4	570	0	16,142
2013	189	13.43	5.819	27	178.7	3.489	0.032	3.521	3,524	49.09%	0.43%	50.30%	0.17%	1,730	15	1,773	6	35,229
2013	196	17.01	5.819	26	224.8	4.157	0.085	4.242	6,345	37.31%	0.69%	57.05%	4.94%	2,368	44	3,620	314	44,820
2013	206	21.63	5.819	28	247.2	4.014	0.125	4.140	8,850	26.64%	0.80%	54.77%	17.79%	2,357	71	4,847	1,575	50,744
2013	218	22.90	5.819	28	252.0	4.066	0.151	4.217	12,137	20.22%	0.70%	47.45%	31.63%	2,454	85	5,759	3,839	60,580
2013	227	23.76	5.819	27	257.6	3.620	0.169	3.789	13,645	16.60%	0.92%	42.21%	40.28%	2,265	125	5,759	5,496	58,172
2013	241	25.00	5.819	29		2.893	0.656	3.549	16,809	10.88%	2.25%	30.32%	56.55%	1,830	378	5,097	9,505	51,763
2013	256	25.39	5.819	29		1.162	1.636	2.798	17,959	4.62%	6.44%	23.07%	65.88%	829	1,156	4,143	11,831	40,569
2013	268	26.00	5.819	28		0.378	1.894	2.272	18,531	1.34%	7.51%	22.45%	68.70%	249	1,391	4,160	12,730	36,898

CSP 2014 Maize

Site 3

Year	Sample Taken (DOY)	Growth Stage Index	Plant Population per m2 from POPULATION DATA SHEET	Number of plants in sample	Height (cm)	Green Leaf LAI (m2 m2)	Est. Dead Leaf LAI (m2 m2)	Total LAI (m2 m2)	Total Dry Above Ground Biomass (kg/ha)	Pct. Biomass in Green Leaves	Pct. Biomass in Dead Leaves	Pct. Biomass in Stem	Pct. Biomass in Repro	Green Leaf Biomass	Dead Leaf Biomass	Stem Biomass	Repro Biomass	Total Fresh Above Ground Biomass (kg/ha)
2014	147	0.00	30.745		0.0	0.000	0.000	0.000	0	0.0%	0.0%	0.0%	0.0%	0	0	0	0	0
2014	153	0.50	29.932	24.8	7.5	0.054	0.001	0.055	42	66.0%	0.8%	33.2%	0.0%	28	0	14	0	286
2014	162	2.00	29.932	26.3	14.0	0.165	0.001	0.166	108	66.9%	0.5%	32.6%	0.0%	72	1	35	0	591
2014	168	3.00	29.932	27.5	17.5	0.289	0.005	0.294	173	58.8%	1.3%	40.0%	0.0%	102	2	69	0	917
2014	175	4.17	29.932	22.0	26.2	0.564	0.005	0.569	354	59.8%	0.6%	39.7%	0.0%	212	2	140	0	2,075
2014	182	7.17	29.932	23.7	32.3	0.996	0.007	1.003	643	55.4%	0.5%	44.1%	0.0%	356	3	283	0	3,548
2014	189	10.00	29.932	24.5	41.7	1.555	0.019	1.574	1075	50.9%	0.7%	48.4%	0.0%	547	8	520	0	5,620
2014	197	10.00	29.932	23.7	58.7	2.565	0.049	2.614	2086	45.6%	1.0%	53.4%	0.0%	951	21	1114	0	9,984
2014	203	11.00	29.932	23.0	67.5	2.861	0.066	2.927	2492	41.5%	1.1%	55.9%	1.5%	1034	28	1393	37	11,907
2014	210	12.00	29.932	26.3	79.8	3.418	0.072	3.490	3377	37.8%	1.0%	55.1%	6.1%	1277	32	1860	208	15,048
2014	218	13.03	29.932	25.5	77.8	3.364	0.070	3.435	3767	33.0%	0.8%	50.4%	15.8%	1243	30	1898	596	18,169
2014	225	13.00	29.932	25.2	88.2	3.698	0.058	3.756	5004	29.2%	0.5%	46.6%	23.6%	1463	26	2333	1183	21,238
2014	231	13.10	29.932	25.8	84.5	3.567	0.044	3.611	5356	25.3%	0.4%	40.7%	33.6%	1357	20	2177	1802	22,239
2014	251	14.03	29.932	27.2	81.7	2.879	0.048	2.927	6499	17.2%	0.3%	29.7%	52.8%	1115	21	1932	3431	22,055
2014	265	17.80	29.93	24.3	77.8	0.389	0.811	1.199	7389	2.1%	5.0%	27.0%	65.8%	155	370	1998	4866	19,552
2014	279	19.00	29.93	26.3	79.7	0.000	0.005	0.005	5887	0.0%	0.0%	21.5%	78.5%	0	2	1266	4619	9,141

CSP 2015 Maize

Site 3

Year	Sample Taken (DOY)	Growth Stage Index	Plant Population per m2 from POPULATION DATA SHEET	Number of plants in sample	Height (cm)	Green Leaf LAI (m2 m2)	Est. Dead Leaf LAI (m2 m2)	Total LAI (m2 m2)	Total Dry Above Ground Biomass (kg/ha)	Pct. Biomass in Green Leaves	Pct. Biomass in Dead Leaves	Pct. Biomass in Stem	Pct. Biomass in Repro	Green Leaf Biomass	Dead Leaf Biomass	Stem Biomass	Repro Biomass	Total Fresh Above Ground Biomass (kg/ha)
2015	133	0.0		0	0.0	0	0	0	0	-	-	-	-	0	0	0	0	
2015	142	1.0	5.223	27	8.0	0.01	0.00	0.01	2	75.4%	0.0%	24.6%	0.0%	1	0	0	0	16
2015	148	1.6	5.223	24	13.7	0.012	0.000	0.012	5	72.54%	0.00%	27.46%	0.00%	3	0	1	0	36
2015	154	3.1	5.223	23	21.3	0.039	0.000	0.039	17	67.88%	0.00%	32.12%	0.00%	12	0	5	0	121
2015	160	4.6	5.223	24	39.0	0.126	0.000	0.126	82	61.32%	0.00%	38.68%	0.00%	51	0	32	0	760
2015	168	6.4	5.223	28	68.0	0.516	0.000	0.516	353	60.73%	0.00%	39.27%	0.00%	214	0	138	0	3,282
2015	174	6.8	5.223	27	98.5	1.090	0.000	1.090	833	56.94%	0.00%	43.06%	0.00%	475	0	359	0	8,045
2015	181	8.9	5.223	25	142.9	2.318	0.003	2.321	1,988	53.94%	0.05%	46.01%	0.00%	1072	1	915	0	21,424
2015	191	13.2	5.223	25	204.2	3.658	0.003	3.661	4,110	49.07%	0.05%	50.83%	0.04%	2017	2	2089	2	36,525
2015	202	20.5	5.223	25	273.4	3.594	0.064	3.658	7,052	32.09%	0.57%	58.75%	8.59%	2263	40	4144	605	42,203
2015	210	21.5	5.223	27	287.4	3.915	0.132	4.047	8,874	27.21%	0.97%	55.83%	15.98%	2415	86	4954	1418	51,775
2015	223	24.0	5.223	27	286.1	3.704	0.139	3.843	13,051	19.43%	0.67%	42.53%	37.38%	2535	88	5550	4878	57,555
2015	231	24.7	5.223	28	284.3	3.670	0.165	3.835	14,320	16.35%	0.78%	36.11%	46.76%	2341	112	5170	6696	**58,495**
2015	243	25.0	5.223	27	281.3	3.040	0.396	3.436	16,508	12.58%	1.59%	29.98%	55.85%	2078	262	4949	9220	54,476
2015	257	25.0	5.223	28	278.3	0.977	1.657	2.634	17,547	4.14%	7.43%	24.16%	64.26%	727	1305	4239	11276	43,895

