DISSERTATION

PRECISION NITROGEN MANAGEMENT ACROSS SITE-SPECIFIC MANAGEMENT ZONES IN IRRIGATED MAIZE PRODUCTION SYSTEMS

Submitted by

Daniel Joseph Inman II

Department of Soil and Crop Sciences

Colorado State University

In partial fulfillment of the requirements
for the Doctor of Philosophy Degree
Colorado State University
Fort Collins, Colorado
Summer 2006

UMI Number: 3233341

COLORADO STATE UNIVERSITY

July 6, 2006

We hereby recommend that the dissertation prepared under our supervision by Daniel Inman entitled "Precision Nitrogen Management Across Site-Specific Management Zones in Irrigated Maize Production Systems" be accepted as fulfilling, in part, requirements for the degree of Doctor of Philosophy.

Graduate Committee

Dr. Rajiv Khosla
Adviser

Dr. Dwayne G. Westfall

Dr. Robin M. Reich

Dr. Michael A. Lefsky

Dr. Gary A. Peterson
Department Head

ABSTRACT OF DISSERTATION

PRECISION NITROGEN MANAGEMENT ACROSS SITE-SPECIFIC MANAGEMENT ZONES IN IRRIGATED MAIZE PRODUCTION SYSTEMS

In the United States, crop nitrogen-use efficiency (NUE) is very low. Approximately 33% of all N applied towards cereal crop production is captured in the harvested grain. Precision agricultural practices have shown potential for increasing crop NUE. This dissertation investigates three aspects of precision N management: management zones, aerial remote sensing, and active remote sensing. The specific objectives were: (i) to characterize the within field spatial variability of N uptake across irrigated corn production fields, (ii) to quantify and compare N uptake and grain yield across three site specific management zones (SSMZs), (iii) to compare grain yield response to applied N between management zones, (iv) to examine the relationships between normalized difference vegetation index (NDVI) determined early in the growing season, site-specific management zones, and relative maize yield; (v) to determine if NDVI can be used to estimate relative maize yield; (vi) to determine if site-specific management zones can be used in conjunction with remote sensing to provide yield estimates in irrigated maize, and (vii) to evaluate the effectiveness of using a hand-held active remote sensing instrument to estimate yield potential in irrigated maize. This study was conducted on commercially-operated irrigated production maize fields throughout northeastern Colorado. For objectives i, ii, and iii, fields were classified into high, medium, and low site specific management zones. Treatments consisted of a control and two uniform N application rates over three site years (one field over two consecutive years and another field over one year). Nitrogen fertilizer rates varied with site year and ranged from 56 kg N ha^{-1} to 268 kg N ha^{-1}. Above ground biomass samples were collected at physiological maturity and analyzed for total N. For objective iv, v, and vi, aerial imagery was acquired at approximately the eight-leaf crop growth stage. Grain was harvested using a commercial-combine outfitted with a yield monitor at the crop's physiological maturity. Objective iv was analyzed using percent areal agreement, kappa statistics, and regression analysis. Objectives v and vi were analyzed using regression analysis with cross-validation and indicator variables. For objective vii, the GreenSeeker™ active remote sensing unit was used to measure red and near infrared reflectance of the crop canopy. Grain was harvested by hand at physiological maturity. Presidedress soil nitrate samples (PSNT) were collected from the plots at the time of sensing. The crop was hand-harvested at physiological maturity. NDVI was calculated from the reflectance data and normalized by dividing by the number of growing-degree days from planting to sensing. A response index (RI) was calculated the ratio of the reflectance of an area of interest to the reflectance of an N-rich portion of the field. Regression analysis was used to model grain yield. Cross validation was used to validate regression models. Nitrogen uptake and grain yield within management zones was found to be less spatially variable than the whole field. Nitrogen uptake, grain yield, and grain yield response to applied N were found to be statistically different ($p < 0.05$) across management zones. NDVI and grain yield had a slight to substantial areal association, with kappa statistics ranging between 0.10 to 0.63 and % areal agreement from 13 to 67. Models estimating grain yield from NDVI had coefficients of determination as high as 82%. Management zones resulted in only marginal improvements in the yield estimations. A strong relationship was found between NDVI determined from the GreenSeeker and observed grain yield (R^2 = 0.76). Overall, results from this dissertation highlight the potential of site-specific management zones, aerial remote sensing, and active remote sensing to characterize N needs and/or yield limiting factors across irrigated maize fields.

Daniel J. Inman
Dept. Soil and Crop Sciences
Colorado State University
Summer 2006

ACKNOWLEDGEMENTS

Completion of this dissertation was made possible through the support, encouragement, and assistance of others. Specifically, I would like to thank my family for their encouragement and Stefanie for her moral support and companionship. I would also like to thank Tim Shaver for his advice and assistance through my graduate work and during my time as a research associate.

My graduate committee worked very closely with me throughout this entire project. Thanks to Dr. Khosla for his tutelage and for the opportunity he gave me to take this work on. I would also like to thank Dr. Khosla for bringing me on as a research associate during the latter half of my doctorate work. In addition to providing me financial peace-of-mind, being a research associate allowed me to gain valuable field experience and provided a platform from which I could develop my publication track record. I am very grateful for Dr. Reich's tremendous contributions, not only to this dissertation, but to the journal publications that he has been integrally involved with. Also, thanks to Dr. Reich for his patience in explaining complex statistical procedures. Thanks to Dr, Westfall for his wisdom and advice throughout my research, and to Dr. Lefsky for his remote sensing expertise and his advice.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPEDICIES

CHAPTER 1

Nitrogen Uptake Across Site Specific Management Zones in Irrigated Corn Production Systems

ABSTRACT

Development of improved fertilizer management practices has the potential to improve fertilizer use efficiency and the environment. Site-specific management zones (SSMZs) are effective for classifying production fields into areas of similar yield limiting factors. SSMZs have not been evaluated on the basis of N uptake and grain yield. The objectives of this study were (i) to characterize the within field spatial variability of N uptake across irrigated corn production fields, (ii) to quantify and compare N uptake and grain yield across three SSMZs, and (iii) to compare grain yield response to applied N between SSMZs. This study was conducted on continuous corn (*Zea Mays* L.) irrigated fields in northeastern Colorado. Fields were classified into high, medium, and low-productivity level management zones. Treatments were a control and two uniform N application rates. Nitrogen fertilizer rates varied with site year and ranged from 56 kg N ha^{-1} to 268 kg N ha^{-1}. Above ground biomass samples were collected at physiological maturity and analyzed for total N. Between management zones, N uptake, grain yield, and grain yield response to applied N were found to be statistically different ($p < 0.05$). Management zones were found to be less spatially variable than the whole field. The SSMZs accurately characterized variability in N uptake as well as grain yield response toapplied N. Thus, variation in N uptake and grain yield can potentially be managed using SSMZs.

INTRODUCTION

Plant nutrients such as N, phosphorus (P), and potassium (K) are often applied to plants to ensure economically viable grain yields in large-scale cropping systems (Swanson, 1982; Mengel, 1990). Development of improved nutrient management strategies has been a primary focus of agricultural research for over ten years (Gauer et al., 1992; Spellman et al., 1996; Mulla and Bhatti, 1997; Khosla and Alley, 1999; Khosla et al., 2002). Crop management strategies that improve nutrient use efficiency may increase farm profits and greatly reduce the deleterious environmental effects associated with fertilizer loss.

Nitrogen is often the most limiting nutrient in agro-ecosystems and is therefore applied in the highest quantities (Havlin et al., 1999; FAO, 2001). According to the Food and Agriculture Organization of the United Nations, about 82 million Mg of nitrogenous fertilizers were applied globally in 2001 (FAO, 2001). Of that, 60% was used for cereal production (Alexandratos, 1995). Raun and Johnson (1999) estimate that only 33% of nitrogen applied as fertilizer for cereal crop production is recovered in the harvested grain. Although there are many causes for low nitrogen-use efficiency (NUE), application of N in amounts that exceed crop requirements has received the most attention from the public because of the purported link between nitrogen fertilizer and groundwater contamination. Nitrogen applied in excess elevates post-harvest NO_3-N levels in the soil and increases the potential for leaching of NO_3-N into groundwater supplies (Schepers et al., 1991).

In-field spatial variability of soil and crop parameters has long been recognized as affecting overall crop yield (Johnson et al., 2003). Studies indicate that within-field yield variation can be attributed to several factors including, but not limited to, variability in soil types, changes in landscape position, cropping history, soil physical and chemical properties, as well as nutrient availability across fields (Wibawa et al., 1993; Sawyer, 1994; Penney et al., 1996). Variable rate application (VRA) of N fertilizers to manage inherent soil spatial variability has been shown to increase NUE in some crops. In eastern Washington, Mulla and Bhatti (1997) showed that N application could be reduced by as much as 42 kg ha^{-1} using VRA. Khosla and Alley (1999) found that using VRA on a 14.4 ha field in Virginia reduced total N applied by 22 kg N ha^{-1} without a reduction in grain yield when compared to a uniform N treatment. Moreover, the results of Mulla and Bhatti (1997), Khosla and Alley (1999), Khosla et al., (2002), and Hornung et al., (2003) all demonstrated that N input optimization via high N application rates in more productive areas and low N rates in less productive areas has potential to increase NUE.

Site specific Management Zones

The use of site specific management zones (SSMZ) for VRA has been shown to be a simple and effective way to increase NUE (Khosla et al., 2002; Hornung et al., 2003). Site specific management zones are defined as homogeneous sub-regions of a field that have similar yield limiting factors (Doerge, 1999; Khosla and Shaver, 2001). Numerous methods and combinations of methods have been used to delineate management zones including remotely sensed imagery (Bhatti et al., 1991), yield data (Mulla and Bhatti, 1997), farmer's experience combined with bare soil imagery and topography (Fleming et al., 1999), soil electrical conductivity (Sudduth et al., 1998), grid-soil sampling, and soil survey information (Franzen et al., 2000). Conceptually, using a management zone delineation technique, a production field could be classified into management zones that reflect the zone's productivity potential. For example, a field may be classified into three zones; high, medium, and low productivity potential management zones (Fleming et al., 2004). Using the management zones approach, agricultural inputs are envisaged to be applied variably across the field in accordance with the productivity potential of the management zone. However, within a management zone, agricultural inputs are applied uniformly at a constant rate.

Nitrogen Uptake and Variability

Nitrogen management strategies that create a balance between N input and the crop N uptake could help alleviate problems associated with N loss (Grant et al., 2002). Accumulated soil N is highly susceptible to leaching and can potentially threaten groundwater supplies. Sustainable nutrient management practices should ideally replenish soil nutrients, which are depleted through crop uptake and harvest to soil fertility levels that can support economic crop growth and yield (Grant et al., 2002; Heckman et al., 2003). One means of maintaining soil N fertility levels without exceeding crop N requirements is to tailor N inputs to meet the specific crop N requirements. Published crop nutrient removal values are available from federal and state agencies (USDA, 2003) and have been used to help guide producers in making more informed application decisions. However, the usefulness of values reported in such publications is questionable. Heckman et al., (2003) made the point that "[nutrient removal] values that were established in the past may not be correct for current agronomic technologies such as hybrid, higher plant populations, yield potential, fertilizer practice, and soil conditions." In their study, Heckman et al., (2003) found that mean nutrient (N, P, and K) concentrations in corn (*Zea Mays* L.) grain across 23 site years were similar to published reference values. However, their results also revealed that nutrient concentration variability within a single corn hybrid grown across six site years was as high as that of ten different hybrids grown across 23 site years (Heckman et al., 2003). Therefore, using average nutrient removal values as a means to estimate nutrient removal across varying conditions is questionable. For this reason most university soil analysis labs make N fertilizer recommendations based on a N requirement (amount of N required to produce one unit of grain yield) in conjunction with an estimated yield goal and residual soil nitrate-nitrogen test results.

Review of the current literature indicates that N uptake has not been thoroughly studied from a SSMZ perspective. We hypothesize that SSMZs can be used to effectively characterize N uptake spatial variability and could establish the usefulness for variable nutrient (N) application using SSMZs across the field.

The objectives of this study were (i) to characterize the within-field variability of N uptake across irrigated corn production fields, (ii) to quantify and compare N uptake and grain yield across three site specific management zones, and (iii) to compare grain yield response to applied N between site specific management zones.

MATERIALS AND METHODS

Study Sites

This study was conducted over three site years (one field over two consecutive years and another field over one year). Sites were located in northeastern Colorado under a continuous corn cropping system, with center-pivot sprinkler irrigation for all site years. Study sites ranged from 51 to 89 ha in size.

Site years I and II were on a field mapped as having Bijou (coarse-loamy, mixed, superactive, mesic, Ustic Haplargid), Truckton (coarse-loamy, mixed, superactive, mesic, Aridic Argiustoll), and Valentine (mixed, mesic, Typic Ustipsamment) soil series (Soil Survey Staff, 1968). These soils are characterized as being very deep. The Truckton is well drained, Bijou is somewhat excessively drained, and the Valentine is excessively drained. Both Truckton and Bijou soils are derived from arkose parent material and occur on terraces, fans, and uplands. Valentine soils are eolian derived and occur on uplands.

Site year III was located on a field that was mapped as having Albinas (fine-loamy, mixed, superactive, mesic Pachic Argiustoll), Ascalon (fine-loamy, mixed, superactive, mesic, Aridic Argiustoll), and Haxton (fine-loamy, mixed, superactive, mesic Pachic Argiustoll) soil series (Soil Survey Staff, 1981). These soils are characterized as being very deep, well drained, and have accumulated carbonates in the soil solum. The Ascalon series occurs on upland positions and is formed from calcareous parent material. The Haxtun series consist of eolian deposits that overlay buried soil, occuring in drainages and depressions. The Albinas series is alluvial and occurs on fans and terraces.

Experimental Procedure

Prior to planting, soil samples were collected at depths of 0 - 30 cm and 30 - 60 cm. A systematic unaligned sampling grid was used with a sampling density of 2.5 samples per hectare on the entire field (independent of management zones). Each geo-referenced soil sample consisted of four to six cores that were composited into one sample. Soil samples were air-dried and ground to pass a 2-mm sieve (Soil Survey Staff, 1996). Soil pH was analyzed using a 1:1 soil water mixture (Thomas, 1996). Particle size analysis was conducted using the hydrometer method (Bouyoucos, 1962). A summary of soil texture, pH, and organic matter for each site year is presented in Table 1.1. Total NO_3 -N was determined using the method of Mulvaney (1996).

Table 1.1. Mean, minimum, and maximum values for texture, organic matter, and pH for site years I, II, and III.

		--------------------%--------------------				
Site Year†		Sand	Silt	Clay	Organic Matter	pH
I and II	Mean	86	5	9	0.95	7.7
	Min	72	2	4	0.5	7.3
	Max	94	10	20	1.6	8.1
III	Mean	58	27	15	1.6	7.5
	Min	41	14	9	1	6.3
	Max	27	40	21	2.3	8.2

† Site years I and II were on the same field over two consecutive growing seasons.

Corn was planted at 75,000 plants ha^{-1} with a row spacing of 76 cm. Site years I and II were planted with Pioneer hybrid 34G81 and site year III was planted with Pioneer hybrid 34K77. Site-specific management zones were delineated on all fields using the commercially available AgriTrak Professional™ software (Fleming et al., 1999). This program relies on three Geographic Information System (GIS) data layers: (i) bare soil aerial imagery on conventionally tilled land; (ii) farmer's perception of field topography; and (iii) farmer's past crop and soil management experience. These data layers were incorporated into a MapInfo™ (GIS) data base to run mathematical interpolation surfaces to develop three management zones (Khosla et al., 2002). Traits such as dark color, low-lying topography, and historic high yields were designated as a zone of potentially high productivity or high zone. Details of this technique are provided in Fleming et al. (1999), Khosla et al. (2002), and Koch et al., (2004).

Table 1.2. Nitrogen treatments for site years I, II, and III. Where treatment 1 = recommended N rate from (Mortvedt et al., 1996), treatment 2 = half the recommended N rate, and treatment 3 = control.

	Treatment		
Site Year	1	2	3
	kg N ha^{-1}		
I	238	127	0
II	192	96	0
III	114	56	0

Nitrogen applications were made at the six-leaf crop growth stage (V6) using undiluted urea ammonium nitrate 32% solution applied with an 8-row cultivator. Nitrogen treatments were based on the N rate algorithm given by Mortvedt et al., (1996) for each site year. The three N treatments were: (1) the recommended N rate (as determined from the CSU Cooperative Extension N rate algorithm for corn), (2) approximately half the recommended rate, and (3) a control treatment (0 kg N ha^{-1}) (Table 1.2). Experimental strips were randomly allocated and consisted of 24-rows of corn that spanned the length of the field (>700m). Treatments were replicated once and were nested within management zones. At the crop's physiological maturity (R6 growth stage) above ground biomass samples were collected for grain yield and N content analysis. Four samples were randomly located and collected from each experimental unit (treatment in each management zone). Each sample consisted of two 1-m long sections of a corn row. Samples were separated into grain, husk and cob, and leaf and stalk portions, air-dried to a constant weight, analyzed for grain yield, and ground. Samples were then analyzed for total N concentration. Nitrogen uptake was found by the percentage of total N contained in the above-ground portion of the samples multiplied by the biomass weight and then converted to kg of N ha^{-1}. Grain yield was determined by converting the total grain weight per sample at 15.5% moisture to Mg ha^{-1}.

Fields, management zones, treatment strips, soil sample positions, and grain yield samples were all logged using a differentially-corrected Trimble™ Ag 114 global positioning system (DGPS) unit. All GIS analysis and data processing were performed using MapInfo 7.0 and ArcView 3.2.

Data Analysis

Statistical analysis was performed using SPLUS 6.1 and SAS 8.0. Grain yield and N uptake differences between management zones were analyzed using a fixed-effect, two factor nested design analysis of variance (ANOVA) in which treatments were nested within management zones. In the ANOVA model, observational errors (i.e., sub-samples within treatments) were nested within experimental errors. When ANOVA was found significant at $P<0.05$, mean separation was performed using least squares difference (LSD) at $P<0.05$.

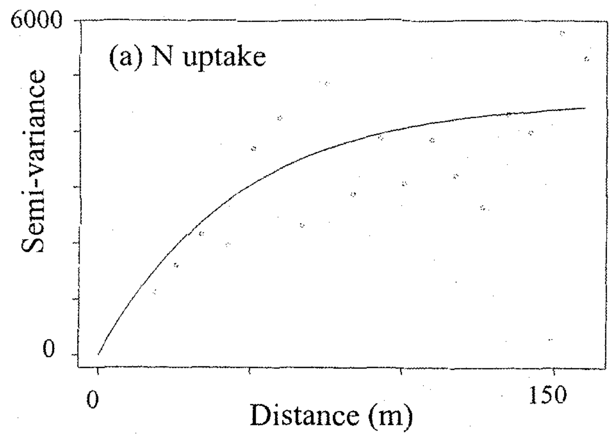
For this study semi-variograms were used model the variance in N uptake and grain yield, separately, as a function of distance between sample locations. Details about fitting semi-variograms are provided Cressie (1993). Moran's I was used to test for significant spatial auto-correlation in N uptake and grain yield for each site year and for each management zone within each site year. A spatial auto-regressive model was used to regress grain yield on N uptake for each site year. Inverse distance weighting was used to create the spatial weight matrices used in Moran's I and spatial auto-regressive model. Since site years I and II were located on the same field, an *F-test* of unequal variance was used to test if grain yield and N uptake were equal across growing seasons at $p < 0.05$.

Least squares regression analysis was used to model grain yield response to applied N and to examine the relationship between soil properties and N uptake. Binary indicator variables were introduced in the grain yield response models to test for differences among management zones (high, medium, and low). A complete review of the use and interpretation of indicator variables is provided by Neter et al., (1996). Best-fit regression models for grain yield response to N were determined using the All-Possible Regressions Procedure (SAS Institute, 2001). The criteria used for determining the "best" subset of independent variables within the All-Possible Regressions Procedure were (i) coefficient of determination (R^2), (ii) Mallow's C_p, and (iii) Akaike's information criteria. Therefore, models that had high coefficients of determinations while minimizing both Mallow's Cp and Akaike's information coefficient were considered for further investigation. Mallow;s Cp statistic is concerned with the total mean squared error of the *n* fitted values for each subset regression model. Ideally, Mallow's C_p should be no greater than $p + 1$, where p is the number of independent variables included in the regression analysis. The closer Mallow's C_p is to p, the lower the mean squared error of the model and the lower the overall bias (Neter et al., 1996). Akaike's Information Criteria provides a measure of "goodness of fit" for the range of values in a given data set. Akaike's Information Criteria was included to allow for comparisons between models; Burnham and Anderson (2002) provide a complete description on using Akaike's Information Criteria for comparison of multiple models. Significance of each regression model (both spatial auto-regressive models and least-squares models) was tested using an F-test for lack of fit (Neter et al., 1996). Significance of the independent variables was tested, to determine if they were significantly different than zero, using a two-tailed t-test. Regression parameters were considered to be significant at $p < 0.05$ level of significance. Independent variables that were significant at the $p < 0.05$ level of significance were retained in the model. Residuals of the regression models were investigated by examining residual plots and testing for normality residuals using Shapiro-Wilk test (Neter et al., 1996).

RESULTS AND DISCUSSION

Within-Field Spatial Variability

Results from the semi-variograms indicate that both site year I and II have significant spatial dependence for both N uptake and grain yield, with the former having stronger spatial structure (Figure 1.1). Results from Moran's I and spatial auto-regressive model are presented in Table 1.3. Coefficients from Moran's I further support significant



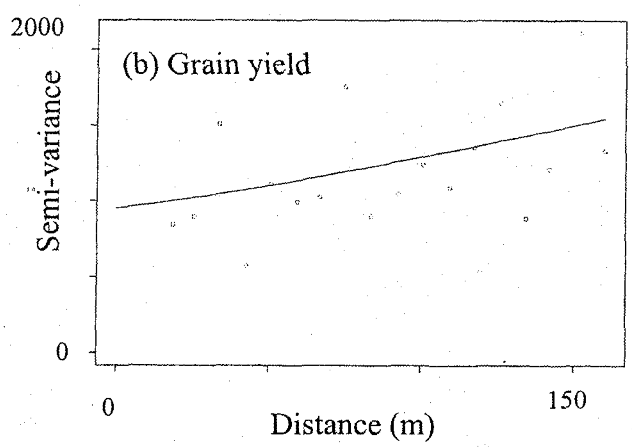


Figure 1.1. Semi-variogram for N uptake and grain yield for site year I.

spatial dependence for both, N uptake and grain yield. Mean N uptake, grain yield, and coefficient of variation (CV) for each site year are shown in Table 1.4. Taylor et al., (1998) and Washmon (2002) used the CV as a measure of spatial variability for crop parameters. Shahandeh et al. (2005) reported that "the coefficient of variation is a useful statistic for measuring the spatial variability of soil properties." In our study, CVs ranged from 22 to 35% for N uptake and 18 to 21% for grain yield. The observed variability in N uptake and grain yield about their respective means, as indicated by the CVs, reflects the heterogeneity of these parameters across the whole field. Average N uptake values for all site years were in agreement with published reference N uptake values (Potash and Phosphate Institute, 2004), and ranged from 161 to 261 kg N ha^{-1}. Our results, like those of Heckman et al., (2003), raise questions about the usefulness of mean nutrient uptake values. Considering that the N uptake spatially variable,, using mean N uptake values to target N application rates potentially could have resulted in some portions of the fields being under or over fertilized.

Table 1.3. Moran's I for whole field N uptake and grain yield and coefficient of determination from spatial auto-regressive models regressing grain yield on N uptake for all site years.

Site Year	N Uptake	Grain Yield	Grain Yield on N Uptake
	---Moran's I---		----r^2----
I	0.15	0.11	0.97
II	0.14	0.11	0.98
III	ns	ns	ns

Because site years I and II were on the same field over two consecutive growing seasons, we were interested in seeing if the spatial variability of N uptake was temporally stable. Site years I and II had similar CVs for N uptake, 29 and 35%, respectively. An *F-test* of unequal variances between site years I and II indicated that variance in N uptake was statistically equal ($p \geq 0.05$) over the two growing seasons. In addition, for site years I and II a negative linear relationship was found between sand percentage and N uptake as well as sand percentage and organic matter, $r^2 = 0.30$, $r^2 = 0.51$, $p < 0.05$, respectively. For the sites used in this study, regions of high sand content (80-91% sand, Table 1.1) have less mineralizable N, less available water, and are more prone to N loss through leaching under irrigated systems and therefore lower crop N uptake. Results of the *F-test* and regression analysis indicated that the similarity in spatial pattern variability across the field in site years I and II is reflective of the spatial pattern of stable soil properties (i.e., texture).

Table 1.4. Mean N uptake, mean grain yield, and coefficient of variations (CV) for site year I, II, and III.

Site Year	Mean N Uptake -- (kg N ha^{-1}) --	N Uptake CV[†] ---- (%) ----	Grain Yield -- (Mg ha^{-1}) --	Grain Yield CV ---- (%) ----
I	214	29	11.6	20
II	261	35	9.9	21
III	161	22	10.2	18

[†] Coefficient of variation (CV) = (standard deviation / mean) * 100

Grain yield for all site years was typical of this region (Table 1.4), with yields ranging from 9.9 to 11.6 Mg ha^{-1}. Grain yield variability was lower (CV = 18 - 21%) than that observed for N uptake (CV = 22 - 35%). Grain yield also exhibited less spatial variability than N uptake (Figure. 1.1, Table 1.3).

As with the N uptake results, CVs for grain yield between site years I and II were similar, 20 and 21%, respectively (Table 1.4). Using an *F-test* of unequal variances, it was found that grain yield variances were statistically equal between the two growing seasons ($p \geq 0.05$). Nitrogen uptake measurements taken at physiological maturity (R6 growth stage) were well correlated to grain yield in all site years ($r = 0.64$ to 0.80, $p < 0.05$). These results were similar to those reported by Muchow (1988) and Katsvairo et al. (2003). The relationships were much stronger using spatial auto-regressive models ($r^2 = 0.97$ to 0.98, $p < 0.05$), indicating that these two parameters are spatially dependant (Table 1.3). The outcome from the above statistical analyses (CVs, *F-test* of unequal variances, and spatial autoregressive models) suggest that the patterns of spatial variability in soil properties correspond to patterns of spatial variability in grain yield. Our results indicate that the effectiveness of N management practices are limited by soil properties, i.e., low yielding areas (low zone) may continue to be low yielding until the soil properties of such areas are improved. Therefore the fields used in this study would be good candidates for site specific N management using a management zone approach. Fields that have highly variable crop parameters, due to variability in soil properties, would conceptually be better managed using the SSMZ approach.

Variability Between Management Zones

Mean N uptake across SSMZs and N application treatments are presented in Figure 1.2. The N uptake was found to be significantly different for the N application treatments in this study ($P<0.05$). Mean N uptake increased with increasing SSMZ productivity potential. Nitrogen uptake differed significantly between SSMZs for all N

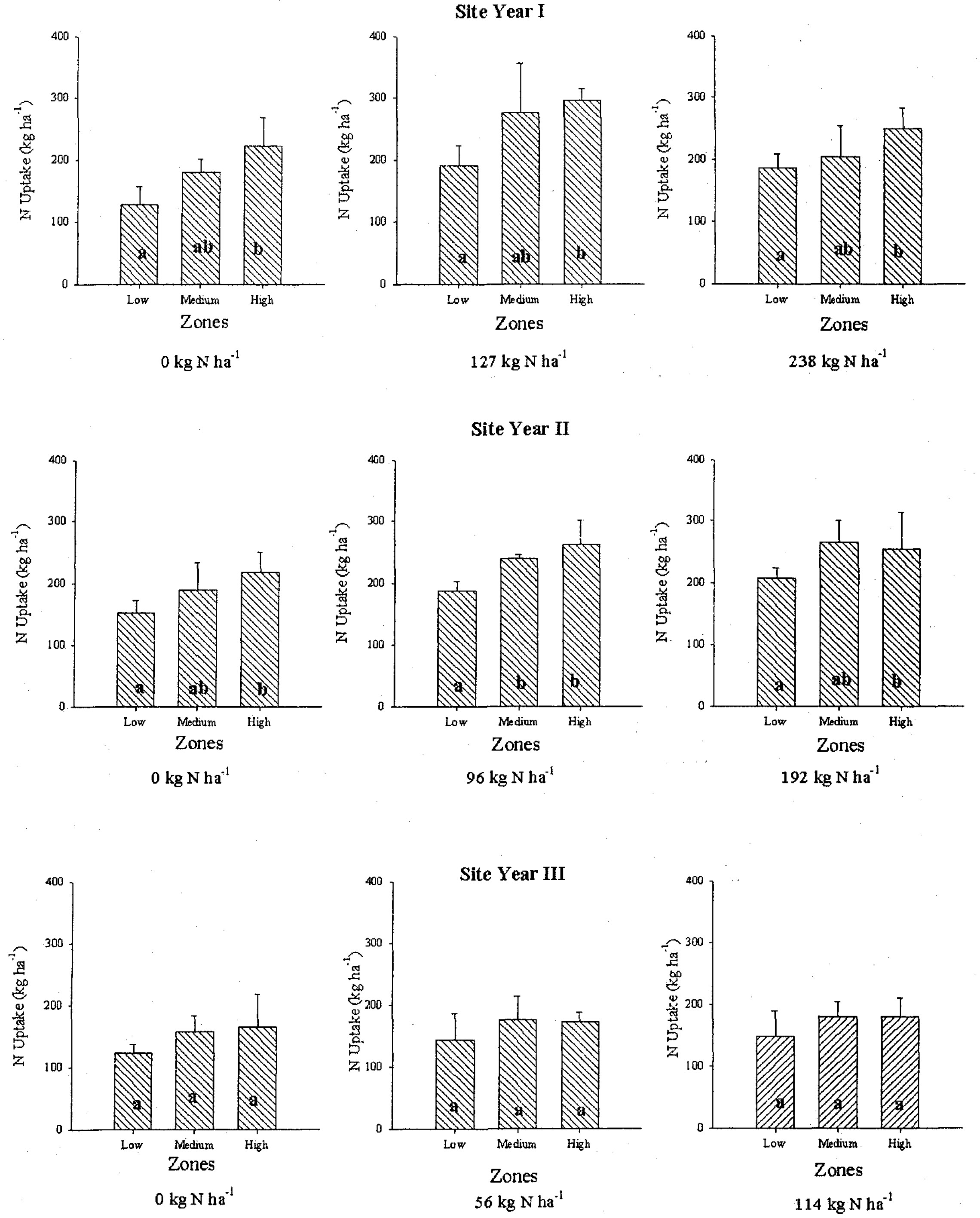


Figure 1.2. Mean N uptake across low, medium, and high management zones for site year I,II, and III. Error bars represent standard deviation of the mean. Different letters are significantly different ($p < 0.05$).

application rates for site years I and II. This supports our hypothesis that SSMZs have the potential to characterize spatial variability in N uptake. Using the SSMZ approach, the low and high productivity zones were consistently separable for site years I and II based on N uptake ($p < 0.05$).

Medium productivity management zone separation was not as distinctive as separation of low and high management zones. Such a finding was not surprising because medium productivity zones contain isolated and small inclusions of both high and low management zones. Westfall et al., (2003) reported that a considerable amount of smoothing occurs in management zone delineation, making it feasible for commercial fertilizer application equipment to apply variable rate N within management zones.

Although not significantly different, site year III mean N uptake values followed a similar trend as was observed for site years I and II. We believe N uptake values for site year III were impacted by hail damage that occurred during the mid-vegetative crop growth stage (V-8 to V-10 crop growth stage). The damage was moderate, reducing the overall biomass and the crop's photosynthetic ability, and thus reducing overall crop N uptake across the field.

Mean grain yields were significantly different for the N application treatments in this study ($P<0.05$) (Figure 1.3). In sites years I and II, the medium zone was found to be statistically equal to the low zone for the control treatment and high zone for the 192 kg N ha^{-1} treatment. Most likely, inclusions of isolated and small areas of low and high zones within the medium zone prevented an unambiguous classification of grain yield. For site year III, we observed a lack of response between management zones ($p < 0.05$)

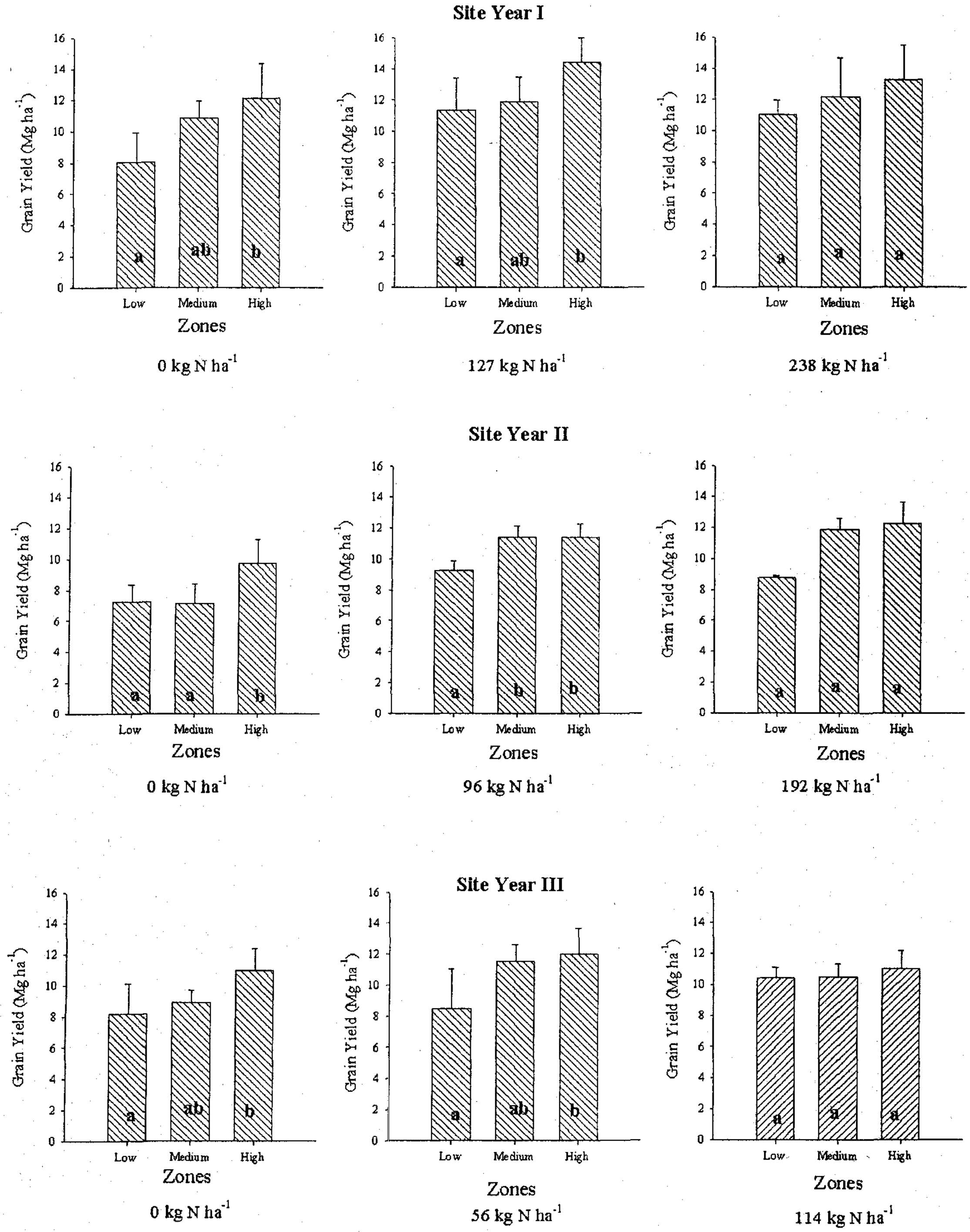


Figure 1.3. Mean grain yield across low, medium, and high management zones for site year I, II, and III. Error bars represent one standard deviation of the mean. Different letters are significantly different ($p < 0.05$).

for the third N treatment (114 kg N ha^{-1}). However, the overall trend was similar to the trends seen in site years I and II.

Mean N uptake, average grain yield, CV, and Moran's I for SSMZs from each site year are presented in Table 1.5. All N uptake CVs and Moran's I results (for the high, medium, and low management zones) were equal to or significantly lower than the CVs and Moran's I observed for the whole field. For site years I and II, CVs for mean grain yield were lower in the high and medium zones than the grain yield CVs observed for the whole field. For site year III, the medium and low zones had lower CVs for mean grain yield than the whole field. This was expected and logical because SSMZs are homogeneous sub-regions within a field (Doerge, 1999). Across SSMZs and site years, N uptake and grain yield CVs ranged from 16 to 28% and 11 to 24%, respectively. Comparing the N uptake and grain yield CVs within management zones to CVs for the whole field, SSMZs were successful in differentiating spatial variability.

Table 1.5. Mean N uptake, average grain yield, CV[†], and Moran's I for site-specific management zones (SSMZs) for all site years.

Site Year	SSMZ	Mean N Uptake	CV	Moran's I	Mean Grain Yield	CV	Moran's I
		-- kg N ha^{-1} --	%		--- Mg ha^{-1} ---	%	
	High	213	15	0.06	13.3	15	0.002
I	Med	254	15	0.06	11.5	15	0.05
	Low	177	21	0.14	10.3	21	0.16
	High	236	16	0.05	11.7	16	0.09
II	Med	230	17	0.08	10.6	17	0.06
	Low	180	24	0.06	8.9	24	0.04
	High	170	21	ns[‡]	10.22	21	ns
III	Med	173	11	ns	11.15	11	ns
	Low	139	18	ns	9.3	18	ns

[†] Coefficient of variation (CV) = (standard deviation / mean) * 100
[‡]ns = not significant at $p < 0.05$

Nitrogen Response

Grain yield response to applied N for each site year is presented in Figure 1.4. Using regression analysis, the indicator variables for SSMZs were statistically different ($p < 0.05$) for site years I and II. This suggests that each management zone may differ significantly in its capacity to utilize applied N. For site years I and II we found that N response for SSMZs was best described using a curvilinear function, with asymptotes being reached at approximately 125 kg N ha^{-1} and 100 kg N ha^{-1}, respectively. Site year III was modeled using a linear function, indicating that the optimum N rate was not met. Intercepts were statistically different ($p < 0.05$) between the low and high and between the medium and high zones. Grain yield response to applied N for site year III was most likely limited because of hail damage that occurred between the eight and ten-leaf crop growth stage.

CONCLUSION

In this study, grain yield and N uptake across irrigated corn production fields was shown to exhibit significant spatial variability. The pattern and scale of the spatial variability was found to be stable over two years. As anticipated, site specific management zones exhibited less N uptake and grain yield spatial variability within individual zones than on a whole field basis. Between management zones, N uptake and grain yield were statistically different. Grain yield response to N was also shown to be significantly different across management zones. This study showed that spatially variable crop parameters could potentially be managed using SSMZs. Furthermore, these

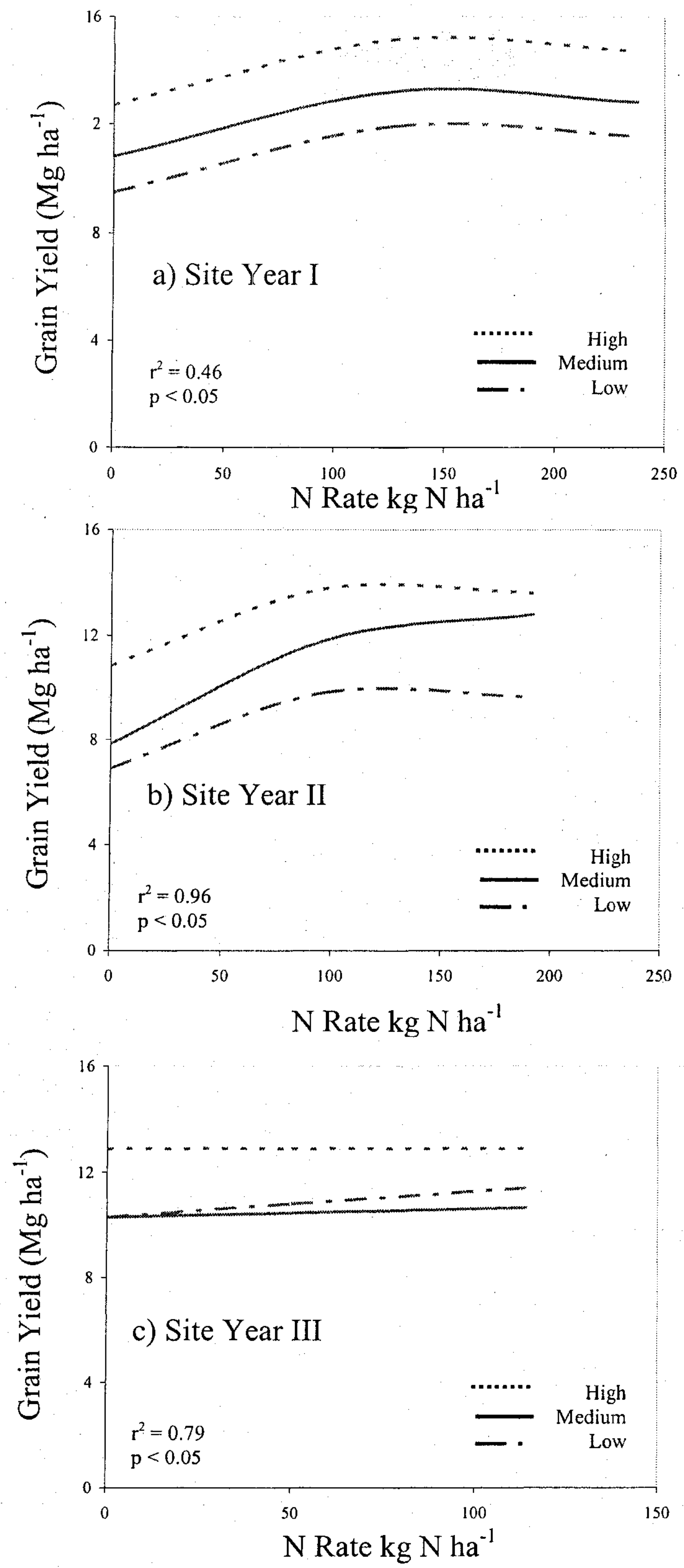


Figure 1.4. Grain yield response to applied N across site-specific management zones in irrigated corn production systems for site years I, II, and III.

results are encouraging because development of improved N application algorithms for site specific management must be consistent over time. More research is needed to develop site specific N recommendation algorithms that account for in-field N uptake variability.

REFERENCES

Alexandratos, N. (ed.). 1995. World agriculture: Towards 2010: An FAO study. FAO, Rome, and John Wiley & Sons, New York.

Bhatti, A.U., D.J. Mulla, and B.E. Frazier. 1991. Estimation of soil properties and wheat yields on complex eroded hills using geostatistics and Thematic Mapper images. Remote Sens. Environ. 37:181-191.

Bouyoucos, G.J. 1962. Hydrometer method improved for making particle size analysis of Soils. Agron. J. 54: 464-465.

Burnham, K.P. and D.R. Anderson. 2002. Model Selection and Multimodel Inference: a Practical Information-Theoretic Approach. 2nd Ed. Springer-Verlag. New York, NY.

Cressie, N.A. 1993. Statistics for Spatial Data. Wiley. New York, NY.

Doerge, T. 1999. Defining management zones for precision farming. Crop Insights:8(21) 1-5.

FAO. 2001. FAOSTAT: Statistics database. [Online] [Subset Fertilizer within Agriculture database] Available at http://apps.fao.org. (verified 6 Aug 2003).

Fleming, K.L., D.G. Westfall, D.W. Wiens, L.E. Rothe, J.E. Cipra, and D.F. Heermann. 1999. Evaluating farmer developed management zone maps for precision farming. p.335-343. *In*: P.C. Robert, R.H. Rust, and W.E. Larson (eds) Precision

Agriculture. Proceedings of the 4th Intl. Conf., ASA, CSSA, and SSSA, Madison, W.I.

Fleming, K.L., D.F. Heermann, and D.G. Westfall. 2004. Evaluating soil color with farmer input and apparent soil electrical conductivity for management zone delineation. Agron. J. 96:1581-1587.

Franzen, D.W., A.D. Halvorson, and V.L. Hofman. 2000. Management zones for soil N and P levels in the Northern Great Plains. In: P.C. Robert, R.H. Rust, and W.E. Larson (eds) Precision Agriculture. Proceedings of the 5th Intl. Conf., ASA, CSSA, and SSSA, Madison, W.I.

Gauer, L.E., C.A. Grant, D.T. Gehl, and L.D. Bailey. 1992. Effects of nitrogen fertilization on grain protein content, nitrogen uptake, and nitrogen use efficiency of six spring wheat (Triticum aestivum L.) cultivars, in relation to estimate moisture supply. Can. J. Plant Sci. 72:235-241.

Grant, C.A., G.A. Peterson, and C.A. Campbell. 2002. Nutrient considerations for diversified cropping systems in the Northern Great Plains. Agron. J. 94:186-198.

Havlin, J.L., J.D. Beaton, S.L. Tinsdale, and W.L. Nelson. 1999. Soil fertility and fertilizers. Pearson Education, Upper Saddle River, NJ.

Heckman, J.R., J.T. Sims, D.B. Beegle, F.J. Coale, S.J. Herbert, T.W. Bruulsema, and W.J. Bamka. 2003. Nutrient removal by corn grain harvest. Agron. J. 95:587-591.

Hornung, A, R. Khosla, R. Reich, and D.G. Westfall. 2003. Evaluation of site specific management zones: Grain yield and nitrogen use efficiency. In: J. Stafford and A. Werner (eds) Precision Agriculture. Proceedings of the 4th European Conf. June 15-19, Berlin, Germany.

Johnson, C.K., D.A. Mortensen, B.J. Weinhold, J.F. Shanahan, and J.W. Doran. 2003. Site specific management zones based on soil electrical conductivity in a semiarid cropping system. Agron. J. 95: 303-315.

Katsvairo,T.W., W.J. Cox, H.M. Van Es, and M. Glos. 2003. Spatial yield response of two corn hybrids at two nitrogen levels. Agron. J. 95: 1012-1022.

Khosla, R., K. Fleming, J.A. Delgado, T. Shaver, and D.G. Westfall. 2002. Use of site specific management zones to improve nitrogen management for precision agriculture. J. Soil Water Conserv. Vol. 57 (6) 515-518.

Khosla, R. and T. Shaver. 2001. Zoning in on nitrogen needs. Colorado State University Agronomy Newsletter 21(1):24-26.

Khosla, R. and M.M. Alley. 1999. Soil-specific nitrogen management on Mid-Atlantic Coastal Plain soils. Better Crops. 83(3):6-7.

Koch. B., R. Khosla, M. Frasier, D.G. Westfall, and D. Inman. 2004. Economic feasibility of variable rate nitrogen application utilizing site-specific management zones. Agron. J. 96: 1572-1580.

Mengel, K. 1990. Impacts of intensive palnt nutrient management on crop production and environment. Trans. Of the 14th Intl. Congress of Soil Sci., Plenary Papers. Kyoto, Japan Intl.Soc. Soil Sci., pp42-52.

Mortvedt, J.J., D.G. Westfall, and R.L. Croissant. 1996. Fertilizing corn. Colorado State Univ. Coop. Ext. Fact Sheet. No. 0.538, Fort Collins, CO.

Muchow, R.C. 1988. Effect of nitrogen supply on the comparative productivity of maize and sorgum in a semi-arid tropical environment: III Grain yield and nitrogen accumulation. Field Crops Res. 18:31-43.

Mulla, D.J. and A.U. Bhatti. 1997. An evaluation of indicator properties affecting spatial patterns in N and P requirements for winter wheat yield. p. 145-153. *In* J.V. Stafford (ed) Precision Agriculture '97, 1st European Conf. Prec. Ag., Warwick Univ., UK, 7-10 Sept. 1997.

Mulvaney, R.L. 1996. Nitrogen-inorganic forms. p. 1146 - 1162. *In* Sparks, D.L., et al., Methods of Soil Analysis. Part 3, Chemical Methods, Chapter 4. Soil Sci. Soc. Am., Madison, WI.

Neter, J., M.H. Kunter, C.J. Nachtscheim, and W.Wasserman. 1996. Applied Linear Regression Models 3rd ed. McGraw-Hill/Irwin publishers, Chicago, IL.

Penney, D.C., S.C. Nolan, R.C. McKenzie, T.W. Goddard, and L. Kryzanowski. 1996. Yield and nutrient mapping for site specific fertilizer management. Comm. Soil Sci. Plant Anal. 27:1265-1279.

Potash and Phosphate Institute. 2004. Nutrient uptake and removal by field crops. [Online]. Available at http://www.ppi-ppic.org. (Verified Feb 2, 2004)

Raun, W.R. and G.V. Johnson. 1999. Improving nitrogen use efficiency for cereal production. Agron. J. 91:357-363.

SAS Institute. 2001. Statistical Analysis Software Version 8. SAS Institute, Cary, NC. USA.

Sawyer, J.E. 1994. Concepts of variable rate technology with considerations for fertilizer application. J. Prod. Agric. 7:195-201.

Schepers, J.S., M.G. Moravek, E.E. Alberts, and K.D. Frank. 1991. Maize production impacts on groundwater quality. J. Environ. Qual. 20:12-16.

Shahandeh, H., A.L. Wright, F.M. Hons, and R.J. Lasano. 2005. Spatial and temporal variation of soil nitrogen parameters related to soil texture and corn yield. Agron. J. 97:772-782.

Soil Survey Staff. 1968. Soil Survey of Morgan County, Colorado. USDA Cooperative Soil Survey. Government Printing Office, Washington, D.C.

Soil Survey Staff. 1981. Soil Survey of Yuma County, Colorado. USDA Cooperative Soil Survey. Government Printing Office, Washington, D.C.

