Nitrogen and Water Management across Site-Specific Management Zones using Active Remote Sensing

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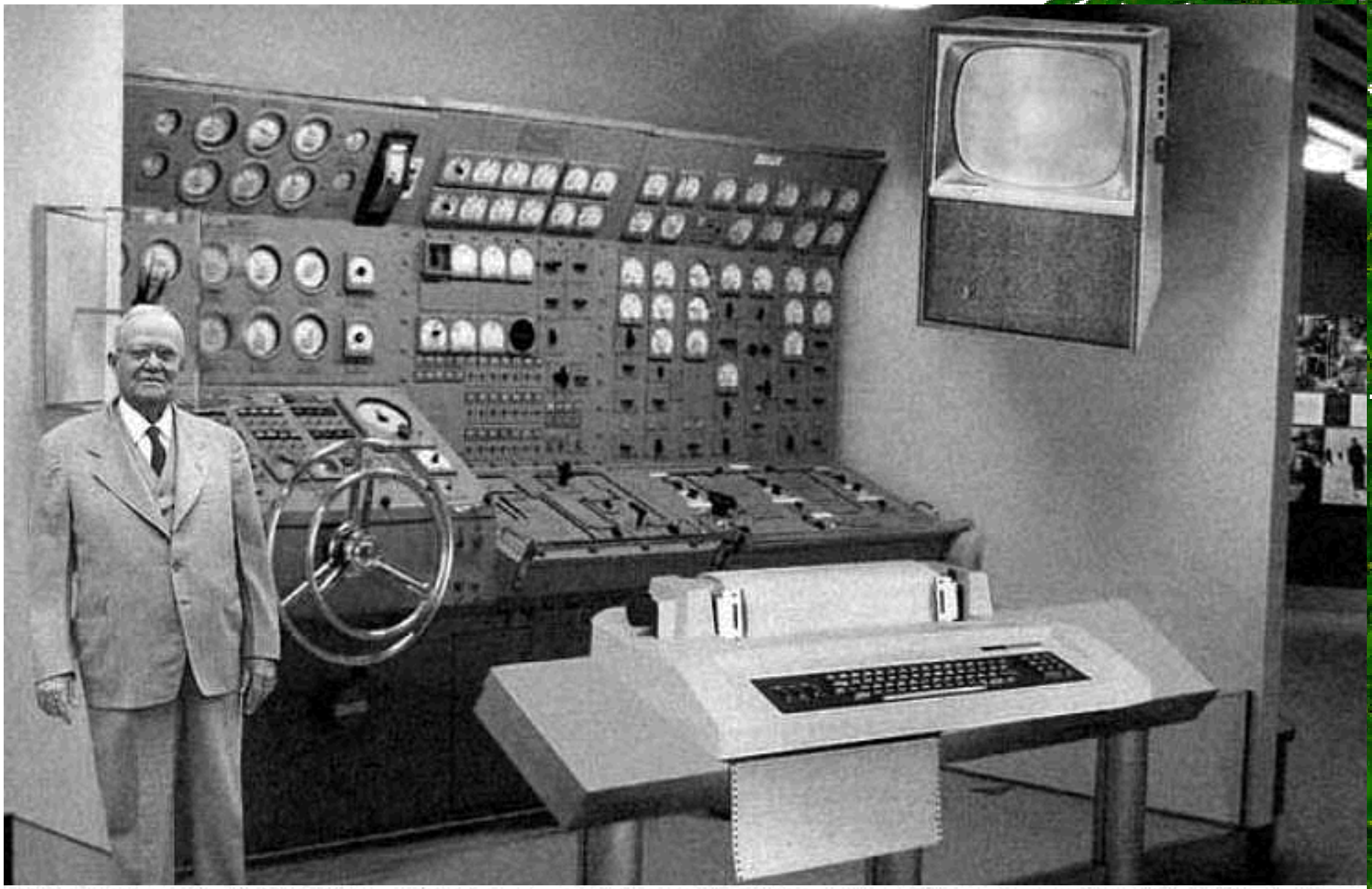


Scientists from the RAND Corporation have created this model to illustrate how a "home computer" could look like in the year 2004. However the needed technology will not be economically feasible for the average home. Also the scientists readily admit that the computer will require not yet invented technology to actually work, but 50 years from now scientific progress is expected to solve these problems. With teletype interface and the Fortran language, the computer will be easy to use.