CSP 2016 Maize

Site 3

Year	Sample Taken (DOY)	Growth Stage Index	Plant Population per m2 from POPULATION DATA SHEET	Number of plants in sample	Height (cm)	Green Leaf LAI (m2 m2)	Est. Dead Leaf LAI (m2 m2)	Total LAI (m2 m2)	Total Dry Above Ground Biomass (kg/ha)	Pct. Biomass in Green Leaves	Pct. Biomass in Dead Leaves	Pct. Biomass in Stem	Pct. Biomass in Repro	Green Leaf Biomass	Dead Leaf Biomass	Stem Biomass	Repro Biomass	Total Fresh Above Ground Biomass (kg/ha)
2016	150	0.00			0.0	0.000	0.000	0.000	0	0.0%	0.0%	0.0%	0.0%	0	0	0	0	0
2016	158	0.50	28.551	21.8	6.3	0.048	0.000	0.048	37	67.3%	0.0%	32.7%	0.0%	25	0	12	0	255
2016	166	1.67	28.551	21.5	12.5	0.147	0.000	0.147	81	67.9%	0.0%	32.1%	0.0%	55	0	26	0	428
2016	173	2.93	28.551	22.2	20.7	0.205	0.000	0.205	164	55.5%	0.0%	44.5%	0.0%	91	0	73	0	870
2016	182	5.43	28.551	23.8	38.2	1.021	0.000	1.021	673	54.0%	0.0%	46.0%	0.0%	363	0	310	0	3,959
2016	189	7.73	28.551	22.0	44.5	1.112	0.040	1.152	832	52.6%	2.5%	44.8%	0.0%	438	21	373	0	5,062
2016	195	9.90	28.551	19.8	54.2	2.045	0.037	2.082	1422	48.6%	1.3%	50.1%	0.0%	691	19	712	0	9,777
2016	202	10.00	28.551	20.2	70.8	2.433	0.074	2.507	1825	43.3%	1.9%	54.8%	0.0%	790	35	1000	0	11,218
2016	209	10.23	28.551	20.8	82.3	3.257	0.103	3.360	2850	38.7%	1.6%	59.7%	0.0%	1104	46	1701	0	15,705
2016	216	11.00	28.551	19.5	97.7	4.254	0.073	4.327	4011	34.6%	0.8%	61.6%	3.0%	1388	32	2471	120	22,769
2016	223	12.00	28.551	19.0	113.5	4.606	0.104	4.710	5636	30.9%	0.8%	59.3%	9.0%	1740	47	3343	506	27,792
2016	230	13.00	28.551	18.3	118.0	4.629	0.093	4.722	7070	27.2%	0.6%	54.1%	18.1%	1921	42	3825	1283	33,545
2016	250	13.90	28.551	23.5	107.8	4.084	0.061	4.146	9095	17.6%	0.3%	39.8%	42.3%	1603	27	3620	3845	35,314
2016	264	14.00	28.551	21.7	98.8	3.068	0.388	3.456	9904	11.4%	1.7%	34.4%	52.6%	1129	167	3403	5205	36,755
2016	279	0.00	28.55	22.5	99.8	0.014	0.255	0.269	7663	0.1%	1.5%	30.6%	67.8%	4	114	2348	5197	13,885

Table A.3 Total Fresh Biomass, B/M and Moderated neutron intensity data of ARCD CSP3 site from 2011 to 2016 during growing season

Date	Total Fresh Biomass (kg/ha)	B/M	MOD
5/26/2011	31	0.436305	1170.75
6/5/2011	398	0.400139	1128.417
6/17/2011	1,824	0.404062	1224.542
6/28/2011	11,960	0.433532	1083.083
7/8/2011	34,462	0.452454	1154.208
7/15/2011	38,936	0.447223	1152.208
7/26/2011	43,678	0.452226	1193.958
8/4/2011	53,530	0.465058	1171.708
8/15/2011	52,871	0.484286	1123.208
8/25/2011	48,985	0.443556	1176.625
9/13/2011	40,537	0.426281	1177.917
9/29/2011	31,936	0.402899	1226.083
5/30/2012	288	0.406226	1182.174
6/6/2012	385	0.3842	1197.542
6/15/2012	1,161	0.467317	1108
6/21/2012	1,972	0.451483	1086.125
6/28/2012	4,770	0.422013	1157.917
7/9/2012	4,085	0.376176	1182.583
7/17/2012	10,977	0.375153	1261.417
7/24/2012	12,200	0.363677	1257
7/31/2012	14,320	0.371928	1250.375
8/9/2012	15,652	0.354851	1278.875
8/17/2012	18,268	0.349511	1292.375
9/4/2012	22,066	0.397742	1227.875
9/20/2012	8,690	0.394558	1252.333
5/28/2013	50	0.441064	1124.375
6/4/2013	204	0.413555	1115.5
6/12/2013	1,135	0.411948	1140.625
6/20/2013	4,164	0.403719	1149.333
6/28/2013	16,142	0.432335	1077.042
7/8/2013	35,229	0.412255	1174.75
7/15/2013	44,820	0.407355	1140.917
7/25/2013	50,744	0.428923	1202.625
8/6/2013	60,580	0.47257	1121.708
8/15/2013	58,172	0.470869	1128.875
8/29/2013	51,763	0.431168	1182.458
9/13/2013	40,569	0.460638	1081.083
9/25/2013	36,898	0.444873	1155.625

6/2/2014	286	0.44643	1101.917
6/11/2014	591	0.407027	1188.792
6/17/2014	917	0.431694	1129.542
6/24/2014	2,075	0.424167	1084.417
7/1/2014	3,548	0.426692	1126.208
7/8/2014	5,620	0.420935	1154.083
7/16/2014	9,984	0.381521	1195.167
7/22/2014	11,907	0.390231	1199.625
7/29/2014	15,048	0.373214	1203.542
8/6/2014	18,169	0.418191	1156.417
8/13/2014	21,238	0.408181	1161.875
8/19/2014	22,239	0.406486	1267.375
9/8/2014	22,055	0.440983	1091.917
9/22/2014	19,552	0.431048	1085.792
10/6/2014	9,141	0.418991	1192.833
5/22/2015	16	0.402567	1095.375
5/28/2015	36	0.409178	1136.625
6/3/2015	121	0.430051	1118.75
6/9/2015	760	0.406593	1178.542
6/17/2015	3,282	0.427919	1084.5
6/23/2015	8,045	0.413533	1035.958
6/30/2015	21,424	0.426499	1136.042
7/10/2015	36,525	0.459742	1102.917
7/21/2015	42,203	0.45111	1159.417
7/29/2015	51,775	0.487663	1099.167
8/11/2015	57,555	0.493334	1046.458
8/19/2015	58,495	0.497383	1128.333
8/31/2015	54,476	0.49715	1074.917
9/14/2015	43,895	0.465812	1151.125
6/6/2016	255	0.400436	1271.167
6/14/2016	428	0.386132	1261.333
6/21/2016	870	0.444794	1097.958
6/30/2016	3,959	0.411169	1191.667
7/7/2016	5,062	0.453804	1178.375
7/13/2016	9,777	0.438933	1122.667
7/20/2016	11,218	0.436932	1129.542
7/27/2016	15,705	0.410458	1221.625
8/3/2016	22,769	0.47285	1095.542
8/10/2016	27,792	0.434421	1174.042
8/17/2016	33,545	0.471942	1114.958
9/6/2016	35,314	0.449775	1149.167
9/20/2016	36,755	0.461419	1115.917
10/5/2016	13,885	0.440365	1236.208

Table A.4 Multi-year observed standing biomass weight summary and GrWDRVI data of US-Ne3 site. This form was first generated and used by W, Avery, 2016.

ID	Year	Month	Day	Field Number	DOY	Crop (maize =1, soybean =2)	Observed Standing Wet Biomass (kg/m^2)	GrWDRVI
1	2003	6	9	1	160	1	0.0142	0.2341
2	2003	6	14	1	165	1	0.0657	0.2880
3	2003	6	16	1	167	1	0.1203	0.2538
4	2003	6	23	1	174	1	0.5657	0.3779
5	2003	6	23	1	174	1	0.5657	0.4038
6	2003	7	2	1	183	1	1.9377	0.4422
7	2003	7	3	1	184	1	2.1399	0.4314
8	2003	7	10	1	191	1	3.7161	0.5567
9	2003	7	11	1	192	1	3.9499	0.5473
10	2003	7	13	1	194	1	4.4014	0.6025
11	2003	7	14	1	195	1	4.6135	0.6546
12	2003	7	25	1	206	1	5.8348	0.6320
13	2003	7	26	1	207	1	5.8745	0.5521
14	2003	7	28	1	209	1	5.9566	0.6874
15	2003	8	3	1	215	1	6.3009	0.6847
16	2003	8	8	1	220	1	6.6196	0.7314
17	2003	8	10	1	222	1	6.7314	0.6607
18	2003	8	15	1	227	1	6.9519	0.6544
19	2003	8	17	1	229	1	7.0154	0.6797
20	2003	8	24	1	236	1	7.1186	0.7305
21	2003	8	24	1	236	1	7.1186	0.7542
22	2003	8	29	1	241	1	7.0723	0.5934
23	2003	9	4	1	247	1	6.8942	0.5659
24	2003	9	6	1	249	1	6.8098	0.5607
25	2003	9	7	1	250	1	6.7634	0.5881
26	2003	9	15	1	258	1	6.3119	0.4932
27	2003	9	16	1	259	1	6.2474	0.5137
28	2003	9	23	1	266	1	5.7657	0.4029
29	2003	9	25	1	268	1	5.6224	0.4459
30	2004	5	14	1	135	1	0.0001	0.3030
31	2004	5	26	1	147	1	0.0099	0.2260
32	2004	5	27	1	148	1	0.0121	0.2181
33	2004	6	4	1	156	1	0.0447	0.3012
34	2004	6	7	1	159	1	0.0744	0.2508
35	2004	6	13	1	165	1	0.2736	0.3810
36	2004	6	14	1	166	1	0.3358	0.2920
37	2004	6	22	1	174	1	1.2104	0.4486
38	2004	6	23	1	175	1	1.3593	0.4623
39	2004	6	25	1	177	1	1.6765	0.4095
40	2004	6	30	1	182	1	2.5540	0.4751
41	2004	7	4	1	186	1	3.3007	0.6403
42	2004	7	4	1	186	1	3.3007	0.6422
43	2004	7	18	1	200	1	5.4594	0.8630
44	2004	7	18	1	200	1	5.4594	0.7199
45	2004	7	19	1	201	1	5.5565	0.6372
46	2004	7	20	1	202	1	5.6452	0.7349
47	2004	7	27	1	209	1	6.0302	0.7056
48	2004	7	27	1	209	1	6.0302	0.6560
49	2004	8	7	1	220	1	6.3285	0.6927
50	2004	8	8	1	221	1	6.3898	0.7879