Soil Survey Staff. 1996. Soil Survey Laboratory Methods Manual. Soil Survey Investigation Report No. 42 version 3.0. National Soil Survey Center, Lincoln, NE.

Spellman, D.E., A. Rongni, D.G. Westfall, R.M. Waskom, and P.N. Soltanpour. 1996. Pre-sidedress nitrate soil testing to manage nitrogen fertility in irrigated corn in a semi-arid environment. Commun. Soil Sci. Plant Anal., 27:561-574.

Sudduth, K.A., N.R. Kitchen, and S.T. Drummond. 1998. Soil conductivity sensing on clay-pan soil: Comparison of electromagnetic induction and direct methods. p. 979-990. *In*: Robert, P.C., R.H. Rust, and W.E. Larson (eds) Precision Agriculture. Proceedings of the 4th Intl. Conf., ASA, CSSA, and SSSA, Madison, W.I.

Swanson, E.R. 1982. Economic implications of controls on nitrogen fertilizer use. p. 773-790. *In:* Stephenson, F.J. (ed.). Nitrogen in agricultural soils. Agronomy 22, ASA SSSA, Madison, WI.

Taylor, R.K., G.J. Kluitenburg, M.D. Schrock, N. Zhang, J.P. Schmidt, and J.L. Halvin. 1998. Using yield monitor data to determine spatial crop production potential.

ASAE Paper No. 981048. Presented at 1998 International Meeting, Orlando, FL. ASAE.

Thomas, G.W. 1996. Soil pH and soil acidity. p. 475–490. *In* Sparks, D.L. et al., Methods of soil analysis. Part 3—Chemical methods. SSSA Book Ser. No. 5. SSSA and ASA, Madison, WI

USDA. 2003. Natural Resources Conservation Service Crop Nutrient Tool. [Online] Available at: http://npk.nrcs.usda.gov/nutrient_body.html. (verified Oct. 20, 2003).

Washmon, C.N. 2002. Within field variability in wheat grain yields over nine years in Oklahoma. J. Plant Nutr. 25(12):2655-2662.

Westfall, D.G., W.J. Gangloff, R. Khosla, R.M. Reich, A. Hornung, D.F. Heermann, H.J. Farahani, and K. Fleming. 2003. Development of production level management zones for nitrogen fertilization. p 141-142. *In*: Werner, A. and A. Jarfe (eds) Program book of the joint conference of ECPA-ECPLF. Wageningen Academic Publishers, The Netherlands.

Wibawa, W.D., D.L. Dludlu, L.J. Swenson, D.G. Hopkins, and W.C. Danke. 1993. Variable fertilizer application based on yield goal, soil fertility, and soil map unit. J. Prod. Agric. 6:255-261.

CHAPTER 2

Normalized Difference Vegetation Index and Site-Specific Management Zones for In-Season Yield Estimation in Irrigated Maize

ABSTRACT

Remote sensing has been used to indirectly obtain crop information for over fifty years. The objectives of this study were (i) to examine the relationships between normalized difference vegetation index determined early in the growing season, site-specific management zones, and relative maize yield; (ii) to determine if normalized difference vegetation index (NDVI) can be used to estimate relative maize yield; and (iii) to determine if site-specific management zones can be used in conjunction with remote sensing to provide yield estimates in irrigated maize. This study was conducted on continuous maize irrigated fields over six site years in northeastern Colorado. Imagery was acquired at approximately the eight-leaf crop growth stage. Grain was harvested at the end of the growing season and statistically compared to NDVI calculated from the remote sensing data. NDVI and grain yield was significantly different across management zones ($p \leq 0.05$). A slight to substantial areal association between NDVI and relative grain yield was found (K = 0.10 to 0.63). Coefficients of determination from regression models were as high as 82% ($p < 0.05$). Including management zones as independent variables in the regression models resulted in marginal improvements. Regression models combined across growing seasons were generally better than the individual site-year regression models. Results indicate that NDVI can be used to

estimate relative yield during the early growing season in irrigated maize. Yield estimates using NDVI were site-specific.

INTRODUCTION

Nitrogen use efficiency (NUE) in the United States has remained stagnant for over two decades (Frink et al., 1999). Raun and Johnson (1999) estimate that NUE for cereal crops is only 33%; well below the reported average of 50% for all crops combined (Hardy and Havelka, 1975). Taking into account the projected population growth of the world, the consequences of continued low crop NUE are dire. Frink et al. (1999) estimate that by the year 2070 a 345% increase in cropped land will be necessary to feed the world's population if NUE and crop yields are not improved. Application of nitrogen (N) in amounts that exceed crop requirements, combined with other factors, has contributed to low crop NUE. Developing N fertilizer application strategies that optimize N is one of the key components needed to increase overall crop NUE.

Agronomists have recognized the potential of using remote sensing as a tool to rapidly acquire crop information for nearly fifty years (e.g., Colwell, 1956; Hoffer, 1967). For most agronomic purposes, reflectance in the visible and near infrared portions of the electromagnetic spectrum is of primary interest. Leaves absorb approximately 40% of all incident solar radiation (Campbell, 2002). Absorption by photosynthetic pigments present in the leaf dominates the visible light reflectance spectrum of a leaf. Chlorophyll-*a* has absorption maximums at 440 nm (blue) and 670 nm (red), whereas leaf reflectance in the near infrared (NIR) is dominated primarily by the internal structure of the leaf (i.e., lignin and cellulose present in the mesophyll cells) (Campbell, 2002). As plants develop normally, the reflectance of the red wavelength band is reduced (i.e., increased absorption by chlorophyll) whereas reflectance in the NIR is increased (i.e., more mesophyll cells being developed). Although chlorophyll-*a* has an absorption maximum at 440 nm, blue light reflectance is generally considered marginal with regard to high altitude remote sensing because of the large amount of Rayleigh scattering by the atmosphere (Campbell, 2002). Using ratios that make use of chlorophyll absorption and NIR reflectance, the relative health of the plant and/or crop may be inferred. Chlorophyll density (μg chl cm^{-3}) of the leaf is directly affected by plant N content and availability.

Spectral vegetation indices such as the normalized difference vegetation index (NDVI) have been shown to be useful for indirectly obtaining crop information such as photosynthetic activity, productivity potential, and potential yield (Peñuelas et al., 1994; Thenkabail et al., 2000; Ma et al., 2001; Raun et al., 2001; Báez-González et al., 2002). Normalized difference vegetation index is a broadband index that is well correlated to leaf area index (LAI), green biomass (Peñuelas et al., 1994), and photosynthetic activity (Aparicio et al. 2002; Campbell, 2002; Garty et al., 2001; Sellers, 1985). The NDVI has been shown in some studies to be useful for estimating grain yield in certain crops. Raun et al. (2001) showed expected yield as determined from NDVI had a strong relationship with actual grain yield in winter wheat (*Triticum aestivum* L.), $r^2 = 0.83$, $p < 0.0001$. Ma et al. (2001) reported that NDVI could be used to reliably predict low and high yield in soybeans (*Glycine max.* L).

One commonality in many studies that utilize NDVI or similar vegetation indices to estimate grain yield is that the estimates are better when LAI is low (i.e. during the early growing season or during senescence). However, because of the row-spacing used in maize crops, soil background can mask the reflectance of the crop. Soil reflectance is affected primarily by texture, mineral composition, organic matter, and moisture. In general, soil is a strong reflector of light in the red and NIR regions of the spectrum. Studies have suggested that vegetation indices should be adjusted to minimize the effects of soil reflectance (Baret et al., 1988; Huete, 1989; Rondeaux et al., 1996). Soil-adjusted vegetation indices such as the SAVI developed by Huete (1989) use a single *constant* (*L*) to adjust for soil interference; this constant changes with changes in percent canopy closure. Logically, use of a "*constant*" correction factor has limitations when applied to fields that have spatially variable soil albeto. However, recent research suggests that spatial variability of several soil parameters (e.g., bulk density, soil texture, organic matter, and soil moisture) can be readily accounted for using site-specific management zones (SSMZ) based on bare-soil color. Coupling SSMZ with NDVI is one logical extension of the current research into remote sensing and precision agriculture.

Site-Specific Management Zones

Site-specific management zones are a simple and effective approach to site-specific management (Miao et al., 2005). Doerge (1999) defined SSMZ as being homogeneous sub-regions of a field that have similar yield limiting factors. Studies have shown that the SSMZ approach to N management can increase NUE as compared to traditional uniform N management (Khosla et al., 2002; Hornung et al., 2003). Numerous methods of management zone delineation have been proposed in the literature including: soil survey maps (Franzen et. al., 2002), soil electrical conductivity with elevation and slope (Fridgen et al., 2000), yield monitor data (Hornung et al., 2006), and bare-soil imagery (Fleming et al., 1999), to name a few. Regardless of the method used to delineate the SSMZ, they are used to classify a field into manageable units that differ in productivity potential.

Soil-color based management zones have been shown to accurately characterize soil physical properties such as texture, moisture, and organic matter (Mzuku et al., 2005). Soil-color based management zones utilize bare-soil imagery, farmer's perception of field topography, and farmer's past crop and soil management experience. Characteristics such as regions of dark color, areas of low-lying topography, and areas of historic high yields as reported by the farmer are designated as zones of potentially high productivity or high zones (Fleming et al., 1999; Khosla et al., 2002; Koch et al., 2004; Inman et al., 2005). We hypothesize that NDVI can be used in conjunction with soil-color based management zones to provide in-season estimates of grain yield in irrigated maize production systems.

Objectives:

(1) To examine the relationship between in-season normalized difference vegetation index, site-specific management zones, and relative maize yield.

(2) To determine if normalized difference vegetation index can be used to estimate relative maize yield.

(3) To determine if site-specific management zones can be used in conjunction with remote sensing to provide in-season yield estimates in irrigated maize.

MATERIALS AND METHODS

Study Sites

This study was conducted over six site-years on three irrigated continuous maize fields in eastern Colorado, USA. Site years I and IV were furrow irrigated and located on the Agricultural Research Development and Education Center near Fort Collins, Colorado. Site years II and V and III and VI were commercially operated center-pivot irrigated maize fields located near Wiggins and Yuma, Colorado, respectively. At each field location, experiments were conducted over two consecutive growing seasons.

Site years I and IV were mapped as Fort Collins loam (fine-loamy, mixed, superactive, mesic Aridic Haplustalf). The Fort Collins loam is a very deep, well drained soil that forms in mixed eolian sediments and alluvium and occurs on terraces, hills, plains, and alluvial fans (Soil Survey Staff, 1980).

Site years II and V had Bijou loamy sand (coarse-loamy, mixed, superactive, mesic, Ustic Haplargid), Truckton coarse loamy sand (coarse-loamy, mixed, superactive, mesic, Aridic Argiustoll), and Valentine fine sand (mixed, mesic, Typic Ustipsamment) soil series. These soils are very deep. The Truckton is well drained, Bijou is somewhat excessively drained, and the Valentine is excessively drained. Both Truckton and Bijou soils are derived from arkose parent material and occur on terraces, fans, and uplands. Valentine soils are eolian derived and occur on uplands (Soil Survey Staff, 1968).

Site years III and VI were located on a field that had Albinas loam (fine-loamy, mixed, superactive, mesic Pachic Argiustoll), Ascalon fine sandy loam (fine-loamy, mixed, superactive, mesic, Aridic Argiustoll), and Haxton loamy sand (fine-loamy, mixed, superactive, mesic Pachic Argiustoll) soil series. These soils are very deep, well drained, and have accumulated carbonates in the soil solum. The Ascalon series occurs on upland positions and is formed from calcareous parent material. The Haxtun series consist of eolian deposits that overlay buried soil, occurring in drainages and depressions. The Albinas series is alluvial and occurs on fans and terraces (Soil Survey Staff, 1981).

Experimental Procedure

Site years I and IV were planted with Garst hybrid 8802 at a row spacing of 76 cm and a planting density of 76,500 plants ha^{-1}. Site years II and V were planted with Pioneer hybrid 34G81 at 83,000 plants ha^{-1} with a row spacing of 76 cm. Site years III and VI were planted with Pioneer hybrid 33B50 at 84,000 plants ha^{-1} with a row spacing of 76 cm.

Soil-color based management zones were delineated using the commercially available AgriTrak Professional™ software for zone delineation (Fleming et al., 1999). This program relies on the following data layers: (i) bare soil aerial imagery of a conventionally tilled field; (ii) farmer's perception of field topography; and (iii) farmer's past crop and soil management experience. The management zone delineation process was as follows. Black and white aerial imagery was acquired in the spring (i.e., after tillage operations) by aircraft from an altitude of approximately 3100m. After image acquisition, we met with cooperating farmers to gather their input. Using the aerial imagery as a template, the cooperating farmers created polygons based on their knowledge and past management experiences with the fields. In other words, using a stylus, the cooperating farmers delineated areas of the fields that were consistently low yielding, consistently high yielding, areas that were upland positions and areas that were low lying or drainages. Following the farmer's input, the image was classified into three management zones (high, medium, and low) reflecting the relative productivity of each zone. Traits such as regions of dark color, areas of low-lying topography, and areas of historic high yields as reported by the farmer were designated as a zone of potentially high productivity or high zone (Fleming et al., 1999; Khosla et al., 2002; Koch et al., 2004; Inman et al., 2005).

During early vegetative growth (eight-leaf crop growth stage), remotely sensed imagery was acquired by aircraft using a DuncanTech MS 3100 digital camera. Remotely sensed imagery was acquired from an altitude of approximately 3100 m above the ground surface and had a spatial resolution of 1 meter. The DuncanTech MS 3100 is a high-resolution 3-chip digital camera that acquires multi-spectral imagery using a beam-splitting prism along with three charge-coupled imaging sensors. The DuncanTech MS 3100 acquires imagery in the 400 to 1100-nm range, with individual bands approximating the LandSat TM satellite bands 1 through 4. Geometric correction was performed on all imagery in ERDAS Imagine 8.6 (Leica Geosystems GIS & Mapping LLC, Atlanta, GA USA) using image-to-image registration; root mean square error was less than 1 pixel for all images. Radiance was converted to apparent reflectance using the histogram minimization method of Chavez (1975) in ERDAS Imagine software.

Grain was harvested at physiological maturity. Site years II, III, V, and VI were harvested using a combine equipped with a yield monitor and a differentially corrected global positioning system (DGPS) unit. Yield monitor data were cleaned by correcting errors associated with the changing speed of the combine, correcting for the width of the combine header, adjusting for the grain flow rate (lag errors), and removing other erroneous yield points (i.e., overlapping points and points that were outside of the field boundary) (Hornung et al. 2003, Hornung et al., 2006). Because site years I and IV were located on a small experimental field, grain was hand-harvested within each management zone using randomly located, geo-referenced sample locations. Each sample was replicated four times and consisted of two 1-m long sections of a maize row (Inman et al., 2005). All grain yield samples were air-dried to a constant weight and reported at 155 g kg^{-1} moisture.

For all site-years, remotely sensed imagery and grain yield data were re-sampled to a common spatial resolution of ten meters using cubic convolution. Each band (i.e., green, red, and near infrared) was overlain with the geo-referenced yield monitor data. Using ArcView 3.2, data was extracted pixel-by-pixel for each geographic location, thus for each pixel there was latitude, longitude, grain yield, reflectance in the green, red, and near infrared portions of the electromagnetic spectrum. From this large data set of $n > 30{,}000$, a random sub-sample of 2000 points was collected for regression model building and statistical analysis. Normalized difference vegetation index (NDVI) was calculated using Eq. 1.

$$NDVI = (NIR - R) / (NIR + R) \quad [Eq.1]$$

Where NIR = near infrared band and R = red band

The relative yield for a given observation was calculated by dividing the observed values by the maximum value for the site-year (Brouder et al., 2000).

Data Analysis

Objective 1: Analysis of variance (ANOVA) was used to determine if NDVI and grain yield were significantly different between management zones. When the ANOVA was significant at $p \leq 0.05$, Fishers LSD mean separation was performed. Because the data sets used in this study were large (e.g., > 30,000 data points) the F-tests used in ANOVA could give incorrect results, i.e., ANOVA could indicate a significant difference when in reality the difference is very small and not "agronomically" significant. For this reason the large data sets were re-sampled. The following procedure was used to determine the optimum sample size for ANOVA and LSD (Hornung, 2004). Subsets of 10, 20, 30, 40, and 50 data points were randomly selected from each dataset. Bootstrapping, with 5000 iterations was used to obtain an estimate of the mean and variance from each subset (Efron and Tibshirani, 1993). Bootstrapping is a re-samping procedure used to estimate the sampling distribution of an estimator via re-samping with replacement from the original sample (Neter et al., 1996). In bootstrapping, sub-samples of the original data are repeatedly analyzed. Each sub-sample is a random sample with replacement from the full dataset (Efron and Tibshirani, 1993). Secondly, ANOVA was performed for each sub-sample data set. The estimates of the mean and variance were compared to the population mean and variance. The sub-sample with the least bias, i.e., with a mean closest to the population mean and the least variance (MSE from ANOVA) was selected as the optimum sub-sample size for analysis.

The relationship between NDVI determined early in the growing season, site-specific management zones, and relative maize yield was quantitatively compared using K-means clustering, percent areal agreement, and Kappa statistics. K-means clustering was used to group the data into three NDVI clusters and three relative yield clusters using

Splus 6.2 (Insightful corp. Seattle, WA, USA). Three clusters were chosen to correspond to the number of management zones. Clusters were then quantitatively compared to management zones using percent areal agreement and Kappa statistics (Campbell, 2002). Percent areal agreement and Kappa are calculated using an x-by-x "error matrix" in which x is the number of categories (Campbell, 2002). In our study, we wanted to determine how management zones (high, medium, and low) compare to high, medium, and low NDVI clusters as well as high, medium, and low relative yield clusters. Percent areal agreement is an overall measure of how well the categories of an error matrix correspond to each other. Campbell (2002) stated that even a chance assignment of pixels to categories can produce very high percent areal agreement. The Kappa statistic is a more robust measure of the success of a classification because it adjusts for chance agreement (i.e., a random classification). The Kappa statistic is interpreted as how well a classification performs as compared to a chance classification of the same data set. More detailed information regarding the calculation, use, and interpretation of the Kappa statistic is provided in Campbell (2002) and Landis and Koch (1977).

Objective 2: Least squares regression analysis was used to determine if NDVI can be used to estimate relative maize yield.

Objective 3: Least squares regression analysis with indicator variables was used to determine if site-specific management zones can be used in conjunction with remote sensing to provide early-season yield estimates (SAS Institute, 2001). Indicator variables were used in the regression models to account for site-specific management zones (i.e., high, medium, and low) and site-years. Indicator variables are one means of quantifying categorical data within regression analysis (Neter et al., 1996). For this study, binary variables were assigned to each management zone and each site year and included as independent variables in the regression analysis (e.g., $X_1 = 1$ if high zone, $X_1 = 0$ otherwise; $X_2 = 1$ if medium zone, $X_2 = 0$ otherwise, $X_3 = 1$ if site year 1, $X_3 = 0$ otherwise, etc.). Neter et al. (1996) provide a complete explanation of the use and interpretation of indicator variables in regression modeling.

Regression Model Selection and Validation

The following regression model selection and validation procedures were used for regression models developed for objectives 2 and 3 of this study. Regression model selection was accomplished through the All Possible Regression procedure (SAS Institute, 2001). Significance of each regression model was tested using an F-test for lack of fit (Neter et al., 1996). Significance of the independent variables, in each model, was tested to determine if they were significantly different than zero, using a two-tailed t-test. Regression parameters were considered to be significant at $p \leq 0.05$ level of significance. Independent variables that were significant at the $p \leq 0.05$ level of significance were retained in the model. Residuals of the regression models were evaluated via residual plots and normality testing using the Shapiro-Wilk test (Neter et al., 1996). Moran's I was also used to test for spatial auto-correlation in the residuals (Cressie, 1993). Observations that were potential outliers were tested using a t-test of studentized deleted residuals, the critical probability level was determined using Bonferroni joint estimation procedure; true outliers were removed from the regression models and the regression models were re-evaluated (Neter et al., 1996).

The Jackknife procedure (Efron, 1982) was used to obtain residual estimates and to validate the regression models for site years I and IV. Jackknifing is a non-parametric method for estimating the sampling distribution of a statistic. The procedure works by computing the statistic of interest with an element deleted; it repeats this process "n" times, where "n" is equal to the number of elements in the dataset. In contrast to Bootstrapping, the Jacknife procedure works with *subsets* of the data set as opposed to *sub-samples* of the data. Where each subset has one randomly chosen element deleted. The Jackknife procedure was chosen for site years I and IV only, because of the limited data set available for these site years. For site years II, III, V, and VI cross-validation of the regression models was performed using the "holdout method" (Neter et al., 1996). This method of cross-validation involves splitting the data into "*regression model building*" and "*regression model testing*" subsets. For this study, both the *regression model building* and *regression model testing* subsets consisted of n=2000 data points. The best-fit regression models were used with the *regression model testing* subset to make grain yield estimates. The estimated grain yield data were then compared to the observed grain yield data from the *regression model testing* subset; the difference from the observed and the predicted values were used to calculate the *mean squared prediction error* (MSPR). To asses the performance of the regression models, the MSPR was compared to the *mean squared error* (MSE) from the best-fit regression model; ideally the MSE and MSPR should be similar (Neter et al., 1996). Regression model bias was also calculated from the predicted values derived from the regression model testing subset; bias estimates were tested using a two-sided t-test to determine if the bias was significantly different from zero.

RESULTS AND DISCUSSION

NDVI, SSMZ, and Relative Grain Yield

Results of the sub-sampling and the bootstrapping procedure are presented in Tables 2.1 and 2.2. Overall, a sub-sample of 30 was chosen for ANOVA and mean separation procedures. Across site years, sub-samples of 30 produced estimates of the mean and variance that was closest to the population mean and variance.

Results of ANOVA and mean separation for NDVI across management zones are presented in Figure 2.1. Across management zones, NDVI was found to be statistically different. In four out of six site years, the NDVI increased with the productivity potential of the management zones. These results suggest that areas of higher productivity potential have higher NDVI, perhaps because of more robust crop growth due to better growing conditions. Mzuku et al. (2005) showed that soil color based management zones differ on the basis of soil texture, organic matter, and soil moisture. Comparing the NDVI results to the ANOVA and mean separation performed on grain yield across management zones (Figure 2.2), the trends are similar. Grain yield was significantly different across management zones in four out of six site years. When comparing plots of NDVI across management zones to plots of grain yield across management zones, statistical differences are nearly identical. These results agree with those of Ma et al. (2001) and

Table 2.1. Comparison of population means and population variances with sub-sample means and sub-sample variances of NDVI for site year II.

Zone	Sub-sample Size	Sub-sample Mean	Population Mean	Sub-sample Mean Variance	Population Mean Variance
			NDVI		
	10	0.243		0.016	
	20	0.234		0.015	
Low	30	0.257	0.265	0.014	0.014
	40	0.256		0.012	
	50	0.247		0.014	
	10	0.293		0.008	
	20	0.314		0.009	
Medium	30	0.325	0.328	0.009	0.007
	40	0.325		0.009	
	50	0.322		0.011	
	10	0.331		0.010	
	20	0.346		0.009	
High	30	0.322	0.319	0.007	0.005
	40	0.328		0.004	
	50	0.351		0.006	

Table 2.2. Comparison of population means and population variances with sub-sample means and sub-sample variances of grain yield for site year VI.

Zone	Sub-sample Size	Sub-sample Mean	Population Mean	Sub-sample Mean Variance	Population Mean Variance
	------------------	------------------	Mg ha^{-1}	------------------	------------------
	10	7.53		1.53	
	20	7.89		1.29	
Low	30	7.97	7.98	1.32	1.28
	40	7.74		1.32	
	50	7.73		1.31	
	10	8.63		1.30	
	20	8.35		1.25	
Medium	30	8.32	8.31	1.01	1.02
	40	8.42		1.00	
	50	8.44		1.00	
	10	8.38		0.62	
	20	8.48		0.46	
High	30	8.13	8.01	0.59	1.04
	40	8.41		1.01	
	50	8.16		0.78	

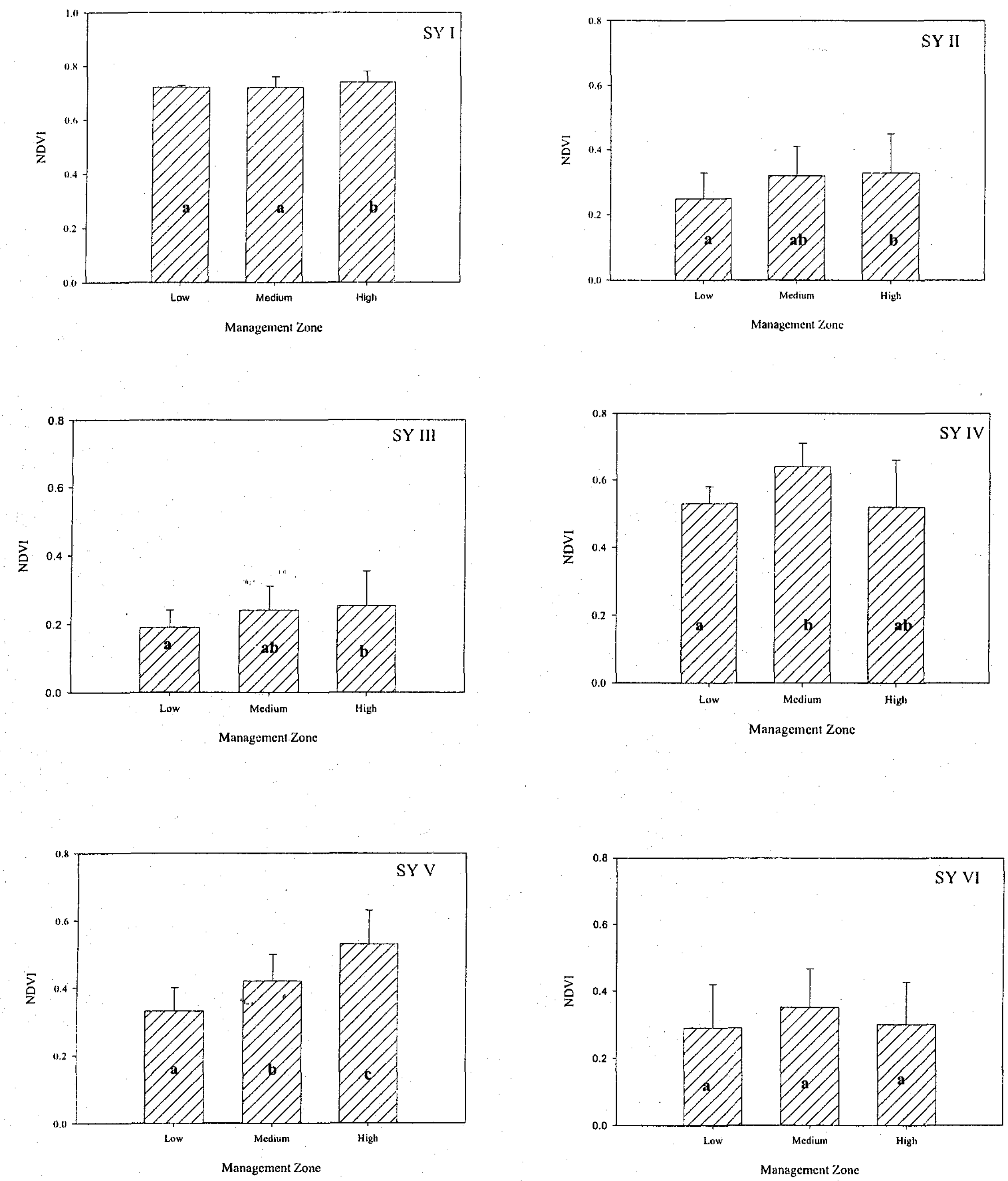


Figure 2.1. Mean NDVI across management zones for all site years. Within a site-year bars with different letters are significantly different at $p \leq 0.05$ level of significance.

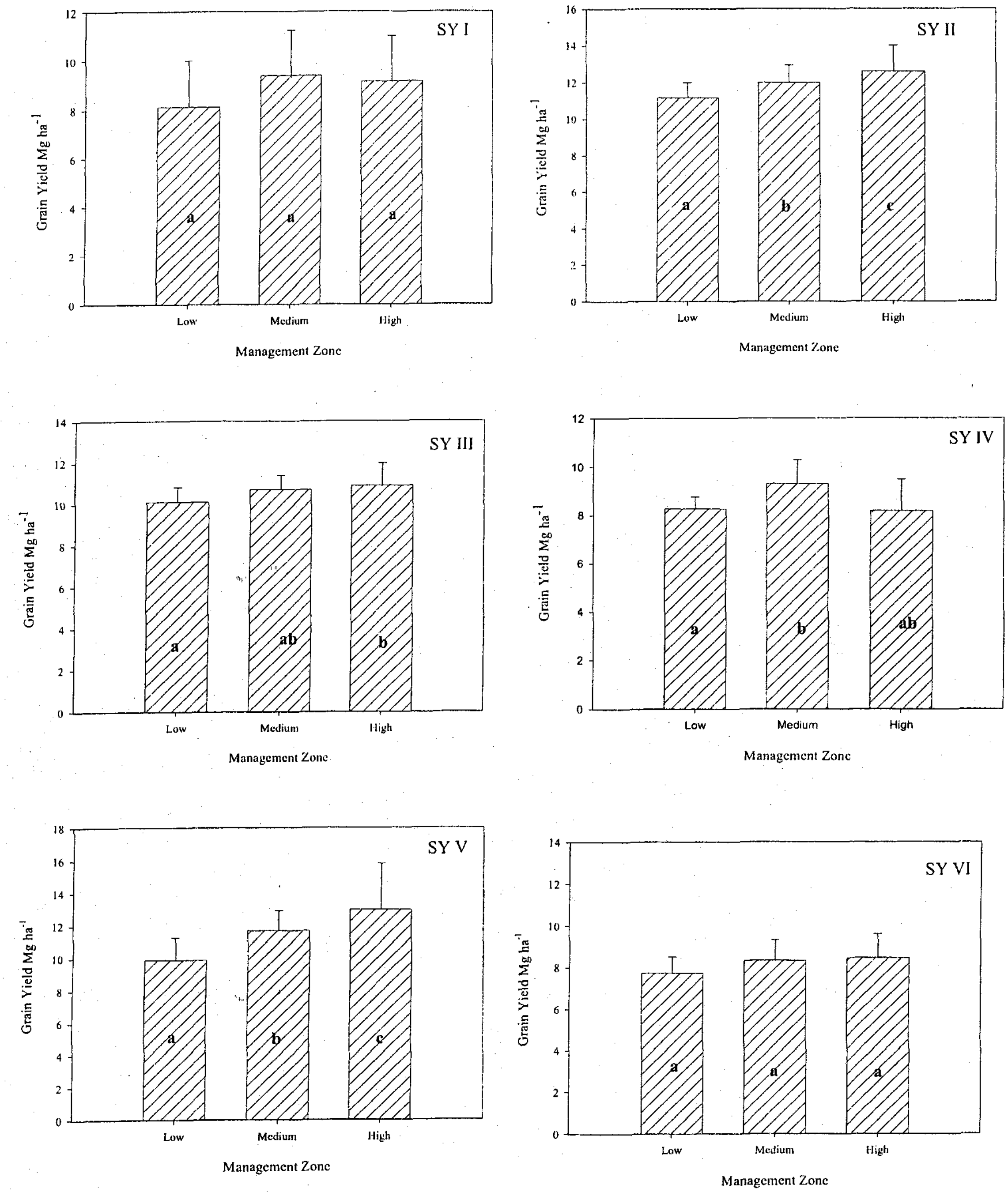


Figure 2.2. Mean grain yield across management zones for all site years. Within a site-year bars with different letters are significantly different at $p \leq 0.05$ level of significance.

suggest that trends in NDVI at the eight leaf crop growth stage are similar to trends in harvested grain yield.

Maps of management zones, relative yield, and NDVI for site year III are presented in Figure 2.3. Percent areal agreement and corresponding Kappa statistics for areal comparisons between management zones, relative yield, and NDVI are presented for each site-year in Table 2.3. Landis and Koch (1977) provide a general framework for interpreting the strength of agreement using Kappa statistics; these guidelines are provided in Table 2.4. Relative yield and NDVI had the strongest areal association across site-years. Percent areal agreement ranged from 40 to 75% and Kappa statistics ranged from 0.10 to 0.63 (Table 2.1). Based on the guidelines of Landis and Koch (1977), these results show that in-season NDVI has a fair to substantial agreement (Table 2.4) with relative grain yield in five out of six site years. Overall these results suggest that the spatial pattern of NDVI determined at the eight-leaf crop growth stage corresponds to the spatial pattern of relative grain yield. These results were sensible because NDVI has been shown to be an effective index for inferring leaf area index and biomass as well as other biophysical variables (Sellers, 1985; Peñuelas et al., 1994; Thenkabail et al., 2000; Garty et al., 2001; Ma et al., 2001; Raun et al., 2001; Aparicio et al. 2002; Báez-González et al., 2002; Campbell, 2002). There is a strong relationship between crop growth (i.e., vigor) and crop yield, and hence it is logical that areas of the field with more biomass (as determined by NDVI) will likely produce more grain yield, as was the case in this study (Serrano et al., 2000).

Percent areal agreement between relative yield and SSMZ ranged from 26 to 57 % (Table 2.3) across all sites years. While Kappa statistics ranged from -0.15 to 0.25

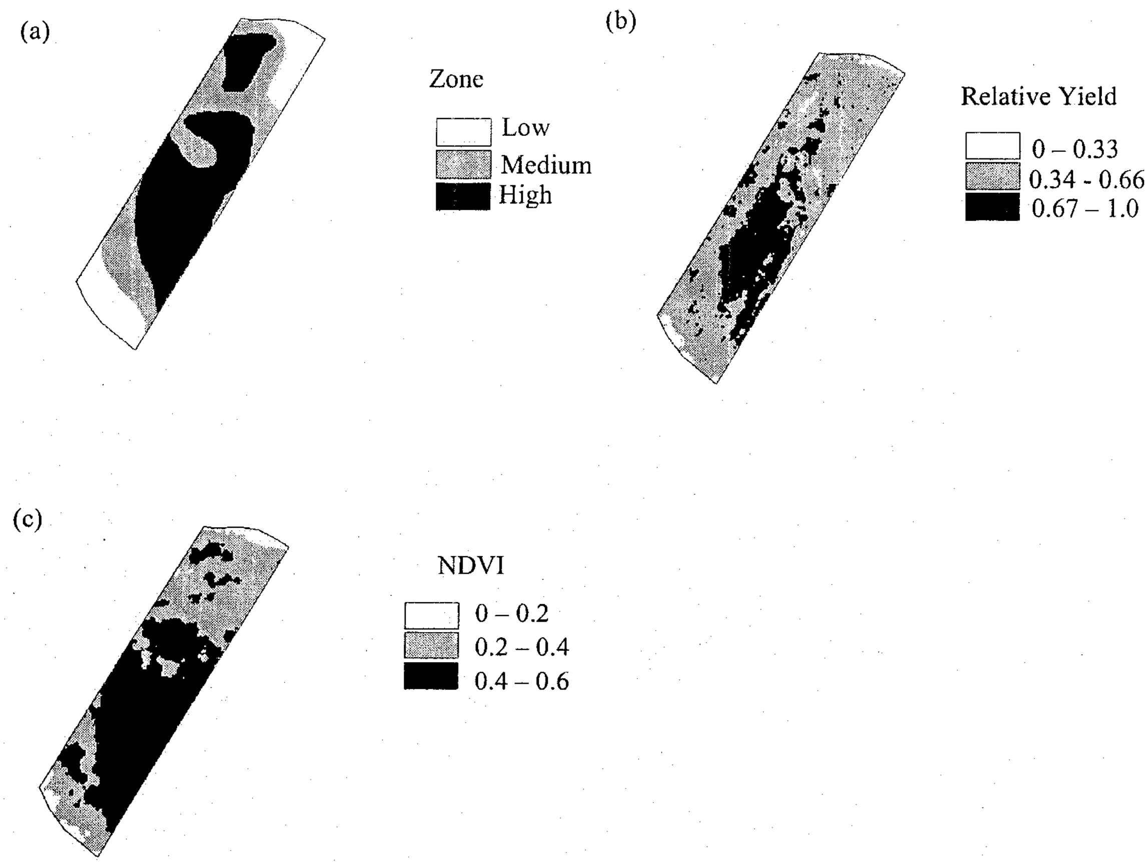


Figure 2.3. Maps showing (a) management zones, (b) relative yield, and (c) normalized difference vegetation index (NDVI) for site year III.

(Table 2.3), indicating a poor to fair agreement. Four out of six site years had a slight to fair agreement between relative yield and SSMZ. Similar results have been reported in Hornung et al. (2006). Likewise, across all site years, areal agreement between NDVI and SSMZ was poor to moderate, as indicated by Kappa statistics (Table 2.3). Four out of six site years had slight to moderate agreement. Water stress likely influenced the results from site years I and IV. Studies have reported that, under stress, crops exhibit decreased NIR reflectance and increased red reflectance; thus decreasing the overall NDVI (Ma et al., 2000; Peñuelas et al., 1997; Gamon et al., 1992). Field observations from site years I and IV indicated that the high zone experienced some water stress. Normalized difference vegetation index acquired at the eight-leaf crop growth stage is affected by intra-seasonal variability; hence the spatial distribution of NDVI will likely deviate, to some degree, from the SSMZ, which were delineated prior to planting.

Table 2.3. Areal agreement and kappa statistics between relative yield (RY), normalized difference vegetation index (NDVI), and site-specific management zones (SSMZ) for all site years.

	Site Year					
	I	II	III	IV	V	VI
Comparison	% Areal Agreement					
RY & NDVI	40	55	51	75	57	68
RY & SSMZ	26	48	46	25	57	44
NDVI & SSMZ	13	50	43	33	67	41
	Kappa Statistic					
RY & NDVI	0.10	0.28	0.22	0.63	0.26	0.52
RY & SSMZ	-0.10	0.16	0.20	-0.15	0.25	0.10
NDVI & SSMZ	-0.25	0.24	0.16	0	0.43	0.12

Table 2.4. Guidelines for interpreting kappa statistics. From Landis and Koch (1977).

Kappa Statistic	Strength of Agreement
< 0	Poor
0 – 0.20	Slight
0.21 – 0.40	Fair
0.41 – 0.60	Moderate
0.61 – 0.80	Substantial
0.81 – 1.0	Almost Perfect

NDVI and Grain Yield Estimates

Scatter plots of NDVI versus relative yield are presented in Figure 2.4. From the scatter plots, trends between NDVI and relative yield are evident. Visually, observed trends between NDVI and relative yield appear somewhat dissimilar across site years. Regression model results are presented in Table 2.5. Regression model coefficients were statistically different between site years ($p < 0.05$), indicating that the relationship between NDVI and maize yield is indeed different between site years. Similar results were reported by Ma et al. (2001) in which it was shown that NDVI- soybean yield regression model parameters were not stable across study sites and growing seasons. Regression model parameters and NDVI-yield relationships are apt to change across sites and growing seasons because of a myriad of interacting factors such as soil type, canopy structure, yield potential, and productivity (Ma et al., 2001) as well as hybrid differences (Ma et al., 2001; Shanahan et al., 2001). Likewise, in this study, it is likely that the differences between site years are due, in large part, to differences in soil types and maize cultivars. These results indicate that NDVI/yield relationships are site-specific and underscore one potential limitation with regard to using NDVI for large-scale (i.e., regional) yield estimates.

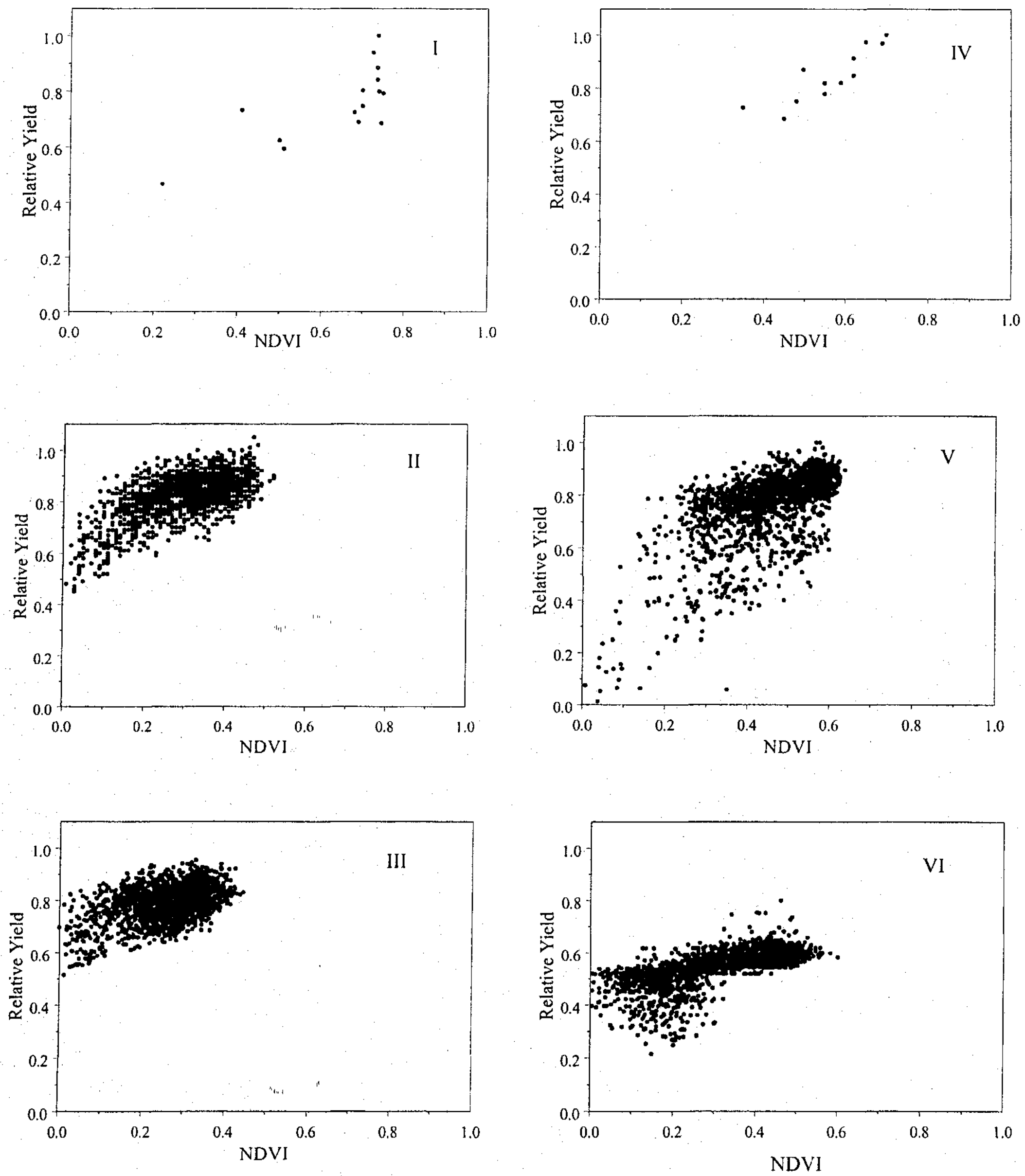


Figure 2.4. Scatter plots of normalized difference vegetation index (NDVI) versus relative yield for all sites years. Site years are designated by roman numeral in the upper right-hand portion of each scatter plot.

Table 2.5. Regressing relative yield on normalized vegetation index (NDVI). Regression model, coefficient of determination, Moran's I of the residuals, mean squared error (MSE), mean squared error of prediction as determined from cross validation, bias of prediction, and p value of bias (i.e., H_o bias = 0, H_a bias ≠ 0). Regression models were significant at $P < 0.01$.

Site Year	Model	R^2	Morans's I (ε_i)	MSE	MSPR	Bias (%)	Bias p-value
I	$\hat{Y} = 0.43 + 0.26(NDVI) + 0.38(NDVI)^2$	0.57	Ns[†]	0.009	0.007	0.1	Ns
II	$\hat{Y} = 0.57 + 1.37(NDVI) - 1.55\ (NDVI)^2$	0.44	Ns	0.052	0.061	6.9	<0.01
III	$\hat{Y} = 0.63 + 1.31(NDVI) - 3.9\ (NDVI)^2 + 5.05(NDVI)^3$	0.25	Ns	0.006	0.007	0.2	Ns
IV	$\hat{Y} = 1.0 - 1.6(NDVI) + 2.29(NDVI)^2$	0.82	Ns	0.002	0.001	0.3	Ns
V	$\hat{Y} = 0.18 + 2.03(NDVI) - 1.53(NDVI)^2$	0.42	Ns	0.011	0.013	1.5	<0.01
VI	$\hat{Y} = 0.49 - 0.57(NDVI) + 3.9\ (NDVI)^2 - 4.6(NDVI)^3$	0.47	Ns	0.003	0.005	0.1	Ns

[†] Ns = Not significant at $p < 0.05$

Regression models were significant at the $p < 0.05$ level of significance and the coefficients of determination (R^2) associated with the regression models ranged from 0.25 to 0.82 (Table 2.5). These results agree with Ma et al. (2001), in which they reported that soybean yield and NDVI had R^2 values ranging from 0.45 to 0.80. Similarly, Shanahan et al. (2001) reported correlation coefficients as high as 0.78 for maize yield and NDVI, determined at the six leaf growth stage. For all regression models evaluated, the MSPR and MSE were similar, thus indicating that the NDVI-relative yield regression models provide good estimates of relative maize yield within a given study site and growing season (Table 2.5). Regression model bias was not significantly different from zero for four out of six site years. Gauch and Zobel (1988) suggest that "predictive" evaluation (e.g., MSPR) of a regression model is a more informative evaluation criterion than a "postdictive" evaluation (i.e., coefficient of determination). Based on these "*predictive*" criteria, NDVI from aerial imagery does have potential to be used as a tool for estimating grain yield in irrigated maize on a site-specific basis.

SSMZ and Grain Yield Estimates

Indicator variables accounting for SSMZ were found to be statistically significant, in three out of six site years, meaning that NDVI values were different between SSMZ (Table 2.6). The management zone delineation technique used in this study has been shown to accurately characterize soil properties such as soil texture and organic matter (Mzuku et al., 2005). Ma et al. (2001) found that soil type (i.e., clay loam and a sandy loam) can significantly affect the statistical relationship between soybean yield and NDVI. Vegetation indices that are soil-adjusted (e.g., SAVI) are used to remove the

Table 2.6. Regressing relative yield on normalized difference vegetation index with the inclusion of indicator variables to account for site-specific management zones. Site year, regression model, mean squared error (MSE), and coefficient of determination (R^2) are presented. Only site years where indicator variables were significant are presented. All regressions presented are significant at $p < 0.05$.

Site Year	Model	MSE	R^2
II	$\hat{Y} = 0.63 - 1.15(NDVI) - 1.23(NDVI)^2 - 0.05(LZ^{\dagger}) - 0.03(MZ^{\dagger})$	0.057	0.49
III	$\hat{Y} = 0.67 + 1.3(NDVI) - 4.17\ (NDVI)^2 - 0.05(NDVI)^3 - 0.05(LZ) - 0.014(MZ)$	0.06	0.34
V	$\hat{Y} = 0.23 + 2.01(NDVI) - 1.61(NDVI)^2 - 0.03(LZ) - 0.02(MZ)$	0.1	0.43

† LZ: indicator variable for the low management zone; MZ indicator variable for the medium management zone.

influence of soil reflectance from that of the canopy reflectance. While our approach does not completely remove reflectance attributed to soil, it does adjust the overall regression model to account for differences in NDVI between the SSMZ. The inclusion of indicator variables to account for SSMZs in the regression models developed in this study did improve the coefficient of determination in all six cases.

In addition to analyzing each site year individually, data were pooled by site and analyzed further. Combined regression model analysis results are presented in Table 2.7. Regression models were significant at the $p < 0.05$ level of significance. Coefficients of determination for the combined regression models ranged from 0.47 to 0.79. For all site years, indicator variables that accounted for the site year were found to be statistically significant (Table 2.7). These results further indicate that NDVI-based yield regression model parameters are not stable over short time periods (i.e., over two growing seasons). The MSPR and MSE from the combined regression models were similar in two out of three cases. Combined regression models for site years I and IV and site years II and V did not have significant bias in the grain yield estimates, indicating that the models are providing accurate estimates of grain yield. The coefficient of determination associated with the combined regression model from site years III and VI was 0.79. A plot of predicted grain yield values versus the regression model residuals as well as a histogram of the regression model residuals associated with the combined regression model for site years III and VI is presented in Figure 2.5. Overall, the combined regression models explained more variability than the individual regression models (R^2 = 0.47 to 0.79, Table 2.5). These results suggest that site-specific NDVI regression models can be developed over time to estimate grain yield in irrigated maize.

Table 2.7. Regressing relative grain yield on normalized difference vegetation index (NDVI). Combined regression models††, associated coefficient of determination, Moran's I statistic for the residuals, mean squared error (MSE), mean squared error of prediction as determined from cross validation, bias of prediction, and p value of bias (i.e., H_o bias = 0, H_a bias $\neq$ 0).. Regression models were significant at $P < 0.01$.