Changes in Agriculture

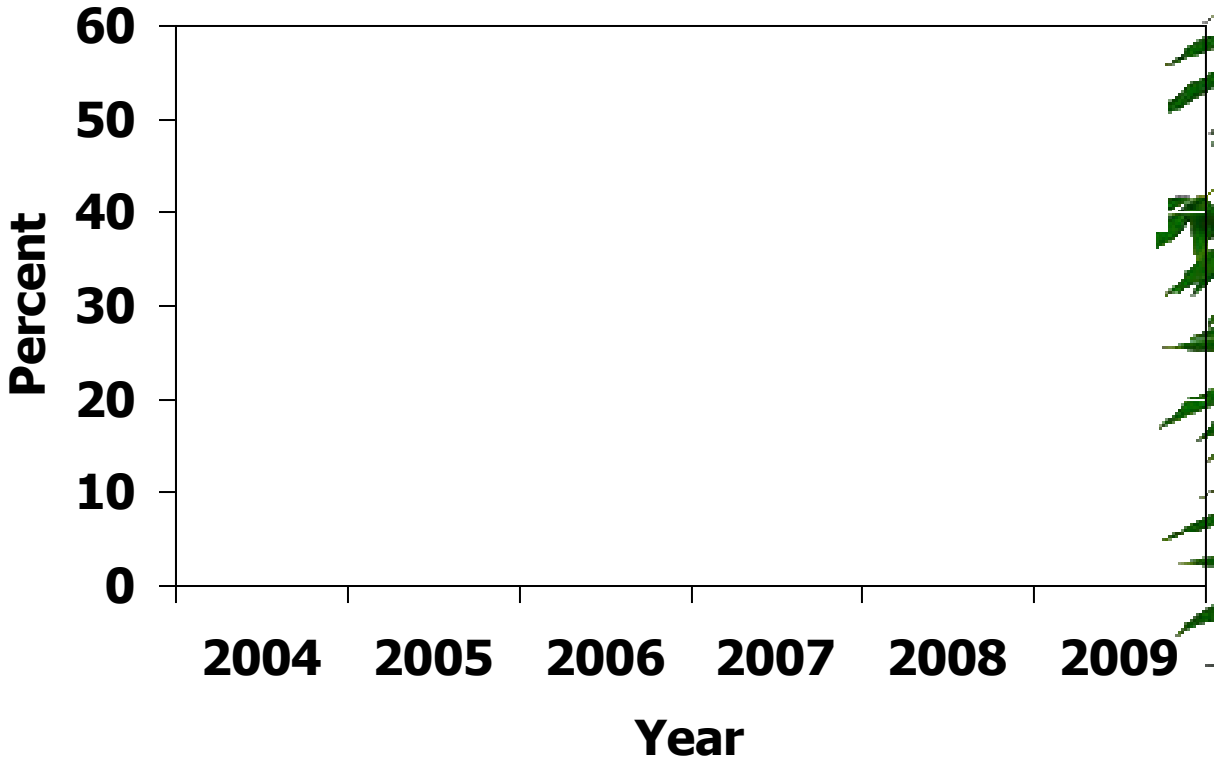
- What is the fastest growing segment of Precision Agriculture?
  - Auto Guidance