51	2004	8	14	1	227	1	6.8078	0.6629
52	2004	8	14	1	227	1	6.8078	0.7046
53	2004	8	21	1	234	1	7.0812	0.6656
54	2004	8	24	1	237	1	7.0732	0.6080
55	2004	8	29	1	242	1	6.9207	0.5006
56	2004	8	30	1	243	1	6.8723	0.6102
57	2004	9	6	1	250	1	6.4053	0.5378
58	2004	9	9	1	253	1	6.1544	0.4627
59	2004	9	13	1	257	1	5.7871	0.4812
60	2004	9	16	1	260	1	5.4913	0.4295
61	2004	9	24	1	268	1	4.6434	0.3402
62	2004	9	25	1	269	1	4.5335	0.3730
63	2004	9	29	1	273	1	4.0903	0.3232
64	2005	5	20	1	140	1	0.0030	0.2395
65	2005	5	23	1	143	1	0.0059	0.2315
66	2005	5	27	1	147	1	0.0099	0.2086
67	2005	6	8	1	159	1	0.0695	0.2297
68	2005	6	17	1	168	1	0.4827	0.3020
69	2005	6	21	1	172	1	0.8833	0.3204
70	2005	6	22	1	173	1	1.0093	0.3548
71	2005	6	28	1	179	1	2.0085	0.4625
72	2005	7	1	1	182	1	2.6499	0.5245
73	2005	7	5	1	186	1	3.5297	0.6603
74	2005	7	19	1	200	1	5.6120	0.6196
75	2005	7	23	1	204	1	6.0460	0.6211
76	2005	7	24	1	205	1	6.1454	0.5464
77	2005	7	28	1	209	1	6.4655	0.7880
78	2005	7	28	1	209	1	6.4655	0.7443
79	2005	8	8	1	220	1	6.3918	0.8040
80	2005	8	9	1	221	1	6.3643	0.7698
81	2005	8	18	1	230	1	6.4063	0.6796
82	2005	8	18	1	230	1	6.4063	0.6700
83	2005	8	27	1	239	1	6.2754	0.7065
84	2005	8	28	1	240	1	6.2360	0.5700
85	2005	8	31	1	243	1	6.0920	0.6162
86	2005	9	3	1	246	1	5.9121	0.5437
87	2005	9	9	1	252	1	5.4601	0.5195
88	2005	9	10	1	253	1	5.3746	0.4308
89	2005	9	16	1	259	1	4.8131	0.4055
90	2005	9	19	1	262	1	4.5067	0.3055
91	2005	9	26	1	269	1	3.7456	0.3327
92	2005	9	27	1	270	1	3.6331	0.3295
93	2005	10	2	1	275	1	3.0632	0.2827
94	2006	5	19	1	139	1	-0.0297	0.1685
95	2006	5	25	1	145	1	-0.0497	0.2069
96	2006	5	28	1	148	1	-0.0201	0.1867
97	2006	6	6	1	157	1	0.3309	0.2795
98	2006	6	9	1	160	1	0.5337	0.2743
99	2006	6	13	1	164	1	0.9028	0.3510
100	2006	6	13	1	164	1	0.9028	0.2862

101	2006	6	20	1	171	1	2.1717	0.4411
102	2006	6	22	1	173	1	2.6630	0.5064
103	2006	7	1	1	182	1	4.7143	0.5563
104	2006	7	1	1	182	1	4.7143	0.5655
105	2006	7	6	1	187	1	5.3059	0.6522
106	2006	7	6	1	187	1	5.3059	0.4973
107	2006	7	15	1	196	1	5.6367	0.6933
108	2006	7	17	1	198	1	5.8326	0.6961
109	2006	7	20	1	201	1	6.1632	0.7199
110	2006	7	26	1	207	1	6.6937	0.6657
111	2006	7	29	1	210	1	6.7856	0.6482
112	2006	8	4	1	216	1	6.6857	0.7076
113	2006	8	5	1	217	1	6.6737	0.6857
114	2006	8	9	1	221	1	6.6727	0.6417
115	2006	8	14	1	226	1	6.6571	0.7834
116	2006	8	14	1	226	1	6.6571	0.6831
117	2006	8	23	1	235	1	6.6230	0.7158
118	2006	8	29	1	241	1	7.3285	0.6134
119	2006	8	30	1	242	1	7.4621	0.6097
120	2006	9	12	1	255	1	5.2796	0.5252
121	2006	9	13	1	256	1	4.5639	0.3806
122	2006	9	17	1	260	1	0.9844	0.3621
123	2007	5	17	1	137	1	0.0014	0.2153
124	2007	5	25	1	145	1	0.0366	0.2558
125	2007	6	7	1	158	1	0.4657	0.2564
126	2007	6	9	1	160	1	0.6425	0.3316
127	2007	6	16	1	167	1	1.6994	0.4618
128	2007	6	16	1	167	1	1.6994	0.4638
129	2007	6	20	1	171	1	2.7227	0.4299
130	2007	6	20	1	171	1	2.7227	0.5661
131	2007	6	30	1	181	1	5.4796	0.6388
132	2007	6	30	1	181	1	5.4796	0.5223
133	2007	7	4	1	185	1	6.0484	0.6777
134	2007	7	11	1	192	1	6.5392	0.7139
135	2007	7	13	1	194	1	6.6473	0.5690
136	2007	7	16	1	197	1	6.9077	0.6203
137	2007	7	20	1	201	1	7.5190	0.7427
138	2007	8	3	1	215	1	8.4266	0.7583
139	2007	8	4	1	216	1	8.3850	0.6563
140	2007	8	9	1	221	1	8.0865	0.6321
141	2007	8	10	1	222	1	8.0149	0.8552
142	2007	8	13	1	225	1	7.7918	0.7205
143	2007	8	14	1	226	1	7.7176	0.7158
144	2007	8	21	1	233	1	7.2583	0.7513
145	2007	8	28	1	240	1	6.8572	0.6983
146	2007	8	30	1	242	1	6.7389	0.6546
147	2007	9	2	1	245	1	6.5490	0.6447
148	2007	9	8	1	251	1	6.0985	0.5598
149	2007	9	11	1	254	1	5.8361	0.5083
150	2007	9	14	1	257	1	5.5544	0.4367

151	2007	9	17	1	260	1	5.2580	0.4080
152	2007	9	22	1	265	1	4.7431	0.3819
153	2008	5	12	1	133	1	0.0032	0.2008
154	2008	5	15	1	136	1	0.0059	0.2480
155	2008	5	16	1	137	1	0.0066	0.2379
156	2008	5	17	1	138	1	0.0072	0.2933
157	2008	5	30	1	151	1	0.0197	0.3693
158	2008	6	6	1	158	1	0.1215	0.2591
159	2008	6	6	1	158	1	0.1215	0.4016
160	2008	6	13	1	165	1	0.4350	0.3162
161	2008	6	16	1	168	1	0.7172	0.3786
162	2008	6	20	1	172	1	1.4044	0.3930
163	2008	6	27	1	179	1	3.3107	0.5412
164	2008	7	2	1	184	1	4.6729	0.5467
165	2008	7	5	1	187	1	5.2829	0.5122
166	2008	7	10	1	192	1	6.0142	0.5479
167	2008	7	11	1	193	1	6.1372	0.6607
168	2008	7	15	1	197	1	6.6287	0.6740
169	2008	7	20	1	202	1	7.3795	0.6614
170	2008	7	22	1	204	1	7.6632	0.7143
171	2008	8	2	1	215	1	6.9763	0.6587
172	2008	8	3	1	216	1	6.8592	0.7607
173	2008	8	7	1	220	1	6.9166	0.6761
174	2008	8	12	1	225	1	7.6414	0.7182
175	2008	8	23	1	236	1	7.7514	0.6246
176	2008	8	26	1	239	1	7.6787	0.6999
177	2008	9	1	1	245	1	7.5914	0.5986
178	2008	9	4	1	248	1	7.5449	0.5137
179	2008	9	17	1	261	1	6.9029	0.4232
180	2008	9	20	1	264	1	6.6249	0.4193
181	2008	9	26	1	270	1	5.9702	0.3568
182	2008	9	27	1	271	1	5.8518	0.3688
183	2008	10	1	1	275	1	5.3630	0.3944
184	2008	10	1	1	275	1	5.3630	0.3619
185	2009	5	6	1	126	1	0.0012	0.2044
186	2009	5	9	1	129	1	0.0048	0.3441
187	2009	5	9	1	129	1	0.0048	0.1871
188	2009	5	18	1	138	1	0.0157	0.2354
189	2009	5	22	1	142	1	0.0216	0.2192
190	2009	5	29	1	149	1	0.1043	0.2607
191	2009	5	29	1	149	1	0.1043	0.2516
192	2009	6	3	1	154	1	0.2781	0.2463
193	2009	6	4	1	155	1	0.3210	0.2583
194	2009	6	23	1	174	1	3.6159	0.6315
195	2009	6	25	1	176	1	4.2540	0.5260
196	2009	6	30	1	181	1	5.0755	0.5956
197	2009	7	8	1	189	1	6.0977	0.6327
198	2009	7	9	1	190	1	6.2157	0.7121
199	2009	7	14	1	195	1	6.4540	0.7445
200	2009	7	23	1	204	1	6.5781	0.8890