Site Year	Model	R^2	Morans's I (ε_i)	MSE	MSPR	Bias (%)	Bias p-value
I & IV	$\hat{Y} = 0.48 + .16(SY4^{\dagger}) + 0.097(NDVI) + 0.77(NDVI)^2$	0.67	Ns‡	0.006	0.005	0.3	Ns
II & V	$\hat{Y} = 0.31 + 1.31\ (NDVI) - 0.61(NDVI)^2 + 0.32(SY2^{\dagger}) - 0.51\ (SY2\ NDVI) - 0.13(Y1\ NDVI)^2$	0.57	Ns	0.008	0.007	1.3	NS
III & VI	$\hat{Y} = 0.46 - 0.06(NDVI) + 1.9(NDVI)^2 - 2.3(NDVI)^3 + 0.25(SY3^{\dagger}) + 0.74(SY3\ NDVI)^2 - 1.96(SY3\ V\ NDVI)^3$	0.79	Ns	0.006	0.044	13.0	0.01

† Indicator variables are as follows: SY2 = site year II, SY3 = site year III, and SY4 = site year IV.
†† Regression models were combined for site years located on the same field across consecutive growing seasons.
‡ Ns = Not significant at $p < 0.05$

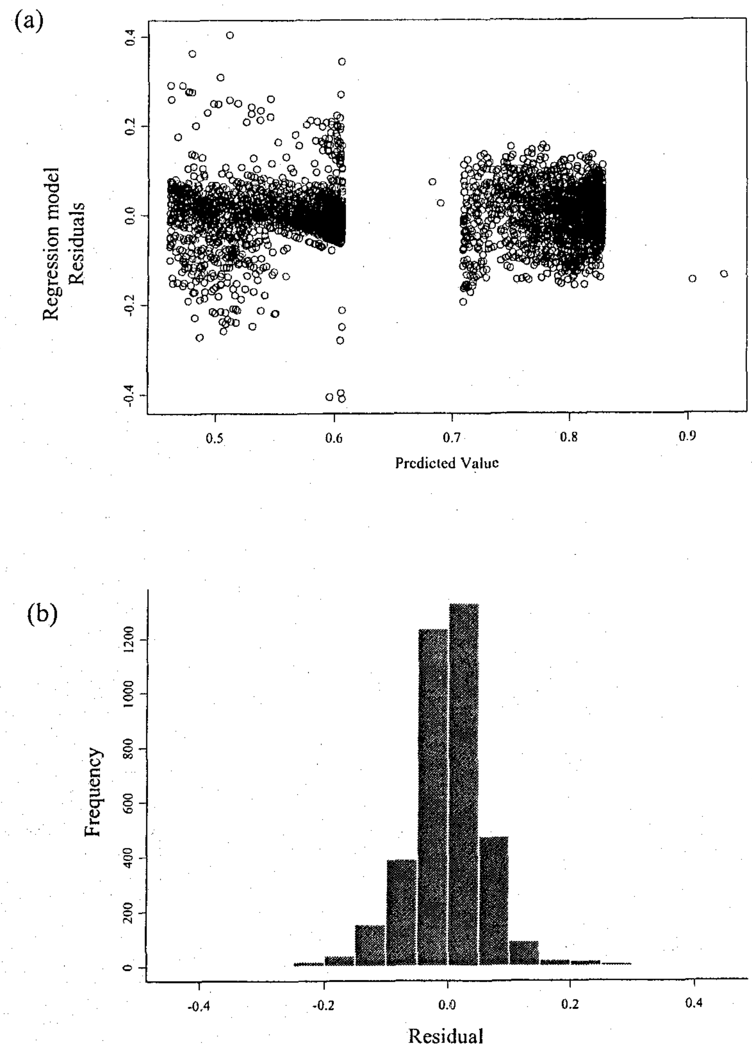


Figure 2.5. Residual versus predicted value plot (a) and histogram plot of the residuals (b) associated with the combined relative yield and NDVI regression model from site years III and VI.

CONCLUSIONS

In this study, NDVI and grain yield were found to be significantly different across site-specific management zones. Across management zones, NDVI and grain yield followed similar trends. Areal comparisons indicated that early-season NDVI can have substantial agreement with relative maize yield. Areal agreement between relative maize yield and management zones as well as NDVI and management zones was not as strong. Early season NDVI was found to provide good estimates of relative maize yield on a site-specific basis. Between management zones NDVI was variable; however, management zones did not significantly improve the grain yield estimates. Individual site year relative yield regression models were found to be site-specific. When relative yield regression models were grouped together by site year they were improved. Overall, our study demonstrates the potential of using remote sensing during the early growing season to make grain yield estimates in irrigated maize. More work should be done, especially over time on the same fields, to further develop the potential of using NDVI for early-season estimation of yield in irrigated maize.

REFERENCES

Aparicio, N., D. Villegas, J.L. Araus, J. Casadesús, and C. Royo. 2002. Relationship between growth traits and spectral vegetation indices in Durum Wheat. Crop Sci. 42:1547-1555.

Báez-González, A.D., P. Chen, M. Tiscareño-López, and R. Srinivasan. 2002. Using satellite and field data with crop growth regression modeling to monitor and estimate maize yield in Mexico. Crop Sci. 42:1943-1949.

Baret, F., G. Guyot, and D.J. Major. 1989. TSAVI: a vegetation index which minimizes soil brightness effects on LAI and APAR estimation. P. 1355-1358. *In:* Proc. IGARRS '89 Can. Symp. Remote Sensing, 12th, Vancouver, BC, Canada. 10-14 July 1989.

Brouder, S.M., D.B. Mengel, and B.S. Hofmann. 2000. Diagnostic efficiency of the blacklayer stalk nitrate and grain nitrogen tests for maize. Agron. J. 92:1236-1247.

Campbell, J.B. 2002. Introduction to remote sensing 3rd ed. The Guilford Press. New York, New York, USA.

Chavez, P.S. 1975. Atmospheric, Solar, and M.T.F. Corrections for ERTS Digital Imagery. Proceedings, American Society of Photogrammetry, Bethesda, MD. Am. Soc. Photogramm. and Remote Sens. pp. 724-932.

Colwell, R.W. 1956. Determining the prevalence of certain cereal crop diseases by means of aerial photography. Hilgardia 26: 223 – 286.

Cressie, N. 1993. Statistics for spatial data: revised edition. Wiley and Sons, New York, NY, USA.

Doerge, T. 1999. Defining management zones for precision farming. Crop Insights. 8(21): 1-5.

Efron, B. 1982. The Jackknife, the bootstrap and other resampling plans. Society of Industrial and Applied Mathmatics, Philadelphia, PA, USA.

Efron, B., and R.J. Tibshirani. 1993. An Introduction to the Bootstrap. Chapman and Hall Publishers, New York, NY.

Fleming, K.L., D.G. Westfall, D.W. Wiens, L.E. Rothe, J.E. Cipra, and D.F. Heermann. 1999. Evaluating farmer developed management zone maps for precision farming. p.335-343. *In*: P.C. Robert, R.H. Rust, and W.E. Larson (eds) Precision Agriculture. Proceedings of the 4th Intl. Conf., ASA, CSSA, and SSSA, Madison, W.I.

Franzen D.W., D.H. Hopkins, M.D. Sweeney, M.K. Ulmer, and A.D. Halvorson. 2002. Evaluation of soil survey scale for zone development of site-specific nitrogen management. Agron. J. 94:381-389.

Fridgen, J.J., N.R. Kitchen, and K.A. Sudduth. 2000. Variability of soil and landscape attributes within sub-field management zones. *In* P.C. Roberts et al. (ed.) Precision agriculture. Proc. Int. Conf., 5th, Bloomington, MN. 16-19 July 2000. ASA, CSSA, and SSA, Madison, WI.

Frink, C.R., P.E. Waggoner, and J.H. Ausubel. 1999. Nitrogen fertilizer: retrospect and prospect. Proc. Natl. Acad. Sci. USA. 96:1175-1180.

Gamon, J.A., J. Peñuelas, and C.B. Field. 1992. A narrow-waveband spectral index that tracks diurnal changes in photosynthetic efficiency. Remote Sens. Environ. 41:31-44.

Garty, J., O. Tamir, L. Hassid, A. Eshel, Y. Cohen, A. Karnieli, and L. Orlovsky. 2001. Photosynthesis, chlorophyll integrity, and spectral reflectance in lichens exposed to air pollution. J. Environ. Qual. 30:884-893.

Gauch, H.G., and R.W. Zobel. 1988. Predictive and postdictive success of statistical analysis of yield trials. Theo. Genet. 76:1-10.

Hardy, R.W.F., and U.D. Havelka. 1975. Nitrogen fixation research: a key to world food? Science. 188:633-643.

Hoffer, R.M. 1967. Interpretation of remote multispectral imagery of agricultural crops. Res. Bull. 831. Purdue Univ. Agric. Exp. Stn., West Lafayette, IL.

Hornung, A, R. Khosla, R. Reich, and D.G. Westfall. 2003. Evaluation of site-specific management zones: Grain yield and nitrogen use efficiency. P. 297-302. *In*: Stafford, J. and A. Werner (eds) Precision Agriculture. Wagenigen Academic Publishers. Wagenigen, The Netherlands.

Hornung, A. 2004. Development and evaluation of site-specific management zones in irrigated maize (*Zea Mays L.*). M.S. Thesis. Colorado State University, Fort Collins, CO.

Hornung, A, R. Khosla, R. Reich, D. Inman, and D.G. Westfall. 2006. Comparison of site-specific management zones: soil-color based and yield-based. Agron J.98: 407 - 415.

Huete, A.R. 1989. A soil-adjusted vegetation index (SAVI). Remote Sens. Environ. 25:295-309.

Inman, D., R. Khosla, and D.G. Westfall. 2005. Nitrogen uptake across site-specific management zones in irrigated corn production systems. Agron. J. 97. 169-176.

Khosla, R., K. Fleming, J.A. Delgado, T. Shaver, and D.G. Westfall. 2002. Use of site-specific management zones to improve nitrogen management for precision agriculture. J. Soil and Water Conserv. 57 (6): 515-518.

Koch. B., R. Khosla, M Frasier, D.G. Westfall, and D. Inman. 2004. Economic feasibility of variable rate nitrogen application utilizing site-specific management zones. Agron. J. 96: 1572-1580.

Landis, R.J. and G.G. Koch. 1977. The measurement of observer agreement for categorical data. Biometrics. 33: 159 – 174.

Ma, B.L., L.M. Lianne, M. Dwyer, C. Costa, E.R. Cober, and M.J. Morrison. 2001. Early prediction of soybean yield from canopy reflectance measurements. Agron. J. 93:1227-1234.

Miao , Y., D.J. Mulla, and P.C. Robert. 2005. Combining soil-landscape and spatial-temporal variability of yield information to delineate site-specific management zones. P. 811-818. *In*: J.V. Stafford (ed) Precision Agriculture '05. Wageningen Academic Publishers. Wageningen, The Netherlands.

Mzuku, M, R. Khosla, R. Reich, D. Inman, F. Smith, and L. MacDonald. 2005. Spatial variability of measured soil properties across site-specific management zones. Soil Sci. Soc.Am. J. 69:(In-Press)

Neter, J., M.H. Kunter, C.J. Nachtscheim, and W. Wasserman. 1996. Applied Linear Regression models 4th ed. McGraw-Hill/Irwin publishers, Chicago, Il USA.

Peñuelas, J., J.A. Gamon, A.L. Fredeen, J. Merino, and C.B. Field. 1994. Reflectance indices associated with physiological changes in nitrogen- and water-limited sunflower leaves. Remote Sens. Environ. 48:135-146.

Raun, W.B. and G.V. Johnson. 1999. Improving nitrogen use efficiency for cereal production. Agron. J. 91:357-363.

Raun, W.R., J.B. Soile, G.V. Johnson, M.L. Stone, E.V. Lukina, W.E. Thomason, and J.S. Schepers. 2001. In-season prediction of potential grain yield in winter wheat using canopy reflectance. Agron. J. 93:131-138.

Rondeaux, G., M. Steven, and F. Baret. 1996. Optimization of soil adjusted vegetation indices. Remote Sens. Environ. 55:95-107.

SAS Institute. 2001. Statistical Analysis Software Version 8. SAS Institute, Cary, NC. USA.

Sellers, P.J. 1985. Canopy reflectance, photosynthesis, and transpiration. Int. J. Remote Sens. 6:1335-1372.

Serrano, L, I. Filella, and J. Peñuelas. 2000. Remote sensing of biomass and yield of winter wheat under different nitrogen supplies. Crop Sci. 40:723-731.

Shanahan, J.F., J.S.Schepers, D.D. Francis, G.E. Varvel, W.W. Wilhelm, J.M. Tringe, M.R. Schlemmer, and D.J. Major. 2001. Use of remote-sensing imagery to estimate corn grain yield. Agron. J. 93:583-589.

Shapiro, S.S. and Wilk, M.B. 1965. An analysis of variance test for normality. Biometrika. 52: 591 – 611.

Soil Survey Staff. 1968. Soil Survey of Morgan County, Colorado. Gov. Print. Office, Washington, D.C.

Soil Survey Staff. 1980. Soil Survey of Larimer County, Colorado. Gov. Print. Office, Washington, D.C.

Soil Survey Staff. 1981. Soil Survey of Yuma County, Colorado. Gov. Print. Office, Washington, D.C.

Thenkabail, P.S., R.B. Smith, and E. DePauw. 2000. Hyperspectral Vegetation Inicies and their relationships with agricultural crop characteristics. Remote Sens. Environ. 71:158-182.

CHAPTER 3

Grain Yield Estimation in Irrigated Maize through Active Remote Sensing

ABSTRACT

Uniform N fertilizer applications have been shown to be inefficient. Advances in agricultural technology have led to the development of active remote sensing equipment that can potentially optimize N fertilizer inputs. The objective of this study was to evaluate the effectiveness of using a hand-held active remote sensing instrument to estimate yield potential in irrigated maize. This study was conducted over four site years on two irrigated maize fields in Eastern Colorado. At the eight-leaf crop growth stage, the GreenSeeker™ active remote sensing unit was used to measure red and near infrared reflectance of the crop canopy. Pre-sidedress soil nitrate samples (PSNT) were collected from the plots at the time of sensing. Normalized difference vegetation index was calculated from the reflectance data and normalized by dividing by the number days from planting to sensing, where growing degrees were greater than zero. A response index (RI) was calculated as the ratio of the reflectance of an area of interest to the reflectance of an N-rich portion of the field. Regression analysis was used to model grain yield. Grain yields ranged from 5 to 24 Mg ha^{-1}. Coefficient of determination ranged from 0.10 to 0.76. Site years I and III were modeled and cross validated using data from site years II and IV. The coefficient of determination of the best fit model for site years I and III was 0.54. The response index was not a good indicator of PSNT, however, the RI did have a significant relationship with observed grain yield (R^2 = 0.65). Results of this study show

that active remote sensing has potential to be used for in-season estimation of grain yield in irrigated maize.

INTRODUCTION

Improving nitrogen-use efficiency (NUE) could potentially improve farm profitability and lessen the environmental impact associated with large-scale production agriculture. If future worldwide food demands are to be met, in an efficient manner, improvements in nitrogen (N) management need to be made. The long-term effects of low NUE in cereal crops as well as other crops could be serious with regard food supplies and land-use (Frink et al., 1999). Scharf and Alley (1995) stated "the most important question facing agronomists today is how to minimize the loss of N fertilizer and maximize the amount used by the crop." Over the last decade, scientists have focused much research on this global problem. However, improving crop NUE remains a vexing research question for agronomists.

Nitrogen fertilizer in the United States is relatively inexpensive, and therefore can be applied in large quantities. High amounts of N fertilizer (i.e., N applied in excess of the crop's N needs) and poor timing of N application are both significant contributors to the overall low NUE observed in cereal crops. Traditional farming wisdom has been to apply high amounts of N fertilizer throughout the field regardless of spatial variability to insure high yields, and thus economic feasibility. Much of this N fertilizer (50 to 80%) is applied prior to planting (Schepers et al., 1995) where it is exposed to a wide range of N-loss pathways for a long period of time. Throughout many regions in the United States, N application rates for irrigated maize (*Zea Mays L.*) are determined via a N application algorithms that are based on an expected yield goal and N credits (e.g., Mortvedt et al., 1996). Such N rate algorithms were derived statistically from experimental trials over large geographic regions, and thus reflect the average response of the cultivars tested over the growing conditions incurred during the trials. As such, these algorithms can not account for site-specific spatial variability of yield limiting factors. Plant available N has been shown to vary significantly at a field scale as small as $1m^2$ (Raun et al., 1998; Soile et al., 1999). Thus, N fertilizer application strategies that take into account the spatial variability of N could lead to increased NUE and may result in more economically and environmentally sound farming practices (Mulla and Bhatti, 1997; Khosla and Alley, 1999; Koch et al., 2004). Advanced technology, such as high-resolution remote sensing, could potentially be used to characterize the small-scale spatial variability of plant N needs and availability.

Remote Sensing of Crop N

Reflection of light at the leaf-level is primarily dependant on the internal structure of the leaf. Chlorophyll contained in the palisade layer of the leaf controls much of the visible light (400 – 720 nm) reflectance. Chlorophyll absorbs between 70 and 90% of all incident electromagnetic radiation in the blue and red wavelength bands while reflecting light in the green band (Campbell, 2002). The amount of blue and red light absorbed by the leaf is directly proportional to the chlorophyll density of the leaf. On the other hand, reflectance of the near infrared portion of the electromagnetic spectrum (720 – 1300 nm) is predominantly influenced by the leaf's mesophyll cells. The upper layers of the leaf are nearly transparent to near infrared energy. Mesophyll tissue scatters and reflects as much as 60% of all incident near infrared radiation. The degree to which near infrared energy is reflected depends on the structure of the mesophyll cells and cavities between these cells (Campbell, 2002).

Maize plants have 50 to 70 % of plant N contained in the chloroplasts (Vleeshouwers and Jongschaap, 2001). Chlorophyll concentration in the leaf and leaf N concentration are strongly related (r^2 = 0.83) (Ercoli et al., 1993). Scientists have hypothesized that the relative "greenness" of a leaf can be used as a surrogate measure of leaf N concentration. Leaf N content has been shown in laboratory studies to be strongly related to green reflectance (Ercoli et al., 1993; Blackmer et al., 1994) and to the ratio of green reflectance to near infrared reflectance (Schepers et al., 1996). The relationship between plant reflectance and N concentration has also been established in field-scale studies (Bausch and Duke, 1996; Bausch et al., 1996).

Spectral vegetation indices such as the normalized difference vegetation index (NDVI) Eq. [1] are useful for indirectly obtaining crop information such as photosynthetic efficiency, productivity potential, and potential yield (Peñuelas et al. 1994; Thenkabail et al. 2000; Ma et al., 2001; Raun et al. 2001; Báez-González et al. 2002).

NDVI = (near infrared – red) / (near infrared + red) [Eq.1]

Normalized difference vegetation index is a broadband index that is well correlated to leaf area index and green biomass (Peñuelas et al. 1994), and is thus sensitive to photosynthetic efficiency (Aparicio et al. 2002). The NDVI has been shown in studies to be useful for estimating grain yield in certain crops. Raun et al. (2001)

showed expected yield as determined from NDVI had a strong relationship with actual grain yield in winter wheat (*Triticum aestivum* L.), ($r^2 = 0.83$, $p > 0.0001$). Ma et al., (2001) reported that NDVI could be used to reliably predict low and high yield in soybeans (*Glycine max.* L).

Active Remote Sensing

Recent advances in technology have led to the development of "active" remote sensing systems that have their own energy source and are therefore not limited by the constraints that hinder other types of remote sensing (i.e., aerial and satellite imagery and aerial photography). Such active remote sensing systems are now commercially available and, in principle, can be mounted on a fertilizer application boom and used to vary the amount of fertilizer for a given area in "real-time".

Active remote sensing has demonstrated tremendous potential for improving NUE in winter wheat. Raun et al. (2001) showed that NDVI calculated from mid-season (Feakes 4 to 6) reflectance measured using an active remote sensor could be used to estimate grain yield potential. In their study they found that using the number of growing-degree days from the day of planting to the day of sensing as a normalizing factor for the NDVI resulted in regression models that could be applied across most of the nine site years studied (Raun et al., 2001). Because the reflectance measurements were taken during the middle of the growing season there were obviously conditions incurred after sensing that could not be accounted for in the regression models. Accounting for "post sensing" crop stress is one the limiting factors that hinders the development of a sensor-based N-rate algorithm. However, despite post-sensing stresses, NDVI normalized by growing-degree days accounted for over 50% of the variation in observed grain yield (Raun et al., 2001). It is important to point out that, in an attempt to develop a single regression model to estimate grain yield potential from NDVI, data from all sites were combined, despite the fact that the NDVI varied widely between sites (Raun et al., 2001). Adjusting the NDVI by dividing by the growing-degree days accounted for some of the observed inter-site variability.

Raun et al. (2001) pointed out that it is important for sensor-based N-rate algorithms to be applicable across different growing conditions (i.e., soil types, planting densities, cultivars, climate, etc.). Sensor-based algorithms that are site-specific (i.e., require recalibration of the sensor for different field conditions) are simply not pragmatic from a user's perspective. Researchers have studied spectral-based response indices as a means of adjusting for inter-site and intra-seasonal variability. Bausch and Duke (1996) introduced a boom-mounted spectral radiometer-based nitrogen response index (NRI) as a means to monitor N levels in irrigated maize. The NRI from Bausch and Duke (1996) is the ratio of the near-infrared reflectance / green reflectance of an area of interest to the near-infrared reflectance / green reflectance of a well N-fertilized area. Bausch and Diker (2001) showed that the NRI was a good predictor of plant N at the 9- through 12-leaf crop growth stages. However, soil background was found to negatively affect these relationships, and thus the angle of the radiometer influenced the relative strength of the relationships between NRI and plant N (Bausch and Diker, 2001). Similarly, Raun et al. (2005) developed an NDVI response index (RI_{NDVI}) from the ratio of the mean NDVI of a well N-rich area to the mean NDVI of an area receiving the field N rate. This response index was developed to account for temporal variability in mineralized N supplied to the crop. Raun et al. (2002) found that when the RI_{NDVI} is combined with an in-season grain yield estimates, NUE could be improved by more than 15% when compared to traditional farmer N application practices. In a large-scale study, Raun et al. (2005) found that the relationship between in-season grain yield estimates and actual wheat grain yield (Mg ha^{-1}) remained consistent over 30 site years. Raun et al. (2005) also found that the coefficients used in regression models did not differ significantly across time periods; suggesting that reliable and usable yield potential models can be developed with just two years of field data.

Despite the promising work and advancements made towards improving NUE in wheat using active sensing,. there is limited literature available that addresses the use of active remote sensing in irrigated maize. If active remote sensing is as promising in irrigated maize as it has been shown to be in wheat, it could have a tremendous impact on farm economics as well as the environment for maize producing regions.

The overall objective of this study was to evaluate the potential of the GreenSeeker™ hand-held active remote sensing instrument which relies on red and near infrared reflectance to estimate grain yield in irrigated maize. Specific objectives were: (a) to investigate the relationship between NDVI determined from active remote sensing and observed grain yield, (b) develop and evaluate regression models that estimate grain yield from active remote sensing data, and (c) investigate the relationship between reflectance measured using active remote sensing and pre-sidedress soil nitrate test results.

MATERIALS AND METHODS

This study was conducted over four site years (two fields over two consecutive growing seasons). Sites were located in northeastern Colorado, USA under a continuous maize cropping system. Site years I and III were furrow irrigated, while site years II and IV were center-pivot sprinkler irrigated.

Site years I and III were on a field mapped as having Fort Collins Loam (fine-loamy, mixed, superactive, mesic Aridic Haplustalf). Site year II and IV was located on a field that was mapped as having Albinas loam (fine-loamy, mixed, superactive, mesic Pachic Argiustoll), Ascalon fine sandy loam (fine-loamy, mixed, superactive, mesic, Aridic Argiustoll), and Haxtun loamy sand (fine-loamy, mixed, superactive, mesic Pachic Argiustoll) soil series.

Maize was planted at 77,000 plants ha^{-1} for site years I and III and 84,000 plants ha^{-1} for site years II and IV. Row spacing was 76 cm for all site years. Site years I and III were planted with Garst hybrid 8802 and site year II and IV were planted with Pioneer hybrid 34K77.

Experimental Procedure

Experimental plots were randomly located within each field and replicated twelve times. Each experimental plot was 46.2 m^2 (15.2 m by 3.02 m) in size. Pre-sidedress soil nitrate (PSNT) samples were collected from each experimental plot at the eight-leaf crop growth stage. For each experimental plot, multiple PSNT samples were taken from both the planting bed and the furrow to a depth of 30 cm and composited. We collected a total of 48 PSNT samples across all site years (12 samples X four site years). Total NO_3 -N was determined using the method of Mulvaney (1996).

Crop reflectance measurements were acquired on the same day that PSNT samples were collected (the eight-leaf crop growth stage) using a GreenSeeker™† (NTech Industries, Inc., Ukiah, CA, USA) hand-held active remote sensing unit (Figure 3.1). When the unit is held at 46 cm above the target, it records the reflectance of an area 61cm long by 0.64cm wide. The sensor utilizes high intensity light emitting diodes (LED) to emit light in the red (650 ± 10 nm) and near infrared (770 ± 15 nm) bands. Reflectance from the LEDs (red and near infrared reflectance) is measured and recorded. From these data the NDVI is calculated. Reflectance measurements were acquired while holding the unit above the crop canopy and walking the length of each maize row contained in each experimental plot (walking speed was approximately 3.2 km hr^{-1}). Each maize row was 15.2 m long and each plot contained 4 maize rows. The data logger was set to record data every 500 ms, thus for each experimental plot there were approximately 136 data points. These data were averaged for each experimental plot to allow comparison with grain yield data (discussed below) and PSNT samples.

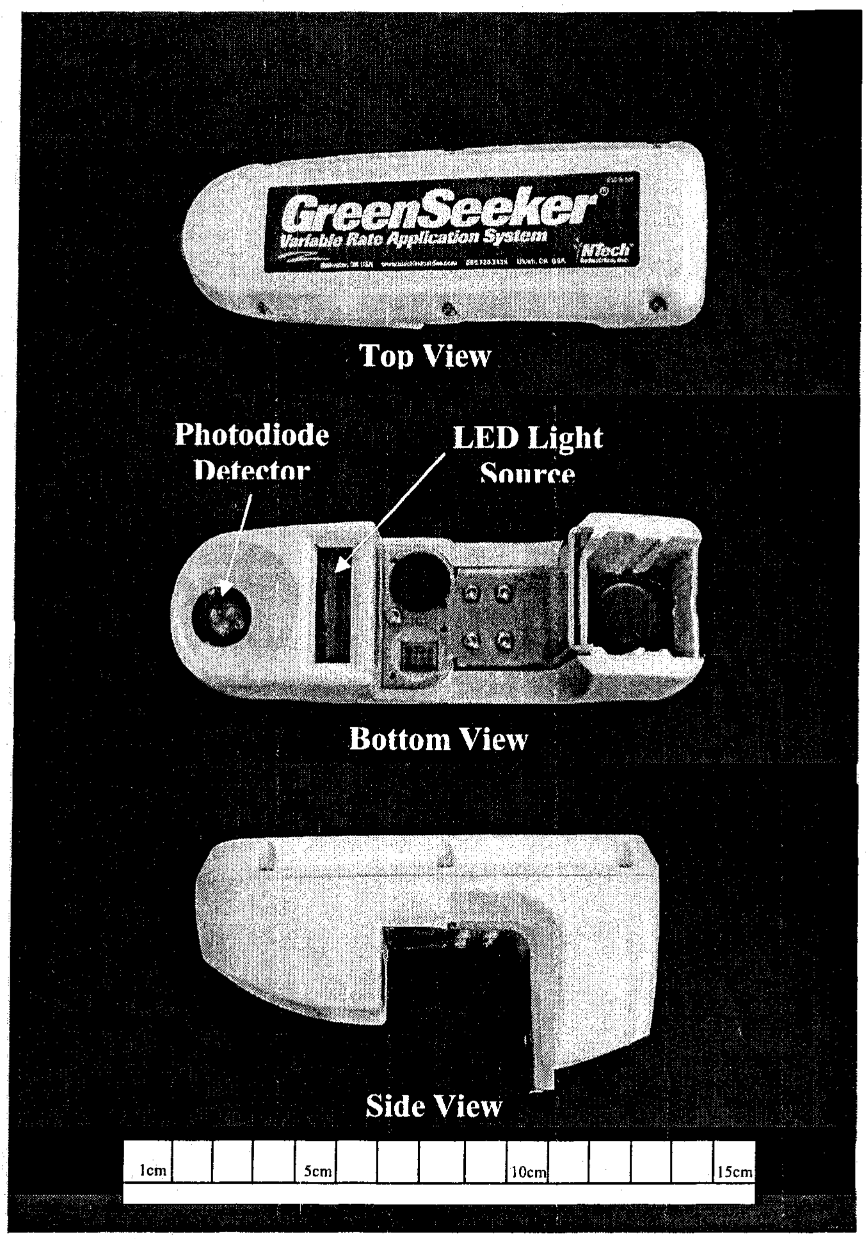


Figure 3.1. Photograph showing the top, bottom, and side views of the GreenSeeker™ unit (NTech Industries, Ukiah, CA USA). Scale is in cm.

For each site year, NDVI data were normalized by dividing the NDVI by the number of days from planting to sensing, where growing degrees were greater than zero (Stone et al., 1996). This normalized NDVI, also known as "in-season estimated yield" (INSEY), is an estimate of the rate of accumulated biomass from the day of crop planting to the day of active remote sensing (Stone et al., 1996). Raun et al. (2005) reported that including only those days where the growing degrees were greater than zero is necessary to remove days where plant growth is not possible. The number of days where growing degrees were greater than zero was found to be highly variable over site years (Stone et al., 1996, Raun et al., 2005). In addition to acquiring reflectance of the experimental plots, reflectance of a nitrogen-rich portion of the field was also acquired as a reference. For each site year, the "nitrogen rich" area was a portion of the field that received 200 kg N ha^{-1}. The nitrogen rich plots were randomly located and were identical in size to the experimental plots (15.2 m by 3.02 m). Using the mean reflectance of the nitrogen rich area, a response index (RI) was calculated Eq. [2]. The RI used in this study is similar, in concept, to the nitrogen reflectance index (NRI) from Bausch and Duke (1996) and Bausch and Diker (2001).

$$RI = \text{NDVI of an area of interest} / \text{NDVI of the nitrogen-rich strip} \quad \text{[Eq.2]}$$

To evaluate the potential of the GreenSeeker™ to estimate grain yield from reflectance measurements taken at the eight-leaf crop growth stage, biomass samples were collected at the crop's physiological maturity (R6 crop growth stage) for grain yield analysis. One biomass sample was randomly located and collected from each experimental plot for each site year. Biomass samples consisted of two 1-m long sections of a maize row. There were a total of 48 biomass samples (12 samples X four site years). Grain yield volume was calculated as Mg ha^{-1} at 155g kg^{-1} moisture.

Data Analysis

Individual Site Years

Statistical analysis was performed using SAS and SPLUS v.6.1 (Insightful corp., Troy NY, USA). Several regression models were investigated and compared for each site year. Thenkabail et al. (2000) and Raun et al. (2005) have shown that non-linear regression models are best for relating remote sensing-based vegetation indices to crop biophysical parameters such as crop yield and biomass. In this study, non-linear least-squares regression analysis, in Splus 6.0, was used to fit an exponential regression model relating grain yield to INSEY. Exponential modeling is frequently used in crop growth studies where the rate of crop growth at a given time is proportional to the amount of crop growth remaining (Neter et al., 1996). The exponential non-linear model was a logical model to explore because INSEY is essentially an estimate of the rate of accumulated biomass (Stone et al., 1996). Also, other studies with the Greenseeker sensor have shown that the relationship between INSEY and grain yield follow a non-linear exponential relationship (Raun et al., 2001, Raun et al., 2002, Raun et al., 2005)

Least-squares regression analysis was used to regress grain yield on INSEY, grain yield on RI, and PSNT on RI. Significance of each regression model was tested using an F-test for lack of fit (Neter et al., 1996). Significance of the independent variables, in each model, was tested to determine if they were significantly different than zero, using a two-tailed t-test. Regression parameters were considered to be significant at $p \leq 0.05$ level of significance. Independent variables that were significant at the $p \leq 0.05$ level of significance were retained in the model. Residuals of the regression models were investigated by examining residual plots and testing for normality residuals using Shapiro-Wilk test (Neter et al., 1996).

Pooled Site Years

Data were pooled across site year and analyzed using cross-validation. The rational behind pooling the data was to facilitate predictive evaluation of the regression models. Gauch and Zobel (1988) state that predictive evaluation of a regression model is a much more informative evaluation criterion than a postdictive evaluation criterion such as the coefficient of determination (R^2). The predictive evaluation criteria used in this study were the mean squared prediction error (MSPR) Eq. [3] and estimate bias Eq. [4].

$$\text{MSPR} = \frac{\sum_{i=1}^{n} (Y_i - \hat{Y}_i)^2}{n} \qquad \text{[Eq.3]}$$

where:

Y_i is the value of the response variable in the *i*th validation case
$\hat{Y}_i$ is the predicted value for the ith validation case based on the model building data set
n is the number of cases in the validation data set

$$\text{Estimate Bias (\%)} = \frac{(\text{mean } Y_i) - (\text{mean } \hat{Y}_i)}{(\text{mean } Y_i)} * 100 \qquad \text{[Eq.4]}$$

where:

Y_i is the value of the response variable in the *i*th validation case
$\hat{Y}_i$ is the predicted value for the ith validation case based on the model building data set

Regression models were evaluated using the "hold out" method of model cross-validation (Neter et al., 1996). Site years I and II were pooled because they shared a common growing season, as were site years III and IV. Site years I and II were used as the regression model building data set and site years III and IV were used as the regression model validation data set. Response variables (i.e., INSEY) from site years III and IV (i.e., the model validation data set) were incorporated into the regression models developed from site years I and II (i.e., the model building data set). For example, INSEY values from site years III and IV were incorporated into the regression models developed from site years I and II; from this, grain yield estimates were made. Grain yield estimates were then compared to observed grain yield from site years III and IV. The GreenSeeker™ has been shown in other studies to produce accurate grain yield estimates from only two years of field data (Raun et al., 2005). Both non-linear and linear models were compared based on their relative predictive performance as determined from the MSPR and bias. A two-sided t-test was used to determine if the bias in estimated grain yield was significantly different than zero.

Raun et al. (2005) found that the coefficients from several regression models developed over 30 site years to predict wheat grain yield using INSEY did not change significantly. In other words, the relationship between INSEY and grain yield was consistent, which has significant implications with regard to the utility and potential of the GreenSeeker™. In addition to the stated objectives, we were also interested in evaluating the consistency of the relationships between GreenSeeker™ data and grain yield across the sites used in this study. As stated earlier, the fields used in this study had different soils, planting densities, and hybrids. To assess the consistency of the relationships observed between INSEY and grain yield, the effect of the site year was included in the regression models. To accomplish this, regression analysis with binary indicator variables was used. Binary indicator variables are one means of quantifying qualitative classes (i.e., site year) within regression analysis (Neter et al., 1996). As mentioned previously, site years I and III were on the same field over two consecutive growing seasons and site years II and IV were on the same field over two consecutive growing seasons. Binary indicator variables were included as independent variables in the regression analysis (e.g., $X_1 = 1$ if site year 1 or III, $X_1 = 0$ otherwise). Neter et al. (1996) provide a complete explanation of the use and interpretation of indicator variables in regression modeling.

RESULTS AND DISCUSSION

Grain yields were variable across site years, and ranged from 5 to 24 Mg ha^{-1}. Site years I and III had lower yields than site years II and IV, likely because of reduced irrigation and a lower maize planting density (7000 fewer plants ha^{-1}).

Grain Yield Estimates and INSEY

Scatter plots of INSEY versus observed and predicted grain yield for each site year is presented in Figure 3.2. Across all sites years, INSEY increased with increasing grain yield. An exponential relationship relating INSEY to yield has been proposed for both wheat and maize (NUE Web, 2005; Raun et al., 2005). Thenkabail et al. (2000) reported that in most cases, non-linear exponential models were best for explaining variability between spectral vegetation indices and crop biophysical parameters across several agricultural crops. However, based on the observed data within each site year, the relationship appears to be linear. The coefficient of determination of the linear regression models for each individual site year ranged from 0.10 to 0.76 ($p < 0.05$).

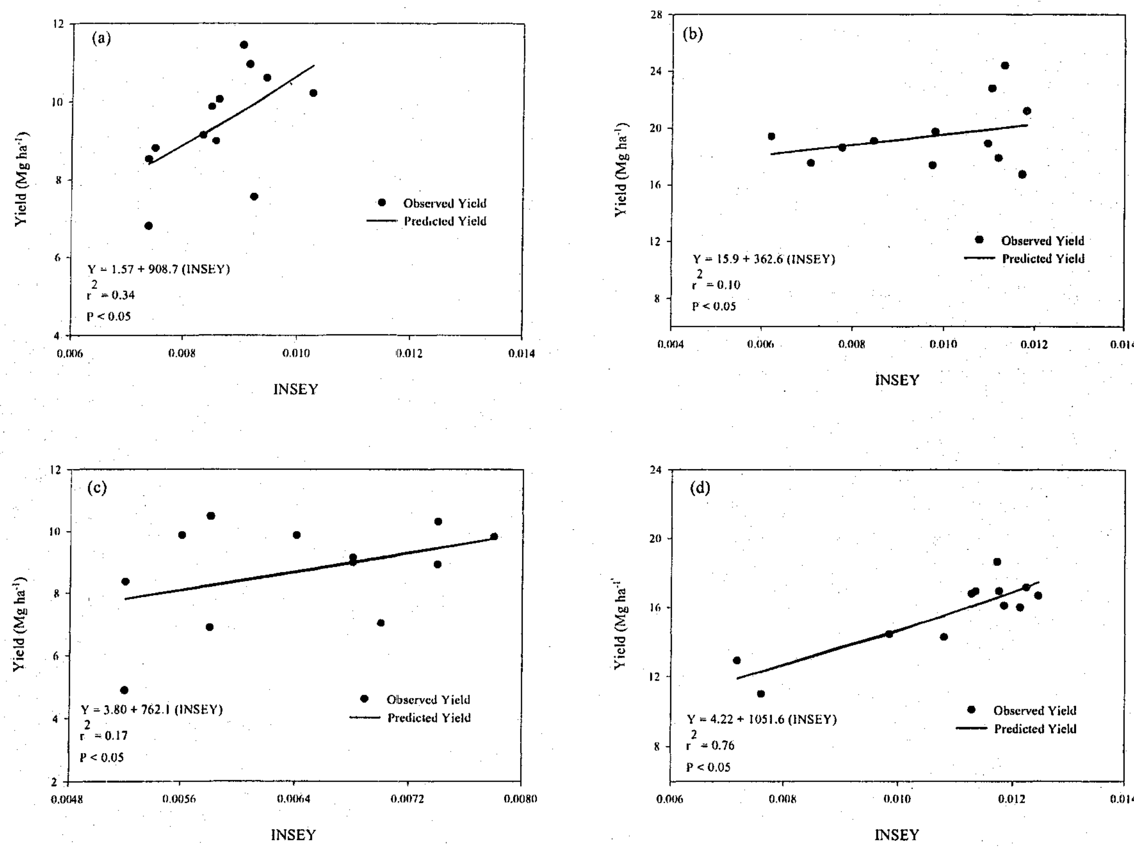


Figure 3.2. Plots of grain yield (Mg ha^{-1}) versus in-season estimated yield† (INSEY) for (a) site year I, (b) site year II, (c) site year III, and (d) site year IV. Regression results and the prediction line (solid) are shown for each plot. Note that site years I and III were on the same field over two consecutive growing seasons as were site years II and IV.

Grain Yield Estimation

From figure 3.2, it is salient that the relationship between grain yield and INSEY across site years is variable. In similar study, Raun et al. (2005) found consistent relationships between maize yield and INSEY across 30 site years. There are a myriad of post-sensing conditions the can impact the relationship between INSEY and harvested grain yield. For the sites used in this study, perhaps normalizing NDVI by using INSEY is not sufficient by itself, to account for variability between site years.

Regression analysis and cross-validation results are presented in Table 3.1. Overall, coefficients of determination of the regression models developed from site years pooled across the first growing season ranged from 0.21 to 0.90 ($p < 0.05$). Based on the results of the cross-validation, the linear regression model provided the most consistent grain yield predictions, as compared to the model building data set (MSE = 4.94, MSPR = 4.54). However; the coefficient of determination for the linear model was low (r^2 = 0.21). When indicator variables accounting for site year were added to the linear regression model, the coefficient of determination improved substantially ($r^2 = 0.90$, $p < 0.05$), but the MSPR increased three-fold compared to the linear regression model without indicator variables. Based on partial sums of squares (data not shown), the indicator variable accounting for site year was the most significant variable, of those tested, for explaining variability in grain yield. Except for the linear regression model, in all of the other regression models tested, adding an indicator variable to account for site year caused INSEY to no longer be significant ($p > 0.05$) as an independent variable in the regression model. These results indicate that there are significant differences between site years and that the effect of site should be considered when developing regression models predicting grain yield from INSEY. This point is further illustrated by the scatter plots of grain yield versus INSEY for the pooled data from site years I and II, and from III and IV (Figure 3.3). From the scatter plots, it is salient that site years I and III have much lower grain yields than site years II and IV. Differences in grain yields between sites can be attributed, in part, to irrigation practices, different planting densities, and hybrid differences. These results illustrate one of the significant hurdles to be overcome towards developing a widely-applicable model to estimate grain yield from active remote sensing data (i.e., site differences). Differences between sites due to hybrid, soils, climatic conditions etc., can significantly affect the relationships between NDVI and yield. Shanahan et al. (2001) found that maize hybrid was a significant source of variability across several spectral vegetation indices. For grain yield predictions in wheat, it has been proposed that the regression model predictions should be adjusted by the standard deviation of the regression curve (Raun et al., 2005). Adjusting the grain yield predictions by one standard deviation was found to more accurately reflect the true yield potential without the post-sensing stresses (Raun et al., 2005).

Table 3.1. Regression function, coefficient of determination (R^2), mean square error (MSE), mean square error of prediction (MSPR), estimate bias (%), and p-value of the estimate bias. All regression models are significant at $p < 0.05$.

Model	R^2	MSE	MSPR	Bias %	Bias P
$\hat{Y}$ (Mg ha^{-1}) = -0.27 + 1599.3 (INSEY[†])	0.21	4.94	4.54	11	ns
$\hat{Y}$ (Mg ha^{-1}) = 84.5 - 17250 (INSEY) + 1016987.9 INSEY^2	0.48	4.31	251.5	34	ns
$\hat{Y}$ (Mg ha^{-1})= 2.92 $e^{(163.64\,(INSEY))}$	0.54	5.37	7.69	8	ns
$\hat{Y}$ (Mg ha^{-1})= 28.4 + 19.47 ln (NDVI[‡])	0.68	3.59	22.83	17	ns
$\hat{Y}$ (Mg ha^{-1}) = 14.98 - 9.52(SY[§]) + 457.34 (INSEY)	0.90	1.81	12.50	16	ns

[†]INSEY: in-season estimated yield = NDVI / growing degree days from crop planting to active remote sensing.
[‡]NDVI: normalized difference vegetation index = (near infrared reflectance - red reflectance) / (near infrared reflectance + red reflectance)
[§]SY= indicator variable for site year I and III (site year I and III were on the same field over two consecutive growing seasons).

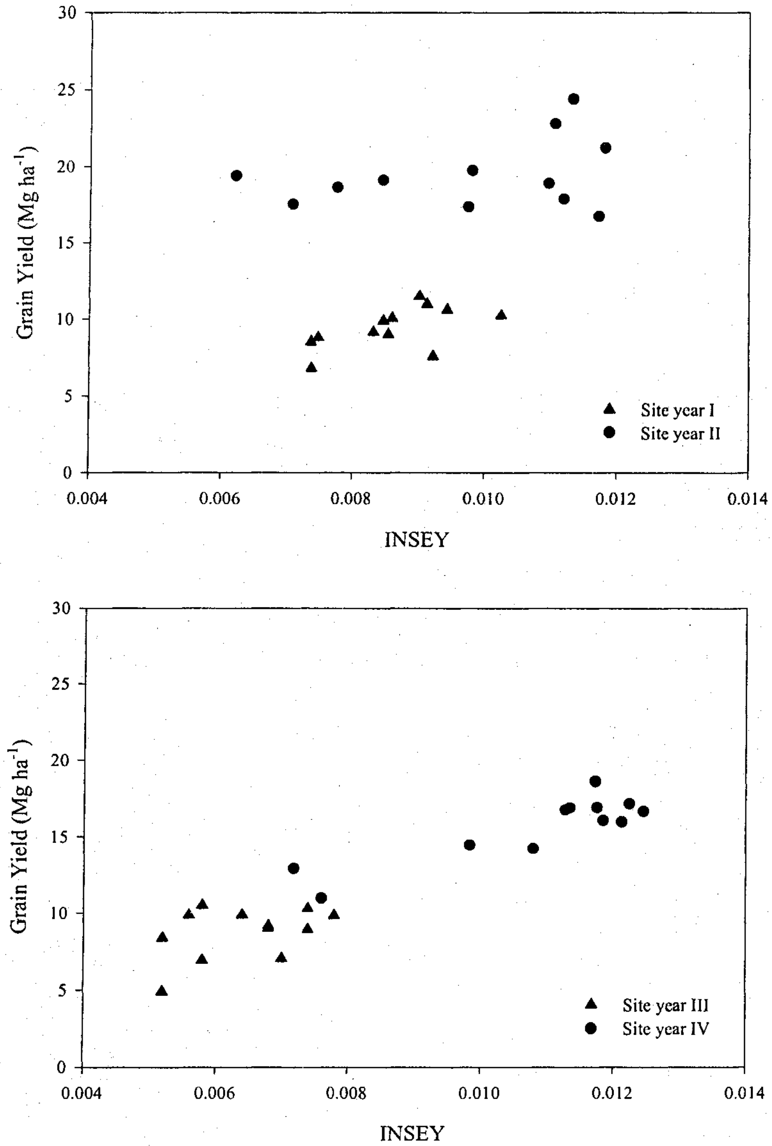


Figure 3.3. Scatter plots of observed grain yield (Mg ha^{-1}) and INSEY† for (a) site years I and II, (b) site years III and IV. Site years I and III were on the same field over two consecutive growing seasons as were site years II and IV. On each scatter plot, site years are distinguished by different graphing symbols. Site years I and III are represented by solid triangles, while site years II and IV are represented by solid circles.

†INSEY: in-season estimated yield= NDVI / growing degree days from crop planting to active remote sensing. Where NDVI = normalized difference vegetation index ((near infrared - red) / (near infrared + red)).

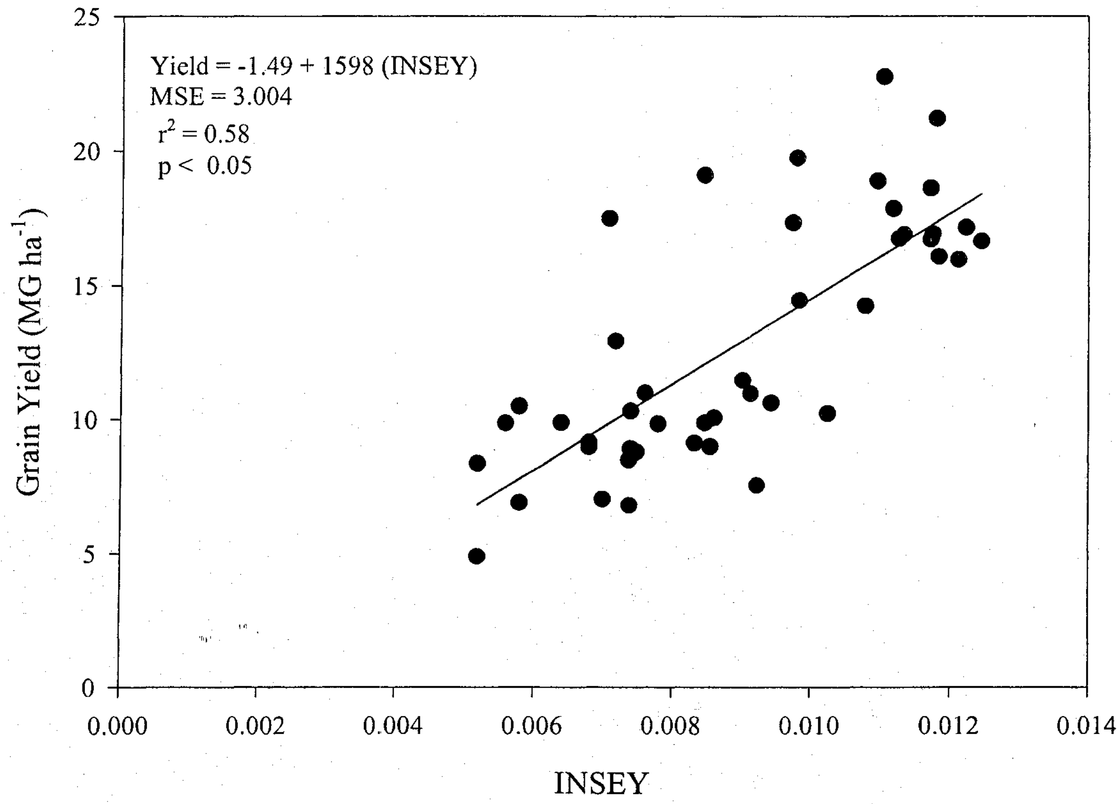


Figure 3.4. Grain yield (Mg ha^{-1}) versus INSEY for all site years combined. Regression results are presented in the upper left-hand corner along with the predicted regression line.

Combining data from all site years and regressing grain yield on INSEY resulted in an r^2 of 0.58 (Figure 3.4). Overall, what is most significant about our results is that they demonstrate that use of active remote sensors such as the GreenSeeker™ to estimate accumulated biomass (INSEY (Stone et al., 1996)), has potential to be used for developing models for estimating grain yield in irrigated maize.