Early 1900s

Early 2000s

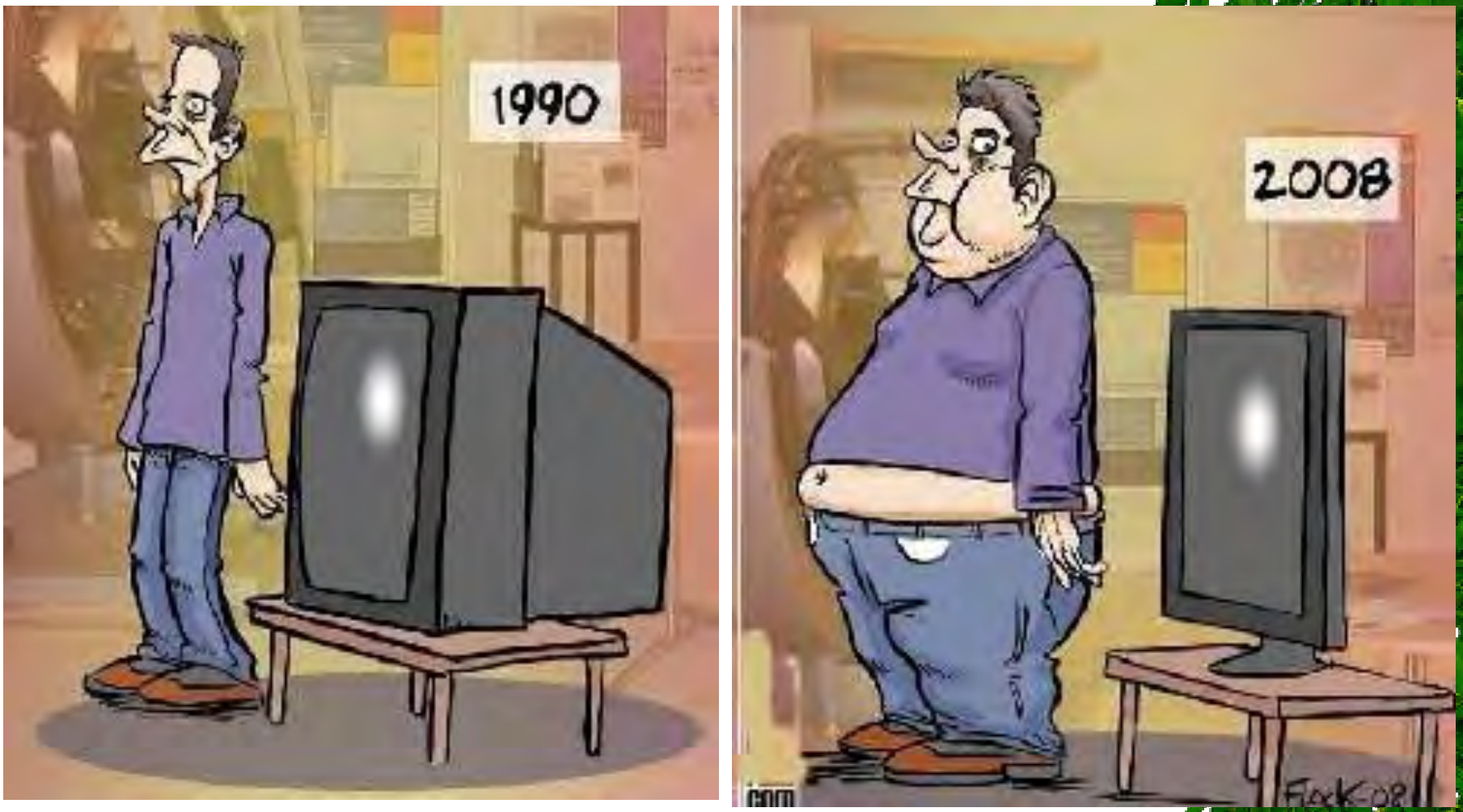
Auto Guidance

- Fastest growing segment of Precision Agriculture



Based on 14th annual nation-wide survey (across 33 states) by Purdue Univ and Crop Life Magazine, 2009.