201	2009	7	25	1	206	1	6.7844	0.7442
202	2009	7	31	1	212	1	7.6585	0.7325
203	2009	8	2	1	214	1	7.9438	0.6470
204	2009	8	6	1	218	1	8.3569	0.6794
205	2009	8	8	1	220	1	8.4707	0.7749
206	2009	8	13	1	225	1	8.4861	0.8009
207	2009	8	14	1	226	1	8.4454	0.7182
208	2009	8	24	1	236	1	7.7446	0.7885
209	2009	8	24	1	236	1	7.7446	0.7323
210	2009	8	29	1	241	1	7.5281	0.6161
211	2009	9	6	1	249	1	7.2781	0.5925
212	2009	9	19	1	262	1	6.5190	0.4140
213	2009	9	20	1	263	1	6.4485	0.4076
214	2010	5	5	1	125	1	-0.0024	0.1842
215	2010	5	9	1	129	1	-0.0113	0.2375
216	2010	5	14	1	134	1	-0.0170	0.2129
217	2010	5	28	1	148	1	0.0459	0.2708
218	2010	6	3	1	154	1	0.1949	0.2644
219	2010	6	21	1	172	1	2.6735	0.4643
220	2010	6	22	1	173	1	2.9054	0.4916
221	2010	6	26	1	177	1	3.7858	0.5151
222	2010	7	1	1	182	1	4.5827	0.5435
223	2010	7	6	1	187	1	5.0019	0.6288
224	2010	7	10	1	191	1	5.1768	0.6755
225	2010	7	14	1	195	1	5.3844	0.6325
226	2010	7	19	1	200	1	5.8770	0.7341
227	2010	7	22	1	203	1	6.1989	0.6380
228	2010	7	27	1	208	1	6.5231	0.6086
229	2010	7	31	1	212	1	6.4746	0.7310
230	2010	8	3	1	215	1	6.4258	0.6329
231	2010	8	8	1	220	1	6.5904	0.6514
232	2010	8	11	1	223	1	6.6941	0.8213
233	2010	8	15	1	227	1	6.6517	0.5898
234	2010	8	16	1	228	1	6.6087	0.7755
235	2010	8	22	1	234	1	6.1415	0.6411
236	2010	8	25	1	237	1	5.8096	0.6097
237	2010	8	29	1	241	1	5.3143	0.5521
238	2011	5	30	1	150	1	0.0045	0.2269
239	2011	5	31	1	151	1	0.0055	0.2100
240	2011	6	6	1	157	1	0.0107	0.2071
241	2011	6	18	1	169	1	0.1998	0.3204
242	2011	6	25	1	176	1	0.6234	0.3199
243	2011	6	27	1	178	1	0.8151	0.3821
244	2011	6	29	1	180	1	1.0519	0.3401
245	2011	7	4	1	185	1	1.9021	0.5142
246	2011	7	8	1	189	1	2.8855	0.4458
247	2011	7	18	1	199	1	4.2897	0.6265
248	2011	7	19	1	200	1	4.2728	0.5421
249	2011	7	20	1	201	1	4.2513	0.7162
250	2011	7	26	1	207	1	4.5111	0.6249

251	2011	8	3	1	215	1	6.0571	0.7659
252	2011	8	3	1	215	1	6.0571	0.7836
253	2011	8	9	1	221	1	6.4408	0.7268
254	2011	8	12	1	224	1	6.4579	0.8609
255	2011	8	18	1	230	1	6.4300	0.6696
256	2011	8	19	1	231	1	6.4221	0.7865
257	2011	8	24	1	236	1	6.3880	0.6770
258	2011	8	25	1	237	1	6.3839	0.6724
259	2011	9	1	1	244	1	6.3578	0.6494
260	2011	9	4	1	247	1	6.3328	0.6797
261	2011	9	6	1	249	1	6.3060	0.6636
262	2011	9	10	1	253	1	6.2183	0.6501
263	2011	9	19	1	262	1	5.8433	0.5168
264	2011	9	20	1	263	1	5.7875	0.5493
265	2011	9	22	1	265	1	5.6681	0.5433
266	2011	9	26	1	269	1	5.3995	0.4637
267	2011	10	1	1	274	1	5.0129	0.4303
268	2011	10	3	1	276	1	4.8458	0.4093
269	2012	5	5	1	126	1	0.0002	0.2812
270	2012	5	10	1	131	1	0.0076	0.2248
271	2012	5	14	1	135	1	0.0245	0.2068
272	2012	5	16	1	137	1	0.0352	0.2127
273	2012	5	17	1	138	1	0.0406	0.1975
274	2012	5	28	1	149	1	0.3507	0.3201
275	2012	5	28	1	149	1	0.3507	0.3280
276	2012	6	4	1	156	1	0.8039	0.4012
277	2012	6	4	1	156	1	0.8039	0.3511
278	2012	6	11	1	163	1	1.7223	0.4927
279	2012	6	12	1	164	1	1.9494	0.4509
280	2012	6	18	1	170	1	3.5064	0.5408
281	2012	6	24	1	176	1	4.3145	0.6611
282	2012	6	26	1	178	1	4.4159	0.5638
283	2012	6	27	1	179	1	4.4667	0.6519
284	2012	7	6	1	188	1	5.5607	0.7058
285	2012	7	10	1	192	1	6.3633	0.6079
286	2012	7	13	1	195	1	6.6639	0.7111
287	2012	7	17	1	199	1	6.5113	0.7457
288	2012	7	22	1	204	1	6.2296	0.6384
289	2012	7	26	1	208	1	6.2299	0.5379
290	2012	7	29	1	211	1	6.2854	0.6099
291	2012	8	2	1	215	1	6.3535	0.6243
292	2012	8	4	1	217	1	6.3616	0.5314
293	2012	8	5	1	218	1	6.3547	0.4382
294	2012	8	15	1	228	1	5.8971	0.4566
295	2012	8	21	1	234	1	5.5771	0.4611
296	2012	8	27	1	240	1	5.2967	0.3604
297	2013	5	15	1	135	1	0.0008	0.2460
298	2013	5	23	1	143	1	0.0115	0.3129
299	2013	5	27	1	147	1	0.0269	0.3123
300	2013	5	31	1	151	1	0.0621	0.2857

301	2013	6	2	1	153	1	0.0898	0.3042
302	2013	6	3	1	154	1	0.1053	0.2748
303	2013	6	13	1	164	1	0.3942	0.3151
304	2013	6	14	1	165	1	0.5000	0.3613
305	2013	6	22	1	173	1	1.9206	0.3716
306	2013	6	28	1	179	1	2.9443	0.5345
307	2013	7	4	1	185	1	3.6886	0.5788
308	2013	7	9	1	190	1	4.2773	0.6434
309	2013	7	18	1	199	1	5.5428	0.6327
310	2013	7	22	1	203	1	5.9403	0.6116
311	2013	7	23	1	204	1	6.0125	0.5986
312	2013	8	17	1	229	1	6.0131	0.7582
313	2013	8	19	1	231	1	6.0136	0.7758
314	2013	8	23	1	235	1	6.0114	0.5968
315	2013	8	26	1	238	1	6.0173	0.7028
316	2003	6	9	2	160	1	0.0049	0.2362
317	2003	6	9	2	160	1	0.0049	0.3367
318	2003	6	14	2	165	1	0.0624	0.3207
319	2003	6	16	2	167	1	0.1382	0.2755
320	2003	6	23	2	174	1	0.8006	0.4571
321	2003	6	23	2	174	1	0.8006	0.4184
322	2003	7	2	2	183	1	2.7231	0.4854
323	2003	7	3	2	184	1	2.9681	0.4044
324	2003	7	11	2	192	1	4.6544	0.5867
325	2003	7	13	2	194	1	4.9685	0.6219
326	2003	7	14	2	195	1	5.1110	0.5391
327	2003	7	25	2	206	1	6.2933	0.6912
328	2003	7	26	2	207	1	6.3959	0.4683
329	2003	7	28	2	209	1	6.6108	0.6982
330	2003	8	3	2	215	1	7.3258	0.6054
331	2003	8	8	2	220	1	7.9875	0.6643
332	2003	8	10	2	222	1	8.2581	0.6007
333	2003	8	15	2	227	1	8.8827	0.6160
334	2003	8	17	2	229	1	9.0906	0.6494
335	2003	8	24	2	236	1	9.4833	0.6235
336	2003	8	24	2	236	1	9.4833	0.5790
337	2003	8	29	2	241	1	9.3938	0.5168
338	2003	9	4	2	247	1	8.9842	0.4947
339	2003	9	6	2	249	1	8.7977	0.4638
340	2003	9	7	2	250	1	8.6981	0.4358
341	2005	5	20	2	140	1	-0.0111	0.2373
342	2005	5	23	2	143	1	-0.0117	0.2176
343	2005	5	27	2	147	1	-0.0032	0.2712
344	2005	5	28	2	148	1	0.0011	0.2575
345	2005	6	8	2	159	1	0.1729	0.2642
346	2005	6	17	2	168	1	0.8001	0.3480
347	2005	6	21	2	172	1	1.3430	0.4189
348	2005	6	22	2	173	1	1.5117	0.3892
349	2005	6	28	2	179	1	2.7775	0.5404
350	2005	7	1	2	182	1	3.4557	0.5595