Grain Yield, Pre-sidedress Soil Nitrate, and Response Index

Identifying areas of the field where there is sufficient and/or insufficient non-fertilizer N (i.e., areas of the field that will respond to fertilizer N) is integral to improving N fertilizer application strategies. Across all site years, pre-sidedress nitrate results ranged from 0.33 to 15.1 ppm (Figure 3.5). Mean PSNT values were 0.8, 8.5, 4.8, and 8.2 ppm for site years I, II, III, and IV, respectively. As expected, observed grain yield was significantly affected by PSNT results ($r^2 = 0.51$, $p < 0.05$). Similar results have been widely reported in the literature (Magdoff et al., 1984; Fox et al., 1989; Meisinger et al., 1992; Binford et al., 1992; Bundy and Andraski, 1995; Sims et al., 1995; and Rozas et al., 2000). Accoring to Spellman et al. (1996), PSNT values of less than 13 ppm in the top 30 cm indicate the need for additional N fertilization. Based on this, all site years used in this study were below the critical level and would have required at least some additional N fertilizer to optimize grain yields. However, it has been widely reported that the PSNT tends to over-estimate N responsiveness (Fox et al., 1989; Meisinger et al., 1992; Bundy and Andraski, 1993; Heckman et al., 1995). The RI used in this study, on the other hand, compares the NDVI of an area of interest to the NDVI of an area that is N sufficient (i.e., requires no additional N). In theory, the RI should indicate if an area has

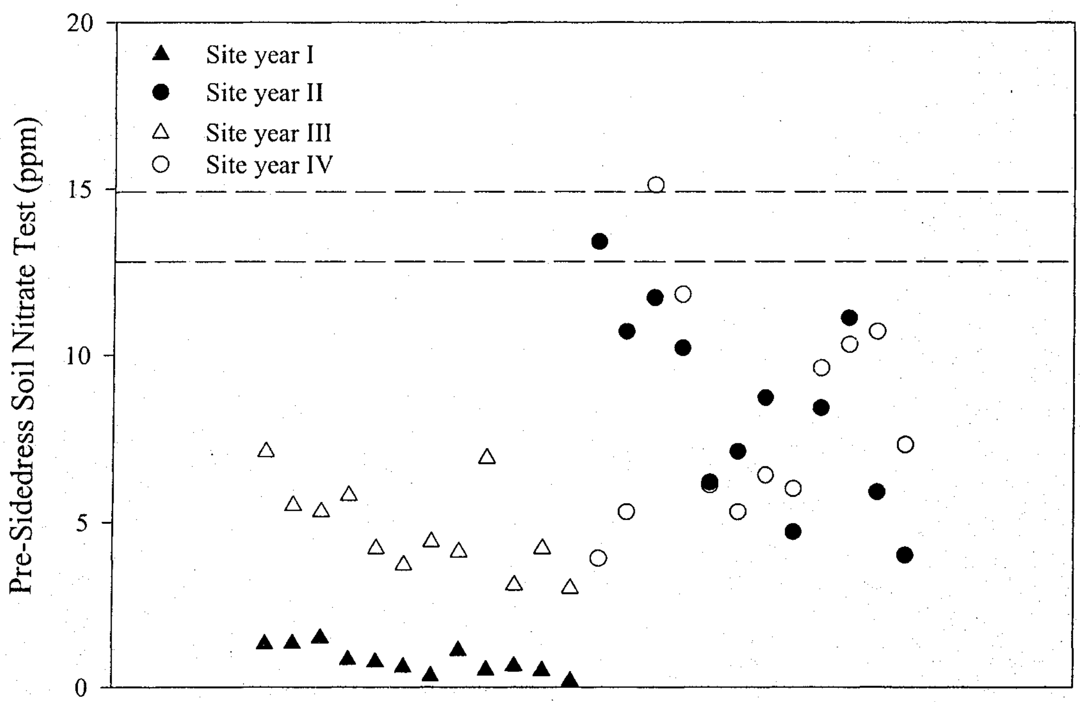


Figure 3.5. Pre-Sidedress Soil Nitrate results for all site years. Site years are distinguished by different graphing symbols. Site year I = solid triangle, Site year II = solid circle, Site year III = open triangle, and site year IV = open circle. Dashed lines represent the upper and lower boundaries of the "optimal" range of PSNT values from Spellman et al. (1996).

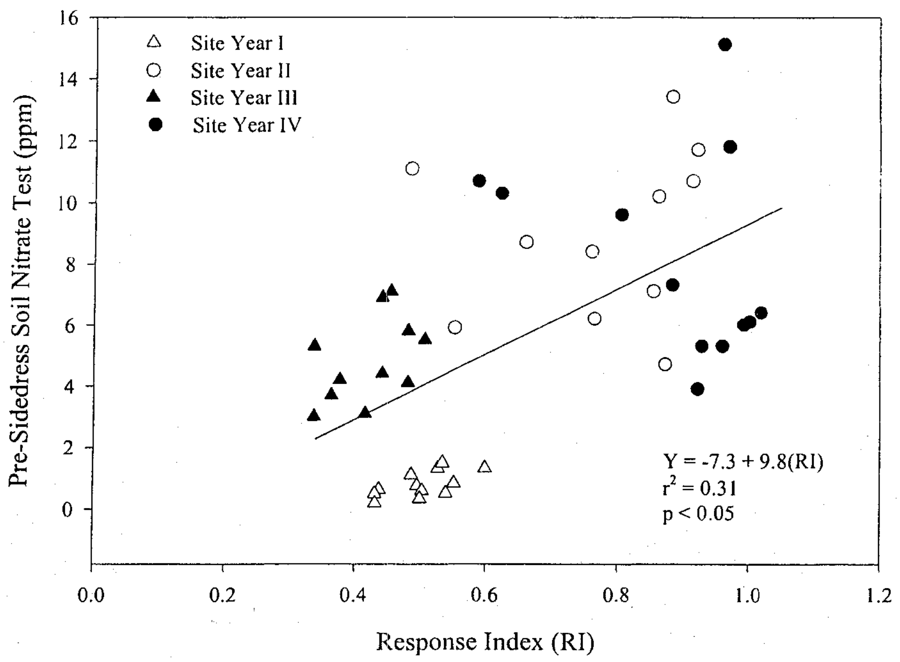


Figure 3.6. Pre-Sidedress Soil Nitrate results versus RI for all site years. Where RI = NDVI of an area of interest / NDVI of a well-fertilized plot.

the potential to respond to additional N. For example, it has been reported that an NRI of 0.95 or less indicates an N deficiency and should receive additional N fertilizer (Bausch and Duke, 1996; Bausch and Diker, 2001). Figure 3.6 presents a scatter plot and regression analysis results of the PSNT regressed against RI for all site years. The RI increased with increasing PSNT values; although statistically significant, the observed relationship between PSNT and RI was not very strong ($r^2 = 0.31$, $p < 0.05$). It has been reported that PSNT-based N fertilizer recommendations can be suspect when used on fields that receive high rainfall amounts and are permeable because of the potential for nitrate to leach from the top 30 cm of the soil (Magdoff, 1991). The fields used in this study had coarse-textured soils and were irrigated (furrow irrigation for site years I and III, and center-pivot sprinkler for site years II and IV), and therefore were probably not ideal candidates for PSNT.

Scatter plots of grain yield (Mg ha^{-1}) versus RI are presented in Figure 3.7. Using a quadratic relationship, the RI explained 65% of the variability in grain yield. In general, grain yield increased steadily with increasing RI up to RI values of 7, at which point the grain yield increased with RI at a decreasing rate. Although not conclusive, these results suggest that the RI has potential to be used for inferring grain yield responsiveness (i.e., what areas should be fertilized) across the fields used in this study. Similarly, Bausch and Diker (2001) found that the NRI was an excellent predictor of nitrogen sufficiency in irrigated maize. However, because of interference from soil background (i.e., NIR scattering by the soil surface) the ability to use NRI to estimate N sufficiency was restricted to growth stages later than the six-leaf crop growth stage. Further research is needed to determine how mounting the GreenSeeker™ on farm implements (e.g., fertilizer spray boom) will affect the strength of the relationships reported in this study. Additionally, more work should be done to better understand and a establish threshold level (i.e., a critical level for N responsiveness) for the RI used in this study.

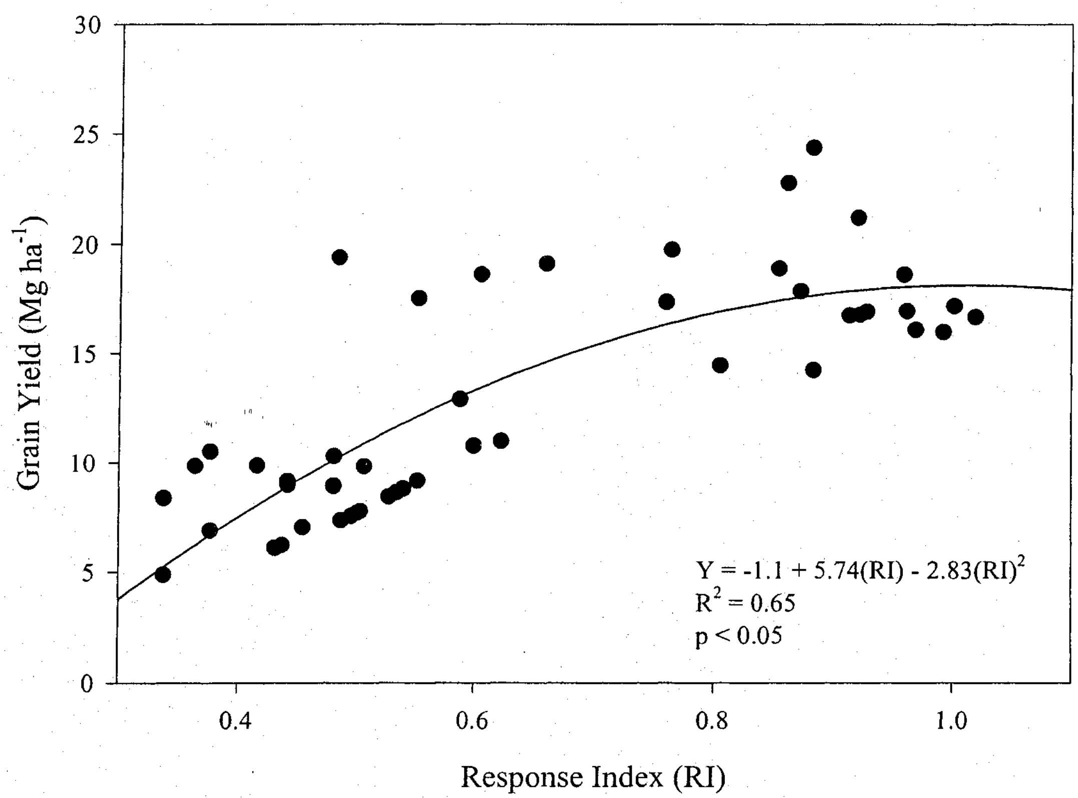


Figure 3.7. Scatter plots of observed grain yield (Mg ha^{-1}) and response index (RI) for all site years.

RI: response index = NDVI of an area of interest / NDVI of a nitrogen-rich area of the field. Where NDVI = normalized difference vegetation index ((near infrared - red) / (near infrared + red))

SUMMARY and CONCLUSIONS

In this study, the GreenSeeker™ active remote sensing unit was used to estimate grain yield in irrigated maize. Across four site years, the observed relationships between grain yield and INSEY followed a linear relationship. The strength of the linear relationship between INSEY and grain yield varied by site year. Grain yield estimates agreed well with observed grain yield, indicating that the GreenSeeker™ has potential to be used for grain yield estimates in irrigated maize.

Results from PSNT sampling did not have a strong relationship with the RI used in this study. However, grain yield and RI did have a strong relationship. These results are promising because they suggest that the GreenSeeker™ has the potential to be used to infer the relative response of an area to additional N fertilizer.

In conclusion, this study shows that the GreenSeeker™ active sensor has potential to provide grain yield estimates in irrigated maize as well as a relative response of a particular area to additional N fertilizer. Other researchers have used this tool to improve NUE in wheat, with great success. Our results suggest that there is potential to do the same in irrigated maize. More research is needed, however, before this is a reality. Areas that need additional study include, but are not limited to the following: (i) collecting more site years of data to determine if the relationship between INSEY and maize yield is stable, (ii) determine the critical level for the RI used in this study, and (iii) does mounting the GreenSeeker™ to farm equipment change any of the fundamental relationships and/or does it introduce interference from the soil background.

REFERENCES

Aparicio, N., D. Villegas, J.L. Araus, J. Casadesús, and C. Royo. 2002. Relationship between growth traits and spectral vegetation indices in Durum Wheat. Crop Sci. 42:1547-1555.

Báez-González, A.D., P. Chen, M. Tiscareño-López, and R. Srinivasan. 2002. Using satellite and field data with crop growth modeling to monitor and estimate maize yield in Mexico. Crop Sci. 42:1943-1949.

Bausch, W.C., and H.R. Duke. 1996. Remote sensing of plant nitrogen status in corn. Trans. Am. Soc. Agric. Eng. 39(6):1869-1875.

Bausch, W.C., H.R. Duke, and C.J. Iremonger. 1996. Assessment of plant nitrogen in irrigated corn. p. 23-32. *In:* P.C. Robert, R.H. Rust, and W.E. Larsen (eds.), Precision Agriculture. Proc. 3rd Int. Conf. ASA, CSSA, SSSA. Madison, WI, USA.

Bausch, W.C., and K. Diker. 2001. Innovative remote sensing techniques to increase nitrogen use efficiency of corn. Commun. Soil. Sci. Plant Anal. 32(7 & 8):1371-1390.

Blackmer, T. M., J. S. Schepers and G. E. Varvel. 1994. Light reflectance compared with other nitrogen stress measurements in maize leaves. Agron. J. 86:934-938.

Binford, G.D., A.M. Blackmer, and M.E. Cerrato. 1992. Relationships between maize yields and soil nitrate in late spring. Agron. J. 84:53-59.

Bundy, L.G., and T.W. Andraski. 1993. Soil and plant nitrogen availability tests for corn following alfalfa. J. Prod. Agric.. 6:200-206.

Bundy, L.G., and T.W. Andraski. 1995. Soil yield potential effects on performance of soil nitrate tests. J. Prod. Agric.. 8:561-568.

Campbell, J.B. 2002. Introduction to remote sensing 3rd ed. The Guilford Press. New York, New York, USA.

Colorado Corn. 1999. Pre-sidedress nitrate test (PSNT) demonstration results. Available on-line at: http://www.anvil-graphics.com/web/sites/ColoCorn/ learn/bmp /psnt.html. Verified January 18, 2006.

Ercoli, L., M. Mariotti, A. Masom, and F. Massantini. 1993. Relationship between nitrogen and chlorophyll content and spectral properties in maize leaves. European Journal of Agronomy. 2:113-117.

Fox, R.H., G.W. Roth, K.V. Iversen, and W.P. Piekielek. 1989. Soil and tissue nitrate tests compared for predicting soil nitrogen availability to maize. Agron. J. 81:971-974.

Frink, C.R., P.E. Waggoner, and J.H. Ausubel. 1999. Nitrogen fertilizer: retrospect and prospect. Proc. Natl. Acad. Sci. USA. 96:1175-1180.

Gauch, H.G., and R.W. Zobel. 1988. Predictive and postdictive success of statistical analysis of yield trials. Theo. Genet. 76:1-10.

Heckman, J.R., W.T. Hlubik, D.J. Prostak, and J.W. Paterson. 1995. Pre-sidedress soil nitrate test for sweet corn. HortScience 30:1033-1036.

Khosla, R. and M.M. Alley. 1999. Soil-specific nitrogen management on Mid-Atlantic Coastal Plain soils. Better Crops. 83(3):6-7.

Koch. B., R. Khosla, M. Frasier, D.G. Westfall, and D. Inman. 2004. Economic feasibility of variable rate nitrogen application utilizing site-specific management zones. Agron. J. 96: 1572-1580.

Ma, B.L., L.M. Lianne, M. Dwyer, C. Costa, E.R. Cober, and M.J. Morrison. 2001. Early prediction of soybean yield from canopy reflectance measurements. Agron.J. 93:1227-1234.

Magdoff, F.R., D. Ross, and J. Amadon. 1984. A soil test for nitrogen availability to maize. Soil Sci. Soc. Am. J. 48:1301-1304.

Magdoff, F.R. 1991. Understanding the Magdoff pre-sidedress nitrate test for corn. J. Prod. Agric. 4:297-305.

Meisinger, J.J., V.A. Bandel, J.S. Angle, B.E. O'Keefe, and C.M. Reynolds. 1992. Pre-sidedress soil nitrate test evaluation in Maryland. Soil Sci. Soc. Am. J. 56:1527-1532.

Mortvedt, J.J., D.G. Westfall, and R.L. Croissant. 1996. Fertilizing corn. Colorado State University Cooperative Extension Fact Sheet. No. 0.538, Fort Collins, CO.

Mulla, D.J. and A.U. Bhatti. 1997. An evaluation of indicator properties affecting spatial patterns in N and P requirements for winter wheat yield. p. 145-153. *In* J.V. Stafford (ed) Precision Agriculture '97, 1st European Conf. Prec. Ag., Warwick Univ., UK, 7-10 Sept. 1997.

Mulvaney, R.L. 1996. Nitrogen-inorganic forms. p. 1146 - 1162. *In* Sparks, D.L., et al., Methods of Soil Analysis. Part 3, Chemical Methods, Chapter 4. Soil Sci. Soc. Am., Madison, WI.

Neter, J., M.H. Kunter, C.J. Nachtscheim, and W. Wasserman. 1996. Applied Linear Regression models 4th ed. McGraw-Hill/Irwin publishers, Chicago, Il USA.

NUE Web. 2005. Outline for generating new crop algorithms for N fertilization. Available at: www.nue.okstate.edu/Algorithm/Algorithm_Outline.htm. Verified December 12, 2005. Oklahoma State University, Stillwater, OK, USA.

Peñuelas, J., J.A. Gamon, A.L. Fredeen, J.Merino, and C.B. Field. 1994. Reflectance indices associated with physiological changes in nitrogen- and water-limited sunflower leaves. Remote Sens. Environ. 48:135-146.

Raun, W.R., J.B. Solie, G.V. Johnson, M.L. Stone, R.W. Whitney, H.L. Lees, H. Sembiring, and S.B. Phillips. 1998. Micro-variability in soil test, plant nutrient, and yield parameters in bermudagrass. Soil Sci. Soc. Am. J. 62:683-690.

Raun, W.R., and G.V. Johnson. 1999. Improving nitrogen use efficiency for cereal production. Agron. J. 91:357-363.

Raun, W.R., J.B. Soile, G.V. Johnson, M.L. Stone, E.V. Lukina, W.E. Thomason, and J.S. Schepers. 2001. In-season prediction of potential grain yield in winter wheat using canopy reflectance. Agron. J. 93:131-138.

Raun, W.R., J.B. Solie, G.V. Johnson, M.L. Stone, R.W. Mullen, K.W. Freeman, W.E. Thomasson, and E.V. Lukina. 2002. Improving nitrogen use efficiency in cereal grain production with optical sensing and variable rate application. Agron. J. 94:815-820.

Raun, W.R., J.B. Solie, M.L. Stone, K.L. Martin, K.W. Freeman, R.W. Mullen, H. Zhang, J.S. Scheppers, and G.V. Johnson. 2005. Optical sensor-based algorithm for crop nitrogen fertilization. Commun. Soil Sci. Plant Anal. 36: 2759-2781.

Rozas, H.S., H.E. Echeverría, G.A. Studdert, and G. Domínguez. 2000. Evaluation of the pre-sidedress soil nitrogen test for no-tillage maize fertilized at planting. Agron. J. 92:1176-1183.

SAS Institute. 2001. Statistical Analysis Software Version 8. SAS Institute, Cary, NC. USA.

Scharf, P., and M.M. Alley. 1995. Nitrogen loss inhibitors evaluated for humid-region wheat production. J. Prod. Agric. 8(2):269-275.

Scheppers, J.S., D.D. Francis, and J.F. Power. 1995. Tissue analysis to improve nitrogen management practices. Clean Water-Clean Environment-21st Century. Vol. II: Nutrients. Am. Soc. Agric. Eng. St. Joseph, MI, USA.

Schepers, J.S., T.M. Blackmer, W.W. Wilhelm, and M. Resende. 1996. Transmittance and reflectance measurements of maize leaves from plants with different nitrogen and water supply. J. Plant Physiol. 148:523-529.

Shanahan, J.F., J.S.Schepers, D.D. Francis, G.E. Varvel, W.W. Wilhelm, J.M. Tringe, M.R. Schlemmer, and D.J. Major. 2001. Use of remote-sensing imagery to estimate corn grain yield. Agron. J. 93:583-589.

Sims, J.T., B.L. Vasilas, K.L. Gartley, B. Milliken, and V. Green. 1995. Evaluation of soil and plant nitrogen tests for maize on manured soils of Atlantic Coastal Plain. Agron. J. 87:213-222.

Solie, J.B., W.R. Raun, and M.L. Stone. 1999. Submeter spatial variability of selected soil and bermudagrass production variables. Soil Sci. Soc. Am. J. 63:1724-1733.

Spellman, D.E., A. Rongni, D.G. Westfall, R.M. Waskom, and P.N. Soltanpour. 1996. Pre-sidedress nitrate soil testing to manage nitrogen fertility in irrigated corn in a semi-arid environment. Commun. Soil Sci. Plant Anal. 27(3&4):561-574.

Stone, M.L., J.B. Soile, W.R. Raun, R.W. Whitney, S.L. Taylor, and J.D. Ringer. 1996. Use of spectral radiance for correcting in-season fertilizer nitrogen deficiencies in winter wheat. Trans. ASAE. 39(5); 1623-1631.

Thenkabail, P.S., R.B. Smith, and E.DePauw. 2000. Hyperspectral Vegetation Indicies and their relationships with agricultural crop characteristics. Remote Sens. Environ. 71:158-182.

Vleeshouwers, L.M., and R.E.E. Jongschaap. 2001. Chlorophyll and nitrogen relations in maize with regards to spectral properties: forcing methods of remote sensing data in crop growth simulation models. Deliverable D06 EU Croma (EVG1-2000-000027). Available online: http: //library. wur.nl /wasp/bestanden/ LUWPUBRD _00121626_A502_001.pdf . Verified 2/22/2005.

APPENDIX A

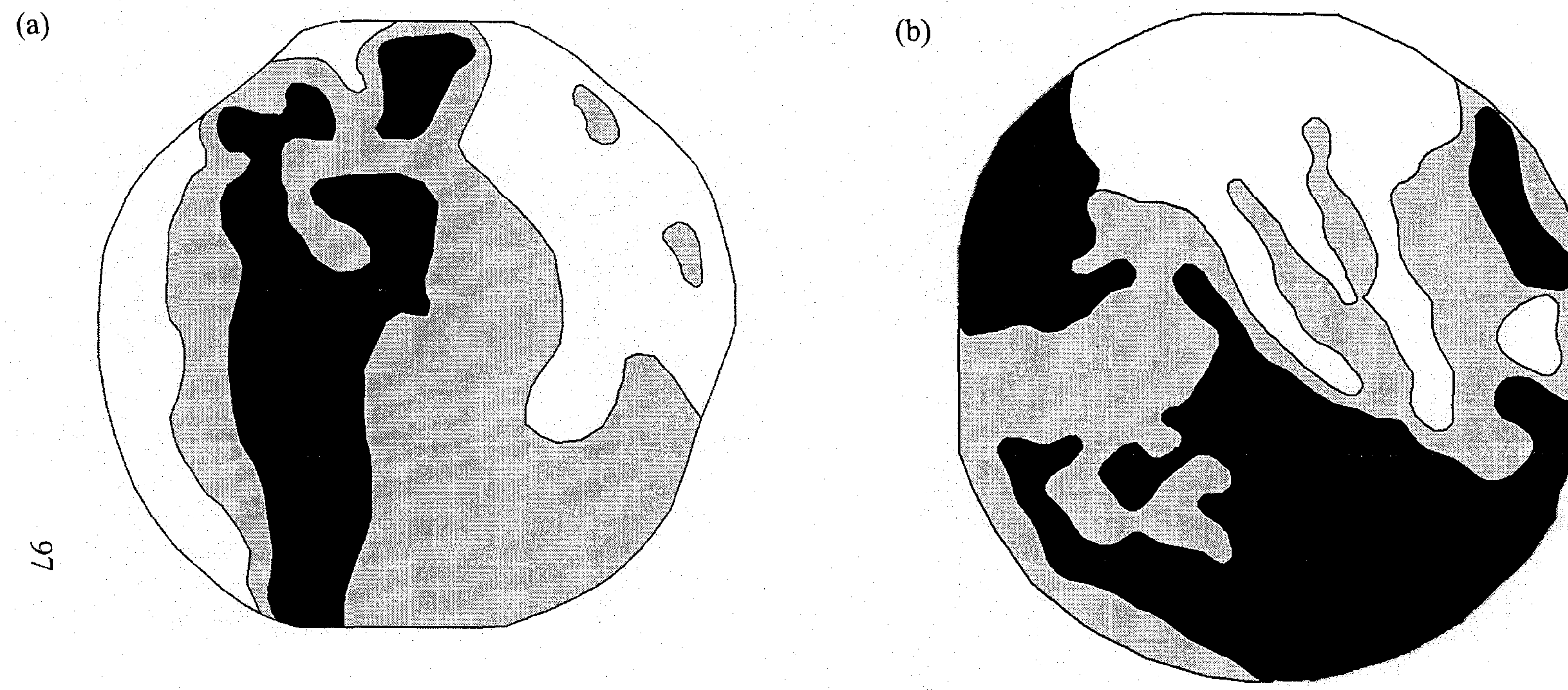


Figure A.1. Site-specific management zones for Chapter 1, (a) site years I and II, (b) site year III. Management zones are as follows: white =low productivity potential zone, gray = medium productivity potential zone, and black = high productivity potential zone.

Table A.1. Data from Chapter 1, Site year I.

X utm	Y utm	Zone	N rate (kg ha^{-1})	Grain wt (g)	Biomass(g)	%N (grain)	% N (total)	Yield (Mg ha^{-1})
582095.75	4464725.40	Low	0	1126.4	1126.4	1.1	2.0	7.5
582109.45	4464746.82	Low	0	1299.6	1299.6	1.2	2.1	8.7
582119.69	4464783.00	Low	0	1571.4	1571.4	1.3	2.2	10.5
582106.54	4464766.92	Low	0	884.1	884.1	1.3	2.4	5.9
582023.64	4464792.33	Low	238	1776.1	1776.1	1.4	2.6	11.8
582059.21	4464848.34	Low	238	1569.9	1569.9	1.1	2.5	10.5
582038.91	4464844.63	Low	238	1829.2	1829.2	1.3	2.4	12.2
582024.76	4464818.76	Low	238	1576.4	1576.4	1.2	2.2	10.5
582076.76	4464784.52	Low	127	1662.5	1662.5	1.8	3.0	11.1
582098.86	4464816.63	Low	127	1783.1	1783.1	3.0	4.0	11.9
582077.42	4464813.88	Low	127	2255.7	2255.7	1.4	2.5	15.0
582054.35	4464767.09	Low	127	1552.9	1552.9	1.4	2.8	10.4
582140.92	4464805.45	Medium	0	1496.8	1496.8	1.2	2.2	10.0
582165.84	4464837.04	Medium	0	1586.9	1586.9	1.2	2.2	10.6
582163.42	4464853.49	Medium	0	1672.0	1672.0	1.3	2.5	11.1
582148.51	4464829.85	Medium	0	1878.8	1878.8	1.2	2.2	12.5
582116.65	4464946.07	Medium	238	1499.8	1499.8	1.2	2.1	10.0
582098.22	4464936.65	Medium	238	1592.9	1592.9	1.3	2.4	10.6
582079.42	4464907.52	Medium	238	1990.4	1990.4	1.2	2.3	13.3
582119.05	4464855.24	Medium	127	1869.2	1869.2	1.3	2.3	12.5
582129.70	4464872.59	Medium	127	1385.7	1385.7	1.3	2.3	9.2
582383.97	4464903.76	Medium	127	1821.7	1821.7	1.1	2.2	12.1
582105.93	4464849.79	Medium	127	1868.7	1868.7	1.3	2.7	12.5

Table A.1 Continued.

X utm	Y utm	Zone	N rate (kg ha^{-1})	Grain wt (g)	Biomass(g)	%N (grain)	% N (total)	Yield (Mg ha^{-1})
582194.26	4464886.04	High	0	1428.2	1428.2	1.5	2.2	9.5
582215.12	4464922.71	High	0	1721.1	1721.1	1.5	2.3	11.5
582195.58	4464905.17	High	0	2009.4	2009.4	1.6	2.8	13.4
582175.44	4464873.42	High	0	2218.2	2218.2	1.2	2.4	14.8
582159.02	4465011.41	High	238	2512.0	2512.0	1.3	2.4	16.7
582177.37	4465052.32	High	238	1870.2	1870.2	1.4	2.4	12.5
582157.87	4465034.80	High	238	1739.6	1739.6	1.4	2.7	11.6
582381.96	4464993.51	High	238	2008.9	2008.9	1.3	2.6	13.4
582155.48	4464914.51	High	127	1993.9	1993.9	1.4	2.8	13.3
582201.96	4464988.22	High	127	2014.4	2014.4	1.5	3.0	13.4
582170.03	4464954.28	High	127	2473.0	2473.0	1.3	2.7	16.5

Table A.2. Data from Chapter 1, Site year II.

X utm	Y utm	Zone	N rate (kg ha^{-1})	Grain wt(g)	Biomass(g)	%N (grain)	%N (total)	Yield (Mg ha^{-1})
582027.51	4464848.95	Low	0	1618.9	1336.2	1.2	2.2	10.8
582041.60	4464873.53	Low	0	1247.9	1306.6	1.1	2.2	8.3
582038.81	4464887.82	Low	0	1677.4	1406.0	1.2	2.0	11.2
582021.12	4464858.87	Low	0	1593.9	1398.2	1.2	2.4	10.6
582017.69	4464969.27	Low	96	1701.4	1419.4	1.3	2.5	11.3
582035.64	4464898.10	Low	96	1721.9	1223.2	1.3	2.3	11.5
582026.15	4464902.77	Low	96	2361.4	1649.2	1.5	2.6	15.7
582014.89	4464884.12	Low	96	1791.4	1384.1	1.1	2.2	11.9
582010.05	4464892.16	Low	192	1622.9	1501.0	1.4	2.6	10.8
582025.65	4464918.09	Low	192	1609.4	1360.1	1.3	2.6	10.7
582026.96	4464939.08	Low	192	1567.4	2037.4	1.3	2.4	10.4
582002.84	4464899.30	Low	192	lost	-	-	-	-
582065.39	4464912.53	Medium	0	1571.4	1469.9	1.2	1.9	10.5
582092.52	4464956.34	Medium	0	2051.4	2004.3	1.3	2.4	13.7
582105.81	4465000.11	Medium	0	2338.4	1266.0	1.0	1.6	15.6
582074.95	4464947.04	Medium	0	2027.4	1185.6	1.0	2.2	13.5
582060.09	4464938.33	Medium	96	2281.9	1704.9	1.2	2.2	15.2
582096.29	4464982.48	Medium	96	2147.9	1887.5	1.3	2.3	14.3
582107.19	4465036.31	Medium	96	2125.4	1612.6	-9.0	8.4	14.2
582070.97	4464977.42	Medium	96	2148.1	1706.9	1.3	2.1	14.3
582073.30	4464997.20	Medium	192	2093.4	1637.5	1.4	2.3	14.0
582108.93	4465056.10	Medium	192	2593.4	1739.6	1.4	2.8	17.3
582115.83	4465096.36	Medium	192	1885.6	1975.7	1.5	2.6	12.6
582080.17	4465028.70	Medium	192	2079.4	1577.6	1.4	2.4	13.9

Table A.2. Continued.

X utm	Y utm	Zone	N rate (kg ha^{-1})	Grain wt(g)	Biomass(g)	%N (grain)	%N (total)	Yield (Mg ha^{-1})
582129.99	4465018.36	High	0	2291.9	1505.4	1.3	2.2	15.3
582156.04	4465060.17	High	0	2015.4	1901.6	1.2	2.2	13.4
582158.57	4465084.72	High	0	2082.9	1580.2	1.0	1.8	13.9
582139.61	4465055.54	High	0	2013.9	2016.4	1.3	2.3	13.4
582136.62	4465064.17	High	96	2369.9	1925.4	1.4	2.5	15.8
582158.64	4465102.27	High	96	2373.4	1493.6	1.3	2.4	15.8
582192.22	4465140.81	High	96	1837.4	1779.1	1.3	2.2	12.2
582150.10	4465106.39	High	96	1572.9	1685.6	1.3	2.3	10.5
582151.07	4465125.83	High	192	2484.4	1685.8	1.4	2.6	16.6
582172.53	4465161.03	High	192	2505.4	1877.9	1.3	2.6	16.7
582181.26	4465193.76	High	192	1916.9	1924.5	1.1	2.0	12.8
582162.47	4465163.37	High	192	2699.9	1819.9	1.1	1.9	18.0

Table A.3. Data from Chapter 1, site year III.

X utm	Y utm	Zone	N rate (kg ha^{-1})	Grain wt (g)	Biomass (g)	%N (grain)	% N (total)	Yield (Mg ha^{-1})
696102.50	4446498.62	Low	0	1655.0	2581.9	1.1	1.9	10.4
696130.45	4446498.68	Low	0	924.8	1738.2	1.1	2.1	5.8
696119.86	4446506.19	Low	0	1195.1	2066.8	1.2	2.2	7.5
696104.37	4446505.12	Low	0	1575.7	2393.2	1.2	2.1	9.9
696115.53	4446515.29	Low	56	1659.8	2677.9	1.2	2.0	10.4
696155.40	4446516.32	Low	56	1655.1	2641.2	1.1	2.0	10.4
696142.48	4446524.54	Low	56	2244.3	3255.0	1.2	2.1	14.1
696124.50	4446524.63	Low	56	1942.8	2831.1	1.1	1.9	12.2
696070.96	4446478.81	Low	114	1994.6	2984.3	1.3	2.4	12.5
696102.64	4446479.74	Low	114	1781.4	2706.3	1.2	1.9	11.2
696096.89	4446488.04	Low	114	1552.5	2489.7	1.3	2.1	9.7
696082.06	4446487.54	Low	114	1940.6	2914.6	1.3	2.3	12.2
696626.98	4446516.34	Medium	0	1644.6	2447.1	1.2	2.2	10.3
696609.33	4446516.44	Medium	0	1534.1	2292.2	1.1	2.3	9.6
696602.89	4446508.39	Medium	0	2012.3	2958.5	1.2	2.0	12.6
696622.11	4446507.22	Medium	0	2029.2	3078.1	1.2	2.1	12.7
696384.82	4446528.72	Medium	56	2194.2	3193.7	1.1	2.0	13.8
696352.17	4446528.42	Medium	56	1796.0	2672.8	1.1	1.8	11.3
696353.18	4446519.45	Medium	56	1815.7	2756.5	1.0	1.7	11.4
696396.37	4446520.35	Medium	56	2084.6	3108.1	1.4	2.6	13.1
696636.71	4446499.60	Medium	114	1688.6	2615.0	1.2	2.1	10.6
696610.94	4446497.27	Medium	114	1628.2	2498.6	1.2	2.3	10.2
696613.95	4446489.46	Medium	114	1954.6	2968.0	1.2	2.1	12.3
696638.34	4446489.20	Medium	114	1654.6	2665.5	1.3	2.3	10.4

Table A.3. Continued.

X utm	Y utm	Zone	N rate (kg ha^{-1})	Grain wt (g)	Biomass (g)	%N (grain)	% N (total)	Yield (Mg ha^{-1})
696571.68	4446515.68	High	0	1607.8	2417.6	1.1	2.0	10.1
696536.76	4446514.33	High	0	1295.7	2080.6	1.0	2.0	8.1
696537.57	4446505.92	High	0	1412.2	2344.7	1.1	2.0	8.9
696566.96	4446506.90	High	0	1491.3	2373.9	1.1	1.9	9.4
696484.98	4446532.21	High	56	1655.8	2708.3	1.2	3.0	10.4
696442.46	4446531.10	High	56	1752.5	2745.0	1.1	2.3	11.0
696513.42	4446523.50	High	56	1303.9	1942.8	1.2	2.2	8.2
696554.91	4446524.47	High	56	813.1	1598.5	1.3	2.4	5.1
696575.99	4446497.36	High	114	1715.6	2712.5	1.3	2.4	10.8
696537.84	4446495.59	High	114	1553.3	2315.3	0.8	1.7	9.7
696526.31	4446486.74	High	114	1774.8	2679.3	0.7	1.7	11.1
696559.80	4446486.94	High	114	1782.0	2803.4	1.2	2.5	11.2

Table A.4. Soil texture data from Chapter 1, site years I and II.

X utm	Y utm	% Sand	% Silt	% Clay
582114.45	4464745.10	89.6	4.4	6
582177.14	4464800.51	85.6	6.4	8
582227.08	4464856.23	83.6	8.4	8
582289.82	4464907.10	83.6	8.4	8
582288.25	4464996.55	77.6	10.4	12
582344.39	4465051.57	79.6	8.4	12
582399.18	4465107.67	83.6	4.4	12
582443.94	4465170.33	87.6	4.4	8
582440.64	4465261.88	89.6	4.4	6
582503.14	4465310.86	91.6	2.4	6
582554.76	4465368.27	89.6	4.4	6
582576.42	4465445.87	89.6	4.4	6
582555.13	4465512.81	91.6	4.4	4
582502.09	4465468.93	91.6	4.4	4
582479.10	4465396.07	91.6	2.4	6
582424.92	4465339.30	89.6	4.4	6
582367.31	4465286.50	87.6	4.4	8
582369.59	4465194.38	79.6	8.4	12
582325.42	4465132.29	81.6	8.4	10
582267.41	4465076.26	79.6	8.4	12
582213.81	4465021.17	81.6	8.4	10
582213.18	4464931.24	85.6	6.4	8
582150.19	4464880.38	89.6	4.4	6
582100.27	4464822.32	87.6	4.4	8
582040.35	4464770.71	93.6	2.4	4
582022.47	4464843.45	87.6	6.4	6
582052.13	4464889.51	89.6	4.4	6
582101.22	4464945.33	87.6	6.4	6
582163.40	4464993.41	81.6	6.4	12
582166.77	4465088.92	79.6	10.4	10
582220.63	4465143.13	83.6	4.4	12
582274.59	4465197.01	85.6	4.4	10
582318.09	4465258.32	73.6	8.4	18
582314.78	4465344.31	89.6	4.4	6
582379.11	4465403.86	91.6	2.4	6
582432.27	4465459.84	87.6	6.4	6
582452.53	4465533.66	89.6	4.4	6
582382.70	4465564.76	89.6	4.4	6
582358.63	4465489.67	89.6	6.4	4
582306.68	4465431.81	91.6	4.4	4
582245.37	4465382.85	87.6	6.4	6
582247.81	4465291.29	83.6	6.4	10
582203.30	4465228.76	79.6	6.4	14
582146.41	4465171.74	81.6	4	14.4
582091.82	4465113.97	79.6	6	14.4

Table A.4. Continued.

X utm	Y utm	% Sand	% Silt	% Clay
582092.34	4465027.17	81.6	6	12.4
582031.21	4464977.32	83.6	6	10.4
581980.14	4464915.37	85.6	4	10.4
581968.00	4465015.71	87.6	4	8.4
582028.08	4465068.87	85.6	4	10.4
582033.89	4465160.19	83.6	4	12.4
582083.38	4465217.46	81.6	6	12.4
582139.31	4465269.13	71.6	8	20.4
582185.33	4465334.02	75.6	8	16.4
582181.21	4465423.57	85.6	4	10.4
582244.95	4465475.66	87.6	2	10.4
582296.66	4465531.95	87.6	2	10.4
582107.67	4465366.37	85.6	2	12.4
582068.46	4465300.99	83.6	6	10.4
582013.68	4465244.67	85.6	4	10.4
581959.93	4465187.13	87.6	2	10.4
581958.94	4465098.64	85.6	4	10.4
582000.68	4465330.22	87.6	2	10.4

Table A.5. Soil texture data from Chapter 1, site year III.

X utm	Y utm	% Sand	% Silt	% Clay
695990.10	4446190.90	58.8	28.4	12.8
696043.91	4446206.63	54.8	30.4	14.8
696116.81	4446206.18	56.8	30.4	12.8
696182.22	4446198.66	60.8	26.4	12.8
696236.57	4446219.72	62.8	26.4	10.8
696305.02	4446210.06	58.8	28.4	12.8
696373.16	4446206.05	62.8	22.4	14.8
696437.12	4446215.05	54.8	28.4	16.8
696501.71	4446229.16	72.8	16.4	10.8
696566.28	4446217.96	58.8	24.4	16.8
696627.43	4446223.65	62.8	26.4	10.8
696691.16	4446241.42	70.8	16.4	12.8
696732.92	4446261.72	64.8	24.4	10.8
696667.83	4446302.46	54.8	30.4	14.8
696606.23	4446287.97	58.8	22.4	18.8
696542.38	4446281.65	54.8	26.4	18.8
696478.69	4446291.88	54.8	30.4	14.8
696411.94	4446278.59	68.8	20.4	10.8
696351.03	4446270.01	58.8	26.4	14.8
696289.64	4446254.54	60.8	24.4	14.8
696224.92	4446248.08	56.8	28.4	14.8
696161.18	4446260.32	54.8	30.4	14.8
696096.01	4446268.62	68.8	22.4	8.8
696034.11	4446236.03	70.8	20.4	8.8
695969.94	4446251.81	50.8	32.4	16.8
695982.94	4446328.90	52.8	32.4	14.8
696017.65	4446298.59	46.8	34.4	18.8
696082.93	4446332.49	48.8	32.4	18.8
696144.46	4446326.53	56.8	30.4	12.8
696208.97	4446311.21	48.8	32.4	18.8
696274.17	4446314.90	56.8	22.4	20.8
696336.30	4446331.95	76.8	14.4	8.8
696400.31	4446342.17	56.8	22.4	20.8
696463.93	4446358.04	54.8	24.4	20.8
696527.15	4446342.79	50.8	30.4	18.8
696590.15	4446349.32	40.8	40.4	18.8

Table A.5 Continued.

X utm	Y utm	% Sand	% Silt	% Clay
696655.60	4446366.47	42.8	36.4	20.8
696718.67	4446324.33	56.8	28.4	14.8
696675.00	4446430.28	42.8	40.4	16.8
696611.63	4446414.98	54.8	26.4	18.8
696547.47	4446410.20	60.8	22.4	16.8
696484.96	4446421.23	59.2	19.6	21.2
696421.85	4446405.94	69.2	17.6	13.2
696358.50	4446396.29	71.2	15.6	13.2
696294.01	4446381.84	59.2	25.6	15.2
696228.85	4446376.15	61.2	23.6	15.2
696165.64	4446387.62	45.2	35.6	19.2
696099.59	4446396.57	45.2	33.6	21.2
696039.42	4446363.25	57.2	29.6	13.2
695976.14	4446380.93	61.2	25.6	13.2
696057.39	4446426.36	77.2	15.6	7.2
696121.14	4446460.12	77.2	13.6	9.2
696183.59	4446451.30	63.2	23.6	13.2
696249.02	4446440.10	57.2	25.6	17.2
696311.53	4446445.62	53.2	31.6	15.2
696375.57	4446458.28	63.2	21.6	15.2
696439.63	4446469.60	67.2	21.6	11.2
696503.03	4446483.58	67.2	23.6	9.2
696568.44	4446473.16	49.2	35.6	15.2
696629.97	4446476.99	57.2	29.6	13.2
696599.57	4446541.07	59.2	25.6	15.2
696535.26	4446535.73	61.2	21.6	17.2
696470.47	4446545.83	49.2	31.6	19.2
696406.77	4446533.51	71.2	17.6	11.2
696343.62	4446526.20	79.2	13.6	7.2
696279.82	4446507.89	69.2	19.6	11.2
696216.67	4446500.92	59.2	23.6	17.2
696152.61	4446515.58	81.2	11.6	7.2
696090.14	4446521.40	55.2	25.6	19.2
696184.00	4446580.38	57.2	21.6	21.2
696246.61	4446565.89	61.2	23.6	15.2
696311.32	4446572.02	55.2	27.6	17.2

APPENDIX B

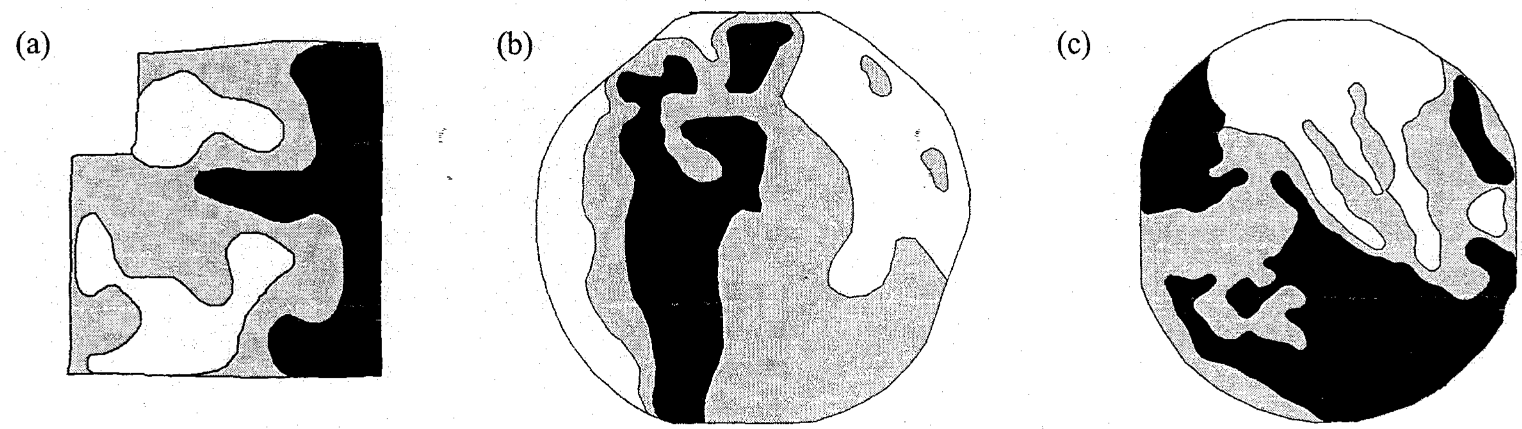


Figure A.2. Fields and management zones for (a) site years I and IV, (b) site years II and V, and (c) site years III and VI. Management zones are as follows: black = high zones, gray = medium zone, and white = low zone. Note that the fields are not at the same scale.

Table A.6. NDVI, relative yield, and management zone data for Chapter 2, site year I.