Talking about Change!!!



Introduction:

Precision nutrient management has been a research focus of agronomists for over a decade.

An important component of precision nutrient management is identifying in-field variability in crops.

Remotely sensed imagery can aid in determining variability, however, there are limitations (Cloud cover, spatial and spectral resolutions and expense).

Using a hand-held or tractor mounted active remote sensing device, these limitations may be overcome.

Introduction:

Remote sensing devices determine N variability using Normalized Difference Vegetation Index (NDVI).

NDVI is a remotely sensed vegetation index that is correlated to leaf area index (LAI) and green biomass.

Different ground based sensors are available.

Sensors:

Holland Scientific Crop Circle:

Amber NDVI

-Visible waveband = 590 nm

-Near infrared = 880 nm

NTech Industries GreenSeeker:

Red NDVI

-Red visible waveband = 660 nm

-Near infrared = 770 nm

Visible ~ 400 to 700nm (G, B, R)

Near infrared ranges ~ 750nm to 1400nm

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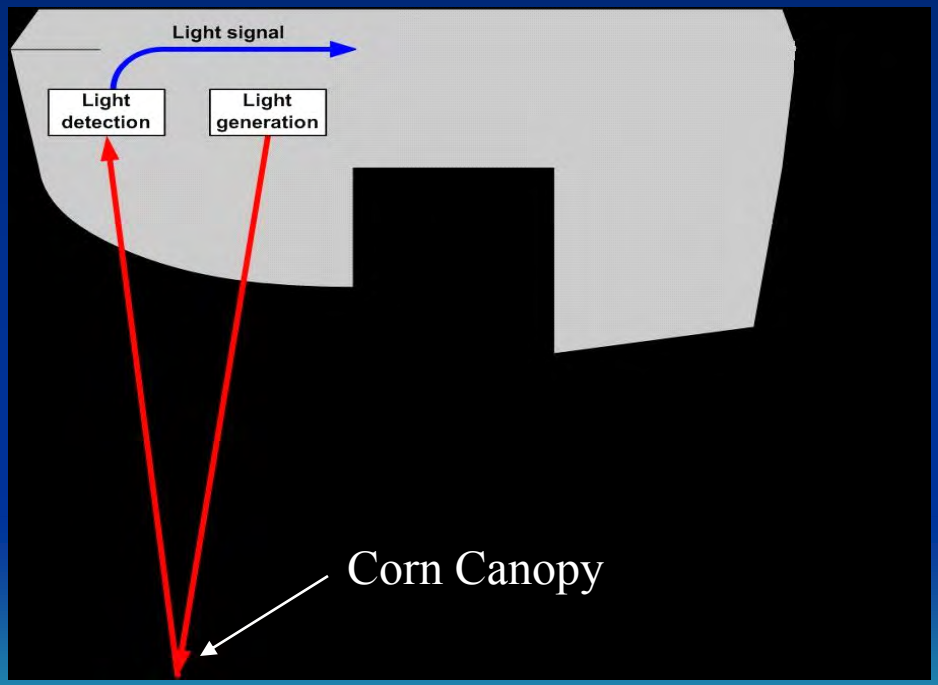
NDVI:

$$\frac{NIR - VIS}{NIR + VIS}$$

Where: NIR = near infrared and VIS = visible light wavelength



Previous work:

-Amber and red sensors had high linear associations with:

Applied N rate & plant N concentration

-The red sensor had more variability in NDVI readings.

-The red sensor required more attention due to the affect of sensor movement speed on NDVI readings.