351	2005	7	5	2	186	1	4.2280	0.6503
352	2005	7	7	2	188	1	4.5057	0.7392
353	2005	7	19	2	200	1	5.7477	0.5785
354	2005	7	23	2	204	1	6.2061	0.5810
355	2005	7	24	2	205	1	6.3018	0.5513
356	2005	7	28	2	209	1	6.5490	0.6651
357	2005	7	28	2	209	1	6.5490	0.6492
358	2005	8	8	2	220	1	6.6195	0.6555
359	2005	8	9	2	221	1	6.6421	0.6690
360	2005	8	18	2	230	1	6.8858	0.7100
361	2005	8	18	2	230	1	6.8858	0.6495
362	2005	8	27	2	239	1	6.9131	0.6294
363	2005	8	28	2	240	1	6.8888	0.5259
364	2005	8	31	2	243	1	6.7721	0.5948
365	2005	9	3	2	246	1	6.5821	0.4819
366	2005	9	9	2	252	1	6.0066	0.4156
367	2005	9	10	2	253	1	5.8910	0.4256
368	2005	9	16	2	259	1	5.1227	0.4180
369	2005	9	19	2	262	1	4.7125	0.3564
370	2007	5	17	2	137	1	0.0034	0.2531
371	2007	5	25	2	145	1	0.0438	0.3017
372	2007	6	9	2	160	1	0.5440	0.3262
373	2007	6	16	2	167	1	1.2516	0.4304
374	2007	6	20	2	171	1	1.8996	0.4332
375	2007	6	20	2	171	1	1.8996	0.5309
376	2007	6	30	2	181	1	4.8505	0.5876
377	2007	6	30	2	181	1	4.8505	0.5212
378	2007	7	4	2	185	1	5.2226	0.6207
379	2007	7	11	2	192	1	5.8544	0.6280
380	2007	7	13	2	194	1	6.2791	0.6450
381	2007	7	16	2	197	1	7.0098	0.5967
382	2007	7	20	2	201	1	7.8330	0.6642
383	2007	7	26	2	207	1	8.5960	0.6355
384	2007	8	4	2	216	1	9.1317	0.5834
385	2007	8	10	2	222	1	9.0101	0.6148
386	2007	8	13	2	225	1	8.8040	0.6047
387	2007	8	14	2	226	1	8.7208	0.6198
388	2007	8	21	2	233	1	8.0672	0.6760
389	2007	8	28	2	240	1	7.5059	0.5817
390	2007	8	30	2	242	1	7.3625	0.6079
391	2007	9	2	2	245	1	7.1511	0.5318
392	2007	9	8	2	251	1	6.7063	0.4523
393	2007	9	11	2	254	1	6.4539	0.4282
394	2007	9	14	2	257	1	6.1714	0.3965
395	2007	9	17	2	260	1	5.8624	0.3590
396	2007	9	22	2	265	1	5.3050	0.3847
397	2007	9	27	2	270	1	4.7193	0.3332
398	2009	5	9	2	129	1	0.0056	0.2681
399	2009	5	9	2	129	1	0.0056	0.2012
400	2009	5	18	2	138	1	0.0159	0.1949

401	2009	5	22	2	142	1	0.0148	0.2041
402	2009	5	29	2	149	1	0.0715	0.2433
403	2009	6	3	2	154	1	0.2162	0.2475
404	2009	6	4	2	155	1	0.2475	0.2506
405	2009	6	23	2	174	1	3.7708	0.5688
406	2009	6	25	2	176	1	4.3396	0.6118
407	2009	6	28	2	179	1	4.8900	0.6709
408	2009	6	30	2	181	1	5.1955	0.6757
409	2009	7	8	2	189	1	6.6528	0.6257
410	2009	7	9	2	190	1	6.8003	0.7956
411	2009	7	14	2	195	1	7.2682	0.8181
412	2009	7	19	2	200	1	7.5344	0.7283
413	2009	7	23	2	204	1	7.8307	0.8416
414	2009	7	31	2	212	1	8.5778	0.7492
415	2009	8	2	2	214	1	8.6980	0.7284
416	2009	8	6	2	218	1	8.8259	0.7798
417	2009	8	8	2	220	1	8.8373	0.8025
418	2009	8	13	2	225	1	8.7296	0.7167
419	2009	8	14	2	226	1	8.6901	0.6846
420	2009	8	24	2	236	1	8.3622	0.7310
421	2009	8	24	2	236	1	8.3622	0.7382
422	2009	8	29	2	241	1	8.2928	0.5604
423	2009	8	30	2	242	1	8.2728	0.6456
424	2009	9	6	2	249	1	7.9916	0.5549
425	2009	9	19	2	262	1	6.9989	0.3791
426	2009	9	20	2	263	1	6.9099	0.4446
427	2010	5	14	2	134	1	0.0027	0.2194
428	2010	5	22	2	142	1	0.0148	0.2492
429	2010	6	17	2	168	1	1.1249	0.3569
430	2010	6	21	2	172	1	1.5130	0.3782
431	2010	6	22	2	173	1	1.6067	0.4335
432	2010	6	26	2	177	1	1.9547	0.4276
433	2010	7	1	2	182	1	2.4428	0.4322
434	2010	7	10	2	191	1	3.9981	0.5912
435	2010	7	14	2	195	1	4.7507	0.5590
436	2010	7	19	2	200	1	5.5207	0.6526
437	2010	7	22	2	203	1	5.8776	0.5873
438	2010	7	27	2	208	1	6.2834	0.5951
439	2010	7	31	2	212	1	6.4276	0.5413
440	2010	8	3	2	215	1	6.4464	0.5929
441	2010	8	8	2	220	1	6.3942	0.6180
442	2010	8	11	2	223	1	6.3617	0.7231
443	2010	8	15	2	227	1	6.3453	0.5953
444	2010	8	22	2	234	1	6.2976	0.6014
445	2010	8	25	2	237	1	6.2301	0.6133
446	2010	8	29	2	241	1	6.0695	0.5349
447	2010	9	3	2	246	1	5.7794	0.5510
448	2010	9	7	2	250	1	5.5049	0.5262
449	2011	5	30	2	150	1	0.0072	0.1922
450	2011	5	31	2	151	1	0.0083	0.2144