NDVI	Relative Yield	Zone
0.73	0.73	Low
0.75	0.47	Low
0.73	0.62	Low
0.74	0.88	Low
0.74	0.80	Low
0.74	0.72	Medium
0.69	0.69	Medium
0.75	0.69	Medium
0.74	0.84	Medium
0.70	0.80	Medium
0.75	0.79	High
0.75	0.75	High
0.65	0.59	High
0.73	0.94	High
0.74	1.00	High

Table A.7. NDVI, relative yield, and management zone data for Chapter 2, site year II.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.01	0.48	Low	0.09	0.60	Low	0.13	0.77	Low
0.02	0.63	Low	0.09	0.68	Low	0.13	0.68	Low
0.02	0.56	Low	0.09	0.51	Low	0.13	0.69	Low
0.03	0.47	Low	0.09	0.64	Low	0.13	0.66	Low
0.03	0.46	Low	0.09	0.80	Low	0.13	0.76	Low
0.03	0.58	Low	0.09	0.66	Low	0.13	0.67	Low
0.03	0.45	Low	0.09	0.70	Low	0.13	0.64	Low
0.03	0.50	Low	0.09	0.54	Low	0.13	0.68	Low
0.04	0.55	Low	0.09	0.55	Low	0.14	0.78	Low
0.04	0.75	Low	0.09	0.63	Low	0.14	0.66	Low
0.04	0.59	Low	0.10	0.56	Low	0.14	0.80	Low
0.04	0.65	Low	0.10	0.52	Low	0.14	0.78	Low
0.04	0.72	Low	0.10	0.57	Low	0.14	0.77	Low
0.04	0.70	Low	0.10	0.62	Low	0.14	0.78	Low
0.04	0.65	Low	0.10	0.75	Low	0.14	0.74	Low
0.04	0.60	Low	0.10	0.74	Low	0.14	0.71	Low
0.04	0.52	Low	0.10	0.62	Low	0.14	0.64	Low
0.04	0.53	Low	0.10	0.64	Low	0.14	0.59	Low
0.04	0.54	Low	0.10	0.63	Low	0.14	0.81	Low
0.05	0.62	Low	0.10	0.79	Low	0.14	0.78	Low
0.05	0.67	Low	0.10	0.78	Low	0.14	0.79	Low
0.05	0.66	Low	0.10	0.75	Low	0.15	0.81	Low
0.05	0.65	Low	0.10	0.76	Low	0.15	0.73	Low
0.05	0.49	Low	0.10	0.63	Low	0.15	0.75	Low
0.05	0.58	Low	0.10	0.76	Low	0.15	0.79	Low
0.05	0.60	Low	0.11	0.69	Low	0.15	0.77	Low
0.05	0.64	Low	0.11	0.57	Low	0.15	0.73	Low
0.05	0.55	Low	0.11	0.80	Low	0.15	0.73	Low
0.06	0.67	Low	0.11	0.60	Low	0.15	0.85	Low
0.06	0.66	Low	0.11	0.52	Low	0.15	0.69	Low
0.06	0.61	Low	0.11	0.67	Low	0.15	0.76	Low
0.06	0.66	Low	0.11	0.64	Low	0.16	0.77	Low
0.06	0.66	Low	0.11	0.58	Low	0.16	0.72	Low
0.06	0.74	Low	0.11	0.58	Low	0.16	0.72	Low
0.06	0.67	Low	0.11	0.65	Low	0.16	0.77	Low
0.07	0.66	Low	0.11	0.63	Low	0.16	0.75	Low
0.07	0.72	Low	0.11	0.62	Low	0.16	0.69	Low
0.07	0.68	Low	0.11	0.56	Low	0.16	0.71	Low
0.07	0.56	Low	0.12	0.83	Low	0.16	0.81	Low
0.07	0.78	Low	0.12	0.72	Low	0.16	0.75	Low
0.08	0.52	Low	0.12	0.71	Low	0.16	0.78	Low
0.08	0.76	Low	0.12	0.75	Low	0.16	0.79	Low
0.08	0.70	Low	0.12	0.74	Low	0.16	0.69	Low
0.08	0.73	Low	0.12	0.69	Low	0.16	0.77	Low
0.08	0.59	Low	0.12	0.79	Low	0.16	0.71	Low

Table A.7. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.17	0.90	Low	0.20	0.67	Low	0.27	0.73	Low
0.17	0.83	Low	0.20	0.86	Low	0.27	0.77	Low
0.17	0.67	Low	0.20	0.63	Low	0.27	0.85	Low
0.17	0.69	Low	0.20	0.73	Low	0.28	0.72	Low
0.17	0.88	Low	0.21	0.83	Low	0.28	0.79	Low
0.17	0.76	Low	0.21	0.83	Low	0.28	0.79	Low
0.17	0.70	Low	0.21	0.76	Low	0.28	0.72	Low
0.17	0.67	Low	0.21	0.87	Low	0.28	0.78	Low
0.17	0.84	Low	0.21	0.81	Low	0.28	0.72	Low
0.17	0.63	Low	0.21	0.75	Low	0.28	0.78	Low
0.17	0.87	Low	0.21	0.68	Low	0.28	0.70	Low
0.17	0.72	Low	0.21	0.73	Low	0.28	0.73	Low
0.17	0.75	Low	0.21	0.75	Low	0.29	0.85	Low
0.17	0.63	Low	0.21	0.91	Low	0.29	0.78	Low
0.17	0.81	Low	0.21	0.71	Low	0.29	0.75	Low
0.17	0.73	Low	0.21	0.78	Low	0.29	0.77	Low
0.17	0.71	Low	0.21	0.71	Low	0.29	0.82	Low
0.17	0.86	Low	0.21	0.66	Low	0.29	0.77	Low
0.17	0.70	Low	0.21	0.72	Low	0.29	0.96	Low
0.17	0.72	Low	0.21	0.62	Low	0.29	0.76	Low
0.17	0.73	Low	0.22	0.74	Low	0.29	0.74	Low
0.17	0.72	Low	0.22	0.70	Low	0.29	0.82	Low
0.17	0.78	Low	0.22	0.88	Low	0.29	0.75	Low
0.18	0.77	Low	0.22	0.68	Low	0.29	0.88	Low
0.18	0.73	Low	0.22	0.66	Low	0.29	0.79	Low
0.18	0.83	Low	0.23	0.94	Low	0.29	0.85	Low
0.18	0.68	Low	0.23	0.67	Low	0.29	0.68	Low
0.18	0.78	Low	0.23	0.72	Low	0.29	0.83	Low
0.18	0.74	Low	0.23	0.60	Low	0.30	0.78	Low
0.18	0.82	Low	0.24	0.83	Low	0.30	0.72	Low
0.18	0.82	Low	0.24	0.74	Low	0.30	0.88	Low
0.18	0.66	Low	0.24	0.79	Low	0.30	0.86	Low
0.18	0.80	Low	0.24	0.90	Low	0.30	0.90	Low
0.18	0.90	Low	0.24	0.70	Low	0.30	0.73	Low
0.19	0.74	Low	0.24	0.72	Low	0.30	0.81	Low
0.19	0.61	Low	0.24	0.87	Low	0.30	0.83	Low
0.19	0.77	Low	0.25	0.76	Low	0.30	0.75	Low
0.19	0.77	Low	0.25	0.82	Low	0.30	0.83	Low
0.19	0.85	Low	0.25	0.82	Low	0.30	0.85	Low
0.19	0.72	Low	0.25	0.81	Low	0.30	0.82	Low
0.19	0.71	Low	0.25	0.81	Low	0.30	0.79	Low
0.19	0.64	Low	0.25	0.80	Low	0.30	0.84	Low
0.20	0.77	Low	0.25	0.76	Low	0.31	0.86	Low
0.20	0.92	Low	0.26	0.79	Low	0.31	0.91	Low
0.20	0.81	Low	0.26	0.80	Low	0.31	0.73	Low
0.20	0.64	Low	0.26	0.86	Low	0.31	0.84	Low

Table A.7. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.31	0.79	Low	0.34	0.71	Low	0.36	0.79	Low
0.31	0.89	Low	0.34	0.82	Low	0.36	0.85	Low
0.31	0.80	Low	0.34	0.86	Low	0.36	0.80	Low
0.31	0.82	Low	0.34	0.80	Low	0.36	0.79	Low
0.32	0.82	Low	0.34	0.78	Low	0.36	0.78	Low
0.32	0.86	Low	0.34	0.79	Low	0.36	0.87	Low
0.32	0.76	Low	0.34	0.82	Low	0.36	0.65	Low
0.32	0.83	Low	0.34	0.84	Low	0.36	0.86	Low
0.32	0.75	Low	0.34	0.75	Low	0.36	0.84	Low
0.32	0.81	Low	0.34	0.77	Low	0.36	0.81	Low
0.32	0.80	Low	0.34	0.83	Low	0.36	0.88	Low
0.32	0.85	Low	0.34	0.83	Low	0.36	0.69	Low
0.32	0.78	Low	0.35	0.73	Low	0.36	0.87	Low
0.32	0.87	Low	0.35	0.81	Low	0.36	0.96	Low
0.32	0.85	Low	0.35	0.83	Low	0.36	0.88	Low
0.32	0.85	Low	0.35	0.93	Low	0.36	0.83	Low
0.32	0.75	Low	0.35	0.80	Low	0.36	0.82	Low
0.32	0.81	Low	0.35	0.93	Low	0.36	0.90	Low
0.32	0.71	Low	0.35	0.97	Low	0.36	0.83	Low
0.32	0.82	Low	0.35	0.74	Low	0.36	0.82	Low
0.32	0.83	Low	0.35	0.66	Low	0.36	0.78	Low
0.32	0.83	Low	0.35	0.75	Low	0.36	0.82	Low
0.32	0.81	Low	0.35	0.78	Low	0.36	0.93	Low
0.33	0.87	Low	0.35	0.85	Low	0.36	0.82	Low
0.33	0.83	Low	0.35	0.83	Low	0.36	0.78	Low
0.33	0.84	Low	0.35	0.77	Low	0.36	0.82	Low
0.33	0.78	Low	0.35	0.87	Low	0.37	0.90	Low
0.33	0.84	Low	0.35	0.75	Low	0.37	0.82	Low
0.33	0.81	Low	0.35	0.87	Low	0.37	0.89	Low
0.33	0.79	Low	0.35	0.82	Low	0.37	0.79	Low
0.33	0.77	Low	0.35	0.73	Low	0.37	0.87	Low
0.33	0.82	Low	0.35	0.93	Low	0.37	0.87	Low
0.33	0.83	Low	0.35	0.89	Low	0.37	0.92	Low
0.33	0.81	Low	0.35	0.84	Low	0.37	0.79	Low
0.33	0.86	Low	0.35	0.82	Low	0.37	0.81	Low
0.33	0.66	Low	0.36	0.74	Low	0.37	0.82	Low
0.33	0.87	Low	0.36	0.84	Low	0.37	0.84	Low
0.33	0.81	Low	0.36	0.86	Low	0.37	0.88	Low
0.33	0.87	Low	0.36	0.68	Low	0.37	0.77	Low
0.33	0.96	Low	0.36	0.87	Low	0.37	0.71	Low
0.33	0.87	Low	0.36	0.85	Low	0.37	0.89	Low
0.33	0.81	Low	0.36	0.78	Low	0.37	0.87	Low
0.33	0.75	Low	0.36	0.86	Low	0.37	0.81	Low
0.33	0.77	Low	0.36	0.87	Low	0.37	0.84	Low
0.33	0.79	Low	0.36	0.76	Low	0.37	0.80	Low
0.34	0.90	Low	0.36	0.84	Low	0.37	0.76	Low

Table A.7. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.34	0.81	Low	0.36	0.85	Low	0.37	0.85	Low
0.34	0.86	Low	0.36	0.82	Low	0.37	0.94	Low
0.34	0.82	Low	0.36	0.78	Low	0.37	0.82	Low
0.34	0.77	Low	0.36	0.89	Low	0.38	0.89	Low
0.38	0.81	Low	0.40	0.85	Low	0.43	0.84	Low
0.38	0.82	Low	0.40	0.84	Low	0.43	0.79	Low
0.38	0.84	Low	0.40	0.91	Low	0.44	0.92	Low
0.38	0.77	Low	0.40	0.85	Low	0.44	0.93	Low
0.38	0.91	Low	0.40	0.85	Low	0.44	0.83	Low
0.38	0.88	Low	0.40	0.91	Low	0.44	0.95	Low
0.38	0.87	Low	0.40	0.88	Low	0.44	0.83	Low
0.38	0.82	Low	0.40	0.90	Low	0.44	0.97	Low
0.38	0.71	Low	0.40	0.83	Low	0.45	0.91	Low
0.38	0.85	Low	0.40	0.77	Low	0.45	0.89	Low
0.38	0.73	Low	0.40	0.89	Low	0.45	0.88	Low
0.38	0.86	Low	0.40	0.87	Low	0.45	0.98	Low
0.38	0.83	Low	0.40	0.83	Low	0.45	0.82	Low
0.38	0.90	Low	0.40	0.85	Low	0.45	0.86	Low
0.38	0.86	Low	0.40	0.88	Low	0.46	0.86	Low
0.38	0.86	Low	0.41	0.85	Low	0.46	0.85	Low
0.38	0.88	Low	0.41	0.81	Low	0.46	0.98	Low
0.38	0.79	Low	0.41	0.89	Low	0.46	0.96	Low
0.38	0.87	Low	0.41	0.83	Low	0.48	0.86	Low
0.38	0.81	Low	0.41	0.80	Low	0.11	0.59	Medium
0.38	0.89	Low	0.41	0.88	Low	0.13	0.68	Medium
0.38	0.84	Low	0.41	0.95	Low	0.13	0.75	Medium
0.38	0.79	Low	0.41	0.87	Low	0.13	0.83	Medium
0.38	0.90	Low	0.41	0.88	Low	0.14	0.72	Medium
0.38	0.77	Low	0.41	0.83	Low	0.14	0.80	Medium
0.38	0.80	Low	0.41	0.91	Low	0.14	0.76	Medium
0.38	0.87	Low	0.41	0.81	Low	0.14	0.83	Medium
0.38	0.85	Low	0.41	0.80	Low	0.14	0.62	Medium
0.39	0.92	Low	0.41	0.84	Low	0.14	0.61	Medium
0.39	0.96	Low	0.41	0.86	Low	0.14	0.84	Medium
0.39	0.91	Low	0.41	0.90	Low	0.14	0.76	Medium
0.39	0.90	Low	0.41	0.83	Low	0.14	0.79	Medium
0.39	0.83	Low	0.41	0.88	Low	0.14	0.67	Medium
0.39	0.95	Low	0.41	0.91	Low	0.14	0.80	Medium
0.39	0.90	Low	0.41	0.83	Low	0.14	0.71	Medium
0.39	0.82	Low	0.41	0.91	Low	0.15	0.84	Medium
0.39	0.94	Low	0.41	0.87	Low	0.15	0.78	Medium
0.39	0.88	Low	0.42	0.96	Low	0.15	0.71	Medium
0.39	0.86	Low	0.42	0.82	Low	0.15	0.71	Medium
0.39	0.86	Low	0.42	0.92	Low	0.15	0.61	Medium
0.39	0.89	Low	0.42	0.84	Low	0.15	0.86	Medium
0.39	0.91	Low	0.42	0.84	Low	0.15	0.68	Medium

Table A.7. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.39	0.89	Low	0.42	0.88	Low	0.15	0.84	Medium
0.39	0.81	Low	0.42	0.91	Low	0.15	0.82	Medium
0.39	0.85	Low	0.42	0.86	Low	0.15	0.87	Medium
0.39	0.84	Low	0.42	0.93	Low	0.15	0.78	Medium
0.39	0.89	Low	0.42	0.74	Low	0.16	0.77	Medium
0.39	0.86	Low	0.42	0.86	Low	0.16	0.71	Medium
0.40	0.92	Low	0.43	0.84	Low	0.16	0.86	Medium
0.40	0.88	Low	0.43	0.87	Low	0.16	0.76	Medium
0.16	0.61	Medium	0.19	0.80	Medium	0.22	0.82	Medium
0.17	0.86	Medium	0.19	0.81	Medium	0.22	0.79	Medium
0.17	0.72	Medium	0.19	0.84	Medium	0.22	0.74	Medium
0.17	0.75	Medium	0.20	0.75	Medium	0.22	0.90	Medium
0.17	0.74	Medium	0.20	0.78	Medium	0.22	0.87	Medium
0.17	0.86	Medium	0.20	0.79	Medium	0.22	0.80	Medium
0.17	0.71	Medium	0.20	0.95	Medium	0.22	0.75	Medium
0.17	0.82	Medium	0.20	0.82	Medium	0.22	0.77	Medium
0.17	0.72	Medium	0.20	0.82	Medium	0.22	0.87	Medium
0.17	0.79	Medium	0.20	0.78	Medium	0.22	0.82	Medium
0.17	0.82	Medium	0.20	0.81	Medium	0.22	0.81	Medium
0.17	0.90	Medium	0.20	0.82	Medium	0.22	0.81	Medium
0.17	0.84	Medium	0.20	0.78	Medium	0.22	0.84	Medium
0.17	0.79	Medium	0.20	0.82	Medium	0.22	0.77	Medium
0.17	0.66	Medium	0.20	0.76	Medium	0.22	0.78	Medium
0.17	0.70	Medium	0.20	0.80	Medium	0.22	0.79	Medium
0.17	0.69	Medium	0.20	0.86	Medium	0.22	0.82	Medium
0.17	0.69	Medium	0.20	0.83	Medium	0.23	0.85	Medium
0.18	0.70	Medium	0.20	0.89	Medium	0.23	0.84	Medium
0.18	0.77	Medium	0.20	0.83	Medium	0.23	0.83	Medium
0.18	0.71	Medium	0.20	0.72	Medium	0.23	0.88	Medium
0.18	0.77	Medium	0.20	0.78	Medium	0.23	0.77	Medium
0.18	0.74	Medium	0.20	0.74	Medium	0.23	0.97	Medium
0.18	0.73	Medium	0.20	0.79	Medium	0.23	0.87	Medium
0.18	0.93	Medium	0.20	0.77	Medium	0.23	0.79	Medium
0.18	0.77	Medium	0.20	0.80	Medium	0.23	0.86	Medium
0.18	0.67	Medium	0.20	0.81	Medium	0.23	0.59	Medium
0.18	0.87	Medium	0.21	0.71	Medium	0.23	0.81	Medium
0.18	0.69	Medium	0.21	0.89	Medium	0.23	0.82	Medium
0.18	0.78	Medium	0.21	0.76	Medium	0.23	0.80	Medium
0.18	0.81	Medium	0.21	0.68	Medium	0.23	0.81	Medium
0.18	0.77	Medium	0.21	0.77	Medium	0.23	0.90	Medium
0.18	0.76	Medium	0.21	0.82	Medium	0.23	0.74	Medium
0.18	0.78	Medium	0.21	0.81	Medium	0.23	0.91	Medium
0.18	0.79	Medium	0.21	0.85	Medium	0.23	0.86	Medium
0.18	0.77	Medium	0.21	0.87	Medium	0.23	0.88	Medium
0.18	0.81	Medium	0.21	0.82	Medium	0.23	0.81	Medium
0.18	0.72	Medium	0.21	0.86	Medium	0.23	0.79	Medium

Table A.7. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.18	0.73	Medium	0.21	0.80	Medium	0.23	0.88	Medium
0.18	0.93	Medium	0.21	0.78	Medium	0.23	0.81	Medium
0.19	0.89	Medium	0.21	0.77	Medium	0.23	0.81	Medium
0.19	0.80	Medium	0.21	0.77	Medium	0.23	0.79	Medium
0.19	0.72	Medium	0.21	0.93	Medium	0.24	0.85	Medium
0.19	0.76	Medium	0.21	0.83	Medium	0.24	0.75	Medium
0.19	0.81	Medium	0.21	0.78	Medium	0.24	0.77	Medium
0.19	0.86	Medium	0.21	0.73	Medium	0.24	0.83	Medium
0.19	0.74	Medium	0.21	0.75	Medium	0.24	0.76	Medium
0.19	0.86	Medium	0.21	0.79	Medium	0.24	0.71	Medium
0.19	0.91	Medium	0.21	0.76	Medium	0.24	0.78	Medium
0.19	0.79	Medium	0.21	0.85	Medium	0.24	0.85	Medium
0.24	0.86	Medium	0.26	0.76	Medium	0.28	0.85	Medium
0.24	0.81	Medium	0.26	0.75	Medium	0.28	0.82	Medium
0.24	0.82	Medium	0.26	0.78	Medium	0.28	0.84	Medium
0.24	0.79	Medium	0.26	0.82	Medium	0.28	0.83	Medium
0.24	0.76	Medium	0.26	0.82	Medium	0.28	0.88	Medium
0.24	0.93	Medium	0.26	0.76	Medium	0.28	0.77	Medium
0.24	0.76	Medium	0.26	0.65	Medium	0.28	0.85	Medium
0.24	0.86	Medium	0.26	0.92	Medium	0.28	0.85	Medium
0.24	0.89	Medium	0.26	0.76	Medium	0.28	0.77	Medium
0.24	0.81	Medium	0.26	0.79	Medium	0.28	0.88	Medium
0.25	0.80	Medium	0.26	0.81	Medium	0.29	0.77	Medium
0.25	0.82	Medium	0.26	0.84	Medium	0.29	0.85	Medium
0.25	0.80	Medium	0.26	0.86	Medium	0.29	0.82	Medium
0.25	0.86	Medium	0.26	0.85	Medium	0.29	0.84	Medium
0.25	0.83	Medium	0.26	0.90	Medium	0.29	0.84	Medium
0.25	0.87	Medium	0.26	0.87	Medium	0.29	0.86	Medium
0.25	0.85	Medium	0.27	0.77	Medium	0.29	0.78	Medium
0.25	0.86	Medium	0.27	0.82	Medium	0.29	0.95	Medium
0.25	0.82	Medium	0.27	0.90	Medium	0.29	0.84	Medium
0.25	0.76	Medium	0.27	0.76	Medium	0.29	0.80	Medium
0.25	0.88	Medium	0.27	0.82	Medium	0.29	0.85	Medium
0.25	0.81	Medium	0.27	0.79	Medium	0.29	0.70	Medium
0.25	0.86	Medium	0.27	0.89	Medium	0.29	0.87	Medium
0.25	0.87	Medium	0.27	0.87	Medium	0.29	0.82	Medium
0.25	0.89	Medium	0.27	0.82	Medium	0.30	0.78	Medium
0.25	0.77	Medium	0.27	0.77	Medium	0.30	0.80	Medium
0.25	0.75	Medium	0.27	0.80	Medium	0.30	0.82	Medium
0.25	0.80	Medium	0.27	0.86	Medium	0.30	0.82	Medium
0.25	0.88	Medium	0.27	0.88	Medium	0.30	0.84	Medium
0.25	0.73	Medium	0.27	0.82	Medium	0.30	0.85	Medium
0.25	0.84	Medium	0.27	0.86	Medium	0.30	0.88	Medium
0.25	0.81	Medium	0.27	0.82	Medium	0.30	0.69	Medium
0.25	0.83	Medium	0.27	0.79	Medium	0.30	0.88	Medium
0.25	0.82	Medium	0.27	0.87	Medium	0.30	0.72	Medium

Table A.7. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.25	0.79	Medium	0.27	0.89	Medium	0.30	0.72	Medium
0.25	0.88	Medium	0.27	0.86	Medium	0.30	0.85	Medium
0.25	0.81	Medium	0.27	0.75	Medium	0.30	0.85	Medium
0.26	0.89	Medium	0.27	0.79	Medium	0.30	0.81	Medium
0.26	0.79	Medium	0.27	0.89	Medium	0.30	0.70	Medium
0.26	0.87	Medium	0.27	0.86	Medium	0.30	0.84	Medium
0.26	0.92	Medium	0.27	0.87	Medium	0.30	0.87	Medium
0.26	0.82	Medium	0.28	0.89	Medium	0.30	0.81	Medium
0.26	0.86	Medium	0.28	0.68	Medium	0.30	0.85	Medium
0.26	0.80	Medium	0.28	0.86	Medium	0.30	0.79	Medium
0.26	0.83	Medium	0.28	0.82	Medium	0.31	0.76	Medium
0.26	0.77	Medium	0.28	0.83	Medium	0.31	0.87	Medium
0.26	0.80	Medium	0.28	0.84	Medium	0.31	0.85	Medium
0.26	0.85	Medium	0.28	0.87	Medium	0.31	0.82	Medium
0.26	0.92	Medium	0.28	0.91	Medium	0.31	0.81	Medium
0.26	0.83	Medium	0.28	0.90	Medium	0.31	0.88	Medium
0.31	0.97	Medium	0.33	0.77	Medium	0.34	0.87	Medium
0.31	0.83	Medium	0.33	0.80	Medium	0.34	0.90	Medium
0.31	0.83	Medium	0.33	0.84	Medium	0.34	0.86	Medium
0.31	0.73	Medium	0.33	0.76	Medium	0.34	0.89	Medium
0.31	0.84	Medium	0.33	0.80	Medium	0.34	0.93	Medium
0.31	0.82	Medium	0.33	0.75	Medium	0.34	0.86	Medium
0.31	0.88	Medium	0.33	0.78	Medium	0.34	0.85	Medium
0.31	0.78	Medium	0.33	0.79	Medium	0.34	0.93	Medium
0.31	0.86	Medium	0.33	0.81	Medium	0.34	0.90	Medium
0.31	0.77	Medium	0.33	0.75	Medium	0.35	0.90	Medium
0.31	0.77	Medium	0.33	0.89	Medium	0.35	0.88	Medium
0.31	0.78	Medium	0.33	0.87	Medium	0.35	0.89	Medium
0.31	0.81	Medium	0.33	0.73	Medium	0.35	0.70	Medium
0.31	0.85	Medium	0.33	0.81	Medium	0.35	0.85	Medium
0.31	0.90	Medium	0.33	0.76	Medium	0.35	0.91	Medium
0.31	0.77	Medium	0.33	0.87	Medium	0.35	0.87	Medium
0.31	0.79	Medium	0.33	0.94	Medium	0.35	0.91	Medium
0.32	0.84	Medium	0.33	1.00	Medium	0.35	0.76	Medium
0.32	0.82	Medium	0.33	0.79	Medium	0.35	0.81	Medium
0.32	0.87	Medium	0.33	0.85	Medium	0.35	0.84	Medium
0.32	0.79	Medium	0.33	0.80	Medium	0.35	0.85	Medium
0.32	0.84	Medium	0.33	0.77	Medium	0.35	0.79	Medium
0.32	0.82	Medium	0.33	0.82	Medium	0.35	0.90	Medium
0.32	0.96	Medium	0.33	0.84	Medium	0.35	0.84	Medium
0.32	0.89	Medium	0.33	0.83	Medium	0.35	0.91	Medium
0.32	0.87	Medium	0.33	0.87	Medium	0.35	0.88	Medium
0.32	0.81	Medium	0.33	0.75	Medium	0.35	0.81	Medium
0.32	0.84	Medium	0.33	0.72	Medium	0.35	0.82	Medium
0.32	0.81	Medium	0.33	0.80	Medium	0.35	0.85	Medium
0.32	0.89	Medium	0.34	0.86	Medium	0.35	0.82	Medium

Table A.7. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.32	0.83	Medium	0.34	0.85	Medium	0.35	0.84	Medium
0.32	0.91	Medium	0.34	0.87	Medium	0.35	0.85	Medium
0.32	0.89	Medium	0.34	0.91	Medium	0.35	0.84	Medium
0.32	0.77	Medium	0.34	0.81	Medium	0.35	0.85	Medium
0.32	0.77	Medium	0.34	0.85	Medium	0.35	0.88	Medium
0.32	0.93	Medium	0.34	0.86	Medium	0.35	0.87	Medium
0.32	0.89	Medium	0.34	0.84	Medium	0.35	0.85	Medium
0.32	0.93	Medium	0.34	0.84	Medium	0.35	0.92	Medium
0.32	0.90	Medium	0.34	0.89	Medium	0.35	0.89	Medium
0.32	0.84	Medium	0.34	0.82	Medium	0.35	0.85	Medium
0.32	0.78	Medium	0.34	0.86	Medium	0.35	0.92	Medium
0.32	0.83	Medium	0.34	0.80	Medium	0.35	0.89	Medium
0.32	0.74	Medium	0.34	0.79	Medium	0.35	0.82	Medium
0.32	0.76	Medium	0.34	0.78	Medium	0.35	0.89	Medium
0.32	0.85	Medium	0.34	0.85	Medium	0.35	0.81	Medium
0.32	0.95	Medium	0.34	0.89	Medium	0.35	0.88	Medium
0.32	0.78	Medium	0.34	0.82	Medium	0.35	0.81	Medium
0.32	0.76	Medium	0.34	0.91	Medium	0.35	0.83	Medium
0.32	0.79	Medium	0.34	0.85	Medium	0.35	0.83	Medium
0.32	0.78	Medium	0.34	0.86	Medium	0.35	0.90	Medium
0.35	0.79	Medium	0.36	0.80	Medium	0.37	0.87	Medium
0.35	0.82	Medium	0.36	0.89	Medium	0.37	0.90	Medium
0.35	0.80	Medium	0.36	0.81	Medium	0.37	0.87	Medium
0.35	0.84	Medium	0.36	0.84	Medium	0.37	0.89	Medium
0.35	0.84	Medium	0.36	0.82	Medium	0.37	0.77	Medium
0.35	0.84	Medium	0.36	0.90	Medium	0.37	0.92	Medium
0.35	0.90	Medium	0.36	0.89	Medium	0.37	0.84	Medium
0.35	0.80	Medium	0.36	0.87	Medium	0.37	0.83	Medium
0.35	0.79	Medium	0.36	0.79	Medium	0.37	0.87	Medium
0.35	0.91	Medium	0.36	0.91	Medium	0.37	0.71	Medium
0.35	0.78	Medium	0.36	0.88	Medium	0.37	0.95	Medium
0.36	0.95	Medium	0.37	0.93	Medium	0.37	0.95	Medium
0.36	0.94	Medium	0.37	0.81	Medium	0.37	0.88	Medium
0.36	0.81	Medium	0.37	0.89	Medium	0.37	0.84	Medium
0.36	0.88	Medium	0.37	0.90	Medium	0.38	0.89	Medium
0.36	0.87	Medium	0.37	0.86	Medium	0.38	0.80	Medium
0.36	0.84	Medium	0.37	0.87	Medium	0.38	0.84	Medium
0.36	0.86	Medium	0.37	0.90	Medium	0.38	0.85	Medium
0.36	0.88	Medium	0.37	0.87	Medium	0.38	0.84	Medium
0.36	0.87	Medium	0.37	0.84	Medium	0.38	0.82	Medium
0.36	0.81	Medium	0.37	0.82	Medium	0.38	0.91	Medium
0.36	0.81	Medium	0.37	0.81	Medium	0.38	0.89	Medium
0.36	0.91	Medium	0.37	0.95	Medium	0.38	0.78	Medium
0.36	0.85	Medium	0.37	0.83	Medium	0.38	0.79	Medium
0.36	0.87	Medium	0.37	0.86	Medium	0.38	0.85	Medium
0.36	0.87	Medium	0.37	0.87	Medium	0.38	0.84	Medium

Table A.7. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.36	0.87	Medium	0.37	0.87	Medium	0.38	0.84	Medium
0.36	0.85	Medium	0.37	0.83	Medium	0.38	0.81	Medium
0.36	0.83	Medium	0.37	0.86	Medium	0.38	0.90	Medium
0.36	0.85	Medium	0.37	0.85	Medium	0.38	0.87	Medium
0.36	0.85	Medium	0.37	0.84	Medium	0.38	0.84	Medium
0.36	0.82	Medium	0.37	0.88	Medium	0.38	0.83	Medium
0.36	0.88	Medium	0.37	0.92	Medium	0.38	0.86	Medium
0.36	0.86	Medium	0.37	0.89	Medium	0.38	0.82	Medium
0.36	0.93	Medium	0.37	0.79	Medium	0.38	0.82	Medium
0.36	0.80	Medium	0.37	0.88	Medium	0.38	0.80	Medium
0.36	0.91	Medium	0.37	0.86	Medium	0.38	0.80	Medium
0.36	0.81	Medium	0.37	0.84	Medium	0.38	0.86	Medium
0.36	0.86	Medium	0.37	0.79	Medium	0.38	0.91	Medium
0.36	0.89	Medium	0.37	0.84	Medium	0.38	0.84	Medium
0.36	0.82	Medium	0.37	0.96	Medium	0.38	0.88	Medium
0.36	0.78	Medium	0.37	0.80	Medium	0.38	0.87	Medium
0.36	0.84	Medium	0.37	0.85	Medium	0.38	0.89	Medium
0.36	0.88	Medium	0.37	0.86	Medium	0.38	0.93	Medium
0.36	0.93	Medium	0.37	0.87	Medium	0.38	0.86	Medium
0.36	0.89	Medium	0.37	0.97	Medium	0.38	0.86	Medium
0.36	0.88	Medium	0.37	0.90	Medium	0.38	0.87	Medium
0.36	0.80	Medium	0.37	0.82	Medium	0.38	0.88	Medium
0.36	0.79	Medium	0.37	0.85	Medium	0.38	0.87	Medium
0.36	0.93	Medium	0.37	0.89	Medium	0.38	0.89	Medium
0.38	0.80	Medium	0.40	0.89	Medium	0.41	0.88	Medium
0.38	0.83	Medium	0.40	0.81	Medium	0.41	0.78	Medium
0.38	0.84	Medium	0.40	0.94	Medium	0.41	0.92	Medium
0.38	0.84	Medium	0.40	0.94	Medium	0.41	0.83	Medium
0.39	0.84	Medium	0.40	0.84	Medium	0.41	0.87	Medium
0.39	0.95	Medium	0.40	0.86	Medium	0.41	0.78	Medium
0.39	0.87	Medium	0.40	0.83	Medium	0.41	0.87	Medium
0.39	0.97	Medium	0.40	0.82	Medium	0.41	0.82	Medium
0.39	0.82	Medium	0.40	0.82	Medium	0.41	0.76	Medium
0.39	0.90	Medium	0.40	0.79	Medium	0.41	0.87	Medium
0.39	0.84	Medium	0.40	0.82	Medium	0.41	0.84	Medium
0.39	0.88	Medium	0.40	0.85	Medium	0.41	0.90	Medium
0.39	0.82	Medium	0.40	0.84	Medium	0.41	0.91	Medium
0.39	0.90	Medium	0.40	0.82	Medium	0.42	0.79	Medium
0.39	0.88	Medium	0.40	0.86	Medium	0.42	0.88	Medium
0.39	0.76	Medium	0.40	0.74	Medium	0.42	0.90	Medium
0.39	0.92	Medium	0.40	0.88	Medium	0.42	0.82	Medium
0.39	0.89	Medium	0.40	0.87	Medium	0.42	0.82	Medium
0.39	0.82	Medium	0.40	0.80	Medium	0.42	0.95	Medium
0.39	0.93	Medium	0.40	0.87	Medium	0.42	0.78	Medium
0.39	0.89	Medium	0.40	0.88	Medium	0.42	0.77	Medium
0.39	0.82	Medium	0.40	0.88	Medium	0.42	0.92	Medium

Table A.7. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.39	0.89	Medium	0.40	0.77	Medium	0.42	0.72	Medium
0.39	0.81	Medium	0.40	0.83	Medium	0.42	0.90	Medium
0.39	0.83	Medium	0.40	0.89	Medium	0.42	0.93	Medium
0.39	0.86	Medium	0.40	0.82	Medium	0.42	0.82	Medium
0.39	0.90	Medium	0.40	0.79	Medium	0.42	0.84	Medium
0.39	0.76	Medium	0.40	0.89	Medium	0.42	0.89	Medium
0.39	0.90	Medium	0.40	0.88	Medium	0.42	0.86	Medium
0.39	0.89	Medium	0.40	0.83	Medium	0.42	0.80	Medium
0.39	0.84	Medium	0.40	0.81	Medium	0.42	0.85	Medium
0.39	0.87	Medium	0.41	0.86	Medium	0.42	0.89	Medium
0.39	0.81	Medium	0.41	0.83	Medium	0.42	0.88	Medium
0.39	0.86	Medium	0.41	0.84	Medium	0.42	0.85	Medium
0.39	0.79	Medium	0.41	0.87	Medium	0.42	0.87	Medium
0.39	0.87	Medium	0.41	0.80	Medium	0.42	0.84	Medium
0.39	0.90	Medium	0.41	0.93	Medium	0.42	0.91	Medium
0.39	0.88	Medium	0.41	0.91	Medium	0.42	0.88	Medium
0.39	0.91	Medium	0.41	0.78	Medium	0.42	0.79	Medium
0.39	0.81	Medium	0.41	0.80	Medium	0.43	0.84	Medium
0.39	0.86	Medium	0.41	0.84	Medium	0.43	0.89	Medium
0.39	0.88	Medium	0.41	0.78	Medium	0.43	0.80	Medium
0.39	0.89	Medium	0.41	0.94	Medium	0.43	0.86	Medium
0.39	0.80	Medium	0.41	0.80	Medium	0.43	0.82	Medium
0.39	0.83	Medium	0.41	0.81	Medium	0.43	0.85	Medium
0.39	0.73	Medium	0.41	0.92	Medium	0.43	0.87	Medium
0.40	0.90	Medium	0.41	0.83	Medium	0.43	0.84	Medium
0.40	0.91	Medium	0.41	0.87	Medium	0.43	0.83	Medium
0.40	0.88	Medium	0.41	0.85	Medium	0.43	0.81	Medium
0.40	0.84	Medium	0.41	0.79	Medium	0.43	0.93	Medium
0.43	0.92	Medium	0.45	0.87	Medium	0.47	0.91	Medium
0.43	0.87	Medium	0.45	0.92	Medium	0.47	0.86	Medium
0.43	0.90	Medium	0.45	0.94	Medium	0.47	0.81	Medium
0.43	0.85	Medium	0.45	0.90	Medium	0.48	0.88	Medium
0.43	0.83	Medium	0.45	0.89	Medium	0.48	0.85	Medium
0.43	0.84	Medium	0.45	0.90	Medium	0.48	0.84	Medium
0.43	0.90	Medium	0.45	0.88	Medium	0.48	1.02	Medium
0.43	0.85	Medium	0.45	0.81	Medium	0.48	0.84	Medium
0.43	0.84	Medium	0.45	0.91	Medium	0.48	0.91	Medium
0.43	0.77	Medium	0.45	0.87	Medium	0.48	0.90	Medium
0.43	0.82	Medium	0.45	0.88	Medium	0.48	0.90	Medium
0.43	0.88	Medium	0.45	0.88	Medium	0.49	0.87	Medium
0.43	0.90	Medium	0.45	0.86	Medium	0.49	0.81	Medium
0.43	0.83	Medium	0.45	0.89	Medium	0.49	0.86	Medium
0.43	0.80	Medium	0.45	0.92	Medium	0.49	0.92	Medium
0.43	0.82	Medium	0.45	0.86	Medium	0.51	0.88	Medium
0.43	0.85	Medium	0.45	0.89	Medium	0.52	0.90	Medium
0.44	0.82	Medium	0.45	0.89	Medium	0.52	0.89	Medium

Table A.7. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.44	0.85	Medium	0.45	0.84	Medium	0.09	0.84	High
0.44	0.86	Medium	0.45	0.90	Medium	0.10	0.89	High
0.44	0.78	Medium	0.45	0.97	Medium	0.11	0.84	High
0.44	0.87	Medium	0.46	0.94	Medium	0.12	0.80	High
0.44	0.86	Medium	0.46	0.78	Medium	0.13	0.90	High
0.44	0.83	Medium	0.46	0.93	Medium	0.13	0.83	High
0.44	0.89	Medium	0.46	0.92	Medium	0.14	0.79	High
0.44	0.85	Medium	0.46	1.01	Medium	0.18	0.88	High
0.44	0.88	Medium	0.46	0.90	Medium	0.19	0.91	High
0.44	0.88	Medium	0.46	0.84	Medium	0.19	0.82	High
0.44	0.84	Medium	0.46	0.82	Medium	0.19	0.83	High
0.44	0.86	Medium	0.46	0.85	Medium	0.20	0.89	High
0.44	0.92	Medium	0.46	0.90	Medium	0.20	0.76	High
0.44	0.87	Medium	0.46	0.82	Medium	0.20	0.73	High
0.44	0.82	Medium	0.46	0.79	Medium	0.21	0.92	High
0.44	0.86	Medium	0.46	0.80	Medium	0.21	0.77	High
0.44	0.83	Medium	0.46	0.85	Medium	0.21	0.79	High
0.44	0.88	Medium	0.46	0.86	Medium	0.22	0.79	High
0.44	0.88	Medium	0.46	0.85	Medium	0.22	0.88	High
0.44	0.91	Medium	0.46	0.96	Medium	0.22	0.82	High
0.44	0.89	Medium	0.46	0.80	Medium	0.22	0.81	High
0.44	0.88	Medium	0.46	0.88	Medium	0.22	0.87	High
0.44	0.96	Medium	0.47	0.86	Medium	0.22	0.83	High
0.44	0.88	Medium	0.47	0.84	Medium	0.22	0.80	High
0.44	0.85	Medium	0.47	0.94	Medium	0.22	0.80	High
0.44	0.80	Medium	0.47	0.86	Medium	0.22	0.83	High
0.44	0.82	Medium	0.47	0.86	Medium	0.22	0.86	High
0.44	1.00	Medium	0.47	0.97	Medium	0.23	0.73	High
0.44	0.87	Medium	0.47	0.97	Medium	0.23	0.75	High
0.44	0.87	Medium	0.47	0.89	Medium	0.23	0.77	High
0.44	0.83	Medium	0.47	0.95	Medium	0.23	0.86	High
0.45	0.92	Medium	0.47	0.90	Medium	0.23	0.86	High
0.23	0.81	High	0.26	0.96	High	0.29	0.78	High
0.23	0.82	High	0.26	0.91	High	0.29	0.89	High
0.23	0.76	High	0.26	0.80	High	0.29	0.84	High
0.24	0.86	High	0.26	0.84	High	0.29	0.85	High
0.24	0.86	High	0.26	0.92	High	0.29	0.86	High
0.24	0.80	High	0.26	0.82	High	0.29	0.89	High
0.24	0.86	High	0.26	0.86	High	0.29	0.92	High
0.24	0.87	High	0.26	0.86	High	0.29	0.75	High
0.24	0.83	High	0.26	0.85	High	0.29	0.86	High
0.24	0.82	High	0.26	0.85	High	0.29	0.95	High
0.24	0.76	High	0.26	0.84	High	0.29	0.89	High
0.24	0.84	High	0.27	0.79	High	0.29	0.95	High
0.24	0.78	High	0.27	0.84	High	0.29	0.83	High
0.24	0.86	High	0.27	0.87	High	0.29	0.88	High

Table A.7. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.25	0.72	High	0.27	0.84	High	0.29	0.84	High
0.25	0.82	High	0.27	0.87	High	0.29	0.85	High
0.25	0.80	High	0.27	0.82	High	0.30	0.86	High
0.25	0.89	High	0.27	0.68	High	0.30	0.86	High
0.25	0.86	High	0.27	0.79	High	0.30	0.94	High
0.25	0.96	High	0.27	0.86	High	0.30	0.83	High
0.25	0.84	High	0.27	0.68	High	0.30	0.87	High
0.25	0.85	High	0.27	0.78	High	0.30	0.84	High
0.25	0.84	High	0.27	0.83	High	0.30	0.89	High
0.25	0.80	High	0.27	0.85	High	0.30	0.86	High
0.25	0.94	High	0.27	0.73	High	0.30	0.86	High
0.25	0.81	High	0.27	0.75	High	0.30	0.91	High
0.25	0.81	High	0.27	0.92	High	0.30	0.85	High
0.25	0.83	High	0.27	0.88	High	0.30	0.81	High
0.25	0.85	High	0.27	0.85	High	0.30	0.85	High
0.25	0.90	High	0.27	0.82	High	0.30	0.86	High
0.25	0.90	High	0.27	0.88	High	0.30	0.88	High
0.25	0.82	High	0.28	0.88	High	0.30	0.83	High
0.25	0.83	High	0.28	0.88	High	0.30	0.93	High
0.25	0.91	High	0.28	0.78	High	0.30	0.94	High
0.25	0.84	High	0.28	0.84	High	0.30	0.84	High
0.25	0.87	High	0.28	0.82	High	0.30	0.84	High
0.25	0.95	High	0.28	0.90	High	0.30	0.75	High
0.25	0.87	High	0.28	0.92	High	0.30	0.94	High
0.26	0.88	High	0.28	0.94	High	0.30	0.90	High
0.26	0.76	High	0.28	0.84	High	0.30	0.86	High
0.26	0.86	High	0.28	0.88	High	0.30	0.83	High
0.26	0.87	High	0.28	0.82	High	0.31	0.83	High
0.26	0.86	High	0.28	0.91	High	0.31	0.81	High
0.26	0.81	High	0.28	0.82	High	0.31	0.78	High
0.26	0.84	High	0.28	0.97	High	0.31	0.85	High
0.26	0.88	High	0.28	0.70	High	0.31	0.82	High
0.26	0.88	High	0.29	0.90	High	0.31	0.95	High
0.26	0.81	High	0.29	0.91	High	0.31	0.88	High
0.26	0.88	High	0.29	0.83	High	0.31	0.90	High
0.26	0.71	High	0.29	0.96	High	0.31	0.79	High
0.31	0.86	High	0.34	0.88	High	0.38	0.86	High
0.31	0.82	High	0.34	0.84	High	0.38	0.99	High
0.31	0.78	High	0.34	0.87	High	0.38	0.96	High
0.31	0.89	High	0.34	0.89	High	0.38	0.96	High
0.31	0.84	High	0.34	0.95	High	0.39	0.98	High
0.31	0.87	High	0.34	0.90	High	0.39	0.86	High
0.31	0.95	High	0.34	0.89	High	0.39	0.88	High
0.31	0.95	High	0.34	0.78	High	0.40	0.88	High
0.31	0.91	High	0.34	0.85	High	0.40	0.93	High
0.31	0.92	High	0.35	0.82	High	0.40	0.89	High

Table A.7. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.31	0.98	High	0.35	0.87	High	0.40	0.90	High
0.31	0.81	High	0.35	0.84	High	0.40	0.93	High
0.31	0.85	High	0.35	0.92	High	0.40	0.80	High
0.31	0.86	High	0.35	0.89	High	0.40	0.94	High
0.31	0.94	High	0.35	0.87	High	0.40	0.92	High
0.32	0.88	High	0.35	0.89	High	0.40	0.96	High
0.32	0.91	High	0.36	0.90	High	0.40	0.96	High
0.32	0.88	High	0.36	0.89	High	0.40	0.90	High
0.32	0.87	High	0.36	0.94	High	0.41	0.91	High
0.32	0.83	High	0.36	0.89	High	0.41	0.88	High
0.32	0.89	High	0.36	0.89	High	0.41	0.90	High
0.32	0.75	High	0.36	0.78	High	0.41	0.95	High
0.32	0.84	High	0.36	0.87	High	0.41	0.90	High
0.32	0.82	High	0.36	0.89	High	0.41	0.92	High
0.32	0.84	High	0.36	0.87	High	0.41	0.91	High
0.32	0.79	High	0.36	0.88	High	0.41	0.95	High
0.32	0.79	High	0.36	0.85	High	0.41	0.91	High
0.32	0.94	High	0.36	0.89	High	0.41	0.88	High
0.32	0.92	High	0.36	0.84	High	0.41	0.92	High
0.33	0.91	High	0.36	0.87	High	0.41	0.92	High
0.33	0.92	High	0.36	0.90	High	0.41	1.00	High
0.33	0.86	High	0.36	0.90	High	0.41	0.74	High
0.33	0.84	High	0.36	0.88	High	0.41	0.95	High
0.33	0.79	High	0.36	0.91	High	0.42	0.92	High
0.33	0.85	High	0.37	0.88	High	0.42	0.99	High
0.33	0.85	High	0.37	0.91	High	0.42	0.98	High
0.33	0.87	High	0.37	0.91	High	0.42	0.89	High
0.33	0.88	High	0.37	0.88	High	0.42	0.88	High
0.33	0.87	High	0.37	0.84	High	0.42	0.92	High
0.33	0.80	High	0.37	0.95	High	0.42	0.91	High
0.33	0.96	High	0.37	0.88	High	0.42	0.91	High
0.33	0.91	High	0.37	0.88	High	0.42	0.91	High
0.33	0.86	High	0.37	0.85	High	0.42	0.84	High
0.33	0.92	High	0.37	0.87	High	0.43	0.88	High
0.33	0.90	High	0.37	0.92	High	0.43	0.93	High
0.33	0.91	High	0.37	0.85	High	0.43	0.87	High
0.33	0.94	High	0.38	0.88	High	0.43	0.93	High
0.34	0.81	High	0.38	0.88	High	0.43	0.86	High
0.34	0.93	High	0.38	0.91	High	0.43	0.90	High
0.34	0.83	High	0.38	0.94	High	0.43	0.85	High
0.43	0.93	High	0.45	0.82	High	0.46	0.88	High
0.44	0.96	High	0.45	0.93	High	0.46	0.85	High
0.44	0.85	High	0.45	0.90	High	0.46	0.99	High
0.44	0.87	High	0.45	0.91	High	0.46	0.91	High
0.45	0.88	High	0.45	0.93	High	0.46	0.87	High
0.45	0.86	High	0.45	0.92	High	0.46	0.91	High

Table A.8. NDVI, relative yield, and, management zone data for Chapter 2, site year III.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.08	0.76	Low	0.21	0.78	Low	0.21	0.85	Low
0.30	0.75	Low	0.02	0.69	Low	0.22	0.83	Low
0.30	0.84	Low	0.22	0.81	Low	0.28	0.73	Low
0.28	0.80	Low	0.28	0.80	Low	0.18	0.79	Low
0.34	0.76	Low	0.20	0.75	Low	0.29	0.83	Low
0.23	0.88	Low	0.11	0.80	Low	0.20	0.79	Low
0.18	0.62	Low	0.07	0.56	Low	0.15	0.68	Low
0.32	0.85	Low	0.18	0.83	Low	0.29	0.74	Low
-0.04	0.54	Low	0.18	0.66	Low	0.15	0.80	Low
0.21	0.74	Low	0.28	0.77	Low	0.30	0.83	Low
0.12	0.83	Low	0.21	0.81	Low	0.26	0.81	Low
0.08	0.76	Low	0.32	0.80	Low	0.24	0.82	Low
0.02	0.63	Low	0.18	0.74	Low	0.29	0.73	Low
0.13	0.80	Low	0.23	0.75	Low	0.27	0.80	Low
0.39	0.82	Low	0.30	0.70	Low	0.24	0.81	Low
0.21	0.83	Low	0.25	0.65	Low	0.19	0.70	Low
0.19	0.68	Low	0.39	0.77	Low	0.23	0.73	Low
0.28	0.80	Low	0.34	0.82	Low	0.21	0.77	Low
0.21	0.79	Low	0.26	0.75	Low	0.23	0.65	Low
0.21	0.72	Low	0.21	0.78	Low	0.25	0.67	Low
0.29	0.83	Low	0.25	0.69	Low	0.38	0.82	Low
0.32	0.79	Low	0.28	0.86	Low	0.22	0.69	Low
0.03	0.78	Low	0.17	0.73	Low	0.13	0.73	Low
0.34	0.81	Low	0.24	0.73	Low	0.29	0.83	Low
0.08	0.78	Low	0.20	0.76	Low	0.22	0.81	Low
0.29	0.79	Low	0.33	0.71	Low	0.11	0.79	Low
0.28	0.72	Low	0.19	0.78	Low	0.26	0.81	Low
0.28	0.84	Low	0.09	0.65	Low	0.24	0.84	Low
0.20	0.75	Low	0.30	0.83	Low	0.25	0.80	Low
0.13	0.78	Low	0.25	0.75	Low	0.22	0.77	Low
0.23	0.67	Low	0.28	0.70	Low	0.23	0.68	Low
0.08	0.74	Low	0.31	0.78	Low	0.06	0.72	Low
0.23	0.70	Low	0.27	0.74	Low	0.06	0.66	Low
0.02	0.59	Low	0.03	0.67	Low	0.17	0.76	Low
0.24	0.75	Low	0.33	0.73	Low	0.05	0.58	Low
0.06	0.60	Low	0.29	0.80	Low	0.26	0.66	Low
0.15	0.84	Low	0.14	0.77	Low	0.22	0.78	Low
0.20	0.83	Low	0.32	0.82	Low	0.17	0.83	Low
0.19	0.66	Low	0.23	0.79	Low	0.23	0.75	Low
0.17	0.85	Low	0.23	0.87	Low	0.31	0.83	Low
0.18	0.74	Low	0.21	0.76	Low	0.15	0.65	Low
0.26	0.82	Low	0.14	0.80	Low	0.27	0.80	Low
0.29	0.72	Low	0.27	0.73	Low	0.32	0.77	Low
0.19	0.80	Low	0.18	0.69	Low	0.15	0.77	Low
0.28	0.83	Low	0.20	0.78	Low	0.24	0.83	Low