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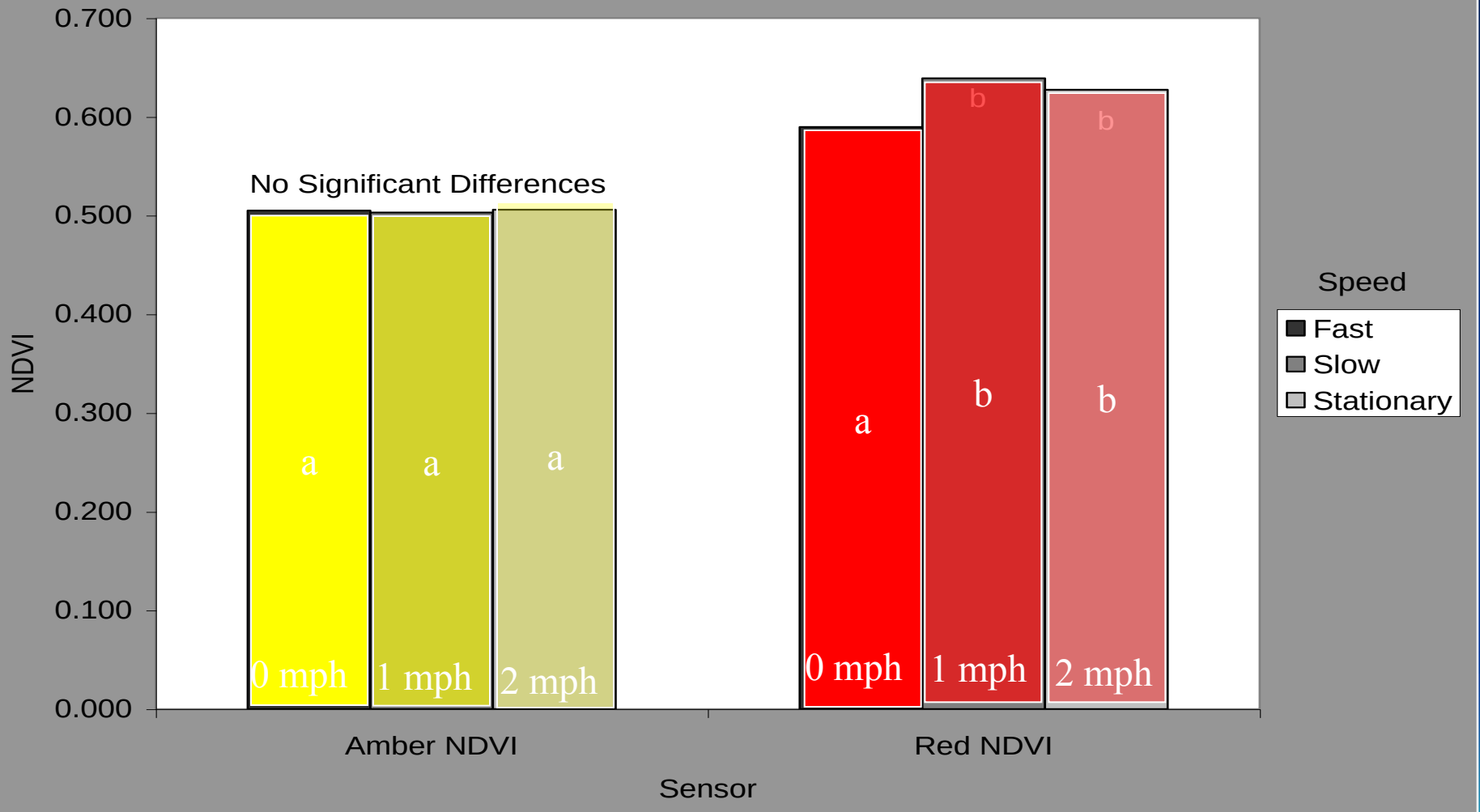