451	2011	6	6	2	157	1	0.0086	0.1916
452	2011	6	7	2	158	1	0.0139	0.2426
453	2011	6	18	2	169	1	0.5082	0.3607
454	2011	6	25	2	176	1	1.0423	0.4897
455	2011	6	27	2	178	1	1.2559	0.4055
456	2011	6	29	2	180	1	1.5406	0.3711
457	2011	7	4	2	185	1	2.6856	0.5086
458	2011	7	8	2	189	1	3.8151	0.5959
459	2011	7	18	2	199	1	5.0942	0.6518
460	2011	7	19	2	200	1	5.1523	0.6277
461	2011	7	20	2	201	1	5.2320	0.7021
462	2011	7	26	2	207	1	6.0969	0.6874
463	2011	8	3	2	215	1	6.5961	0.8568
464	2011	8	3	2	215	1	6.5961	0.7557
465	2011	8	9	2	221	1	6.4575	0.6819
466	2011	8	12	2	224	1	6.4893	0.7991
467	2011	8	18	2	230	1	6.6813	0.6572
468	2011	8	19	2	231	1	6.7129	0.7555
469	2011	8	25	2	237	1	6.8212	0.6401
470	2011	9	1	2	244	1	6.7733	0.6359
471	2011	9	4	2	247	1	6.6975	0.6366
472	2011	9	6	2	249	1	6.6289	0.6947
473	2011	9	10	2	253	1	6.4513	0.5682
474	2011	9	19	2	262	1	5.8982	0.5320
475	2011	9	20	2	263	1	5.8274	0.5169
476	2011	9	26	2	269	1	5.3785	0.4790
477	2011	10	1	2	274	1	4.9833	0.4459
478	2011	10	3	2	276	1	4.8227	0.4033
479	2012	5	5	2	126	1	0.0007	0.2609
480	2012	5	10	2	131	1	0.0069	0.2168
481	2012	5	14	2	135	1	0.0230	0.1862
482	2012	5	16	2	137	1	0.0384	0.2255
483	2012	5	17	2	138	1	0.0486	0.1955
484	2012	5	28	2	149	1	0.4121	0.3467
485	2012	5	28	2	149	1	0.4121	0.3244
486	2012	6	4	2	156	1	0.9587	0.3803
487	2012	6	4	2	156	1	0.9587	0.3355
488	2012	6	11	2	163	1	1.8605	0.4483
489	2012	6	12	2	164	1	2.0860	0.4387
490	2012	6	18	2	170	1	3.7875	0.4613
491	2012	6	24	2	176	1	4.6225	0.5671
492	2012	6	26	2	178	1	4.7600	0.5939
493	2012	6	27	2	179	1	4.8385	0.6315
494	2012	7	6	2	188	1	6.2283	0.6455
495	2012	7	10	2	192	1	6.8497	0.6326
496	2012	7	13	2	195	1	6.8656	0.6642
497	2012	7	17	2	199	1	6.5693	0.6038
498	2012	7	22	2	204	1	6.5395	0.6479
499	2012	7	26	2	208	1	6.7559	0.6057
500	2012	7	29	2	211	1	6.9082	0.6142

501	2012	8	2	2	215	1	7.0494	0.5676
502	2012	8	4	2	217	1	7.0833	0.5331
503	2012	8	5	2	218	1	7.0896	0.5282
504	2012	8	15	2	228	1	6.6870	0.5113
505	2012	8	19	2	232	1	6.3016	0.4375
506	2012	8	21	2	234	1	6.0952	0.4257
507	2012	8	27	2	240	1	5.5558	0.4086
508	2012	8	29	2	242	1	5.4155	0.3838
509	2012	8	30	2	243	1	5.3517	0.3555
510	2012	9	5	2	249	1	5.0379	0.2917
511	2012	9	8	2	252	1	4.9110	0.3168
512	2013	5	15	2	135	1	0.0000	0.2009
513	2013	5	23	2	143	1	0.0100	0.3129
514	2013	5	27	2	147	1	0.0293	0.2577
515	2013	5	31	2	151	1	0.0675	0.2729
516	2013	6	2	2	153	1	0.0958	0.2250
517	2013	6	3	2	154	1	0.1123	0.2455
518	2013	6	13	2	164	1	0.3657	0.2832
519	2013	6	14	2	165	1	0.4226	0.3288
520	2013	6	22	2	173	1	1.8810	0.4079
521	2013	6	28	2	179	1	3.5703	0.5366
522	2013	6	29	2	180	1	3.7654	0.4795
523	2013	7	4	2	185	1	4.3178	0.5239
524	2013	7	9	2	190	1	4.4218	0.6579
525	2013	7	16	2	197	1	5.3211	0.6520
526	2013	7	18	2	199	1	5.7599	0.6806
527	2013	7	23	2	204	1	6.5457	0.6546
528	2013	8	7	2	219	1	6.4347	0.6197
529	2013	8	10	2	222	1	6.7095	0.5603
530	2013	8	17	2	229	1	6.9161	0.7253
531	2013	8	26	2	238	1	6.4687	0.6490
532	2013	8	30	2	242	1	6.2736	0.5899
533	2013	9	2	2	245	1	6.1469	0.5858
534	2013	9	6	2	249	1	5.9771	0.5052
535	2013	9	9	2	252	1	5.8304	0.4296
536	2003	6	9	3	160	1	0.0197	0.3446
537	2003	6	14	3	165	1	0.0888	0.2817
538	2003	6	16	3	167	1	0.1669	0.2969
539	2003	6	23	3	174	1	0.7986	0.3802
540	2003	6	23	3	174	1	0.7986	0.3902
541	2003	6	26	3	177	1	1.2313	0.3533
542	2003	7	2	3	183	1	2.2682	0.4412
543	2003	7	11	3	192	1	3.8191	0.4689
544	2003	7	13	3	194	1	4.0646	0.4788
545	2003	7	14	3	195	1	4.1631	0.5877
546	2003	7	25	3	206	1	4.5673	0.4735
547	2003	7	26	3	207	1	4.5972	0.4539
548	2003	8	3	3	215	1	4.9179	0.5803
549	2003	8	8	3	220	1	5.1488	0.3940
550	2003	8	10	3	222	1	5.2265	0.4219

551	2003	8	17	3	229	1	5.2963	0.4223
552	2003	8	20	3	232	1	5.1742	0.3914
553	2003	8	24	3	236	1	4.8288	0.3968
554	2003	8	24	3	236	1	4.8288	0.4422
555	2003	8	29	3	241	1	4.1705	0.3729
556	2003	9	4	3	247	1	3.2039	0.3846
557	2005	5	16	3	136	1	0.0149	0.2593
558	2005	5	20	3	140	1	0.0190	0.2634
559	2005	5	28	3	148	1	-0.0097	0.2719
560	2005	6	6	3	157	1	0.1248	0.4092
561	2005	6	8	3	159	1	0.2295	0.2433
562	2005	6	16	3	167	1	0.9782	0.3501
563	2005	6	17	3	168	1	1.0967	0.3070
564	2005	6	21	3	172	1	1.5922	0.3548
565	2005	6	22	3	173	1	1.7173	0.3905
566	2005	6	28	3	179	1	2.4077	0.5298
567	2005	7	1	3	182	1	2.6703	0.4721
568	2005	7	5	3	186	1	2.9222	0.5019
569	2005	7	5	3	186	1	2.9222	0.4907
570	2005	7	19	3	200	1	3.9885	0.5510
571	2005	7	23	3	204	1	4.4226	0.4722
572	2005	7	24	3	205	1	4.5197	0.3655
573	2005	7	28	3	209	1	4.8099	0.5552
574	2005	7	28	3	209	1	4.8099	0.5314
575	2005	8	8	3	220	1	4.8682	0.5283
576	2005	8	9	3	221	1	4.8764	0.6139
577	2005	8	18	3	230	1	5.0334	0.6858
578	2005	8	18	3	230	1	5.0334	0.7048
579	2005	8	27	3	239	1	4.8631	0.6498
580	2005	8	28	3	240	1	4.8240	0.4577
581	2005	8	31	3	243	1	4.6907	0.5388
582	2005	9	3	3	246	1	4.5395	0.5389
583	2005	9	9	3	252	1	4.2161	0.4625
584	2005	9	10	3	253	1	4.1622	0.3720
585	2005	9	16	3	259	1	3.8413	0.3765
586	2005	9	19	3	262	1	3.6821	0.3425
587	2005	9	26	3	269	1	3.3122	0.3281
588	2007	5	17	3	137	1	0.0024	0.2017
589	2007	5	18	3	138	1	0.0048	0.2821
590	2007	5	25	3	145	1	0.0280	0.3348
591	2007	6	7	3	158	1	0.2089	0.3181
592	2007	6	16	3	167	1	0.8946	0.3823
593	2007	6	16	3	167	1	0.8946	0.3758
594	2007	6	20	3	171	1	1.4571	0.3769
595	2007	6	20	3	171	1	1.4571	0.4355
596	2007	6	30	3	181	1	3.3049	0.4538
597	2007	7	11	3	192	1	4.2725	0.5729
598	2007	7	13	3	194	1	4.4264	0.5807
599	2007	7	16	3	197	1	4.7090	0.4325
600	2007	7	20	3	201	1	5.1310	0.6587