Table A.8. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.27	0.82	Low	0.10	0.64	Low	0.33	0.77	Low
0.10	0.82	Low	0.25	0.80	Low	0.11	0.68	Low
0.17	0.67	Low	0.21	0.73	Low	0.13	0.81	Low
0.31	0.83	Low	0.23	0.82	Low	0.22	0.80	Low
0.14	0.75	Low	0.17	0.71	Low	0.27	0.81	Low
0.19	0.75	Low	0.26	0.70	Low	0.27	0.84	Low
0.22	0.67	Low	0.23	0.74	Low	0.15	0.79	Low
0.23	0.73	Low	0.33	0.83	Low	0.22	0.76	Low
0.29	0.69	Low	0.28	0.67	Low	0.28	0.72	Low
0.27	0.71	Low	0.20	0.74	Low	0.27	0.82	Low
0.09	0.64	Low	0.20	0.69	Low	0.28	0.86	Low
0.17	0.80	Low	0.16	0.76	Low	0.18	0.86	Low
0.28	0.65	Low	0.28	0.78	Low	0.18	0.79	Low
0.21	0.66	Low	0.31	0.78	Low	0.33	0.80	Low
0.04	0.55	Low	0.21	0.75	Low	0.26	0.82	Low
0.27	0.76	Low	0.25	0.74	Low	0.32	0.80	Low
0.17	0.66	Low	0.26	0.69	Low	0.29	0.76	Low
0.25	0.84	Low	0.20	0.68	Low	0.34	0.85	Low
0.04	0.68	Low	0.13	0.82	Low	0.17	0.81	Low
0.20	0.75	Low	0.12	0.65	Low	0.26	0.81	Low
0.04	0.55	Low	0.17	0.79	Low	0.25	0.76	Low
0.29	0.85	Low	0.24	0.76	Low	0.12	0.66	Low
0.23	0.69	Low	0.07	0.58	Low	0.26	0.73	Low
0.33	0.79	Low	0.20	0.77	Low	0.18	0.81	Low
0.31	0.78	Low	0.08	0.60	Low	0.29	0.82	Low
0.06	0.64	Low	0.28	0.72	Low	0.16	0.69	Low
0.10	0.60	Low	0.28	0.69	Low	0.33	0.78	Low
0.10	0.73	Low	0.21	0.74	Low	0.27	0.79	Low
0.24	0.84	Low	0.15	0.82	Low	0.24	0.84	Low
0.33	0.76	Low	0.13	0.78	Low	0.25	0.75	Low
0.20	0.73	Low	0.24	0.85	Low	0.17	0.71	Low
0.34	0.83	Low	0.29	0.84	Low	0.26	0.71	Low
0.18	0.74	Low	0.33	0.70	Low	0.22	0.77	Low
0.25	0.73	Low	0.21	0.83	Low	0.18	0.66	Low
0.28	0.85	Low	0.30	0.80	Low	0.26	0.79	Low
0.21	0.72	Low	0.32	0.78	Low	0.21	0.70	Low
0.26	0.83	Low	0.23	0.82	Low	0.30	0.83	Low
0.17	0.74	Low	0.21	0.80	Low	0.19	0.69	Low
0.13	0.84	Low	0.23	0.85	Low	0.06	0.55	Low
0.34	0.72	Low	0.20	0.82	Low	0.26	0.75	Low
0.15	0.85	Low	0.36	0.77	Low	0.25	0.64	Low
0.30	0.86	Low	0.24	0.86	Low	0.14	0.64	Low
0.07	0.66	Low	0.31	0.80	Low	0.09	0.75	Low
0.17	0.78	Low	0.28	0.68	Low	0.25	0.75	Low
0.27	0.65	Low	0.37	0.77	Low	0.22	0.88	Low
0.33	0.83	Low	0.12	0.66	Low	0.32	0.81	Low

Table A.8. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.12	0.77	Low	0.25	0.73	Low	0.26	0.64	Low
0.12	0.80	Low	0.37	0.86	Low	0.31	0.78	Low
0.32	0.78	Low	0.22	0.80	Low	0.13	0.83	Low
0.22	0.80	Low	0.02	0.69	Low	0.09	0.77	Low
0.25	0.81	Low	0.32	0.84	Low	0.14	0.75	Low
0.19	0.76	Low	0.28	0.82	Low	0.31	0.84	Low
0.17	0.80	Low	0.21	0.66	Low	0.29	0.81	Low
0.20	0.75	Low	0.26	0.79	Low	0.24	0.82	Low
0.28	0.75	Low	0.24	0.68	Low	0.27	0.70	Low
0.30	0.80	Low	0.26	0.76	Low	0.10	0.62	Low
0.12	0.73	Low	0.27	0.69	Low	0.11	0.72	Low
0.07	0.73	Low	0.32	0.75	Low	0.27	0.72	Low
0.29	0.76	Low	0.24	0.81	Low	0.28	0.83	Low
0.24	0.75	Low	0.04	0.74	Low	0.17	0.69	Low
0.11	0.80	Low	0.06	0.60	Low	0.26	0.69	Low
0.25	0.81	Low	0.35	0.77	Low	0.35	0.81	Low
0.20	0.85	Low	0.31	0.76	Low	0.24	0.79	Low
0.27	0.72	Low	0.26	0.78	Low	0.26	0.70	Low
0.19	0.70	Low	0.30	0.69	Low	0.16	0.80	Low
0.14	0.74	Low	0.19	0.62	Low	0.14	0.67	Low
0.18	0.83	Low	0.05	0.70	Low	0.09	0.65	Low
0.18	0.78	Low	0.15	0.72	Low	0.30	0.76	Low
0.25	0.80	Low	0.29	0.80	Low	0.09	0.67	Low
0.26	0.88	Low	0.17	0.84	Low	0.09	0.66	Low
0.21	0.72	Low	0.33	0.76	Low	0.26	0.87	Low
0.26	0.73	Low	0.34	0.76	Low	0.28	0.84	Low
0.20	0.71	Low	0.08	0.72	Low	0.34	0.80	Low
0.29	0.87	Low	0.27	0.76	Low	0.22	0.73	Low
0.20	0.70	Low	0.20	0.74	Low	0.16	0.79	Low
-0.04	0.54	Low	0.24	0.80	Low	0.15	0.63	Low
0.24	0.80	Low	0.03	0.54	Low	0.15	0.71	Low
0.22	0.86	Low	0.21	0.69	Low	0.22	0.68	Low
0.37	0.84	Low	0.22	0.63	Low	0.17	0.83	Low
0.26	0.78	Low	0.27	0.79	Low	0.25	0.70	Low
0.23	0.84	Low	0.08	0.58	Low	0.16	0.73	Low
0.32	0.89	Low	0.16	0.81	Low	0.28	0.68	Low
0.11	0.76	Low	0.24	0.74	Low	0.12	0.72	Low
0.22	0.79	Low	0.36	0.68	Low	0.28	0.69	Low
0.19	0.80	Low	0.16	0.75	Low	0.17	0.76	Low
0.23	0.84	Low	0.22	0.72	Low	0.20	0.84	Low
0.26	0.81	Low	0.22	0.75	Low	0.23	0.86	Low
0.26	0.76	Low	0.11	0.76	Low	0.20	0.74	Low
0.30	0.86	Low	0.23	0.75	Low	0.23	0.69	Low
0.04	0.66	Low	0.22	0.67	Low	0.18	0.85	Low
0.14	0.80	Low	0.13	0.76	Low	0.17	0.80	Low
0.30	0.77	Low	0.20	0.68	Low	0.30	0.88	Low

Table A.8. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.24	0.76	Low	0.25	0.80	Low	0.30	0.74	Low
-0.01	0.67	Low	0.18	0.69	Low	0.27	0.79	Low
0.17	0.78	Low	0.28	0.74	Low	0.30	0.75	Low
0.26	0.69	Low	0.17	0.84	Low	0.34	0.69	Low
0.37	0.71	Low	0.17	0.65	Low	0.23	0.70	Low
0.29	0.82	Low	0.29	0.84	Low	0.09	0.71	Low
0.35	0.77	Low	0.28	0.69	Low	0.07	0.72	Low
0.19	0.81	Low	0.23	0.82	Low	0.28	0.78	Low
0.20	0.73	Low	0.27	0.80	Low	0.26	0.69	Low
0.32	0.78	Low	0.40	0.84	Low	0.23	0.76	Low
0.33	0.78	Low	0.22	0.86	Low	0.12	0.73	Low
0.24	0.90	Low	0.34	0.81	Low	0.14	0.80	Low
0.18	0.73	Low	0.28	0.83	Low	0.29	0.87	Low
0.13	0.73	Low	0.31	0.75	Low	0.17	0.71	Low
0.05	0.61	Low	0.20	0.68	Low	0.18	0.82	Low
0.32	0.77	Low	0.10	0.70	Low	0.24	0.82	Low
0.19	0.74	Low	0.16	0.83	Low	0.29	0.82	Low
0.26	0.83	Low	0.28	0.74	Low	0.11	0.70	Low
0.26	0.67	Low	0.41	0.84	Low	0.19	0.76	Low
0.24	0.69	Low	0.23	0.82	Low	0.26	0.67	Low
0.19	0.80	Low	0.27	0.70	Low	0.28	0.75	Low
0.21	0.81	Low	0.06	0.68	Low	0.16	0.63	Low
0.26	0.72	Low	0.31	0.86	Low	0.23	0.76	Low
0.36	0.72	Low	0.12	0.71	Low	0.22	0.86	Low
0.36	0.81	Low	0.21	0.69	Low	0.26	0.77	Low
0.27	0.74	Low	0.29	0.81	Low	0.17	0.61	Low
0.25	0.79	Low	0.22	0.68	Low	0.08	0.77	Low
0.25	0.83	Low	0.28	0.80	Low	0.31	0.83	Low
0.29	0.70	Low	0.08	0.58	Low	0.13	0.66	Low
0.16	0.74	Low	0.30	0.75	Low	0.32	0.82	Low
0.24	0.77	Low	0.06	0.74	Low	0.03	0.65	Low
0.21	0.74	Low	0.18	0.67	Low	0.34	0.84	Low
0.22	0.81	Low	0.25	0.82	Low	0.16	0.79	Low
0.04	0.64	Low	0.21	0.67	Low	0.16	0.80	Low
0.12	0.75	Low	0.21	0.73	Low	0.09	0.66	Low
0.02	0.64	Low	0.22	0.70	Low	0.29	0.72	Low
0.27	0.68	Low	0.03	0.76	Low	0.31	0.66	Low
0.17	0.81	Low	0.20	0.62	Low	0.24	0.80	Low
0.28	0.87	Low	0.28	0.81	Low	0.30	0.78	Low
0.19	0.75	Low	0.26	0.71	Low	0.07	0.68	Low
0.36	0.81	Low	0.27	0.85	Low	0.06	0.65	Low
0.30	0.71	Low	0.01	0.51	Low	0.19	0.69	Low
0.14	0.81	Low	0.18	0.72	Low	0.21	0.68	Low
0.24	0.82	Low	0.06	0.67	Low	0.28	0.67	Low
0.22	0.83	Low	0.25	0.76	Low	0.31	0.74	Low
0.06	0.58	Low	0.29	0.71	Low	0.26	0.71	Low

Table A.8. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.19	0.87	Low	0.26	0.79	Low	0.28	0.75	Low
0.05	0.67	Low	0.16	0.81	Low	0.05	0.73	Low
0.19	0.66	Low	0.09	0.59	Low	0.24	0.69	Low
0.28	0.79	Low	0.30	0.76	Low	0.25	0.83	Low
0.33	0.81	Low	0.18	0.74	Low	0.27	0.67	Low
0.19	0.78	Low	0.20	0.81	Low	0.26	0.77	Low
0.19	0.72	Low	0.26	0.83	Low	0.08	0.61	Low
0.27	0.73	Low	0.19	0.84	Low	0.34	0.73	Low
0.15	0.78	Low	0.18	0.84	Low	0.31	0.76	Low
0.11	0.69	Low	0.28	0.84	Low	0.31	0.71	Low
0.35	0.86	Low	0.23	0.82	Low	0.27	0.80	Low
0.32	0.89	Low	0.32	0.71	Low	0.03	0.72	Low
0.24	0.67	Low	0.25	0.75	Low	0.13	0.78	Low
0.20	0.78	Low	0.16	0.75	Low	0.33	0.77	Low
0.03	0.61	Low	0.23	0.72	Low	0.26	0.74	Low
0.27	0.79	Low	0.36	0.73	Low	0.25	0.78	Low
0.25	0.81	Low	0.26	0.75	Low	0.22	0.75	Low
0.21	0.71	Low	0.25	0.82	Low	0.29	0.81	Low
0.27	0.83	Low	0.20	0.87	Low	0.16	0.68	Low
0.20	0.78	Low	0.20	0.71	Low	0.23	0.79	Low
0.32	0.79	Low	0.27	0.73	Low	0.27	0.78	Low
0.03	0.69	Low	0.31	0.80	Low	0.32	0.76	Medium
0.29	0.78	Low	0.10	0.82	Low	0.21	0.73	Medium
0.05	0.68	Low	0.32	0.85	Low	0.22	0.72	Medium
0.22	0.86	Low	0.32	0.79	Low	0.32	0.73	Medium
0.23	0.75	Low	0.28	0.86	Low	0.32	0.78	Medium
0.10	0.67	Low	0.32	0.87	Low	0.33	0.86	Medium
0.23	0.70	Low	0.31	0.72	Low	0.33	0.82	Medium
0.18	0.84	Low	0.29	0.79	Low	0.34	0.93	Medium
0.28	0.80	Low	0.23	0.79	Low	0.29	0.76	Medium
0.20	0.82	Low	0.21	0.76	Low	0.29	0.89	Medium
0.17	0.73	Low	0.04	0.67	Low	0.15	0.79	Medium
0.29	0.70	Low	0.26	0.74	Low	0.38	0.81	Medium
0.29	0.79	Low	0.09	0.77	Low	0.27	0.88	Medium
0.19	0.88	Low	0.15	0.68	Low	0.13	0.79	Medium
0.21	0.73	Low	0.19	0.78	Low	0.25	0.85	Medium
0.20	0.72	Low	0.04	0.70	Low	0.31	0.77	Medium
0.06	0.60	Low	0.23	0.71	Low	0.19	0.83	Medium
0.31	0.68	Low	0.33	0.79	Low	0.26	0.74	Medium
0.14	0.80	Low	0.18	0.84	Low	0.37	0.88	Medium
0.17	0.79	Low	0.28	0.83	Low	0.30	0.78	Medium
0.05	0.66	Low	0.24	0.67	Low	0.35	0.86	Medium
0.20	0.73	Low	0.23	0.79	Low	0.27	0.85	Medium
0.29	0.68	Low	0.20	0.71	Low	0.26	0.82	Medium
0.05	0.71	Low	0.18	0.84	Low	0.21	0.79	Medium
0.25	0.88	Low	0.22	0.73	Low	0.27	0.68	Medium

Table A.8. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.11	0.75	Low	0.19	0.76	Low	0.27	0.84	Medium
0.39	0.80	Low	0.21	0.74	Low	0.18	0.74	Medium
0.17	0.83	Low	0.25	0.89	Low	0.26	0.84	Medium
0.23	0.79	Low	0.03	0.55	Low	0.35	0.73	Medium
0.02	0.63	Low	0.28	0.82	Low	0.28	0.79	Medium
0.26	0.76	Low	0.08	0.60	Low	0.15	0.81	Medium
0.04	0.60	Low	0.30	0.73	Low	0.32	0.80	Medium
0.21	0.83	Low	0.28	0.68	Low	0.10	0.84	Medium
0.31	0.72	Low	0.28	0.74	Low	0.20	0.71	Medium
0.31	0.71	Low	0.21	0.82	Low	0.11	0.83	Medium
0.12	0.80	Low	0.32	0.75	Low	0.20	0.75	Medium
0.15	0.79	Low	0.32	0.79	Low	0.41	0.81	Medium
0.22	0.80	Low	0.07	0.57	Low	0.29	0.87	Medium
0.34	0.79	Low	0.30	0.82	Low	0.27	0.85	Medium
0.23	0.69	Low	0.20	0.73	Low	0.19	0.84	Medium
0.09	0.73	Low	0.20	0.72	Low	0.26	0.82	Medium
0.19	0.75	Low	0.22	0.77	Low	0.26	0.80	Medium
0.16	0.75	Low	0.11	0.59	Low	0.24	0.75	Medium
0.05	0.56	Low	0.09	0.81	Low	0.33	0.85	Medium
0.21	0.76	Low	0.27	0.82	Low	0.35	0.82	Medium
0.25	0.79	Low	0.26	0.82	Low	0.26	0.84	Medium
0.29	0.79	Low	0.08	0.83	Low	0.27	0.85	Medium
0.32	0.81	Low	0.09	0.74	Low	0.22	0.75	Medium
0.11	0.61	Low	0.27	0.69	Low	0.31	0.72	Medium
0.25	0.79	Low	0.07	0.75	Low	0.28	0.81	Medium
0.09	0.78	Medium	0.26	0.82	Low	0.23	0.83	Medium
0.25	0.68	Medium	0.21	0.71	Medium	0.24	0.76	Medium
0.26	0.77	Medium	0.39	0.79	Medium	0.31	0.85	Medium
0.20	0.78	Medium	0.20	0.70	Medium	0.21	0.84	Medium
0.27	0.82	Medium	0.30	0.87	Medium	0.28	0.81	Medium
0.35	0.78	Medium	0.24	0.72	Medium	0.27	0.87	Medium
0.18	0.82	Medium	0.35	0.80	Medium	0.37	0.86	Medium
0.24	0.79	Medium	0.26	0.85	Medium	0.23	0.88	Medium
0.34	0.75	Medium	0.20	0.79	Medium	0.42	0.85	Medium
0.34	0.77	Medium	0.26	0.85	Medium	0.19	0.85	Medium
0.28	0.81	Medium	0.38	0.85	Medium	0.23	0.71	Medium
0.33	0.74	Medium	0.37	0.80	Medium	0.28	0.69	Medium
0.34	0.84	Medium	0.27	0.79	Medium	0.26	0.84	Medium
0.38	0.78	Medium	0.26	0.80	Medium	0.20	0.84	Medium
0.36	0.83	Medium	0.35	0.79	Medium	0.23	0.76	Medium
0.08	0.76	Medium	0.27	0.81	Medium	0.29	0.84	Medium
0.28	0.77	Medium	0.41	0.85	Medium	0.35	0.89	Medium
0.28	0.82	Medium	0.21	0.80	Medium	0.33	0.88	Medium
0.25	0.70	Medium	0.37	0.84	Medium	0.32	0.69	Medium
0.28	0.86	Medium	0.17	0.84	Medium	0.32	0.86	Medium
0.20	0.75	Medium	0.27	0.81	Medium	0.23	0.84	Medium

Table A.8. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.11	0.77	Medium	0.27	0.88	Medium	0.23	0.83	Medium
0.31	0.83	Medium	0.16	0.88	Medium	0.21	0.87	Medium
0.27	0.79	Medium	0.14	0.71	Medium	0.39	0.94	Medium
0.27	0.77	Medium	0.17	0.81	Medium	0.36	0.85	Medium
0.30	0.79	Medium	0.30	0.86	Medium	0.32	0.94	Medium
0.34	0.87	Medium	0.35	0.77	Medium	0.17	0.73	Medium
0.33	0.79	Medium	0.29	0.86	Medium	-0.01	0.71	Medium
0.15	0.80	Medium	0.30	0.80	Medium	0.35	0.86	Medium
0.30	0.78	Medium	0.26	0.82	Medium	0.26	0.79	Medium
0.42	0.84	Medium	0.28	0.74	Medium	0.22	0.90	Medium
0.36	0.79	Medium	0.11	0.86	Medium	0.30	0.69	Medium
0.33	0.84	Medium	0.15	0.87	Medium	0.16	0.90	Medium
0.30	0.72	Medium	0.20	0.81	Medium	0.21	0.81	Medium
0.33	0.87	Medium	0.12	0.75	Medium	0.37	0.77	Medium
0.38	0.82	Medium	0.29	0.74	Medium	0.26	0.79	Medium
0.31	0.73	Medium	0.19	0.87	Medium	0.27	0.81	Medium
0.29	0.80	Medium	0.35	0.87	Medium	0.36	0.76	Medium
0.17	0.86	Medium	0.34	0.89	Medium	0.39	0.76	Medium
0.22	0.74	Medium	0.14	0.79	Medium	0.26	0.81	Medium
0.35	0.92	Medium	0.26	0.89	Medium	0.34	0.82	Medium
0.34	0.82	Medium	0.27	0.80	Medium	0.31	0.86	Medium
0.18	0.75	Medium	0.06	0.81	Medium	0.42	0.82	Medium
0.30	0.88	Medium	0.26	0.84	Medium	0.26	0.73	Medium
0.14	0.81	Medium	0.20	0.72	Medium	0.30	0.84	Medium
0.27	0.69	Medium	0.32	0.83	Medium	0.26	0.75	Medium
0.24	0.80	Medium	0.28	0.84	Medium	0.31	0.80	Medium
0.22	0.82	Medium	0.22	0.80	Medium	0.28	0.68	Medium
0.14	0.77	Medium	0.27	0.82	Medium	0.30	0.88	Medium
0.23	0.79	Medium	0.30	0.79	Medium	0.22	0.80	Medium
0.18	0.77	Medium	0.14	0.74	Medium	0.25	0.87	Medium
0.36	0.82	Medium	0.19	0.80	Medium	0.35	0.82	Medium
0.29	0.75	Medium	0.18	0.81	Medium	0.18	0.77	Medium
0.22	0.81	Medium	0.23	0.81	Medium	0.36	0.78	Medium
0.21	0.90	Medium	0.30	0.76	Medium	0.32	0.84	Medium
0.28	0.79	Medium	0.30	0.88	Medium	0.24	0.81	Medium
0.17	0.71	Medium	0.25	0.84	Medium	0.31	0.86	Medium
0.34	0.85	Medium	0.22	0.79	Medium	0.28	0.86	Medium
0.33	0.76	Medium	0.38	0.87	Medium	0.26	0.77	Medium
0.36	0.80	Medium	0.28	0.82	Medium	0.13	0.75	Medium
0.16	0.78	Medium	0.35	0.75	Medium	0.17	0.81	Medium
0.39	0.84	Medium	0.15	0.80	Medium	0.22	0.89	Medium
0.25	0.87	Medium	0.34	0.86	Medium	0.19	0.86	Medium
0.38	0.85	Medium	0.32	0.72	Medium	0.30	0.76	Medium
0.30	0.83	Medium	0.20	0.84	Medium	0.34	0.82	Medium
0.33	0.84	Medium	0.17	0.79	Medium	0.29	0.85	Medium
0.29	0.77	Medium	0.33	0.78	Medium	0.19	0.74	Medium

Table A.8. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.32	0.83	Medium	0.03	0.80	Medium	0.25	0.74	Medium
0.24	0.77	Medium	0.28	0.84	Medium	0.32	0.82	Medium
0.39	0.81	Medium	0.18	0.76	Medium	0.32	0.80	Medium
0.24	0.89	Medium	0.26	0.81	Medium	0.23	0.79	Medium
0.20	0.79	Medium	0.33	0.81	Medium	0.38	0.77	Medium
0.30	0.77	Medium	0.39	0.82	Medium	0.34	0.73	Medium
0.31	0.78	Medium	0.21	0.77	Medium	0.31	0.85	Medium
0.22	0.86	Medium	0.07	0.79	Medium	0.27	0.83	Medium
0.34	0.78	Medium	0.44	0.83	Medium	0.29	0.84	Medium
0.20	0.91	Medium	0.32	0.87	Medium	0.36	0.74	Medium
0.16	0.65	Medium	0.21	0.83	Medium	0.36	0.81	Medium
0.33	0.78	Medium	0.21	0.80	Medium	0.26	0.76	Medium
0.32	0.73	Medium	0.15	0.83	Medium	0.36	0.81	Medium
0.16	0.85	Medium	0.36	0.75	Medium	0.26	0.82	Medium
0.26	0.92	Medium	0.33	0.79	Medium	0.37	0.83	Medium
0.21	0.83	Medium	0.04	0.65	Medium	0.31	0.84	Medium
0.36	0.77	Medium	0.24	0.82	Medium	0.20	0.85	Medium
0.28	0.83	Medium	0.30	0.79	Medium	0.30	0.85	Medium
0.37	0.88	Medium	0.14	0.75	Medium	0.30	0.82	Medium
0.30	0.82	Medium	0.29	0.83	Medium	0.29	0.69	Medium
0.31	0.82	Medium	0.38	0.79	Medium	0.31	0.84	Medium
0.19	0.86	Medium	0.28	0.88	Medium	0.27	0.81	Medium
0.26	0.76	Medium	0.29	0.81	Medium	0.24	0.86	Medium
0.15	0.77	Medium	0.32	0.76	Medium	0.38	0.87	Medium
0.22	0.74	Medium	0.23	0.75	Medium	0.39	0.83	Medium
0.24	0.81	Medium	0.18	0.74	Medium	0.22	0.92	Medium
0.14	0.79	Medium	0.33	0.78	Medium	0.33	0.89	Medium
0.28	0.75	Medium	0.37	0.88	Medium	0.35	0.91	Medium
0.23	0.80	Medium	0.20	0.84	Medium	0.30	0.78	Medium
0.13	0.75	Medium	0.31	0.82	Medium	0.38	0.83	Medium
0.39	0.77	Medium	0.23	0.86	Medium	0.30	0.86	Medium
0.30	0.85	Medium	0.31	0.77	Medium	0.34	0.80	Medium
0.34	0.81	Medium	0.30	0.86	Medium	0.26	0.82	Medium
0.29	0.84	Medium	0.39	0.83	Medium	0.24	0.78	Medium
0.32	0.78	Medium	0.34	0.88	Medium	0.17	0.79	Medium
0.29	0.79	Medium	0.20	0.87	Medium	0.23	0.83	Medium
0.28	0.73	Medium	0.34	0.90	Medium	0.21	0.73	Medium
0.26	0.86	Medium	0.25	0.72	Medium	0.34	0.90	Medium
0.36	0.81	Medium	0.32	0.84	Medium	0.27	0.80	Medium
0.25	0.86	Medium	0.23	0.81	Medium	0.34	0.76	Medium
0.34	0.88	Medium	0.18	0.76	Medium	0.31	0.94	Medium
0.10	0.62	Medium	0.39	0.84	Medium	0.26	0.72	Medium
0.27	0.81	Medium	0.21	0.85	Medium	0.19	0.69	Medium
0.28	0.88	Medium	0.32	0.83	Medium	0.30	0.78	Medium
0.28	0.76	Medium	0.20	0.78	Medium	0.25	0.74	Medium
0.26	0.77	Medium	0.21	0.72	Medium	0.22	0.74	Medium

Table A.8. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.33	0.91	Medium	0.15	0.70	Medium	0.20	0.85	Medium
0.24	0.70	Medium	0.41	0.83	Medium	0.34	0.74	Medium
0.06	0.81	Medium	0.34	0.89	Medium	0.26	0.75	Medium
0.25	0.81	Medium	0.17	0.76	Medium	0.33	0.79	Medium
0.23	0.76	Medium	0.25	0.73	Medium	0.17	0.71	Medium
0.37	0.81	Medium	0.27	0.85	Medium	0.21	0.78	Medium
0.17	0.80	Medium	0.37	0.84	Medium	0.27	0.89	Medium
0.28	0.70	Medium	0.34	0.71	Medium	0.29	0.70	Medium
0.27	0.79	Medium	0.41	0.79	Medium	0.19	0.80	Medium
0.29	0.75	Medium	0.27	0.77	Medium	0.30	0.71	Medium
0.36	0.82	Medium	0.41	0.83	Medium	0.19	0.86	Medium
0.29	0.83	Medium	0.37	0.86	Medium	0.36	0.74	Medium
0.29	0.80	Medium	0.20	0.78	Medium	0.21	0.78	Medium
0.18	0.81	Medium	0.17	0.85	Medium	0.30	0.78	Medium
0.28	0.86	Medium	0.22	0.79	Medium	0.01	0.78	Medium
0.28	0.81	Medium	0.25	0.74	Medium	0.25	0.74	Medium
0.18	0.73	Medium	0.25	0.87	Medium	0.13	0.81	Medium
0.31	0.83	Medium	0.29	0.83	Medium	0.18	0.77	Medium
0.27	0.80	Medium	0.05	0.84	Medium	0.10	0.86	Medium
0.16	0.83	Medium	0.27	0.70	Medium	0.25	0.80	Medium
0.26	0.82	Medium	0.32	0.90	Medium	0.36	0.78	Medium
0.36	0.85	Medium	0.30	0.72	Medium	0.21	0.79	Medium
0.34	0.85	Medium	0.20	0.78	Medium	0.22	0.81	Medium
0.34	0.82	Medium	0.34	0.81	Medium	0.31	0.83	Medium
0.32	0.76	Medium	0.35	0.84	Medium	0.31	0.87	Medium
0.29	0.83	Medium	0.29	0.82	Medium	0.25	0.80	Medium
0.17	0.80	Medium	0.30	0.82	Medium	0.35	0.88	Medium
0.31	0.75	Medium	0.36	0.84	Medium	0.25	0.76	Medium
0.29	0.80	Medium	0.31	0.77	Medium	0.33	0.80	Medium
0.28	0.70	Medium	0.32	0.86	Medium	0.36	0.78	Medium
0.41	0.82	Medium	0.26	0.81	Medium	0.33	0.79	Medium
0.32	0.83	Medium	0.33	0.80	Medium	0.35	0.88	Medium
0.24	0.73	Medium	0.28	0.78	Medium	0.19	0.82	Medium
0.22	0.82	Medium	0.23	0.85	Medium	0.36	0.80	Medium
0.20	0.88	Medium	0.36	0.79	Medium	0.31	0.83	Medium
0.27	0.86	Medium	0.32	0.77	Medium	0.28	0.76	Medium
0.31	0.78	Medium	0.15	0.76	Medium	0.25	0.73	Medium
0.36	0.78	Medium	0.38	0.85	Medium	0.31	0.79	Medium
0.14	0.75	Medium	0.34	0.82	Medium	0.32	0.82	Medium
0.32	0.84	Medium	0.11	0.84	Medium	0.34	0.87	Medium
0.29	0.86	Medium	0.29	0.79	Medium	0.28	0.79	Medium
0.32	0.82	Medium	0.31	0.81	High	0.33	0.88	High
0.27	0.76	Medium	0.39	0.82	High	0.36	0.78	High
0.28	0.87	Medium	0.28	0.81	High	0.35	0.84	High
0.19	0.80	Medium	0.27	0.82	High	0.37	0.83	High
0.21	0.80	Medium	0.34	0.89	High	0.21	0.77	High

Table A.8. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.32	0.81	Medium	0.28	0.86	High	0.20	0.79	High
0.25	0.83	Medium	0.32	0.88	High	0.35	0.80	High
0.40	0.84	Medium	0.23	0.87	High	0.28	0.76	High
0.26	0.84	Medium	0.18	0.78	High	0.34	0.75	High
0.38	0.83	Medium	0.35	0.82	High	0.32	0.81	High
0.30	0.84	Medium	0.39	0.83	High	0.25	0.90	High
0.30	0.83	Medium	0.14	0.81	High	0.29	0.73	High
0.20	0.74	Medium	0.19	0.80	High	0.35	0.77	High
0.37	0.91	Medium	0.40	0.81	High	0.08	0.72	High
0.20	0.78	Medium	0.33	0.81	High	0.12	0.85	High
0.11	0.70	Medium	0.40	0.80	High	0.25	0.86	High
0.28	0.80	Medium	0.34	0.77	High	0.33	0.78	High
0.10	0.78	Medium	0.35	0.87	High	0.29	0.85	High
0.40	0.80	Medium	0.37	0.84	High	0.16	0.68	High
-0.02	0.75	Medium	0.06	0.78	High	0.30	0.84	High
0.18	0.83	Medium	0.37	0.86	High	0.26	0.82	High
0.23	0.79	Medium	0.31	0.86	High	0.22	0.83	High
0.35	0.78	Medium	0.25	0.84	High	0.28	0.78	High
0.29	0.91	Medium	0.37	0.84	High	0.23	0.76	High
0.29	0.82	Medium	0.33	0.82	High	0.24	0.80	High
0.21	0.77	Medium	0.37	0.80	High	0.33	0.90	High
0.34	0.82	Medium	0.18	0.83	High	0.39	0.81	High
0.25	0.86	Medium	0.38	0.81	High	0.34	0.82	High
0.25	0.85	Medium	0.35	0.87	High	0.33	0.86	High
0.21	0.78	Medium	0.17	0.69	High	0.35	0.88	High
0.30	0.91	Medium	0.31	0.81	High	0.35	0.83	High
0.29	0.85	Medium	0.18	0.79	High	0.35	0.77	High
0.23	0.83	Medium	0.36	0.81	High	0.37	0.88	High
0.13	0.77	Medium	0.37	0.82	High	0.32	0.79	High
0.27	0.80	Medium	0.21	0.76	High	0.30	0.94	High
0.26	0.80	Medium	0.30	0.77	High	0.35	0.90	High
0.31	0.74	Medium	0.16	0.78	High	0.29	0.91	High
0.07	0.78	High	0.21	0.80	High	0.27	0.76	High
0.36	0.82	High	0.33	0.82	High	0.26	0.92	High
0.36	0.84	High	0.36	0.76	High	0.31	0.79	High
0.30	0.79	High	0.20	0.90	High	0.28	0.86	High
0.39	0.85	High	0.33	0.85	High	0.36	0.79	High
0.33	0.88	High	0.38	0.82	High	0.13	0.80	High
0.31	0.83	High	0.34	0.87	High	0.25	0.73	High
0.33	0.84	High	0.38	0.87	High	0.21	0.83	High
0.34	0.81	High	0.32	0.86	High	0.35	0.82	High
0.25	0.81	High	0.16	0.85	High	0.33	0.84	High
0.09	0.81	High	0.31	0.77	High	0.21	0.73	High
0.38	0.91	High	0.36	0.92	High	0.35	0.78	High
0.33	0.85	High	0.03	0.82	High	0.31	0.86	High
0.32	0.83	High	0.35	0.85	High	0.20	0.84	High

Table A.8. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.35	0.82	High	0.32	0.88	High	0.34	0.91	High
0.25	0.73	High	0.19	0.82	High	0.33	0.88	High
0.10	0.78	High	0.34	0.86	High	0.36	0.85	High
0.24	0.87	High	0.25	0.76	High	0.32	0.86	High
0.33	0.86	High	0.29	0.72	High	0.09	0.85	High
0.36	0.79	High	0.22	0.91	High	0.27	0.79	High
0.35	0.81	High	0.21	0.87	High	0.27	0.86	High
0.33	0.86	High	0.27	0.83	High	0.39	0.83	High
0.22	0.86	High	0.30	0.84	High	0.28	0.76	High
0.34	0.77	High	0.26	0.83	High	0.36	0.79	High
0.33	0.81	High	0.36	0.83	High	0.35	0.84	High
0.26	0.74	High	0.34	0.82	High	0.43	0.82	High
0.32	0.84	High	0.29	0.86	High	0.20	0.84	High
0.14	0.78	High	0.25	0.85	High	0.33	0.90	High
0.19	0.78	High	0.29	0.84	High	0.39	0.90	High
0.15	0.86	High	0.37	0.75	High	0.09	0.71	High
0.34	0.80	High	0.26	0.90	High	0.33	0.92	High
0.24	0.78	High	0.29	0.81	High	0.34	0.85	High
0.19	0.74	High	0.23	0.77	High	0.39	0.79	High
0.30	0.71	High	0.33	0.95	High	0.29	0.91	High
0.26	0.85	High	0.32	0.88	High	0.25	0.77	High
0.39	0.90	High	0.37	0.86	High	0.20	0.81	High
0.29	0.82	High	0.38	0.87	High	0.38	0.78	High
0.36	0.82	High	0.38	0.87	High	0.21	0.74	High
0.29	0.79	High	0.21	0.78	High	0.25	0.78	High
0.31	0.85	High	0.36	0.85	High	0.23	0.93	High
0.34	0.82	High	0.41	0.78	High	0.33	0.85	High
0.26	0.84	High	0.25	0.75	High	0.26	0.84	High
0.09	0.72	High	0.30	0.87	High	0.38	0.85	High
0.34	0.84	High	0.36	0.81	High	0.33	0.83	High
0.31	0.83	High	0.28	0.85	High	0.26	0.84	High
0.17	0.79	High	0.26	0.73	High	0.34	0.88	High
0.38	0.87	High	0.41	0.82	High	0.40	0.83	High
0.24	0.84	High	0.34	0.85	High	0.27	0.83	High
0.25	0.74	High	0.35	0.85	High	0.30	0.78	High
0.28	0.93	High	0.31	0.86	High	0.25	0.84	High
0.31	0.79	High	0.28	0.82	High	0.36	0.88	High
0.33	0.86	High	0.18	0.79	High	0.35	0.79	High
0.33	0.93	High	0.26	0.91	High	0.10	0.80	High
0.30	0.87	High	0.34	0.75	High	0.14	0.79	High
0.32	0.82	High	0.32	0.78	High	0.37	0.87	High
0.30	0.85	High	0.28	0.78	High	0.35	0.90	High
0.35	0.90	High	0.28	0.82	High	0.26	0.76	High
0.35	0.86	High	0.35	0.86	High	0.19	0.90	High
0.28	0.83	High	0.37	0.76	High	0.34	0.88	High
0.32	0.89	High	0.35	0.77	High	0.33	0.81	High

Table A.8. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.30	0.86	High	0.25	0.80	High	0.31	0.79	High
0.35	0.80	High	0.38	0.87	High	0.28	0.80	High
0.31	0.86	High	0.38	0.85	High	0.29	0.73	High
0.33	0.73	High	0.40	0.89	High	0.18	0.88	High
0.35	0.80	High	0.32	0.78	High	0.40	0.90	High
0.37	0.91	High	0.27	0.84	High	0.35	0.85	High
0.31	0.85	High	0.26	0.81	High	0.30	0.83	High
0.33	0.83	High	0.29	0.74	High	0.31	0.82	High
0.23	0.87	High	0.39	0.85	High	0.32	0.77	High
0.34	0.85	High	0.37	0.88	High	0.34	0.84	High
0.31	0.89	High	0.35	0.84	High	0.36	0.88	High
0.33	0.85	High	0.37	0.81	High	0.32	0.92	High
0.23	0.85	High	0.08	0.70	High	0.32	0.84	High
0.31	0.83	High	0.40	0.90	High	0.28	0.70	High
0.34	0.83	High	0.33	0.84	High	0.38	0.81	High
0.28	0.88	High	0.37	0.80	High	0.38	0.87	High
0.34	0.77	High	0.38	0.82	High	0.25	0.89	High
0.29	0.77	High	0.30	0.88	High	0.34	0.91	High
0.34	0.82	High	0.07	0.67	High	0.34	0.83	High
0.42	0.83	High	0.33	0.78	High	0.27	0.79	High
0.28	0.81	High	0.33	0.86	High	0.34	0.86	High
0.35	0.78	High	0.14	0.80	High	0.29	0.86	High
0.15	0.86	High	0.30	0.86	High	0.31	0.85	High
0.33	0.83	High	0.34	0.84	High	0.33	0.91	High
0.36	0.88	High	0.25	0.74	High	0.28	0.76	High
0.41	0.84	High	0.31	0.83	High	0.27	0.77	High
0.35	0.84	High	0.24	0.77	High	0.35	0.88	High
0.35	0.89	High	0.41	0.82	High	0.29	0.85	High
0.33	0.79	High	0.37	0.88	High	0.35	0.74	High
0.41	0.84	High	0.38	0.84	High	0.24	0.85	High
0.37	0.83	High	0.34	0.83	High	0.33	0.81	High
0.32	0.83	High	0.28	0.81	High	0.15	0.86	High
0.35	0.90	High	0.40	0.82	High	0.40	0.81	High
0.27	0.78	High	0.10	0.78	High	0.29	0.81	High
0.40	0.85	High	0.33	0.85	High	0.29	0.78	High
0.31	0.89	High	0.30	0.71	High	0.32	0.77	High
0.25	0.82	High	0.31	0.85	High	0.35	0.79	High
0.39	0.82	High	0.22	0.93	High	0.31	0.77	High
0.33	0.85	High	0.31	0.85	High	0.31	0.84	High
0.30	0.73	High	0.36	0.91	High	0.34	0.83	High
0.26	0.77	High	0.16	0.88	High	0.27	0.79	High
0.38	0.89	High	0.36	0.86	High	0.34	0.83	High
0.33	0.91	High	0.13	0.76	High	0.35	0.89	High
0.36	0.84	High	0.23	0.79	High	0.28	0.71	High
0.30	0.86	High	0.34	0.81	High	0.33	0.91	High
0.37	0.77	High	0.39	0.85	High	0.32	0.73	High

Table A.8. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.20	0.77	High	0.30	0.72	High	0.24	0.73	High
0.36	0.87	High	0.34	0.79	High	0.16	0.85	High
0.00	0.70	High	0.23	0.87	High	0.37	0.78	High
0.31	0.81	High	0.34	0.86	High	0.30	0.84	High
0.29	0.83	High	0.34	0.88	High	0.32	0.91	High
0.36	0.83	High	0.34	0.77	High	0.31	0.89	High
0.33	0.82	High	0.30	0.82	High	0.32	0.85	High
0.40	0.82	High	0.38	0.79	High	0.23	0.82	High
0.36	0.87	High	0.30	0.80	High	0.27	0.81	High
0.36	0.85	High	0.33	0.80	High	0.14	0.78	High
0.08	0.74	High	0.34	0.85	High	0.28	0.84	High
0.31	0.86	High	0.25	0.77	High	0.38	0.83	High
0.30	0.85	High	0.25	0.76	High	0.41	0.83	High
0.40	0.88	High	0.31	0.87	High	0.41	0.79	High
0.20	0.88	High	0.40	0.89	High	0.43	0.92	High
0.38	0.82	High	0.32	0.83	High	0.33	0.90	High
0.30	0.84	High	0.28	0.76	High	0.16	0.84	High
0.17	0.79	High	0.23	0.79	High	0.12	0.74	High
0.31	0.82	High	0.32	0.77	High	0.28	0.85	High
0.31	0.79	High	0.18	0.73	High	0.23	0.70	High
0.36	0.83	High	0.23	0.73	High	0.25	0.72	High
0.20	0.86	High	0.27	0.91	High	0.13	0.81	High
0.30	0.82	High	0.34	0.79	High	0.37	0.91	High
0.24	0.72	High	0.29	0.82	High	0.32	0.89	High
0.28	0.82	High	0.26	0.82	High	0.35	0.85	High
0.21	0.81	High	0.34	0.92	High	0.39	0.83	High
0.24	0.88	High	0.32	0.86	High	0.28	0.79	High
0.25	0.83	High	0.28	0.76	High	0.29	0.82	High
0.36	0.84	High	0.36	0.89	High	0.30	0.86	High
0.32	0.94	High	0.33	0.88	High			
0.39	0.81	High	0.36	0.83	High			
0.34	0.87	High	0.30	0.82	High			
0.24	0.88	High	0.40	0.86	High			
0.21	0.75	High	0.41	0.88	High			
0.10	0.83	High	0.38	0.81	High			
0.34	0.78	High	0.26	0.78	High			
0.30	0.81	High	0.36	0.86	High			
0.32	0.78	High	0.23	0.74	High			
0.31	0.89	High	0.25	0.79	High			
0.26	0.89	High	0.37	0.78	High			
0.24	0.77	High	0.41	0.92	High			
0.29	0.80	High	0.24	0.85	High			
0.32	0.83	High	0.23	0.79	High			
0.39	0.92	High	0.23	0.68	High			
0.34	0.86	High	0.31	0.83	High			
0.35	0.88	High	0.39	0.92	High			

Table A.9. NDVI, relative yield, and zone data for Chapter 2, site year IV.

NDVI	Relative Yield	Zone
0.40	0.82	Low
0.52	0.75	Low
0.50	0.87	Low
0.54	0.82	Low
0.28	0.91	Medium
0.33	1.00	Medium
0.41	0.78	Medium
0.45	0.97	Medium
0.51	0.68	High
0.57	0.84	High
0.45	0.97	High
0.28	0.73	High

Table A.10. NDVI, relative yield, and zone data for Chapter 2, site year V.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.41	0.64	Low	0.45	0.70	Low	0.39	0.74	Low
0.28	0.21	Low	0.44	0.80	Low	0.04	0.14	Low
0.27	0.79	Low	0.45	0.85	Low	0.34	0.78	Low
0.44	0.64	Low	0.32	0.58	Low	0.28	0.53	Low
0.29	0.79	Low	0.17	0.49	Low	0.46	0.74	Low
0.45	0.78	Low	0.04	0.05	Low	0.19	0.49	Low
0.35	0.81	Low	0.10	0.14	Low	0.37	0.62	Low
0.32	0.76	Low	0.43	0.70	Low	0.29	0.75	Low
0.34	0.57	Low	0.42	0.81	Low	0.35	0.79	Low
0.17	0.82	Low	0.29	0.63	Low	0.29	0.71	Low
0.24	0.71	Low	0.43	0.81	Low	0.38	0.82	Low
0.43	0.78	Low	0.26	0.64	Low	0.16	0.39	Low
0.24	0.69	Low	0.44	0.76	Low	0.23	0.25	Low
0.28	0.68	Low	0.39	0.67	Low	0.32	0.68	Low
0.28	0.76	Low	0.33	0.76	Low	0.25	0.73	Low
0.09	0.16	Low	0.37	0.76	Low	0.26	0.64	Low
0.34	0.80	Low	0.43	0.82	Low	0.20	0.26	Low
0.30	0.67	Low	0.18	0.55	Low	0.39	0.79	Low
0.26	0.39	Low	0.39	0.68	Low	0.17	0.67	Low
0.38	0.79	Low	0.14	0.06	Low	0.42	0.81	Low
0.49	0.85	Low	0.38	0.66	Low	0.37	0.75	Low
0.22	0.85	Low	0.24	0.71	Low	0.45	0.78	Low
0.38	0.75	Low	0.34	0.78	Low	0.45	0.70	Low
0.29	0.64	Low	0.45	0.78	Low	0.43	0.79	Low
0.27	0.67	Low	0.31	0.69	Low	0.27	0.36	Low
0.54	0.77	Low	0.29	0.68	Low	0.14	0.64	Low
0.34	0.78	Low	0.41	0.72	Low	0.40	0.81	Low
0.43	0.68	Low	0.39	0.75	Low	0.42	0.72	Low
0.36	0.80	Low	0.46	0.74	Low	0.30	0.68	Low
0.37	0.78	Low	0.09	0.06	Low	0.18	0.57	Low
0.43	0.78	Low	0.35	0.55	Low	0.33	0.68	Low
0.39	0.75	Low	0.39	0.65	Low	0.33	0.75	Low
0.09	0.31	Low	0.40	0.81	Low	0.36	0.81	Low
0.04	0.18	Low	0.37	0.81	Low	0.42	0.65	Low
0.42	0.45	Low	0.20	0.65	Low	0.04	0.01	Low
0.08	0.14	Low	0.26	0.65	Low	0.43	0.76	Low
0.16	0.38	Low	0.31	0.76	Low	0.24	0.52	Low
0.28	0.75	Low	0.05	0.24	Low	0.27	0.23	Low
0.19	0.68	Low	0.42	0.81	Low	0.31	0.59	Low
0.39	0.77	Low	0.40	0.79	Low	0.36	0.61	Low
0.41	0.70	Low	0.18	0.65	Low	0.38	0.62	Low
0.40	0.44	Low	0.28	0.82	Low	0.23	0.33	Low
0.34	0.74	Low	0.17	0.13	Low	0.28	0.68	Low
0.09	0.39	Low	0.27	0.05	Low	0.42	0.83	Low
0.32	0.80	Low	0.51	0.65	Low	0.25	0.32	Low

Table A.10. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.50	0.77	Low	0.34	0.45	Low	0.39	0.78	Low
0.29	0.54	Low	0.42	0.77	Low	0.25	0.02	Low
0.39	0.88	Low	0.32	0.82	Low	0.38	0.86	Low
0.41	0.81	Low	0.21	0.38	Low	0.38	0.82	Low
0.28	0.74	Low	0.40	0.87	Low	0.32	0.76	Low
0.43	0.81	Low	0.30	0.80	Low	0.27	0.35	Low
0.30	0.69	Low	0.43	0.81	Low	0.43	0.81	Low
0.27	0.72	Low	0.09	0.53	Low	0.43	0.68	Low
0.33	0.48	Low	0.39	0.80	Low	0.43	0.32	Low
0.44	0.77	Low	0.45	0.64	Low	0.24	0.79	Low
0.46	0.86	Low	0.27	0.37	Low	0.34	0.76	Low
0.21	0.56	Low	0.43	0.78	Low	0.44	0.71	Low
0.41	0.70	Low	0.36	0.74	Low	0.29	0.76	Low
0.37	0.78	Low	0.45	0.85	Low	0.28	0.75	Low
0.28	0.79	Low	0.29	0.79	Low	0.41	0.75	Low
0.42	0.68	Low	0.42	0.74	Low	0.35	0.74	Low
0.30	0.74	Low	0.28	0.51	Low	0.31	0.58	Low
0.32	0.77	Low	0.25	0.25	Low	0.37	0.73	Low
0.30	0.60	Low	0.41	0.82	Low	0.26	0.67	Low
0.01	0.07	Low	0.24	0.71	Low	0.36	0.75	Low
0.39	0.72	Low	0.37	0.74	Low	0.33	0.44	Low
0.43	0.77	Low	0.25	0.69	Low	0.23	0.26	Low
0.43	0.72	Low	0.29	0.25	Low	0.37	0.74	Low
0.29	0.77	Low	0.46	0.78	Low	0.48	0.72	Low
0.42	0.75	Low	0.44	0.52	Low	0.36	0.76	Low
0.25	0.44	Low	0.34	0.51	Low	0.39	0.80	Low
0.15	0.61	Low	0.48	0.79	Low	0.30	0.58	Low
0.24	0.59	Low	0.19	0.06	Low	0.38	0.72	Low
0.31	0.68	Low	0.41	0.65	Low	0.45	0.83	Low
0.43	0.63	Low	0.31	0.46	Low	0.17	0.39	Low
0.42	0.77	Low	0.31	0.58	Low	0.14	0.65	Low
0.06	0.13	Low	0.43	0.38	Low	0.31	0.50	Low
0.15	0.59	Low	0.26	0.39	Low	0.30	0.80	Low
0.24	0.48	Low	0.32	0.71	Low	0.54	0.78	Low
0.43	0.81	Low	0.40	0.75	Low	0.35	0.57	Low
0.37	0.77	Low	0.46	0.78	Low	0.43	0.73	Low
0.14	0.56	Low	0.09	0.10	Low	0.47	0.73	Low
0.39	0.72	Low	0.38	0.66	Low	0.43	0.81	Low
0.47	0.54	Low	0.18	0.41	Low	0.29	0.30	Low
0.34	0.75	Low	0.10	0.88	Low	0.29	0.68	Low
0.35	0.77	Low	0.48	0.83	Low	0.35	0.78	Low
0.40	0.76	Low	0.34	0.68	Low	0.36	0.26	Low
0.23	0.64	Low	0.32	0.57	Low	0.42	0.72	Low
0.46	0.81	Low	0.29	0.60	Low	0.50	0.80	Low
0.35	0.78	Low	0.29	0.68	Low	0.42	0.79	Low
0.30	0.79	Low	0.45	0.66	Low	0.38	0.83	Low

Table A.10. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.34	0.79	Low	0.26	0.57	Low	0.29	0.33	Low
0.20	0.00	Low	0.35	0.79	Low	0.22	0.41	Low
0.30	0.80	Low	0.48	0.75	Low	0.38	0.70	Low
0.27	0.58	Low	0.40	0.79	Low	0.38	0.76	Low
0.41	0.78	Low	0.35	0.71	Low	0.43	0.83	Low
0.42	0.73	Low	0.25	0.04	Low	0.44	0.82	Low
0.33	0.79	Low	0.27	0.63	Low	0.29	0.70	Low
0.18	0.62	Low	0.43	0.77	Low	0.39	0.70	Low
0.30	0.58	Low	0.40	0.77	Low	0.27	0.56	Low
0.42	0.76	Low	0.40	0.77	Low	0.42	0.76	Low
0.29	0.55	Low	0.16	0.48	Low	0.46	0.79	Medium
0.36	0.57	Low	0.38	0.74	Low	0.51	0.78	Medium
0.47	0.81	Low	0.31	0.58	Low	0.48	0.50	Medium
0.40	0.75	Low	0.52	0.64	Medium	0.40	0.75	Medium
0.26	0.08	Low	0.48	0.88	Medium	0.57	0.88	Medium
0.32	0.43	Low	0.41	0.75	Medium	0.44	0.80	Medium
0.44	0.80	Low	0.39	0.83	Medium	0.45	0.84	Medium
0.28	0.81	Low	0.40	0.79	Medium	0.52	0.81	Medium
0.27	0.56	Low	0.41	0.78	Medium	0.42	0.68	Medium
0.21	0.21	Low	0.53	0.86	Medium	0.41	0.76	Medium
0.30	0.60	Low	0.36	0.73	Medium	0.49	0.84	Medium
0.45	0.82	Low	0.56	0.90	Medium	0.38	0.74	Medium
0.39	0.60	Low	0.51	0.64	Medium	0.30	0.54	Medium
0.38	0.74	Low	0.49	0.63	Medium	0.44	0.76	Medium
0.28	0.74	Low	0.45	0.76	Medium	0.55	0.71	Medium
0.25	0.34	Low	0.33	0.47	Medium	0.40	0.79	Medium
0.36	0.78	Low	0.48	0.72	Medium	0.38	0.64	Medium
0.28	0.70	Low	0.52	0.79	Medium	0.56	0.75	Medium
0.26	0.75	Low	0.58	0.08	Medium	0.43	0.70	Medium
0.38	0.59	Low	0.44	0.79	Medium	0.28	0.71	Medium
0.28	0.75	Low	0.32	0.82	Medium	0.37	0.86	Medium
0.44	0.76	Low	0.43	0.82	Medium	0.31	0.81	Medium
0.07	0.25	Low	0.39	0.75	Medium	0.44	0.81	Medium
0.36	0.69	Low	0.36	0.90	Medium	0.40	0.78	Medium
0.33	0.64	Low	0.29	0.32	Medium	0.41	0.72	Medium
0.37	0.62	Low	0.54	0.78	Medium	0.36	0.75	Medium
0.30	0.75	Low	0.49	0.85	Medium	0.45	0.81	Medium
0.32	0.67	Low	0.41	0.84	Medium	0.43	0.85	Medium
0.23	0.66	Low	0.38	0.17	Medium	0.36	0.78	Medium
0.34	0.59	Low	0.32	0.76	Medium	0.52	0.77	Medium
0.43	0.79	Low	0.42	0.75	Medium	0.53	0.90	Medium
0.38	0.59	Low	0.49	0.83	Medium	0.51	0.79	Medium
0.27	0.87	Low	0.35	0.74	Medium	0.31	0.78	Medium
0.34	0.77	Low	0.34	0.82	Medium	0.35	0.73	Medium
0.37	0.83	Low	0.59	0.80	Medium	0.50	0.75	Medium
0.34	0.75	Low	0.41	0.72	Medium	0.58	0.82	Medium

Table A.10. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.30	0.79	Low	0.45	0.88	Medium	0.39	0.72	Medium
0.31	0.72	Low	0.48	0.85	Medium	0.43	0.86	Medium
0.30	0.56	Low	0.54	0.79	Medium	0.49	0.81	Medium
0.42	0.72	Low	0.29	0.75	Medium	0.38	0.00	Medium
0.25	0.69	Low	0.29	0.65	Medium	0.47	0.81	Medium
0.45	0.69	Low	0.45	0.77	Medium	0.55	0.84	Medium
0.29	0.74	Low	0.33	0.71	Medium	0.46	0.82	Medium
0.44	0.46	Low	0.41	0.83	Medium	0.26	0.83	Medium
0.08	0.36	Low	0.41	0.79	Medium	0.46	0.78	Medium
0.29	0.74	Low	0.47	0.87	Medium	0.37	0.80	Medium
0.37	0.77	Low	0.44	0.86	Medium	0.43	0.75	Medium
0.40	0.81	Low	0.41	0.80	Medium	0.53	0.77	Medium
0.25	0.49	Low	0.59	0.79	Medium	0.43	0.82	Medium
0.10	0.00	Low	0.36	0.77	Medium	0.51	0.84	Medium
0.26	0.61	Low	0.39	0.61	Medium	0.45	0.85	Medium
0.39	0.76	Medium	0.46	0.82	Medium	0.47	0.82	Medium
0.47	0.78	Medium	0.36	0.73	Medium	0.53	0.74	Medium
0.35	0.66	Medium	0.36	0.73	Medium	0.49	0.77	Medium
0.34	0.73	Medium	0.48	0.85	Medium	0.61	0.95	Medium
0.38	0.77	Medium	0.45	0.45	Medium	0.52	0.86	Medium
0.54	0.78	Medium	0.20	0.72	Medium	0.36	0.80	Medium
0.50	0.68	Medium	0.43	0.77	Medium	0.48	0.64	Medium
0.49	0.58	Medium	0.44	0.74	Medium	0.33	0.71	Medium
0.42	0.44	Medium	0.56	0.81	Medium	0.57	0.76	Medium
0.49	0.75	Medium	0.48	0.89	Medium	0.35	0.74	Medium
0.47	0.73	Medium	0.50	0.71	Medium	0.37	0.84	Medium
0.44	0.80	Medium	0.38	0.79	Medium	0.41	0.70	Medium
0.38	0.70	Medium	0.42	0.78	Medium	0.26	0.77	Medium
0.43	0.65	Medium	0.41	0.78	Medium	0.42	0.70	Medium
0.49	0.87	Medium	0.52	0.72	Medium	0.30	0.87	Medium
0.44	0.78	Medium	0.54	0.81	Medium	0.40	0.42	Medium
0.48	0.77	Medium	0.46	0.86	Medium	0.37	0.43	Medium
0.44	0.71	Medium	0.48	0.96	Medium	0.45	0.74	Medium
0.18	0.20	Medium	0.48	0.82	Medium	0.49	0.83	Medium
0.36	0.77	Medium	0.27	0.72	Medium	0.39	0.83	Medium
0.39	0.83	Medium	0.52	0.76	Medium	0.44	0.75	Medium
0.44	0.88	Medium	0.41	0.59	Medium	0.42	0.74	Medium
0.34	0.41	Medium	0.41	0.78	Medium	0.45	0.75	Medium
0.43	0.53	Medium	0.42	0.69	Medium	0.37	0.78	Medium
0.30	0.72	Medium	0.30	0.65	Medium	0.44	0.73	Medium
0.58	0.72	Medium	0.43	0.81	Medium	0.36	0.49	Medium
0.51	0.75	Medium	0.30	0.61	Medium	0.50	0.80	Medium
0.33	0.35	Medium	0.42	0.75	Medium	0.43	0.80	Medium
0.42	0.85	Medium	0.38	0.77	Medium	0.31	0.43	Medium
0.49	0.85	Medium	0.27	0.74	Medium	0.49	0.80	Medium
0.43	0.80	Medium	0.43	0.77	Medium	0.41	0.61	Medium

Table A.10. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.35	0.71	Medium	0.48	0.83	Medium	0.55	0.31	Medium
0.47	0.80	Medium	0.44	0.91	Medium	0.33	0.80	Medium
0.52	0.62	Medium	0.24	0.76	Medium	0.31	0.78	Medium
0.55	0.87	Medium	0.43	0.83	Medium	0.38	0.73	Medium
0.40	0.81	Medium	0.40	0.76	Medium	0.45	0.83	Medium
0.44	0.82	Medium	0.48	0.77	Medium	0.43	0.82	Medium
0.46	0.58	Medium	0.51	0.78	Medium	0.48	0.86	Medium
0.50	0.84	Medium	0.56	0.74	Medium	0.31	0.83	Medium
0.48	0.80	Medium	0.39	0.77	Medium	0.44	0.80	Medium
0.42	0.74	Medium	0.33	0.75	Medium	0.37	0.61	Medium
0.45	0.85	Medium	0.43	0.56	Medium	0.37	0.88	Medium
0.55	0.58	Medium	0.43	0.78	Medium	0.46	0.68	Medium
0.40	0.69	Medium	0.51	0.72	Medium	0.37	0.72	Medium
0.33	0.75	Medium	0.48	0.81	Medium	0.47	0.80	Medium
0.40	0.76	Medium	0.39	0.72	Medium	0.51	0.82	Medium
0.39	0.85	Medium	0.47	0.86	Medium	0.30	0.68	Medium
0.57	0.85	Medium	0.52	0.73	Medium	0.40	0.83	Medium
0.52	0.86	Medium	0.29	0.74	Medium	0.52	0.72	Medium
0.47	0.86	Medium	0.31	0.77	Medium	0.40	0.71	Medium
0.46	0.84	Medium	0.37	0.40	Medium	0.51	0.67	Medium
0.41	0.66	Medium	0.31	0.66	Medium	0.51	0.85	Medium
0.39	0.82	Medium	0.38	0.82	Medium	0.32	0.63	Medium
0.41	0.80	Medium	0.53	0.64	Medium	0.38	0.76	Medium
0.46	0.72	Medium	0.42	0.72	Medium	0.51	0.70	Medium
0.57	0.80	Medium	0.40	0.52	Medium	0.59	0.81	Medium
0.43	0.68	Medium	0.50	0.95	Medium	0.58	0.80	Medium
0.41	0.78	Medium	0.53	0.82	Medium	0.34	0.83	Medium
0.53	0.85	Medium	0.52	0.83	Medium	0.50	0.69	Medium
0.45	0.85	Medium	0.47	0.91	Medium	0.36	0.77	Medium
0.32	0.69	Medium	0.50	0.72	Medium	0.31	0.81	Medium
0.27	0.76	Medium	0.48	0.85	Medium	0.46	0.81	Medium
0.23	0.79	Medium	0.61	0.89	Medium	0.45	0.66	Medium
0.40	0.81	Medium	0.39	0.66	Medium	0.27	0.84	Medium
0.39	0.77	Medium	0.31	0.75	Medium	0.30	0.71	Medium
0.59	0.75	Medium	0.37	0.80	Medium	0.37	0.75	Medium
0.27	0.75	Medium	0.36	0.55	Medium	0.38	0.74	Medium
0.44	0.64	Medium	0.51	0.74	Medium	0.58	0.87	Medium
0.51	0.83	Medium	0.46	0.85	Medium	0.58	0.76	Medium
0.36	0.56	Medium	0.23	0.79	Medium	0.46	0.77	Medium
0.52	0.88	Medium	0.57	0.88	Medium	0.32	0.71	Medium
0.40	0.48	Medium	0.38	0.74	Medium	0.38	0.78	Medium
0.37	0.77	Medium	0.46	0.66	Medium	0.46	0.83	Medium
0.50	0.79	Medium	0.35	0.76	Medium	0.45	0.61	Medium
0.46	0.82	Medium	0.61	0.82	Medium	0.50	0.58	Medium
0.59	0.73	Medium	0.38	0.83	Medium	0.50	0.74	Medium
0.29	0.43	Medium	0.38	0.70	Medium	0.42	0.91	Medium

Table A.10. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.32	0.69	Medium	0.58	0.80	Medium	0.37	0.74	Medium
0.48	0.83	Medium	0.35	0.79	Medium	0.39	0.75	Medium
0.44	0.86	Medium	0.49	0.82	Medium	0.30	0.78	Medium
0.27	0.78	Medium	0.45	0.81	Medium	0.38	0.81	Medium
0.36	0.77	Medium	0.44	0.90	Medium	0.16	0.14	Medium
0.32	0.63	Medium	0.35	0.75	Medium	0.33	0.79	Medium
0.45	0.84	Medium	0.36	0.72	Medium	0.30	0.65	Medium
0.52	0.83	Medium	0.40	0.78	Medium	0.30	0.00	Medium
0.36	0.74	Medium	0.58	0.83	Medium	0.36	0.64	Medium
0.48	0.83	Medium	0.40	0.87	Medium	0.40	0.75	Medium
0.61	0.80	Medium	0.45	0.88	Medium	0.36	0.81	Medium
0.40	0.69	Medium	0.25	0.81	Medium	0.45	0.79	Medium
0.46	0.78	Medium	0.46	0.76	Medium	0.41	0.75	Medium
0.46	0.78	Medium	0.49	0.75	Medium	0.41	0.80	Medium
0.47	0.88	Medium	0.35	0.82	Medium	0.45	0.63	Medium
0.60	0.78	Medium	0.36	0.77	Medium	0.35	0.84	Medium
0.43	0.78	Medium	0.48	0.82	Medium	0.40	0.62	Medium
0.45	0.81	Medium	0.43	0.86	Medium	0.53	0.84	Medium
0.14	0.08	Medium	0.40	0.62	Medium	0.47	0.73	Medium
0.38	0.72	Medium	0.45	0.80	Medium	0.41	0.83	Medium
0.30	0.77	Medium	0.42	0.67	Medium	0.35	0.66	Medium
0.44	0.65	Medium	0.29	0.82	Medium	0.46	0.87	Medium
0.36	0.80	Medium	0.34	0.78	Medium	0.35	0.80	Medium
0.46	0.86	Medium	0.33	0.72	Medium	0.41	0.59	Medium
0.48	0.87	Medium	0.39	0.31	Medium	0.46	0.84	Medium
0.40	0.70	Medium	0.33	0.07	Medium	0.50	0.62	Medium
0.46	0.87	Medium	0.52	0.87	Medium	0.46	0.68	Medium
0.24	0.79	Medium	0.43	0.85	Medium	0.36	0.75	Medium
0.48	0.66	Medium	0.47	0.86	Medium	0.44	0.76	Medium
0.55	0.58	Medium	0.40	0.78	Medium	0.51	0.73	Medium
0.54	0.81	Medium	0.32	0.80	Medium	0.28	0.62	Medium
0.41	0.81	Medium	0.36	0.72	Medium	0.46	0.81	Medium
0.50	0.71	Medium	0.33	0.57	Medium	0.50	0.81	Medium
0.46	0.76	Medium	0.42	0.69	Medium	0.53	0.77	Medium
0.40	0.72	Medium	0.44	0.78	Medium	0.56	0.84	Medium
0.38	0.78	Medium	0.46	0.82	Medium	0.56	0.87	Medium
0.48	0.51	Medium	0.38	0.77	Medium	0.36	0.73	Medium
0.32	0.71	Medium	0.37	0.80	Medium	0.40	0.84	Medium
0.36	0.82	Medium	0.19	0.79	Medium	0.48	0.77	Medium
0.56	0.77	Medium	0.41	0.85	Medium	0.43	0.73	Medium
0.53	0.58	Medium	0.46	0.81	Medium	0.38	0.74	Medium
0.53	0.58	Medium	0.43	0.73	Medium	0.41	0.39	Medium
0.34	0.74	Medium	0.46	0.56	Medium	0.37	0.86	Medium
0.31	0.82	Medium	0.41	0.74	Medium	0.26	0.82	Medium
0.30	0.76	Medium	0.36	0.81	Medium	0.19	0.40	Medium
0.51	0.77	Medium	0.50	0.74	Medium	0.35	0.46	Medium

Table A.10. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.53	0.88	Medium	0.32	0.70	Medium	0.34	0.70	Medium
0.43	0.54	Medium	0.32	0.81	Medium	0.46	0.89	Medium
0.30	0.73	Medium	0.46	0.81	Medium	0.34	0.70	Medium
0.58	0.83	Medium	0.59	0.80	Medium	0.36	0.78	Medium
0.52	0.89	Medium	0.37	0.68	Medium	0.48	0.86	Medium
0.42	0.85	Medium	0.31	0.64	Medium	0.50	0.57	Medium
0.35	0.44	Medium	0.61	0.88	Medium	0.42	0.70	Medium
0.29	0.78	Medium	0.51	0.79	Medium	0.51	0.86	Medium
0.40	0.68	Medium	0.46	0.82	Medium	0.39	0.75	Medium
0.34	0.87	Medium	0.30	0.70	Medium	0.43	0.82	Medium
0.47	0.77	Medium	0.58	0.86	Medium	0.31	0.56	Medium
0.30	0.71	Medium	0.48	0.80	Medium	0.45	0.91	Medium
0.60	0.89	Medium	0.37	0.90	Medium	0.40	0.61	Medium
0.44	0.91	Medium	0.27	0.74	Medium	0.40	0.78	Medium
0.39	0.45	Medium	0.32	0.49	Medium	0.60	0.75	Medium
0.46	0.77	Medium	0.41	0.69	Medium	0.41	0.89	Medium
0.40	0.75	Medium	0.41	0.77	Medium	0.27	0.76	Medium
0.36	0.82	Medium	0.47	0.64	Medium	0.48	0.81	Medium
0.39	0.79	Medium	0.43	0.79	Medium	0.26	0.70	Medium
0.36	0.77	Medium	0.38	0.45	Medium	0.51	0.93	Medium
0.28	0.66	Medium	0.39	0.77	Medium	0.49	0.72	Medium
0.32	0.76	Medium	0.40	0.84	Medium	0.36	0.41	Medium
0.42	0.59	Medium	0.49	0.79	Medium	0.39	0.78	Medium
0.40	0.76	Medium	0.33	0.00	Medium	0.51	0.74	Medium
0.34	0.42	Medium	0.50	0.84	Medium	0.41	0.80	Medium
0.36	0.83	Medium	0.44	0.75	Medium	0.45	0.75	Medium
0.51	0.58	Medium	0.21	0.66	Medium	0.40	0.75	Medium
0.39	0.83	Medium	0.28	0.77	Medium	0.28	0.76	Medium
0.59	0.85	Medium	0.36	0.75	Medium	0.39	0.75	Medium
0.57	0.88	Medium	0.36	0.78	Medium	0.51	0.85	Medium
0.51	0.64	Medium	0.52	0.82	High	0.60	0.89	High
0.35	0.78	Medium	0.48	0.80	High	0.55	0.94	High
0.27	0.80	Medium	0.54	0.83	High	0.53	0.86	High
0.46	0.86	Medium	0.60	0.87	High	0.56	0.92	High
0.40	0.83	Medium	0.59	0.85	High	0.54	0.66	High
0.39	0.84	Medium	0.36	0.01	High	0.45	0.85	High
0.28	0.39	Medium	0.48	0.93	High	0.53	0.84	High
0.50	0.62	Medium	0.55	0.89	High	0.52	0.84	High
0.37	0.61	Medium	0.48	0.82	High	0.43	0.82	High
0.28	0.44	Medium	0.56	0.90	High	0.54	0.86	High
0.37	0.77	Medium	0.59	0.83	High	0.52	0.78	High
0.42	0.86	Medium	0.36	0.77	High	0.45	0.96	High
0.48	0.83	Medium	0.33	0.36	High	0.60	0.92	High
0.44	0.88	Medium	0.17	0.79	High	0.60	0.91	High
0.46	0.75	Medium	0.56	0.88	High	0.33	0.83	High
0.34	0.81	Medium	0.59	0.91	High	0.47	0.78	High

Table A.10. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.32	0.76	Medium	0.43	0.75	High	0.41	0.72	High
0.47	0.77	Medium	0.56	0.91	High	0.57	0.91	High
0.47	0.77	Medium	0.58	0.89	High	0.58	0.81	High
0.46	0.80	Medium	0.55	0.41	High	0.62	0.88	High
0.27	0.38	Medium	0.60	0.88	High	0.54	0.82	High
0.43	0.78	Medium	0.49	0.85	High	0.52	0.91	High
0.50	0.80	Medium	0.52	0.80	High	0.46	0.75	High
0.35	0.74	Medium	0.55	0.87	High	0.48	0.84	High
0.49	0.68	Medium	0.55	0.92	High	0.59	0.84	High
0.28	0.82	Medium	0.52	0.54	High	0.48	0.45	High
0.35	0.41	Medium	0.50	0.78	High	0.62	0.81	High
0.40	0.86	Medium	0.61	0.88	High	0.43	0.65	High
0.42	0.85	Medium	0.55	0.78	High	0.57	0.90	High
0.40	0.74	Medium	0.54	0.71	High	0.48	0.88	High
0.42	0.79	Medium	0.47	0.79	High	0.54	0.85	High
0.33	0.78	Medium	0.29	0.74	High	0.46	0.80	High
0.46	0.81	Medium	0.43	0.67	High	0.54	0.90	High
0.30	0.62	Medium	0.54	0.91	High	0.54	0.83	High
0.43	0.74	Medium	0.48	0.73	High	0.59	0.96	High
0.49	0.83	Medium	0.60	0.83	High	0.47	0.89	High
0.47	0.68	Medium	0.60	0.90	High	0.51	0.87	High
0.33	0.50	Medium	0.50	0.80	High	0.61	0.91	High
0.49	0.56	Medium	0.58	0.81	High	0.56	0.87	High
0.35	0.79	Medium	0.57	0.78	High	0.49	0.85	High
0.41	0.76	Medium	0.54	0.80	High	0.59	0.81	High
0.31	0.69	Medium	0.57	0.86	High	0.57	0.84	High
0.33	0.72	Medium	0.56	0.82	High	0.53	0.87	High
0.44	0.73	Medium	0.50	0.78	High	0.48	0.88	High
0.40	0.76	Medium	0.56	0.93	High	0.58	0.90	High
0.26	0.82	Medium	0.55	0.82	High	0.52	0.75	High
0.41	0.75	Medium	0.58	0.74	High	0.43	0.89	High
0.43	0.73	Medium	0.61	0.91	High	0.52	0.86	High
0.48	0.81	Medium	0.60	0.86	High	0.55	0.89	High
0.38	0.73	Medium	0.53	0.79	High	0.53	0.83	High
0.38	0.79	Medium	0.54	0.83	High	0.50	0.83	High
0.61	0.92	High	0.54	0.82	High	0.60	0.92	High
0.60	0.91	High	0.31	0.75	High	0.54	0.86	High
0.49	0.80	High	0.62	0.87	High	0.58	0.82	High
0.51	0.59	High	0.50	0.12	High	0.49	0.94	High
0.59	0.91	High	0.56	0.87	High	0.61	0.84	High
0.60	0.88	High	0.61	0.85	High	0.58	0.83	High
0.56	0.92	High	0.51	0.84	High	0.59	0.90	High
0.58	0.87	High	0.48	0.80	High	0.57	0.82	High
0.61	0.87	High	0.43	0.48	High	0.60	0.83	High
0.59	0.64	High	0.41	0.63	High	0.52	0.83	High
0.41	0.86	High	0.58	0.89	High	0.53	0.84	High

Table A.10. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.54	0.59	High	0.59	0.83	High	0.60	0.81	High
0.59	0.80	High	0.30	0.82	High	0.58	0.85	High
0.47	0.93	High	0.47	0.68	High	0.54	0.06	High
0.57	0.73	High	0.50	0.84	High	0.45	0.00	High
0.60	0.67	High	0.36	0.46	High	0.37	0.49	High
0.46	0.88	High	0.60	0.83	High	0.52	0.88	High
0.60	0.91	High	0.59	0.86	High	0.55	0.82	High
0.41	0.76	High	0.38	0.74	High	0.38	0.73	High
0.40	0.83	High	0.50	0.85	High	0.34	0.77	High
0.42	0.81	High	0.54	0.89	High	0.60	0.84	High
0.50	0.78	High	0.57	0.83	High	0.51	0.89	High
0.60	0.83	High	0.51	0.93	High	0.63	0.87	High
0.45	0.87	High	0.59	0.69	High	0.60	0.88	High
0.50	0.92	High	0.56	0.83	High	0.49	0.82	High
0.49	0.87	High	0.62	0.84	High	0.52	0.97	High
0.57	0.80	High	0.49	0.81	High	0.34	0.09	High
0.61	0.87	High	0.55	0.84	High	0.57	0.88	High
0.59	0.90	High	0.55	0.81	High	0.55	0.82	High
0.36	0.82	High	0.59	0.87	High	0.41	0.83	High
0.43	0.80	High	0.49	0.82	High	0.62	0.85	High
0.50	0.78	High	0.61	0.91	High	0.50	0.93	High
0.59	0.80	High	0.51	0.79	High	0.41	0.37	High
0.57	0.90	High	0.46	0.85	High	0.54	0.91	High
0.50	0.84	High	0.62	0.93	High	0.58	0.80	High
0.57	0.63	High	0.44	0.71	High	0.56	0.88	High
0.57	0.88	High	0.52	0.82	High	0.51	0.83	High
0.56	0.91	High	0.60	0.82	High	0.59	0.92	High
0.54	0.88	High	0.53	0.83	High	0.59	0.93	High
0.59	0.84	High	0.58	0.91	High	0.58	0.84	High
0.55	0.88	High	0.53	0.66	High	0.58	0.88	High
0.57	0.84	High	0.54	0.85	High	0.57	0.86	High
0.60	0.63	High	0.50	0.78	High	0.55	0.85	High
0.59	0.88	High	0.60	0.84	High	0.49	0.85	High
0.49	0.93	High	0.56	0.87	High	0.59	0.88	High
0.45	0.87	High	0.53	0.86	High	0.48	0.80	High
0.61	0.90	High	0.55	0.92	High	0.54	0.89	High
0.55	0.65	High	0.54	0.69	High	0.60	0.90	High
0.57	0.85	High	0.57	0.81	High	0.55	0.83	High
0.54	0.88	High	0.60	0.59	High	0.48	0.94	High
0.49	0.68	High	0.58	0.79	High	0.55	0.85	High
0.57	0.89	High	0.43	0.81	High	0.62	0.87	High
0.54	0.70	High	0.50	0.82	High	0.47	0.87	High
0.53	0.82	High	0.59	0.92	High	0.57	0.86	High
0.57	0.92	High	0.39	0.00	High	0.62	0.88	High
0.43	0.79	High	0.44	0.42	High	0.52	0.85	High
0.59	0.95	High	0.51	0.84	High	0.55	0.82	High

Table A.10. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.38	0.74	High	0.55	0.80	High	0.56	0.64	High
0.55	0.82	High	0.57	0.91	High	0.43	0.06	High
0.39	0.85	High	0.61	0.90	High	0.42	0.82	High
0.51	0.85	High	0.56	0.93	High	0.52	0.80	High
0.43	0.85	High	0.54	0.76	High	0.60	0.88	High
0.59	0.80	High	0.38	0.74	High	0.53	0.83	High
0.58	0.80	High	0.44	0.91	High	0.53	0.83	High
0.46	0.00	High	0.46	0.75	High	0.55	0.81	High
0.51	0.00	High	0.58	0.91	High	0.55	0.82	High
0.58	0.86	High	0.47	0.77	High	0.62	0.86	High
0.54	0.81	High	0.57	0.83	High	0.59	0.87	High
0.54	0.69	High	0.61	0.88	High	0.43	0.88	High
0.60	0.91	High	0.59	0.86	High	0.55	0.83	High
0.56	0.84	High	0.60	0.90	High	0.56	0.81	High
0.58	0.89	High	0.39	0.70	High	0.55	0.79	High
0.55	0.83	High	0.52	0.83	High	0.53	0.78	High
0.53	0.67	High	0.62	0.86	High	0.49	0.92	High
0.56	0.92	High	0.59	0.84	High	0.55	0.80	High
0.49	0.80	High	0.58	0.88	High	0.54	0.80	High
0.35	0.43	High	0.33	0.77	High	0.39	0.65	High
0.42	0.66	High	0.47	0.83	High	0.61	0.91	High
0.59	0.86	High	0.34	0.50	High	0.48	0.83	High
0.50	0.91	High	0.49	0.82	High	0.56	0.86	High
0.56	0.94	High	0.53	0.77	High	0.60	0.81	High
0.57	0.88	High	0.49	0.84	High	0.59	0.83	High
0.61	0.91	High	0.40	0.80	High	0.46	0.95	High
0.51	0.88	High	0.30	0.74	High	0.60	0.87	High
0.51	0.01	High	0.56	0.79	High	0.57	0.80	High
0.48	0.83	High	0.44	0.76	High	0.47	0.58	High
0.60	0.90	High	0.58	0.85	High	0.57	0.86	High
0.56	0.90	High	0.61	0.88	High	0.57	0.82	High
0.51	0.84	High	0.53	0.85	High	0.57	0.85	High
0.43	0.74	High	0.61	0.91	High	0.55	0.88	High
0.52	0.84	High	0.29	0.28	High	0.56	0.98	High
0.54	0.81	High	0.59	0.86	High	0.48	0.82	High
0.57	1.00	High	0.51	0.88	High	0.51	0.83	High
0.41	0.32	High	0.60	0.89	High	0.52	0.87	High
0.61	0.92	High	0.60	0.84	High	0.29	0.23	High
0.46	0.80	High	0.58	0.85	High	0.60	0.78	High
0.57	0.84	High	0.55	0.91	High	0.53	0.89	High
0.60	0.85	High	0.40	0.87	High	0.55	0.88	High
0.43	0.01	High	0.55	0.80	High	0.58	0.80	High
0.54	0.92	High	0.61	0.92	High	0.53	0.56	High
0.57	0.83	High	0.53	0.90	High	0.52	0.84	High
0.37	0.83	High	0.58	0.84	High	0.48	0.00	High
0.40	0.39	High	0.47	0.95	High	0.48	0.83	High

Table A.10. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.55	0.82	High	0.55	0.80	High	0.49	0.75	High
0.54	0.80	High	0.34	0.00	High	0.55	0.81	High
0.57	0.88	High	0.57	0.00	High	0.57	0.86	High
0.52	0.57	High	0.49	0.78	High	0.57	0.89	High
0.59	0.79	High	0.64	0.90	High	0.59	0.85	High
0.48	0.84	High	0.61	0.81	High	0.60	0.92	High
0.56	0.91	High	0.50	0.82	High	0.48	0.82	High
0.57	0.82	High	0.35	0.79	High	0.50	0.83	High
0.41	0.81	High	0.50	0.00	High	0.56	0.82	High
0.44	0.91	High	0.56	0.80	High	0.35	0.67	High
0.41	0.80	High	0.59	0.88	High	0.57	0.92	High
0.56	0.92	High	0.52	0.89	High	0.54	0.83	High
0.53	0.77	High	0.49	0.81	High	0.37	0.82	High
0.62	0.89	High	0.59	0.81	High	0.59	0.87	High
0.39	0.44	High	0.57	0.92	High	0.58	0.63	High
0.57	0.92	High	0.56	0.91	High	0.49	0.86	High
0.57	0.94	High	0.45	0.85	High	0.58	0.87	High
0.54	0.87	High	0.57	0.83	High	0.50	0.91	High
0.46	0.55	High	0.58	0.85	High	0.57	0.83	High
0.49	0.89	High	0.48	0.85	High	0.45	0.74	High
0.49	0.76	High	0.58	0.85	High	0.59	0.86	High
0.54	0.87	High	0.62	0.93	High	0.58	0.93	High
0.58	0.85	High	0.49	0.82	High	0.52	0.84	High
0.49	0.04	High	0.52	0.55	High	0.61	0.83	High
0.54	0.79	High	0.59	0.89	High	0.55	0.93	High
0.45	0.77	High	0.56	0.88	High	0.58	0.91	High
0.48	0.72	High	0.53	0.03	High	0.51	0.00	High
0.61	0.91	High	0.57	0.86	High	0.60	0.88	High
0.56	0.42	High	0.54	0.80	High	0.45	0.53	High
0.42	0.82	High	0.57	0.87	High	0.59	0.64	High
0.58	0.85	High	0.62	0.87	High	0.56	0.93	High
0.55	0.83	High	0.55	0.83	High	0.58	0.80	High
0.57	0.90	High	0.34	0.64	High	0.56	0.92	High
0.50	0.82	High	0.37	0.74	High	0.49	0.91	High
0.55	0.93	High	0.51	0.87	High	0.56	0.23	High
0.62	0.89	High	0.36	0.83	High	0.43	0.80	High
0.57	0.89	High	0.51	0.79	High	0.62	0.91	High
0.61	0.81	High	0.58	0.87	High	0.56	0.88	High
0.56	0.84	High	0.50	0.76	High	0.52	0.81	High
0.55	0.88	High	0.58	0.89	High	0.55	0.80	High
0.49	0.81	High	0.44	0.15	High	0.60	0.90	High
0.62	0.91	High	0.59	0.91	High	0.38	0.85	High
0.58	0.87	High	0.45	0.91	High	0.35	0.17	High
0.58	0.85	High	0.52	0.92	High	0.51	0.81	High
0.60	0.91	High	0.35	0.52	High	0.42	0.72	High
0.57	0.82	High	0.55	0.78	High	0.59	0.91	High

Table A.10. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.54	0.71	High	0.55	0.87	High	0.57	0.80	High
0.49	0.71	High	0.53	0.87	High	0.44	0.85	High
0.52	0.97	High	0.52	0.82	High	0.53	0.89	High
0.53	0.82	High	0.59	0.89	High	0.55	0.82	High
0.58	0.82	High	0.50	0.26	High	0.52	0.82	High
0.42	0.65	High	0.58	0.91	High	0.51	0.85	High
0.55	0.90	High	0.45	0.77	High	0.37	0.44	High
0.57	0.93	High	0.35	0.72	High	0.47	0.83	High
0.39	0.81	High	0.58	0.80	High	0.48	0.00	High
0.58	0.79	High	0.58	0.84	High	0.59	0.86	High
0.58	1.00	High	0.54	0.86	High	0.52	0.80	High
0.36	0.65	High	0.38	0.83	High	0.61	0.88	High
0.47	0.84	High	0.58	0.92	High	0.55	0.86	High
0.43	0.81	High	0.46	0.69	High	0.60	0.80	High
0.58	0.90	High	0.60	0.92	High	0.60	0.89	High
0.54	0.79	High	0.43	0.68	High	0.61	0.83	High
0.61	0.90	High	0.53	0.82	High	0.50	0.93	High
0.55	0.92	High	0.58	0.81	High	0.54	0.90	High
0.59	0.92	High	0.31	0.02	High	0.60	0.82	High
0.32	0.62	High	0.63	0.85	High	0.53	0.87	High
0.49	0.87	High	0.56	0.83	High	0.58	0.89	High
0.49	0.91	High	0.60	0.90	High	0.44	0.83	High
0.60	0.91	High	0.52	0.86	High	0.60	0.89	High
0.38	0.75	High	0.50	0.82	High	0.60	0.87	High
0.61	0.91	High	0.55	0.87	High	0.48	0.93	High
0.43	0.65	High	0.59	0.82	High	0.58	0.89	High
0.43	0.82	High	0.52	0.84	High	0.50	0.82	High
0.56	0.93	High	0.59	0.86	High	0.55	0.89	High
0.39	0.75	High	0.35	0.22	High	0.55	0.83	High
0.52	0.77	High	0.56	0.87	High	0.56	0.91	High
0.37	0.83	High	0.47	0.85	High	0.41	0.77	High
0.56	0.88	High	0.35	0.45	High	0.52	0.91	High
0.58	0.88	High	0.55	0.61	High	0.36	0.35	High
0.49	0.81	High	0.53	0.89	High	0.59	0.65	High
0.60	0.89	High	0.52	0.83	High	0.35	0.06	High
0.57	0.85	High	0.39	0.51	High	0.54	0.89	High
0.46	0.31	High	0.55	0.78	High	0.55	0.82	High
0.52	0.89	High	0.56	0.84	High	0.57	0.87	High
0.47	0.94	High	0.33	0.81	High	0.56	0.74	High
0.52	0.83	High	0.60	0.89	High	0.56	0.61	High
0.56	0.87	High	0.59	0.86	High	0.46	0.80	High
0.59	0.83	High	0.49	0.80	High	0.36	0.80	High
0.49	0.81	High	0.60	0.88	High	0.56	0.89	High
0.56	0.00	High	0.53	0.66	High	0.57	0.92	High
0.59	0.81	High	0.38	0.81	High	0.54	0.82	High
0.45	0.88	High	0.37	0.00	High	0.52	0.63	High

Table A.10. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.51	0.67	High	0.54	0.80	High	0.55	0.79	High
0.57	0.59	High	0.45	0.82	High	0.52	0.84	High
0.60	0.79	High	0.60	0.86	High	0.55	0.47	High
0.59	0.88	High	0.47	0.64	High	0.57	0.85	High
0.55	0.83	High	0.47	0.87	High	0.50	0.80	High
0.57	0.87	High	0.49	0.82	High	0.58	0.93	High
0.55	0.83	High	0.53	0.89	High	0.35	0.05	High
0.56	0.85	High	0.62	0.89	High	0.55	0.91	High
0.54	0.81	High	0.55	0.91	High	0.56	0.75	High
0.62	0.88	High	0.52	0.86	High	0.56	0.88	High
0.57	0.92	High	0.53	0.79	High	0.54	0.71	High
0.43	0.61	High	0.49	0.81	High	0.53	0.80	High
0.57	0.83	High	0.56	0.89	High	0.47	0.82	High
0.48	0.89	High	0.53	0.90	High	0.57	0.85	High
0.58	0.89	High	0.59	0.84	High	0.52	0.80	High
0.35	0.70	High	0.53	0.55	High	0.55	0.90	High
0.55	0.93	High	0.56	0.82	High	0.44	0.83	High
0.57	0.81	High	0.58	0.92	High	0.54	0.62	High
0.59	0.89	High	0.62	0.90	High	0.56	0.84	High
0.57	0.88	High	0.47	0.75	High	0.54	0.61	High
0.58	0.62	High	0.54	0.86	High	0.53	0.88	High
0.51	0.80	High	0.51	0.83	High	0.54	0.57	High
0.42	0.85	High	0.49	0.93	High	0.58	0.64	High
0.50	0.91	High	0.60	0.80	High	0.58	0.92	High
0.50	0.88	High	0.54	0.00	High	0.50	0.84	High
0.53	0.86	High	0.57	0.89	High	0.58	0.91	High
0.56	0.83	High	0.56	0.94	High	0.57	0.89	High
0.24	0.83	High	0.57	0.83	High	0.16	0.79	High
0.35	0.51	High	0.55	0.61	High	0.57	0.89	High
0.52	0.86	High	0.62	0.93	High	0.57	0.83	High
0.60	0.88	High	0.53	0.00	High	0.55	0.92	High
0.55	0.71	High	0.56	0.89	High	0.45	0.88	High
0.48	0.85	High	0.45	0.77	High	0.48	0.84	High
0.49	0.40	High	0.51	0.86	High	0.50	0.83	High
0.41	0.81	High	0.55	0.86	High	0.57	0.89	High
0.49	0.85	High	0.61	0.91	High	0.54	0.85	High
0.61	0.90	High	0.46	0.82	High	0.60	0.88	High
0.36	0.74	High	0.59	0.85	High	0.50	0.53	High
0.60	0.83	High	0.52	0.84	High	0.53	0.76	High
0.39	0.86	High	0.45	0.77	High	0.44	0.84	High
0.45	0.80	High	0.54	0.79	High	0.57	0.87	High
0.56	0.88	High	0.53	0.57	High	0.53	0.81	High
0.53	0.90	High	0.56	0.93	High	0.62	0.90	High
0.57	0.93	High	0.56	0.90	High	0.55	0.87	High
0.39	0.15	High	0.60	0.85	High	0.56	0.83	High
0.57	0.84	High	0.55	0.83	High	0.55	0.83	High

Table A.10. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.39	0.71	High	0.62	0.91	High	0.56	0.66	High
0.37	0.74	High	0.53	0.77	High	0.54	0.84	High
0.56	0.82	High	0.51	0.82	High	0.58	0.80	High
0.58	0.90	High	0.57	0.89	High	0.61	0.90	High
0.63	0.87	High	0.57	0.61	High	0.55	0.85	High
0.55	0.78	High	0.61	0.90	High	0.50	0.82	High
0.59	0.85	High	0.41	0.82	High	0.34	0.80	High
0.56	0.83	High	0.53	0.65	High	0.50	0.79	High
0.42	0.84	High	0.57	0.84	High	0.43	0.80	High
0.48	0.86	High	0.46	0.96	High	0.35	0.79	High
0.56	0.92	High	0.57	0.81	High	0.60	0.92	High
0.62	0.83	High	0.54	0.78	High	0.49	0.61	High
0.53	0.58	High	0.58	0.83	High	0.45	0.80	High
0.57	0.88	High	0.46	0.59	High	0.40	0.79	High
0.53	0.66	High	0.52	0.82	High	0.59	0.86	High
0.58	0.83	High	0.56	0.45	High	0.54	0.00	High
0.50	0.87	High	0.58	0.80	High	0.59	0.87	High
0.52	0.87	High	0.53	0.57	High	0.59	0.90	High
0.53	0.91	High	0.38	0.87	High	0.39	0.92	High
0.42	0.80	High	0.43	0.84	High	0.56	0.91	High
0.51	0.69	High	0.55	0.83	High	0.53	0.86	High
0.57	0.94	High	0.62	0.88	High	0.61	0.93	High
0.54	0.74	High	0.50	0.00	High	0.58	0.91	High
0.34	0.77	High	0.55	0.86	High	0.62	0.87	High
0.61	0.91	High	0.50	0.83	High	0.55	0.80	High
0.58	0.92	High	0.56	0.90	High	0.57	0.09	High
0.60	0.89	High	0.55	0.82	High	0.58	0.88	High
0.56	0.90	High	0.60	0.83	High	0.61	0.83	High
0.50	0.58	High	0.53	0.75	High	0.49	0.85	High
0.59	0.85	High	0.48	0.82	High	0.54	0.80	High
0.58	0.92	High	0.56	0.87	High	0.42	0.81	High
0.61	0.90	High	0.51	0.81	High			
0.49	0.61	High	0.53	0.89	High			
0.51	0.84	High	0.45	0.86	High			
0.54	0.64	High	0.59	0.95	High			
0.55	0.84	High	0.52	0.90	High			
0.50	0.81	High	0.45	0.83	High			
0.38	0.83	High	0.58	0.98	High			
0.40	0.83	High	0.60	0.89	High			
0.33	0.78	High	0.54	0.87	High			
0.60	0.79	High	0.57	0.88	High			
0.50	0.57	High	0.50	0.85	High			
0.53	0.91	High	0.47	0.73	High			
0.52	0.25	High	0.62	0.88	High			
0.57	0.84	High	0.48	0.81	High			

Table A.11. NDVI, relative yield, and management zone data for Chapter 2, site year VI.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.04	0.53	Low	0.11	0.37	Low	0.14	0.49	Low
0.04	0.50	Low	0.11	0.48	Low	0.15	0.57	Low
0.05	0.45	Low	0.11	0.53	Low	0.15	0.49	Low
0.05	0.40	Low	0.11	0.38	Low	0.15	0.46	Low
0.05	0.47	Low	0.11	0.46	Low	0.15	0.48	Low
0.06	0.41	Low	0.11	0.51	Low	0.15	0.30	Low
0.06	0.49	Low	0.11	0.42	Low	0.15	0.37	Low
0.06	0.53	Low	0.12	0.54	Low	0.15	0.47	Low
0.06	0.53	Low	0.12	0.29	Low	0.15	0.47	Low
0.06	0.53	Low	0.12	0.49	Low	0.15	0.40	Low
0.07	0.44	Low	0.12	0.36	Low	0.15	0.51	Low
0.07	0.46	Low	0.12	0.43	Low	0.15	0.41	Low
0.07	0.48	Low	0.12	0.47	Low	0.15	0.45	Low
0.07	0.50	Low	0.12	0.45	Low	0.15	0.53	Low
0.07	0.42	Low	0.12	0.50	Low	0.15	0.49	Low
0.07	0.52	Low	0.12	0.53	Low	0.15	0.51	Low
0.07	0.39	Low	0.12	0.53	Low	0.15	0.54	Low
0.08	0.50	Low	0.13	0.32	Low	0.16	0.51	Low
0.08	0.47	Low	0.13	0.49	Low	0.16	0.37	Low
0.08	0.51	Low	0.13	0.52	Low	0.16	0.51	Low
0.08	0.32	Low	0.13	0.53	Low	0.16	0.48	Low
0.08	0.47	Low	0.13	0.48	Low	0.16	0.50	Low
0.08	0.52	Low	0.13	0.47	Low	0.16	0.51	Low
0.09	0.48	Low	0.13	0.53	Low	0.16	0.45	Low
0.09	0.50	Low	0.13	0.52	Low	0.16	0.50	Low
0.09	0.47	Low	0.13	0.35	Low	0.16	0.52	Low
0.09	0.51	Low	0.13	0.50	Low	0.16	0.38	Low
0.09	0.42	Low	0.13	0.53	Low	0.16	0.34	Low
0.09	0.53	Low	0.13	0.38	Low	0.16	0.36	Low
0.09	0.39	Low	0.13	0.43	Low	0.16	0.49	Low
0.09	0.49	Low	0.13	0.36	Low	0.16	0.53	Low
0.09	0.53	Low	0.13	0.57	Low	0.16	0.47	Low
0.09	0.48	Low	0.13	0.50	Low	0.16	0.48	Low
0.09	0.53	Low	0.13	0.48	Low	0.16	0.52	Low
0.09	0.48	Low	0.13	0.37	Low	0.17	0.48	Low
0.09	0.46	Low	0.13	0.54	Low	0.17	0.52	Low
0.09	0.49	Low	0.14	0.54	Low	0.17	0.51	Low
0.09	0.50	Low	0.14	0.48	Low	0.17	0.50	Low
0.10	0.52	Low	0.14	0.45	Low	0.17	0.52	Low
0.10	0.39	Low	0.14	0.51	Low	0.17	0.51	Low
0.10	0.35	Low	0.14	0.43	Low	0.17	0.54	Low
0.10	0.53	Low	0.14	0.51	Low	0.17	0.44	Low
0.10	0.48	Low	0.14	0.49	Low	0.17	0.48	Low
0.10	0.38	Low	0.14	0.50	Low	0.17	0.49	Low
0.10	0.37	Low	0.14	0.49	Low	0.17	0.41	Low