601	2007	7	26	3	207	1	5.7039	0.5203
602	2007	8	2	3	214	1	6.0068	0.5152
603	2007	8	4	3	216	1	5.9867	0.6071
604	2007	8	10	3	222	1	5.7261	0.7102
605	2007	8	12	3	224	1	5.6040	0.5514
606	2007	8	13	3	225	1	5.5416	0.6003
607	2007	8	14	3	226	1	5.4800	0.5952
608	2007	8	21	3	233	1	5.1024	0.6689
609	2007	8	28	3	240	1	4.7626	0.5646
610	2007	8	30	3	242	1	4.6597	0.5810
611	2007	9	2	3	245	1	4.4966	0.5056
612	2007	9	8	3	251	1	4.1450	0.5235
613	2007	9	11	3	254	1	3.9602	0.4709
614	2007	9	14	3	257	1	3.7718	0.4025
615	2009	5	9	3	129	1	0.0009	0.2960
616	2009	5	9	3	129	1	0.0009	0.2546
617	2009	5	18	3	138	1	0.0085	0.2526
618	2009	5	22	3	142	1	0.0161	0.2412
619	2009	5	29	3	149	1	0.0743	0.2711
620	2009	5	29	3	149	1	0.0743	0.2325
621	2009	6	3	3	154	1	0.2091	0.2535
622	2009	6	23	3	174	1	3.7505	0.5408
623	2009	6	25	3	176	1	4.3881	0.5449
624	2009	6	28	3	179	1	4.9576	0.5282
625	2009	6	30	3	181	1	5.1814	0.5874
626	2009	7	6	3	187	1	5.7967	0.5331
627	2009	7	8	3	189	1	5.9160	0.6058
628	2009	7	12	3	193	1	5.9023	0.6888
629	2009	7	14	3	195	1	5.8591	0.5718
630	2009	7	23	3	204	1	6.4201	0.7094
631	2009	7	23	3	204	1	6.4201	0.5962
632	2009	7	31	3	212	1	7.0490	0.5570
633	2009	8	2	3	214	1	7.0837	0.5313
634	2009	8	6	3	218	1	7.0041	0.6206
635	2009	8	8	3	220	1	6.9038	0.6411
636	2009	8	13	3	225	1	6.6437	0.6408
637	2009	8	24	3	236	1	6.5925	0.5393
638	2009	9	6	3	249	1	5.9342	0.4091
639	2011	5	17	3	137	1	-0.0003	0.2102
640	2011	5	23	3	143	1	0.0010	0.2108
641	2011	5	30	3	150	1	0.0086	0.2469
642	2011	5	31	3	151	1	0.0107	0.3098
643	2011	6	6	3	157	1	0.0341	0.2381
644	2011	6	7	3	158	1	0.0402	0.2406
645	2011	6	15	3	166	1	0.1386	0.3813
646	2011	6	18	3	169	1	0.2153	0.3112
647	2011	6	27	3	178	1	0.9963	0.3421
648	2011	6	29	3	180	1	1.3940	0.3748
649	2011	7	4	3	185	1	2.6442	0.4955
650	2011	7	8	3	189	1	3.4764	0.4949

651	2011	7	18	3	199	1	3.9639	0.5238
652	2011	7	19	3	200	1	3.9890	0.5840
653	2011	7	20	3	201	1	4.0192	0.6595
654	2011	8	3	3	215	1	5.2761	0.7360
655	2011	8	9	3	221	1	5.4756	0.5785
656	2011	8	12	3	224	1	5.4036	0.6798
657	2011	8	18	3	230	1	5.1691	0.5924
658	2011	8	19	3	231	1	5.1307	0.6727
659	2011	8	25	3	237	1	4.8985	0.5830
660	2011	8	28	3	240	1	4.7743	0.5525
661	2011	9	1	3	244	1	4.5982	0.5197
662	2011	9	4	3	247	1	4.4596	0.4774
663	2011	9	6	3	249	1	4.3645	0.4447
664	2011	9	10	3	253	1	4.1691	0.4137
665	2011	9	19	3	262	1	3.7132	0.3626
666	2011	9	20	3	263	1	3.6616	0.3375
667	2011	9	26	3	269	1	3.3501	0.3319
668	2011	9	29	3	272	1	3.1936	0.2890
669	2013	5	27	3	147	1	0.0029	0.2983
670	2013	5	31	3	151	1	0.0220	0.2847
671	2013	6	3	3	154	1	0.0782	0.3532
672	2013	6	13	3	164	1	0.4198	0.2916
673	2013	6	14	3	165	1	0.4064	0.3020
674	2013	6	28	3	179	1	1.5774	0.4025
675	2013	7	4	3	185	1	2.7877	0.4436
676	2013	7	9	3	190	1	3.6937	0.5307
677	2013	7	18	3	199	1	4.6783	0.6995
678	2013	7	20	3	201	1	4.7993	0.4304
679	2013	7	23	3	204	1	4.9782	0.5403
680	2013	8	7	3	219	1	6.1104	0.5491
681	2013	8	12	3	224	1	5.9754	0.6153
682	2013	8	23	3	235	1	5.5129	0.5157
683	2013	8	30	3	242	1	5.1589	0.4150
684	2013	9	2	3	245	1	4.9363	0.4057
685	2013	9	6	3	249	1	4.6061	0.3905
686	2013	9	9	3	252	1	4.3631	0.3499
687	2013	9	20	3	263	1	3.8177	0.4164
688	2013	9	20	3	263	1	3.8177	0.3788
689	2013	9	22	3	265	1	3.7735	0.3598
690	2004	6	13	2	165	2	0.0162	0.3044
691	2004	6	14	2	166	2	0.0191	0.2637
692	2004	6	22	2	174	2	0.0350	0.3197
693	2004	6	23	2	175	2	0.0357	0.2811
694	2004	6	25	2	177	2	0.0358	0.3144
695	2004	6	30	2	182	2	0.0399	0.2786
696	2004	7	4	2	186	2	0.0671	0.3044
697	2004	7	4	2	186	2	0.0671	0.3711
698	2004	7	18	2	200	2	0.5214	0.5293
699	2004	7	19	2	201	2	0.5687	0.4997
700	2004	7	20	2	202	2	0.6163	0.5225

701	2004	7	27	2	209	2	0.9465	0.5270
702	2004	7	27	2	209	2	0.9465	0.5890
703	2004	8	7	2	220	2	1.4564	0.6307
704	2004	8	8	2	221	2	1.5087	0.7195
705	2004	8	14	2	227	2	1.8821	0.7482
706	2004	8	21	2	234	2	2.4353	0.7317
707	2004	8	24	2	237	2	2.6709	0.7502
708	2004	8	29	2	242	2	3.0040	0.5785
709	2004	8	30	2	243	2	3.0577	0.7100
710	2004	9	6	2	250	2	3.2791	0.6456
711	2004	9	9	2	253	2	3.2756	0.6406
712	2004	9	13	2	257	2	3.1607	0.5307
713	2004	9	16	2	260	2	2.9822	0.5407
714	2004	9	25	2	269	2	2.0090	0.4044
715	2004	9	29	2	273	2	1.4560	0.4102
716	2006	5	25	2	145	2	0.0072	0.2067
717	2006	5	28	2	148	2	0.0172	0.2401
718	2006	6	6	2	157	2	0.0323	0.2623
719	2006	6	9	2	160	2	0.0373	0.2532
720	2006	6	13	2	164	2	0.0563	0.2775
721	2006	6	13	2	164	2	0.0563	0.2466
722	2006	6	20	2	171	2	0.1202	0.2801
723	2006	6	22	2	173	2	0.1378	0.2873
724	2006	7	1	2	182	2	0.2933	0.3443
725	2006	7	6	2	187	2	0.4755	0.4193
726	2006	7	6	2	187	2	0.4755	0.3373
727	2006	7	15	2	196	2	0.9590	0.5310
728	2006	7	17	2	198	2	1.0897	0.5608
729	2006	7	20	2	201	2	1.3065	0.5781
730	2006	7	26	2	207	2	1.8392	0.7345
731	2006	7	29	2	210	2	2.1366	0.7055
732	2006	8	4	2	216	2	2.6367	0.7375
733	2006	8	5	2	217	2	2.7114	0.7138
734	2006	8	9	2	221	2	3.0404	0.7654
735	2006	8	14	2	226	2	3.5170	0.8410
736	2006	8	14	2	226	2	3.5170	0.8564
737	2006	8	23	2	235	2	3.6697	0.7500
738	2006	8	29	2	241	2	3.4337	0.7156
739	2006	8	30	2	242	2	3.3925	0.6755
740	2006	9	12	2	255	2	2.8308	0.5726
741	2006	9	13	2	256	2	2.7785	0.4360
742	2006	9	17	2	260	2	2.5443	0.4331
743	2006	9	19	2	262	2	2.4093	0.4506
744	2006	9	24	2	267	2	2.0115	0.4025
745	2006	9	26	2	269	2	1.8316	0.3589
746	2006	10	1	2	274	2	1.3471	0.2848
747	2008	5	30	2	151	2	0.0128	0.2240
748	2008	6	6	2	158	2	0.0266	0.2553
749	2008	6	6	2	158	2	0.0266	0.2303
750	2008	6	13	2	165	2	0.0440	0.2327

751	2008	6	16	2	168	2	0.0647	0.2602
752	2008	6	20	2	172	2	0.0905	0.3076
753	2008	6	27	2	179	2	0.1233	0.3277
754	2008	7	2	2	184	2	0.2440	0.3018
755	2008	7	5	2	187	2	0.3517	0.4006
756	2008	7	10	2	192	2	0.4340	0.3939
757	2008	7	11	2	193	2	0.4330	0.4004
758	2008	7	15	2	197	2	0.4764	0.3915
759	2008	7	20	2	202	2	0.8040	0.4977
760	2008	7	22	2	204	2	1.0005	0.4997
761	2008	8	2	2	215	2	1.9237	0.6164
762	2008	8	3	2	216	2	1.9480	0.7016
763	2008	8	7	2	220	2	2.0672	0.7148
764	2008	8	7	2	220	2	2.0672	0.7371
765	2008	8	12	2	225	2	2.4633	0.7920
766	2008	8	23	2	236	2	3.0778	0.7330
767	2008	8	26	2	239	2	3.0645	0.6934
768	2008	9	1	2	245	2	3.1069	0.6354
769	2008	9	4	2	248	2	3.1869	0.5992
770	2008	9	17	2	261	2	3.1138	0.5101
771	2008	9	20	2	264	2	2.8151	0.3885
772	2008	9	26	2	270	2	1.8219	0.3212
773	2008	9	27	2	271	2	1.6234	0.2922
774	2004	6	14	3	166	2	0.0134	0.2933
775	2004	6	14	3	166	2	0.0134	0.2594
776	2004	6	23	3	175	2	0.0380	0.3301
777	2004	6	25	3	177	2	0.0448	0.3213
778	2004	7	4	3	186	2	0.1226	0.3559
779	2004	7	4	3	186	2	0.1226	0.3581
780	2004	7	12	3	194	2	0.3453	0.6006
781	2004	7	18	3	200	2	0.6065	0.4723
782	2004	7	19	3	201	2	0.6559	0.4548
783	2004	7	20	3	202	2	0.7070	0.5014
784	2004	7	27	3	209	2	1.1176	0.5328
785	2004	7	27	3	209	2	1.1176	0.5084
786	2004	8	7	3	220	2	1.8625	0.5756
787	2004	8	8	3	221	2	1.9122	0.7668
788	2004	8	14	3	227	2	2.0611	0.6124
789	2004	8	21	3	234	2	2.1907	0.6433
790	2004	8	24	3	237	2	2.3224	0.4894
791	2004	8	29	3	242	2	2.5749	0.6152
792	2004	8	30	3	243	2	2.6211	0.6369
793	2004	9	6	3	250	2	2.7796	0.6860
794	2004	9	9	3	253	2	2.7028	0.4600
795	2004	9	13	3	257	2	2.4156	0.5142
796	2004	9	16	3	260	2	2.0747	0.3410
797	2004	9	24	3	268	2	0.7721	0.3248
798	2004	9	25	3	269	2	0.5824	0.3250
799	2006	5	28	3	148	2	0.0111	0.3431
800	2006	6	6	3	157	2	0.0506	0.2366

801	2006	6	9	3	160	2	0.0669	0.2497
802	2006	6	13	3	164	2	0.0799	0.2746
803	2006	6	13	3	164	2	0.0799	0.2721
804	2006	6	20	3	171	2	0.1145	0.3145
805	2006	6	22	3	173	2	0.1598	0.3373
806	2006	6	29	3	180	2	0.3795	0.3028
807	2006	7	1	3	182	2	0.4089	0.3220
808	2006	7	6	3	187	2	0.4707	0.4238
809	2006	7	6	3	187	2	0.4707	0.3264
810	2006	7	15	3	196	2	1.1710	0.5050
811	2006	7	17	3	198	2	1.3643	0.5042
812	2006	7	20	3	201	2	1.5198	0.5366
813	2006	7	26	3	207	2	1.7565	0.5846
814	2006	7	29	3	210	2	2.0207	0.5602
815	2006	8	4	3	216	2	2.5559	0.6355
816	2006	8	5	3	217	2	2.6215	0.6253
817	2006	8	9	3	221	2	2.8070	0.7757
818	2006	8	14	3	226	2	2.8771	0.8251
819	2006	8	14	3	226	2	2.8771	0.5998
820	2006	8	23	3	235	2	2.8740	0.8396
821	2006	8	30	3	242	2	2.8026	0.7065
822	2006	9	12	3	255	2	2.3503	0.5755
823	2006	9	13	3	256	2	2.3027	0.5311
824	2006	9	17	3	260	2	2.1021	0.4783
825	2006	9	19	3	262	2	1.9975	0.4769
826	2006	9	24	3	267	2	1.7283	0.3974
827	2006	9	26	3	269	2	1.6180	0.4000
828	2006	10	1	3	274	2	1.3374	0.3232
829	2006	10	7	3	280	2	0.9947	0.3019
830	2008	5	30	3	151	2	0.0098	0.2384
831	2008	5	31	3	152	2	0.0123	0.2631
832	2008	6	6	3	158	2	0.0273	0.2600
833	2008	6	6	3	158	2	0.0273	0.3786
834	2008	6	13	3	165	2	0.0458	0.2697
835	2008	6	16	3	168	2	0.0591	0.2736
836	2008	6	20	3	172	2	0.0944	0.2451
837	2008	6	27	3	179	2	0.1602	0.3592
838	2008	7	2	3	184	2	0.2069	0.3006
839	2008	7	5	3	187	2	0.2706	0.4011
840	2008	7	10	3	192	2	0.4728	0.3814
841	2008	7	11	3	193	2	0.5089	0.3924
842	2008	7	15	3	197	2	0.4885	0.4045
843	2008	7	20	3	202	2	0.2960	0.4536
844	2008	7	22	3	204	2	0.4258	0.5591
845	2008	8	2	3	215	2	0.8138	0.5241
846	2008	8	3	3	216	2	0.7651	0.7256
847	2008	8	7	3	220	2	1.1968	0.7963
848	2008	8	7	3	220	2	1.1968	0.7722
849	2008	8	12	3	225	2	2.1793	0.8285
850	2008	8	16	3	229	2	2.4206	0.6117

851	2008	8	23	3	236	2	2.5001	0.6076
852	2008	9	1	3	245	2	2.8020	0.5683
853	2008	9	4	3	248	2	2.8931	0.5095
854	2008	9	17	3	261	2	2.5105	0.4559
855	2008	9	20	3	264	2	2.0774	0.3826
856	2010	5	28	3	148	2	0.0006	0.3465
857	2010	6	17	3	168	2	0.0589	0.3070
858	2010	6	21	3	172	2	0.0926	0.3478
859	2010	6	22	3	173	2	0.1027	0.2775
860	2010	6	26	3	177	2	0.1503	0.2703
861	2010	7	1	3	182	2	0.2250	0.3654
862	2010	7	6	3	187	2	0.3247	0.4275
863	2010	7	10	3	191	2	0.4411	0.3843
864	2010	7	14	3	195	2	0.5975	0.4626
865	2010	7	19	3	200	2	0.8444	0.5100
866	2010	7	27	3	208	2	1.3663	0.5716
867	2010	7	27	3	208	2	1.3663	0.5601
868	2010	7	31	3	212	2	1.7395	0.5261
869	2010	8	3	3	215	2	2.0382	0.6299
870	2010	8	8	3	220	2	2.3554	0.5602
871	2010	8	11	3	223	2	2.4110	0.5355
872	2010	8	15	3	227	2	2.4600	0.7649
873	2010	8	20	3	232	2	2.5629	0.5806
874	2010	8	22	3	234	2	2.6078	0.6878
875	2010	8	25	3	237	2	2.6685	0.6405
876	2010	8	29	3	241	2	2.7191	0.5513
877	2010	9	3	3	246	2	2.6955	0.7540
878	2010	9	7	3	250	2	2.5807	0.6091
879	2010	9	12	3	255	2	2.3260	0.6074
880	2010	9	14	3	257	2	2.1949	0.5725
881	2010	9	26	3	269	2	1.1684	0.3523
882	2010	9	28	3	271	2	0.9729	0.3262
883	2010	9	30	3	273	2	0.7750	0.3600
884	2012	5	28	3	149	2	0.0167	0.2216
885	2012	5	28	3	149	2	0.0167	0.2652
886	2012	6	4	3	156	2	0.0338	0.2726
887	2012	6	18	3	170	2	0.1359	0.2712
888	2012	6	24	3	176	2	0.3313	0.2626
889	2012	6	26	3	178	2	0.4225	0.3053
890	2012	6	27	3	179	2	0.4563	0.3302
891	2012	7	6	3	188	2	0.3472	0.4139
892	2012	7	10	3	192	2	0.4710	0.4006
893	2012	7	17	3	199	2	1.0977	0.4480
894	2012	7	22	3	204	2	1.2049	0.4651
895	2012	7	29	3	211	2	1.3682	0.4266
896	2012	8	4	3	217	2	1.5034	0.5105
897	2012	8	5	3	218	2	1.5148	0.3278
898	2012	8	15	3	228	2	1.7589	0.4280
899	2012	8	21	3	234	2	2.0125	0.4507
900	2012	8	27	3	240	2	2.2198	0.4436
901	2012	8	29	3	242	2	2.2569	0.3771
902	2012	8	30	3	243	2	2.2668	0.3124
903	2012	9	5	3	249	2	2.1688	0.3280
904	2012	9	8	3	252	2	2.0045	0.3427
905	2012	9	15	3	259	2	1.4007	0.2541
906	2012	9	19	3	263	2	0.9777	0.2671