Table A.11. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.10	0.52	Low	0.14	0.50	Low	0.17	0.52	Low
0.10	0.50	Low	0.14	0.51	Low	0.17	0.44	Low
0.10	0.32	Low	0.14	0.55	Low	0.17	0.52	Low
0.11	0.36	Low	0.14	0.55	Low	0.17	0.52	Low
0.11	0.52	Low	0.14	0.41	Low	0.17	0.41	Low
0.11	0.49	Low	0.14	0.53	Low	0.17	0.42	Low
0.18	0.55	Low	0.20	0.49	Low	0.22	0.46	Low
0.18	0.49	Low	0.20	0.54	Low	0.22	0.57	Low
0.18	0.47	Low	0.20	0.52	Low	0.22	0.51	Low
0.18	0.33	Low	0.20	0.37	Low	0.22	0.44	Low
0.18	0.52	Low	0.20	0.52	Low	0.22	0.44	Low
0.18	0.28	Low	0.20	0.27	Low	0.22	0.54	Low
0.18	0.51	Low	0.20	0.46	Low	0.22	0.34	Low
0.18	0.49	Low	0.20	0.46	Low	0.23	0.51	Low
0.18	0.50	Low	0.20	0.47	Low	0.23	0.54	Low
0.18	0.46	Low	0.20	0.57	Low	0.23	0.47	Low
0.18	0.48	Low	0.20	0.55	Low	0.23	0.44	Low
0.18	0.51	Low	0.20	0.52	Low	0.23	0.51	Low
0.18	0.45	Low	0.20	0.54	Low	0.23	0.44	Low
0.18	0.40	Low	0.20	0.53	Low	0.23	0.54	Low
0.18	0.50	Low	0.20	0.55	Low	0.23	0.47	Low
0.18	0.40	Low	0.21	0.62	Low	0.23	0.53	Low
0.18	0.45	Low	0.21	0.57	Low	0.23	0.50	Low
0.18	0.39	Low	0.21	0.29	Low	0.23	0.31	Low
0.18	0.53	Low	0.21	0.54	Low	0.23	0.51	Low
0.18	0.50	Low	0.21	0.41	Low	0.23	0.52	Low
0.18	0.53	Low	0.21	0.43	Low	0.23	0.50	Low
0.18	0.28	Low	0.21	0.53	Low	0.23	0.49	Low
0.18	0.49	Low	0.21	0.36	Low	0.23	0.59	Low
0.19	0.34	Low	0.21	0.55	Low	0.24	0.43	Low
0.19	0.53	Low	0.21	0.51	Low	0.24	0.56	Low
0.19	0.50	Low	0.21	0.42	Low	0.24	0.51	Low
0.19	0.55	Low	0.21	0.28	Low	0.24	0.46	Low
0.19	0.40	Low	0.21	0.47	Low	0.24	0.46	Low
0.19	0.44	Low	0.21	0.48	Low	0.24	0.52	Low
0.19	0.47	Low	0.21	0.49	Low	0.24	0.58	Low
0.19	0.51	Low	0.21	0.53	Low	0.24	0.44	Low
0.19	0.40	Low	0.21	0.53	Low	0.24	0.54	Low
0.19	0.56	Low	0.21	0.43	Low	0.24	0.53	Low
0.19	0.56	Low	0.21	0.53	Low	0.24	0.55	Low
0.19	0.52	Low	0.21	0.56	Low	0.24	0.56	Low
0.19	0.44	Low	0.21	0.53	Low	0.24	0.53	Low
0.19	0.53	Low	0.21	0.46	Low	0.24	0.57	Low
0.19	0.53	Low	0.21	0.39	Low	0.24	0.36	Low
0.19	0.46	Low	0.22	0.54	Low	0.24	0.53	Low

Table A.11. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.19	0.53	Low	0.22	0.54	Low	0.25	0.49	Low
0.19	0.48	Low	0.22	0.28	Low	0.25	0.51	Low
0.19	0.54	Low	0.22	0.41	Low	0.25	0.54	Low
0.20	0.35	Low	0.22	0.42	Low	0.25	0.50	Low
0.20	0.35	Low	0.22	0.59	Low	0.25	0.55	Low
0.20	0.37	Low	0.22	0.43	Low	0.25	0.52	Low
0.20	0.29	Low	0.22	0.49	Low	0.25	0.46	Low
0.20	0.48	Low	0.22	0.50	Low	0.25	0.53	Low
0.20	0.49	Low	0.22	0.56	Low	0.25	0.42	Low
0.20	0.60	Low	0.22	0.44	Low	0.25	0.54	Low
0.20	0.47	Low	0.22	0.54	Low	0.26	0.42	Low
0.20	0.52	Low	0.22	0.35	Low	0.26	0.51	Low
0.26	0.47	Low	0.30	0.58	Low	0.35	0.55	Low
0.26	0.46	Low	0.30	0.47	Low	0.35	0.57	Low
0.26	0.47	Low	0.30	0.52	Low	0.35	0.60	Low
0.26	0.52	Low	0.30	0.59	Low	0.35	0.57	Low
0.26	0.42	Low	0.30	0.55	Low	0.35	0.63	Low
0.26	0.60	Low	0.30	0.59	Low	0.35	0.55	Low
0.26	0.62	Low	0.30	0.54	Low	0.35	0.56	Low
0.27	0.55	Low	0.30	0.57	Low	0.35	0.59	Low
0.27	0.53	Low	0.30	0.58	Low	0.35	0.52	Low
0.27	0.54	Low	0.30	0.58	Low	0.35	0.55	Low
0.27	0.47	Low	0.30	0.59	Low	0.35	0.56	Low
0.27	0.64	Low	0.30	0.33	Low	0.36	0.62	Low
0.27	0.57	Low	0.30	0.55	Low	0.36	0.59	Low
0.27	0.54	Low	0.30	0.59	Low	0.36	0.57	Low
0.27	0.53	Low	0.31	0.52	Low	0.36	0.54	Low
0.27	0.57	Low	0.31	0.54	Low	0.36	0.54	Low
0.27	0.39	Low	0.31	0.57	Low	0.36	0.53	Low
0.27	0.57	Low	0.31	0.60	Low	0.36	0.59	Low
0.27	0.54	Low	0.32	0.58	Low	0.36	0.57	Low
0.27	0.53	Low	0.32	0.56	Low	0.36	0.59	Low
0.27	0.53	Low	0.32	0.58	Low	0.36	0.57	Low
0.27	0.56	Low	0.32	0.54	Low	0.36	0.65	Low
0.27	0.55	Low	0.32	0.56	Low	0.36	0.59	Low
0.27	0.33	Low	0.32	0.54	Low	0.36	0.59	Low
0.28	0.57	Low	0.32	0.55	Low	0.36	0.62	Low
0.28	0.59	Low	0.32	0.56	Low	0.37	0.55	Low
0.28	0.60	Low	0.32	0.58	Low	0.37	0.58	Low
0.28	0.56	Low	0.32	0.69	Low	0.37	0.56	Low
0.28	0.53	Low	0.32	0.56	Low	0.37	0.55	Low
0.28	0.55	Low	0.33	0.49	Low	0.37	0.56	Low
0.28	0.57	Low	0.33	0.55	Low	0.37	0.54	Low
0.28	0.57	Low	0.33	0.58	Low	0.37	0.54	Low
0.28	0.50	Low	0.33	0.52	Low	0.37	0.58	Low

Table A.11. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.28	0.51	Low	0.33	0.58	Low	0.37	0.55	Low
0.28	0.56	Low	0.33	0.55	Low	0.37	0.63	Low
0.29	0.55	Low	0.33	0.54	Low	0.37	0.57	Low
0.29	0.55	Low	0.33	0.58	Low	0.37	0.52	Low
0.29	0.52	Low	0.33	0.59	Low	0.38	0.55	Low
0.29	0.48	Low	0.34	0.55	Low	0.38	0.58	Low
0.29	0.54	Low	0.34	0.55	Low	0.38	0.57	Low
0.29	0.57	Low	0.34	0.59	Low	0.38	0.57	Low
0.29	0.57	Low	0.34	0.59	Low	0.38	0.59	Low
0.29	0.58	Low	0.34	0.55	Low	0.38	0.55	Low
0.29	0.59	Low	0.34	0.55	Low	0.38	0.58	Low
0.29	0.54	Low	0.34	0.58	Low	0.38	0.60	Low
0.29	0.52	Low	0.34	0.56	Low	0.38	0.57	Low
0.29	0.56	Low	0.34	0.61	Low	0.38	0.54	Low
0.29	0.59	Low	0.34	0.57	Low	0.38	0.62	Low
0.30	0.55	Low	0.34	0.61	Low	0.38	0.55	Low
0.30	0.41	Low	0.34	0.54	Low	0.38	0.59	Low
0.30	0.56	Low	0.35	0.52	Low	0.38	0.57	Low
0.39	0.57	Low	0.41	0.65	Low	0.44	0.56	Low
0.39	0.59	Low	0.41	0.64	Low	0.44	0.59	Low
0.39	0.70	Low	0.41	0.63	Low	0.44	0.55	Low
0.39	0.52	Low	0.41	0.64	Low	0.44	0.55	Low
0.39	0.57	Low	0.41	0.57	Low	0.44	0.57	Low
0.39	0.59	Low	0.41	0.56	Low	0.44	0.59	Low
0.39	0.59	Low	0.41	0.58	Low	0.44	0.60	Low
0.39	0.61	Low	0.41	0.59	Low	0.45	0.55	Low
0.39	0.58	Low	0.42	0.55	Low	0.45	0.56	Low
0.39	0.54	Low	0.42	0.56	Low	0.45	0.68	Low
0.39	0.55	Low	0.42	0.61	Low	0.45	0.58	Low
0.39	0.57	Low	0.42	0.57	Low	0.45	0.60	Low
0.39	0.64	Low	0.42	0.61	Low	0.45	0.57	Low
0.39	0.65	Low	0.42	0.56	Low	0.45	0.62	Low
0.39	0.58	Low	0.42	0.54	Low	0.45	0.59	Low
0.39	0.54	Low	0.42	0.59	Low	0.45	0.60	Low
0.39	0.61	Low	0.42	0.58	Low	0.45	0.61	Low
0.40	0.58	Low	0.42	0.58	Low	0.45	0.58	Low
0.40	0.59	Low	0.42	0.60	Low	0.45	0.63	Low
0.40	0.54	Low	0.43	0.59	Low	0.45	0.64	Low
0.40	0.63	Low	0.43	0.54	Low	0.45	0.57	Low
0.40	0.56	Low	0.43	0.63	Low	0.45	0.57	Low
0.40	0.52	Low	0.43	0.57	Low	0.45	0.60	Low
0.40	0.58	Low	0.43	0.58	Low	0.46	0.54	Low
0.40	0.52	Low	0.43	0.59	Low	0.46	0.57	Low
0.40	0.54	Low	0.43	0.54	Low	0.46	0.59	Low
0.40	0.57	Low	0.43	0.56	Low	0.46	0.59	Low

Table A.11. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.40	0.58	Low	0.43	0.61	Low	0.46	0.57	Low
0.40	0.62	Low	0.43	0.62	Low	0.46	0.58	Low
0.40	0.63	Low	0.43	0.55	Low	0.46	0.54	Low
0.40	0.56	Low	0.43	0.60	Low	0.46	0.54	Low
0.40	0.61	Low	0.43	0.61	Low	0.46	0.57	Low
0.40	0.62	Low	0.43	0.62	Low	0.46	0.58	Low
0.40	0.52	Low	0.43	0.63	Low	0.46	0.63	Low
0.40	0.75	Low	0.43	0.54	Low	0.46	0.64	Low
0.40	0.55	Low	0.43	0.56	Low	0.46	0.58	Low
0.41	0.55	Low	0.43	0.59	Low	0.46	0.54	Low
0.41	0.63	Low	0.43	0.57	Low	0.46	0.56	Low
0.41	0.62	Low	0.44	0.55	Low	0.46	0.54	Low
0.41	0.52	Low	0.44	0.57	Low	0.46	0.58	Low
0.41	0.56	Low	0.44	0.57	Low	0.46	0.62	Low
0.41	0.62	Low	0.44	0.63	Low	0.47	0.56	Low
0.41	0.52	Low	0.44	0.65	Low	0.47	0.58	Low
0.41	0.56	Low	0.44	0.59	Low	0.47	0.59	Low
0.41	0.56	Low	0.44	0.55	Low	0.47	0.55	Low
0.41	0.56	Low	0.44	0.58	Low	0.47	0.56	Low
0.41	0.58	Low	0.44	0.52	Low	0.47	0.59	Low
0.41	0.75	Low	0.44	0.56	Low	0.47	0.60	Low
0.41	0.54	Low	0.44	0.57	Low	0.47	0.59	Low
0.41	0.58	Low	0.44	0.61	Low	0.47	0.60	Low
0.41	0.58	Low	0.44	0.59	Low	0.47	0.58	Low
0.47	0.61	Low	0.50	0.60	Low	0.08	0.46	Medium
0.47	0.56	Low	0.50	0.61	Low	0.08	0.38	Medium
0.47	0.58	Low	0.50	0.64	Low	0.08	0.45	Medium
0.47	0.59	Low	0.50	0.58	Low	0.09	0.49	Medium
0.47	0.61	Low	0.51	0.60	Low	0.09	0.49	Medium
0.47	0.58	Low	0.51	0.60	Low	0.09	0.53	Medium
0.47	0.58	Low	0.51	0.60	Low	0.09	0.54	Medium
0.47	0.60	Low	0.51	0.62	Low	0.09	0.49	Medium
0.47	0.68	Low	0.51	0.64	Low	0.09	0.47	Medium
0.47	0.57	Low	0.51	0.60	Low	0.09	0.49	Medium
0.47	0.58	Low	0.51	0.62	Low	0.09	0.53	Medium
0.47	0.58	Low	0.51	0.59	Low	0.09	0.47	Medium
0.47	0.56	Low	0.51	0.62	Low	0.09	0.52	Medium
0.48	0.57	Low	0.51	0.58	Low	0.09	0.51	Medium
0.48	0.60	Low	0.51	0.62	Low	0.10	0.45	Medium
0.48	0.62	Low	0.52	0.56	Low	0.10	0.54	Medium
0.48	0.57	Low	0.52	0.59	Low	0.10	0.48	Medium
0.48	0.60	Low	0.52	0.59	Low	0.10	0.52	Medium
0.48	0.58	Low	0.53	0.59	Low	0.10	0.31	Medium
0.48	0.59	Low	0.53	0.66	Low	0.10	0.51	Medium
0.48	0.61	Low	0.53	0.59	Low	0.10	0.45	Medium

Table A.11. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.48	0.59	Low	0.53	0.60	Low	0.11	0.47	Medium
0.48	0.59	Low	0.53	0.57	Low	0.11	0.53	Medium
0.48	0.58	Low	0.53	0.61	Low	0.11	0.37	Medium
0.48	0.61	Low	0.55	0.61	Low	0.11	0.54	Medium
0.48	0.64	Low	0.56	0.59	Low	0.11	0.54	Medium
0.48	0.56	Low	0.58	0.60	Low	0.11	0.45	Medium
0.48	0.56	Low	0.61	0.59	Low	0.11	0.49	Medium
0.48	0.58	Low	0.01	0.46	Medium	0.11	0.51	Medium
0.49	0.58	Low	0.01	0.52	Medium	0.11	0.49	Medium
0.49	0.63	Low	0.01	0.49	Medium	0.12	0.54	Medium
0.49	0.60	Low	0.01	0.39	Medium	0.12	0.55	Medium
0.49	0.58	Low	0.02	0.52	Medium	0.12	0.58	Medium
0.49	0.59	Low	0.02	0.41	Medium	0.12	0.53	Medium
0.49	0.59	Low	0.03	0.51	Medium	0.12	0.55	Medium
0.49	0.61	Low	0.04	0.53	Medium	0.12	0.40	Medium
0.49	0.55	Low	0.04	0.45	Medium	0.12	0.47	Medium
0.49	0.59	Low	0.04	0.43	Medium	0.12	0.53	Medium
0.49	0.60	Low	0.04	0.40	Medium	0.12	0.38	Medium
0.49	0.60	Low	0.04	0.54	Medium	0.12	0.51	Medium
0.49	0.61	Low	0.04	0.45	Medium	0.12	0.49	Medium
0.49	0.54	Low	0.05	0.32	Medium	0.13	0.40	Medium
0.49	0.60	Low	0.06	0.31	Medium	0.13	0.62	Medium
0.50	0.58	Low	0.06	0.47	Medium	0.13	0.57	Medium
0.50	0.60	Low	0.06	0.47	Medium	0.13	0.50	Medium
0.50	0.68	Low	0.06	0.51	Medium	0.13	0.51	Medium
0.50	0.55	Low	0.07	0.55	Medium	0.13	0.46	Medium
0.50	0.59	Low	0.08	0.45	Medium	0.13	0.51	Medium
0.50	0.60	Low	0.08	0.45	Medium	0.13	0.50	Medium
0.50	0.57	Low	0.08	0.54	Medium	0.14	0.62	Medium
0.50	0.58	Low	0.08	0.52	Medium	0.14	0.49	Medium
0.14	0.25	Medium	0.17	0.54	Medium	0.22	0.46	Medium
0.14	0.51	Medium	0.17	0.51	Medium	0.22	0.52	Medium
0.14	0.53	Medium	0.17	0.51	Medium	0.22	0.54	Medium
0.14	0.34	Medium	0.17	0.35	Medium	0.22	0.54	Medium
0.14	0.48	Medium	0.17	0.54	Medium	0.22	0.54	Medium
0.14	0.53	Medium	0.17	0.56	Medium	0.22	0.46	Medium
0.14	0.50	Medium	0.18	0.40	Medium	0.22	0.46	Medium
0.14	0.53	Medium	0.18	0.49	Medium	0.22	0.50	Medium
0.14	0.51	Medium	0.18	0.50	Medium	0.22	0.44	Medium
0.14	0.39	Medium	0.18	0.51	Medium	0.22	0.53	Medium
0.14	0.49	Medium	0.18	0.44	Medium	0.22	0.53	Medium
0.14	0.50	Medium	0.18	0.48	Medium	0.22	0.42	Medium
0.14	0.51	Medium	0.18	0.53	Medium	0.22	0.54	Medium
0.14	0.52	Medium	0.18	0.51	Medium	0.22	0.43	Medium
0.14	0.54	Medium	0.18	0.36	Medium	0.22	0.31	Medium

Table A.11. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.15	0.52	Medium	0.18	0.48	Medium	0.22	0.53	Medium
0.15	0.34	Medium	0.18	0.46	Medium	0.22	0.51	Medium
0.15	0.51	Medium	0.18	0.43	Medium	0.22	0.52	Medium
0.15	0.52	Medium	0.19	0.57	Medium	0.22	0.54	Medium
0.15	0.51	Medium	0.19	0.53	Medium	0.23	0.59	Medium
0.15	0.41	Medium	0.19	0.51	Medium	0.23	0.28	Medium
0.15	0.47	Medium	0.19	0.53	Medium	0.23	0.47	Medium
0.15	0.37	Medium	0.19	0.53	Medium	0.23	0.53	Medium
0.15	0.48	Medium	0.19	0.50	Medium	0.23	0.53	Medium
0.15	0.35	Medium	0.19	0.32	Medium	0.23	0.50	Medium
0.15	0.51	Medium	0.19	0.55	Medium	0.23	0.53	Medium
0.15	0.62	Medium	0.19	0.42	Medium	0.23	0.58	Medium
0.15	0.59	Medium	0.20	0.53	Medium	0.23	0.58	Medium
0.16	0.41	Medium	0.20	0.51	Medium	0.23	0.59	Medium
0.16	0.52	Medium	0.20	0.53	Medium	0.23	0.42	Medium
0.16	0.50	Medium	0.20	0.54	Medium	0.23	0.41	Medium
0.16	0.48	Medium	0.20	0.55	Medium	0.23	0.55	Medium
0.16	0.58	Medium	0.20	0.52	Medium	0.23	0.59	Medium
0.16	0.58	Medium	0.20	0.42	Medium	0.24	0.55	Medium
0.16	0.38	Medium	0.20	0.52	Medium	0.24	0.48	Medium
0.16	0.30	Medium	0.20	0.37	Medium	0.24	0.33	Medium
0.16	0.54	Medium	0.20	0.56	Medium	0.24	0.63	Medium
0.16	0.38	Medium	0.20	0.46	Medium	0.24	0.56	Medium
0.16	0.47	Medium	0.20	0.52	Medium	0.24	0.49	Medium
0.16	0.50	Medium	0.20	0.43	Medium	0.24	0.56	Medium
0.16	0.51	Medium	0.21	0.27	Medium	0.24	0.50	Medium
0.17	0.51	Medium	0.21	0.49	Medium	0.24	0.49	Medium
0.17	0.49	Medium	0.21	0.54	Medium	0.24	0.52	Medium
0.17	0.55	Medium	0.21	0.39	Medium	0.24	0.54	Medium
0.17	0.52	Medium	0.21	0.37	Medium	0.24	0.48	Medium
0.17	0.46	Medium	0.21	0.60	Medium	0.24	0.54	Medium
0.17	0.53	Medium	0.21	0.40	Medium	0.24	0.56	Medium
0.17	0.53	Medium	0.21	0.42	Medium	0.24	0.48	Medium
0.17	0.53	Medium	0.21	0.49	Medium	0.24	0.49	Medium
0.17	0.51	Medium	0.21	0.48	Medium	0.24	0.47	Medium
0.17	0.44	Medium	0.22	0.55	Medium	0.24	0.53	Medium
0.25	0.52	Medium	0.27	0.41	Medium	0.31	0.59	Medium
0.25	0.53	Medium	0.27	0.54	Medium	0.31	0.55	Medium
0.25	0.56	Medium	0.27	0.55	Medium	0.31	0.54	Medium
0.25	0.46	Medium	0.27	0.62	Medium	0.31	0.57	Medium
0.25	0.54	Medium	0.27	0.53	Medium	0.31	0.59	Medium
0.25	0.42	Medium	0.27	0.54	Medium	0.31	0.61	Medium
0.25	0.54	Medium	0.27	0.59	Medium	0.31	0.61	Medium
0.25	0.56	Medium	0.27	0.61	Medium	0.31	0.55	Medium
0.25	0.62	Medium	0.28	0.59	Medium	0.31	0.55	Medium

Table A.11. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.25	0.51	Medium	0.28	0.54	Medium	0.32	0.62	Medium
0.25	0.53	Medium	0.28	0.54	Medium	0.32	0.54	Medium
0.25	0.55	Medium	0.28	0.62	Medium	0.32	0.63	Medium
0.25	0.58	Medium	0.28	0.54	Medium	0.32	0.59	Medium
0.25	0.59	Medium	0.28	0.53	Medium	0.32	0.57	Medium
0.25	0.58	Medium	0.28	0.55	Medium	0.32	0.48	Medium
0.25	0.58	Medium	0.28	0.55	Medium	0.32	0.55	Medium
0.26	0.62	Medium	0.28	0.59	Medium	0.32	0.57	Medium
0.26	0.56	Medium	0.28	0.59	Medium	0.32	0.59	Medium
0.26	0.52	Medium	0.28	0.54	Medium	0.32	0.60	Medium
0.26	0.55	Medium	0.28	0.55	Medium	0.32	0.61	Medium
0.26	0.59	Medium	0.29	0.57	Medium	0.32	0.63	Medium
0.26	0.28	Medium	0.29	0.56	Medium	0.32	0.59	Medium
0.26	0.53	Medium	0.29	0.56	Medium	0.32	0.54	Medium
0.26	0.49	Medium	0.29	0.55	Medium	0.32	0.52	Medium
0.26	0.49	Medium	0.29	0.59	Medium	0.32	0.55	Medium
0.26	0.57	Medium	0.29	0.52	Medium	0.32	0.56	Medium
0.26	0.36	Medium	0.29	0.57	Medium	0.32	0.57	Medium
0.26	0.55	Medium	0.29	0.62	Medium	0.32	0.60	Medium
0.26	0.61	Medium	0.29	0.55	Medium	0.32	0.62	Medium
0.26	0.53	Medium	0.29	0.57	Medium	0.33	0.55	Medium
0.26	0.53	Medium	0.29	0.53	Medium	0.33	0.55	Medium
0.26	0.53	Medium	0.29	0.54	Medium	0.33	0.55	Medium
0.26	0.55	Medium	0.30	0.56	Medium	0.33	0.56	Medium
0.26	0.55	Medium	0.30	0.57	Medium	0.33	0.63	Medium
0.26	0.55	Medium	0.30	0.62	Medium	0.33	0.58	Medium
0.26	0.55	Medium	0.30	0.55	Medium	0.33	0.59	Medium
0.26	0.58	Medium	0.30	0.57	Medium	0.33	0.61	Medium
0.27	0.51	Medium	0.30	0.60	Medium	0.33	0.60	Medium
0.27	0.40	Medium	0.30	0.55	Medium	0.33	0.59	Medium
0.27	0.57	Medium	0.30	0.59	Medium	0.33	0.61	Medium
0.27	0.53	Medium	0.30	0.33	Medium	0.33	0.62	Medium
0.27	0.55	Medium	0.30	0.62	Medium	0.33	0.54	Medium
0.27	0.55	Medium	0.30	0.53	Medium	0.33	0.56	Medium
0.27	0.53	Medium	0.30	0.53	Medium	0.33	0.57	Medium
0.27	0.55	Medium	0.30	0.58	Medium	0.33	0.58	Medium
0.27	0.56	Medium	0.30	0.53	Medium	0.33	0.58	Medium
0.27	0.53	Medium	0.30	0.56	Medium	0.33	0.58	Medium
0.27	0.58	Medium	0.30	0.62	Medium	0.33	0.63	Medium
0.27	0.59	Medium	0.30	0.58	Medium	0.34	0.54	Medium
0.27	0.50	Medium	0.30	0.58	Medium	0.34	0.66	Medium
0.27	0.48	Medium	0.24	0.47	Medium	0.34	0.55	Medium
0.34	0.55	Medium	0.36	0.58	Medium	0.39	0.56	Medium
0.34	0.52	Medium	0.36	0.58	Medium	0.39	0.55	Medium
0.34	0.55	Medium	0.36	0.60	Medium	0.39	0.57	Medium

Table A.11. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.34	0.59	Medium	0.37	0.60	Medium	0.39	0.58	Medium
0.34	0.62	Medium	0.37	0.55	Medium	0.39	0.60	Medium
0.34	0.75	Medium	0.37	0.56	Medium	0.39	0.68	Medium
0.34	0.60	Medium	0.37	0.58	Medium	0.39	0.62	Medium
0.34	0.55	Medium	0.37	0.57	Medium	0.39	0.55	Medium
0.34	0.55	Medium	0.37	0.57	Medium	0.39	0.57	Medium
0.35	0.55	Medium	0.37	0.58	Medium	0.39	0.61	Medium
0.35	0.60	Medium	0.37	0.60	Medium	0.39	0.62	Medium
0.35	0.57	Medium	0.37	0.55	Medium	0.39	0.56	Medium
0.35	0.62	Medium	0.37	0.56	Medium	0.39	0.57	Medium
0.35	0.58	Medium	0.37	0.62	Medium	0.39	0.58	Medium
0.35	0.57	Medium	0.37	0.54	Medium	0.39	0.58	Medium
0.35	0.58	Medium	0.37	0.58	Medium	0.40	0.63	Medium
0.35	0.59	Medium	0.37	0.58	Medium	0.40	0.55	Medium
0.35	0.56	Medium	0.37	0.55	Medium	0.40	0.62	Medium
0.35	0.54	Medium	0.37	0.58	Medium	0.40	0.64	Medium
0.35	0.57	Medium	0.37	0.57	Medium	0.40	0.56	Medium
0.35	0.55	Medium	0.37	0.55	Medium	0.40	0.59	Medium
0.35	0.53	Medium	0.37	0.56	Medium	0.40	0.62	Medium
0.35	0.55	Medium	0.37	0.63	Medium	0.40	0.58	Medium
0.35	0.55	Medium	0.37	0.63	Medium	0.40	0.60	Medium
0.35	0.56	Medium	0.37	0.64	Medium	0.40	0.63	Medium
0.35	0.62	Medium	0.37	0.62	Medium	0.40	0.55	Medium
0.35	0.58	Medium	0.38	0.58	Medium	0.40	0.57	Medium
0.35	0.58	Medium	0.38	0.63	Medium	0.40	0.57	Medium
0.35	0.60	Medium	0.38	0.52	Medium	0.40	0.58	Medium
0.35	0.57	Medium	0.38	0.59	Medium	0.40	0.56	Medium
0.35	0.90	Medium	0.38	0.56	Medium	0.40	0.55	Medium
0.35	0.58	Medium	0.38	0.60	Medium	0.40	0.62	Medium
0.35	0.60	Medium	0.38	0.57	Medium	0.40	0.58	Medium
0.35	0.55	Medium	0.38	0.60	Medium	0.40	0.59	Medium
0.35	0.55	Medium	0.38	0.62	Medium	0.40	0.61	Medium
0.36	0.59	Medium	0.38	0.64	Medium	0.40	0.65	Medium
0.36	0.59	Medium	0.38	0.57	Medium	0.40	0.59	Medium
0.36	0.57	Medium	0.38	0.57	Medium	0.40	0.57	Medium
0.36	0.56	Medium	0.38	0.61	Medium	0.40	0.57	Medium
0.36	0.57	Medium	0.38	0.64	Medium	0.40	0.57	Medium
0.36	0.60	Medium	0.38	0.54	Medium	0.40	0.64	Medium
0.36	0.55	Medium	0.38	0.57	Medium	0.41	0.55	Medium
0.36	0.60	Medium	0.39	0.61	Medium	0.41	0.57	Medium
0.36	0.56	Medium	0.39	0.55	Medium	0.41	0.57	Medium
0.36	0.60	Medium	0.39	0.60	Medium	0.41	0.56	Medium
0.36	0.62	Medium	0.39	0.56	Medium	0.41	0.58	Medium
0.36	0.60	Medium	0.39	0.52	Medium	0.41	0.66	Medium
0.36	0.53	Medium	0.39	0.58	Medium	0.41	0.63	Medium

Table A.11. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.36	0.57	Medium	0.39	0.57	Medium	0.41	0.56	Medium
0.36	0.54	Medium	0.39	0.55	Medium	0.41	0.62	Medium
0.41	0.60	Medium	0.43	0.57	Medium	0.44	0.60	Medium
0.41	0.59	Medium	0.43	0.58	Medium	0.44	0.61	Medium
0.41	0.57	Medium	0.43	0.60	Medium	0.44	0.64	Medium
0.41	0.62	Medium	0.43	0.64	Medium	0.44	0.55	Medium
0.41	0.53	Medium	0.43	0.65	Medium	0.44	0.58	Medium
0.41	0.55	Medium	0.43	0.65	Medium	0.45	0.64	Medium
0.42	0.58	Medium	0.43	0.56	Medium	0.45	0.68	Medium
0.42	0.58	Medium	0.43	0.55	Medium	0.45	0.58	Medium
0.42	0.60	Medium	0.43	0.56	Medium	0.45	0.60	Medium
0.42	0.56	Medium	0.43	0.57	Medium	0.45	0.57	Medium
0.42	0.58	Medium	0.43	0.58	Medium	0.45	0.59	Medium
0.42	0.63	Medium	0.43	0.60	Medium	0.45	0.62	Medium
0.42	0.58	Medium	0.43	0.61	Medium	0.45	0.56	Medium
0.42	0.60	Medium	0.43	0.56	Medium	0.45	0.62	Medium
0.42	0.57	Medium	0.43	0.61	Medium	0.45	0.58	Medium
0.42	0.57	Medium	0.43	0.63	Medium	0.45	0.55	Medium
0.42	0.59	Medium	0.43	0.56	Medium	0.45	0.58	Medium
0.42	0.55	Medium	0.43	0.59	Medium	0.45	0.60	Medium
0.42	0.60	Medium	0.43	0.59	Medium	0.45	0.61	Medium
0.42	0.55	Medium	0.43	0.66	Medium	0.45	0.65	Medium
0.42	0.55	Medium	0.43	0.59	Medium	0.45	0.56	Medium
0.42	0.59	Medium	0.43	0.60	Medium	0.45	0.63	Medium
0.42	0.56	Medium	0.43	0.61	Medium	0.45	0.54	Medium
0.42	0.59	Medium	0.43	0.58	Medium	0.45	0.58	Medium
0.42	0.55	Medium	0.43	0.62	Medium	0.45	0.63	Medium
0.42	0.59	Medium	0.44	0.63	Medium	0.45	0.54	Medium
0.42	0.59	Medium	0.44	0.55	Medium	0.45	0.55	Medium
0.42	0.61	Medium	0.44	0.57	Medium	0.45	0.59	Medium
0.42	0.54	Medium	0.44	0.58	Medium	0.45	0.61	Medium
0.42	0.55	Medium	0.44	0.56	Medium	0.45	0.58	Medium
0.42	0.56	Medium	0.44	0.63	Medium	0.45	0.62	Medium
0.42	0.57	Medium	0.44	0.64	Medium	0.45	0.55	Medium
0.42	0.59	Medium	0.44	0.66	Medium	0.45	0.58	Medium
0.42	0.64	Medium	0.44	0.67	Medium	0.45	0.61	Medium
0.42	0.64	Medium	0.44	0.57	Medium	0.45	0.63	Medium
0.42	0.58	Medium	0.44	0.57	Medium	0.45	0.64	Medium
0.42	0.56	Medium	0.44	0.63	Medium	0.45	0.65	Medium
0.42	0.55	Medium	0.44	0.54	Medium	0.46	0.56	Medium
0.42	0.61	Medium	0.44	0.56	Medium	0.46	0.56	Medium
0.42	0.58	Medium	0.44	0.62	Medium	0.46	0.58	Medium
0.42	0.63	Medium	0.44	0.57	Medium	0.46	0.58	Medium
0.42	0.56	Medium	0.44	0.59	Medium	0.46	0.61	Medium
0.42	0.75	Medium	0.44	0.56	Medium	0.46	0.56	Medium

Table A.11. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.43	0.58	Medium	0.44	0.55	Medium	0.46	0.70	Medium
0.43	0.57	Medium	0.44	0.58	Medium	0.46	0.59	Medium
0.43	0.56	Medium	0.44	0.58	Medium	0.46	0.58	Medium
0.43	0.60	Medium	0.44	0.57	Medium	0.46	0.56	Medium
0.43	0.65	Medium	0.44	0.54	Medium	0.46	0.59	Medium
0.43	0.56	Medium	0.44	0.58	Medium	0.46	0.54	Medium
0.43	0.56	Medium	0.44	0.59	Medium	0.46	0.54	Medium
0.43	0.57	Medium	0.44	0.59	Medium	0.46	0.56	Medium
0.46	0.59	Medium	0.48	0.56	Medium	0.50	0.60	Medium
0.46	0.59	Medium	0.48	0.58	Medium	0.50	0.61	Medium
0.46	0.60	Medium	0.48	0.60	Medium	0.50	0.61	Medium
0.46	0.63	Medium	0.48	0.63	Medium	0.50	0.61	Medium
0.46	0.60	Medium	0.48	0.59	Medium	0.50	0.62	Medium
0.46	0.58	Medium	0.48	0.62	Medium	0.50	0.62	Medium
0.46	0.80	Medium	0.48	0.57	Medium	0.50	0.68	Medium
0.46	0.58	Medium	0.48	0.57	Medium	0.50	0.55	Medium
0.46	0.65	Medium	0.48	0.60	Medium	0.50	0.61	Medium
0.46	0.58	Medium	0.48	0.60	Medium	0.50	0.60	Medium
0.46	0.60	Medium	0.48	0.60	Medium	0.51	0.61	Medium
0.46	0.61	Medium	0.48	0.63	Medium	0.51	0.64	Medium
0.46	0.56	Medium	0.48	0.57	Medium	0.51	0.56	Medium
0.47	0.56	Medium	0.48	0.67	Medium	0.51	0.60	Medium
0.47	0.60	Medium	0.48	0.57	Medium	0.51	0.62	Medium
0.47	0.60	Medium	0.48	0.62	Medium	0.51	0.56	Medium
0.47	0.60	Medium	0.48	0.55	Medium	0.51	0.60	Medium
0.47	0.56	Medium	0.48	0.58	Medium	0.52	0.61	Medium
0.47	0.56	Medium	0.49	0.73	Medium	0.52	0.59	Medium
0.47	0.60	Medium	0.49	0.60	Medium	0.52	0.60	Medium
0.47	0.60	Medium	0.49	0.62	Medium	0.52	0.61	Medium
0.47	0.61	Medium	0.49	0.54	Medium	0.52	0.60	Medium
0.47	0.63	Medium	0.49	0.59	Medium	0.52	0.60	Medium
0.47	0.64	Medium	0.49	0.61	Medium	0.52	0.60	Medium
0.47	0.56	Medium	0.49	0.64	Medium	0.52	0.57	Medium
0.47	0.56	Medium	0.49	0.57	Medium	0.52	0.57	Medium
0.47	0.57	Medium	0.49	0.58	Medium	0.52	0.64	Medium
0.47	0.60	Medium	0.49	0.59	Medium	0.52	0.58	Medium
0.47	0.63	Medium	0.49	0.60	Medium	0.52	0.58	Medium
0.47	0.64	Medium	0.49	0.60	Medium	0.52	0.60	Medium
0.47	0.56	Medium	0.49	0.61	Medium	0.52	0.60	Medium
0.47	0.58	Medium	0.49	0.59	Medium	0.53	0.60	Medium
0.47	0.59	Medium	0.49	0.62	Medium	0.53	0.58	Medium
0.47	0.61	Medium	0.49	0.74	Medium	0.53	0.61	Medium
0.47	0.61	Medium	0.49	0.60	Medium	0.53	0.62	Medium
0.47	0.55	Medium	0.49	0.60	Medium	0.54	0.62	Medium
0.47	0.63	Medium	0.49	0.57	Medium	0.54	0.61	Medium

Table A.11. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.47	0.58	Medium	0.49	0.58	Medium	0.54	0.60	Medium
0.47	0.55	Medium	0.49	0.58	Medium	0.54	0.63	Medium
0.47	0.57	Medium	0.49	0.59	Medium	0.54	0.58	Medium
0.47	0.60	Medium	0.50	0.57	Medium	0.54	0.59	Medium
0.47	0.61	Medium	0.50	0.59	Medium	0.55	0.61	Medium
0.47	0.61	Medium	0.50	0.63	Medium	0.55	0.62	Medium
0.47	0.54	Medium	0.50	0.58	Medium	0.56	0.58	Medium
0.47	0.56	Medium	0.50	0.63	Medium	0.56	0.60	Medium
0.47	0.57	Medium	0.50	0.61	Medium	0.57	0.60	Medium
0.48	0.58	Medium	0.50	0.56	Medium	0.60	0.58	Medium
0.48	0.56	Medium	0.50	0.59	Medium	0.60	0.58	Medium
0.48	0.56	Medium	0.50	0.56	Medium	0.61	0.58	Medium
0.48	0.61	Medium	0.50	0.59	Medium	0.61	0.58	Medium
0.48	0.62	Medium	0.50	0.60	Medium	0.66	0.58	Medium
0.68	0.57	Medium	0.14	0.43	High	0.20	0.54	High
0.68	0.58	Medium	0.14	0.53	High	0.20	0.45	High
0.71	0.58	Medium	0.14	0.52	High	0.20	0.54	High
0.00	0.40	High	0.14	0.40	High	0.20	0.25	High
0.01	0.52	High	0.14	0.46	High	0.20	0.39	High
0.02	0.41	High	0.14	0.52	High	0.21	0.56	High
0.02	0.54	High	0.14	0.47	High	0.21	0.51	High
0.02	0.47	High	0.15	0.49	High	0.21	0.46	High
0.02	0.45	High	0.15	0.50	High	0.21	0.48	High
0.03	0.36	High	0.15	0.55	High	0.21	0.44	High
0.03	0.52	High	0.15	0.21	High	0.21	0.46	High
0.03	0.40	High	0.15	0.49	High	0.21	0.53	High
0.04	0.45	High	0.15	0.52	High	0.21	0.43	High
0.04	0.49	High	0.15	0.49	High	0.22	0.50	High
0.04	0.48	High	0.15	0.51	High	0.22	0.54	High
0.04	0.51	High	0.15	0.46	High	0.22	0.50	High
0.04	0.52	High	0.15	0.50	High	0.22	0.42	High
0.04	0.54	High	0.15	0.52	High	0.22	0.51	High
0.05	0.51	High	0.16	0.51	High	0.22	0.42	High
0.05	0.50	High	0.16	0.52	High	0.22	0.54	High
0.05	0.52	High	0.16	0.49	High	0.22	0.52	High
0.06	0.47	High	0.16	0.52	High	0.22	0.57	High
0.06	0.52	High	0.16	0.46	High	0.23	0.55	High
0.07	0.42	High	0.16	0.32	High	0.23	0.31	High
0.07	0.48	High	0.16	0.51	High	0.23	0.42	High
0.08	0.50	High	0.16	0.49	High	0.23	0.47	High
0.08	0.49	High	0.16	0.40	High	0.23	0.36	High
0.09	0.51	High	0.17	0.47	High	0.23	0.59	High
0.09	0.54	High	0.17	0.50	High	0.23	0.59	High
0.09	0.50	High	0.17	0.45	High	0.23	0.50	High
0.10	0.51	High	0.17	0.47	High	0.23	0.41	High

Table A.11. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.10	0.48	High	0.17	0.47	High	0.23	0.51	High
0.10	0.49	High	0.18	0.56	High	0.23	0.52	High
0.10	0.45	High	0.18	0.37	High	0.23	0.49	High
0.11	0.47	High	0.18	0.50	High	0.24	0.57	High
0.11	0.53	High	0.18	0.48	High	0.24	0.48	High
0.11	0.49	High	0.18	0.33	High	0.24	0.56	High
0.11	0.50	High	0.18	0.53	High	0.24	0.51	High
0.11	0.50	High	0.18	0.57	High	0.24	0.52	High
0.12	0.52	High	0.19	0.44	High	0.24	0.51	High
0.12	0.50	High	0.19	0.48	High	0.25	0.42	High
0.12	0.50	High	0.19	0.44	High	0.25	0.46	High
0.12	0.53	High	0.19	0.49	High	0.25	0.60	High
0.13	0.41	High	0.19	0.54	High	0.25	0.54	High
0.13	0.43	High	0.19	0.46	High	0.25	0.46	High
0.13	0.55	High	0.19	0.48	High	0.25	0.39	High
0.13	0.48	High	0.19	0.52	High	0.25	0.59	High
0.13	0.31	High	0.19	0.46	High	0.25	0.51	High
0.13	0.54	High	0.19	0.50	High	0.25	0.51	High
0.14	0.31	High	0.19	0.46	High	0.25	0.60	High
0.14	0.52	High	0.20	0.54	High	0.25	0.43	High
0.25	0.48	High	0.32	0.55	High	0.38	0.57	High
0.25	0.54	High	0.32	0.55	High	0.38	0.59	High
0.25	0.55	High	0.32	0.53	High	0.38	0.59	High
0.25	0.55	High	0.32	0.55	High	0.39	0.59	High
0.26	0.54	High	0.32	0.52	High	0.39	0.59	High
0.26	0.53	High	0.32	0.59	High	0.40	0.58	High
0.26	0.56	High	0.32	0.54	High	0.40	0.54	High
0.26	0.59	High	0.32	0.56	High	0.40	0.57	High
0.26	0.56	High	0.32	0.42	High	0.40	0.58	High
0.26	0.43	High	0.32	0.56	High	0.40	0.62	High
0.27	0.46	High	0.32	0.53	High	0.40	0.63	High
0.27	0.55	High	0.33	0.58	High	0.40	0.63	High
0.27	0.53	High	0.33	0.58	High	0.41	0.56	High
0.27	0.48	High	0.33	0.61	High	0.41	0.52	High
0.27	0.52	High	0.33	0.58	High	0.41	0.62	High
0.27	0.60	High	0.33	0.53	High	0.41	0.62	High
0.27	0.62	High	0.33	0.56	High	0.41	0.55	High
0.27	0.54	High	0.34	0.61	High	0.41	0.58	High
0.27	0.54	High	0.34	0.61	High	0.41	0.58	High
0.28	0.53	High	0.34	0.53	High	0.42	0.63	High
0.28	0.59	High	0.34	0.56	High	0.42	0.54	High
0.28	0.55	High	0.34	0.57	High	0.42	0.55	High
0.28	0.42	High	0.35	0.55	High	0.42	0.56	High
0.28	0.57	High	0.35	0.60	High	0.42	0.60	High
0.28	0.56	High	0.35	0.58	High	0.42	0.62	High

Table A.11. Continued.

NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone	NDVI	Relative Yield	Zone
0.28	0.58	High	0.35	0.61	High	0.42	0.57	High
0.28	0.56	High	0.35	0.55	High	0.42	0.62	High
0.28	0.59	High	0.35	0.57	High	0.42	0.55	High
0.28	0.49	High	0.35	0.54	High	0.42	0.60	High
0.29	0.53	High	0.35	0.58	High	0.43	0.58	High
0.29	0.60	High	0.35	0.58	High	0.43	0.57	High
0.29	0.53	High	0.36	0.58	High	0.43	0.57	High
0.29	0.56	High	0.36	0.57	High	0.43	0.58	High
0.29	0.58	High	0.36	0.58	High	0.43	0.61	High
0.29	0.55	High	0.36	0.59	High	0.44	0.61	High
0.29	0.59	High	0.36	0.62	High	0.44	0.56	High
0.29	0.61	High	0.36	0.56	High	0.44	0.60	High
0.30	0.61	High	0.36	0.59	High	0.44	0.54	High
0.30	0.54	High	0.36	0.56	High	0.44	0.57	High
0.30	0.42	High	0.36	0.57	High	0.44	0.56	High
0.30	0.58	High	0.37	0.60	High	0.44	0.57	High
0.30	0.57	High	0.37	0.55	High	0.44	0.59	High
0.31	0.59	High	0.37	0.56	High	0.44	0.58	High
0.31	0.57	High	0.37	0.58	High	0.45	0.60	High
0.31	0.54	High	0.37	0.57	High	0.45	0.58	High
0.31	0.55	High	0.37	0.62	High	0.45	0.58	High
0.31	0.61	High	0.37	0.59	High	0.45	0.56	High
0.31	0.52	High	0.38	0.59	High	0.45	0.56	High
0.31	0.57	High	0.38	0.58	High	0.45	0.62	High
0.31	0.56	High	0.38	0.60	High	0.45	0.57	High
0.32	0.58	High	0.38	0.56	High	0.46	0.56	High
0.46	0.57	High	0.47	0.60	High			
0.46	0.59	High	0.48	0.63	High			
0.46	0.64	High	0.49	0.61	High			
0.46	0.60	High	0.49	0.58	High			
0.46	0.57	High	0.49	0.61	High			
0.46	0.57	High	0.49	0.58	High			
0.46	0.60	High	0.49	0.57	High			
0.46	0.60	High	0.50	0.57	High			
0.46	0.62	High	0.50	0.60	High			
0.46	0.58	High	0.51	0.60	High			
0.46	0.61	High	0.51	0.61	High			
0.46	0.57	High	0.51	0.59	High			
0.47	0.59	High	0.51	0.63	High			
0.47	0.60	High	0.52	0.63	High			
0.47	0.56	High	0.52	0.60	High			
0.47	0.59	High	0.54	0.63	High			
0.47	0.59	High	0.56	0.62	High			
0.47	0.61	High	0.56	0.59	High			
0.47	0.56	High	0.64	0.58	High			

APPENDIX C

Table A.12. Management zone, NDVI, simple ratio (SR), days from planting to sensing, INSEY, grain yield, and PSNT for chapter 3, site year I.

Zone	NDVI	SR	Days	INSEY	Grain Yield (Mg ha^{-1})	PSNT
Low	0.41	0.43	45	0.009235	8	0.50
Low	0.33	0.38	45	0.007483	9	0.63
Low	0.33	0.42	45	0.007377	9	0.49
Low	0.33	0.41	45	0.007383	7	0.18
Medium	0.40	0.46	45	0.009027	11	0.59
Medium	0.46	0.45	45	0.010254	10	0.33
Medium	0.41	0.46	45	0.009142	11	1.10
Medium	0.42	0.47	45	0.009442	11	0.50
High	0.38	0.42	45	0.008477	10	1.32
High	0.38	0.51	45	0.008612	10	1.48
High	0.38	0.51	45	0.008556	9	0.82
High	0.37	0.51	45	0.008329	9	0.75

Table A.13. Management zone, NDVI, simple ratio (SR), days from planting to sensing, INSEY, grain yield, and PSNT for chapter 3, site year II.

Zone	NDVI	SR	Days	INSEY	Grain Yield (Mg ha^{-1})	PSNT
Low	0.59	0.27	60	0.009752	17	8.40
Low	0.37	0.47	60	0.006215	19	11.10
Low	0.43	0.41	60	0.007085	18	5.90
Low	0.47	0.38	60	0.007764	19	4.00
Medium	0.59	0.27	60	0.009807	20	6.20
Medium	0.66	0.21	60	0.010962	19	7.10
Medium	0.51	0.34	60	0.008465	19	8.70
Medium	0.67	0.20	60	0.011193	18	4.70
High	0.68	0.20	60	0.011329	24	13.40
High	0.70	0.18	60	0.011725	17	10.70
High	0.71	0.18	60	0.011819	21	11.70
High	0.66	0.21	60	0.011057	23	10.20

Table A.14. Management zone, NDVI, simple ratio (SR), days from planting to sensing, INSEY, and grain yield for chapter 3, site year III.

Zone	NDVI	SR	Days	INSEY	Grain Yield (Mg ha^{-1})	PSNT
Low	0.34	0.50	50	0.0068	9	7.10
Low	0.32	0.52	50	0.0064	10	5.50
Low	0.29	0.56	50	0.0058	7	5.30
Low	0.26	0.59	50	0.0052	5	5.80
Medium	0.29	0.55	50	0.0058	10	4.20
Medium	0.28	0.56	50	0.0056	10	3.70
Medium	0.34	0.49	50	0.0068	9	4.40
Medium	0.37	0.47	50	0.0074	10	4.10
High	0.35	0.48	50	0.007	7	6.90
High	0.39	0.44	50	0.0078	10	3.10
High	0.26	0.59	50	0.0052	8	4.20
High	0.37	0.47	50	0.0074	9	3.00

Table A.15. Management zone, NDVI, simple ratio (SR), days from planting to sensing, INSEY, and grain yield for chapter 3, site year IV.

Zone	NDVI	SR	Days	INSEY	Grain Yield (Mg ha^{-1})	PSNT
Low	0.62	0.24	63	0.009839	14	3.90
Low	0.48	0.36	63	0.007605	11	5.30
Low	0.45	0.38	63	0.007178	13	15.10
Low	0.68	0.19	63	0.010794	14	11.80
Medium	0.77	0.13	63	0.012234	17	6.10
Medium	0.74	0.15	63	0.011724	19	5.30
Medium	0.78	0.12	63	0.01245	17	6.40
Medium	0.76	0.13	63	0.012125	16	6.00
High	0.71	0.17	63	0.011272	17	9.60
High	0.71	0.17	63	0.011342	17	10.30
High	0.74	0.15	63	0.011752	17	10.70
High	0.75	0.15	63	0.011842	16	7.30