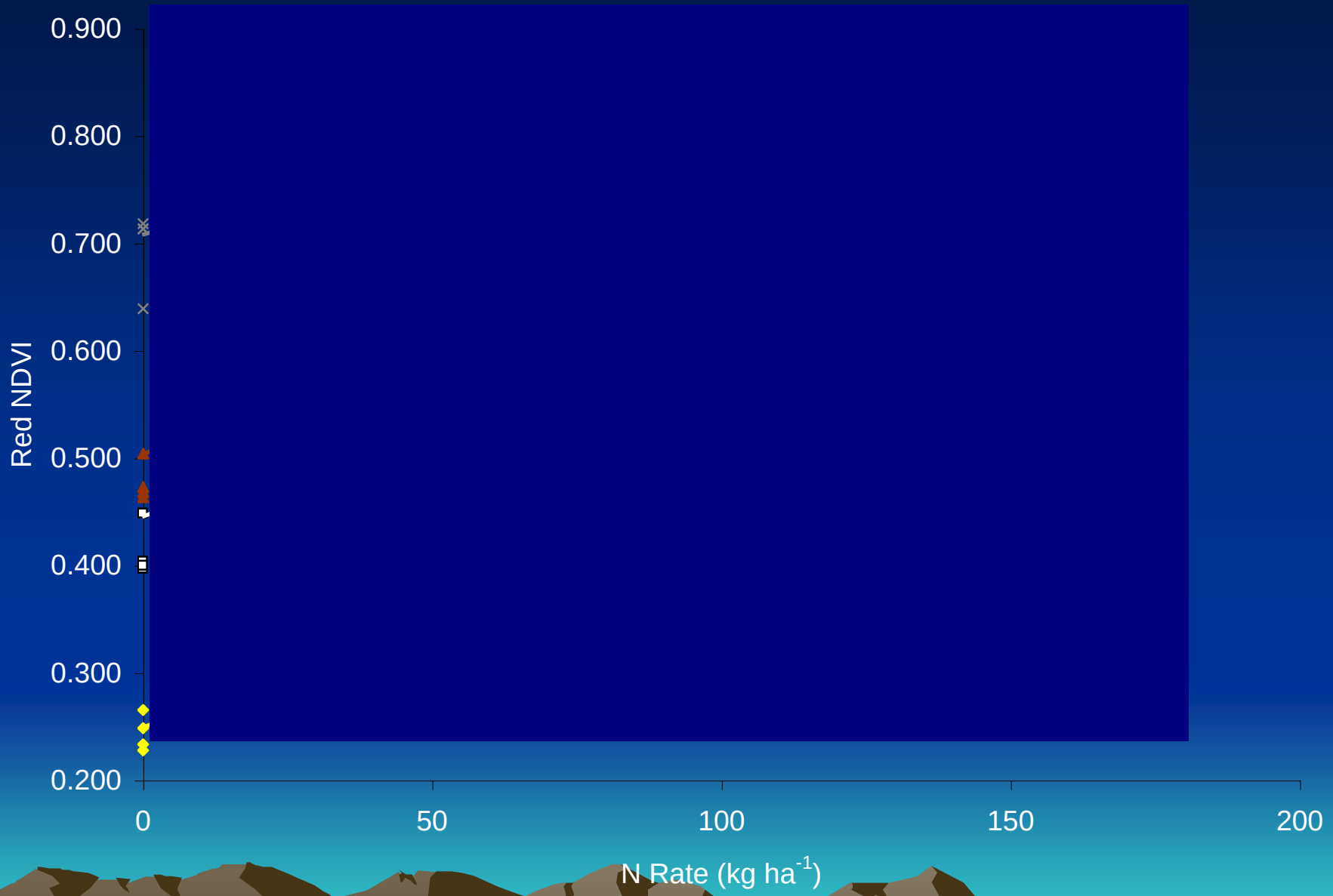
Sensor Movement Speed:



Red NDVI correlation with 4 fluid Nitrogen application rates (site year 1)



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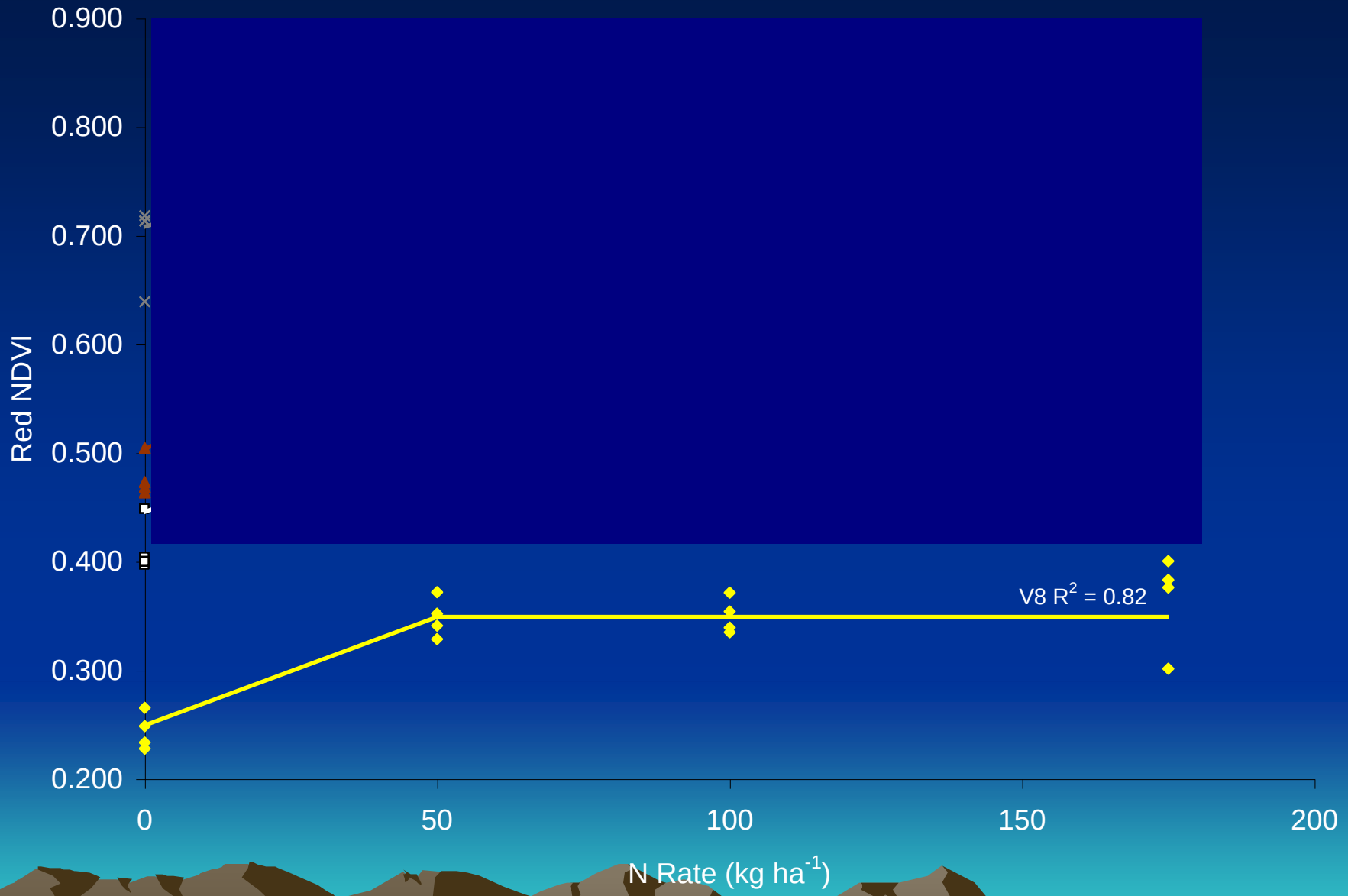
Red NDVI correlation with 4 fluid Nitrogen application rates (site year 1)



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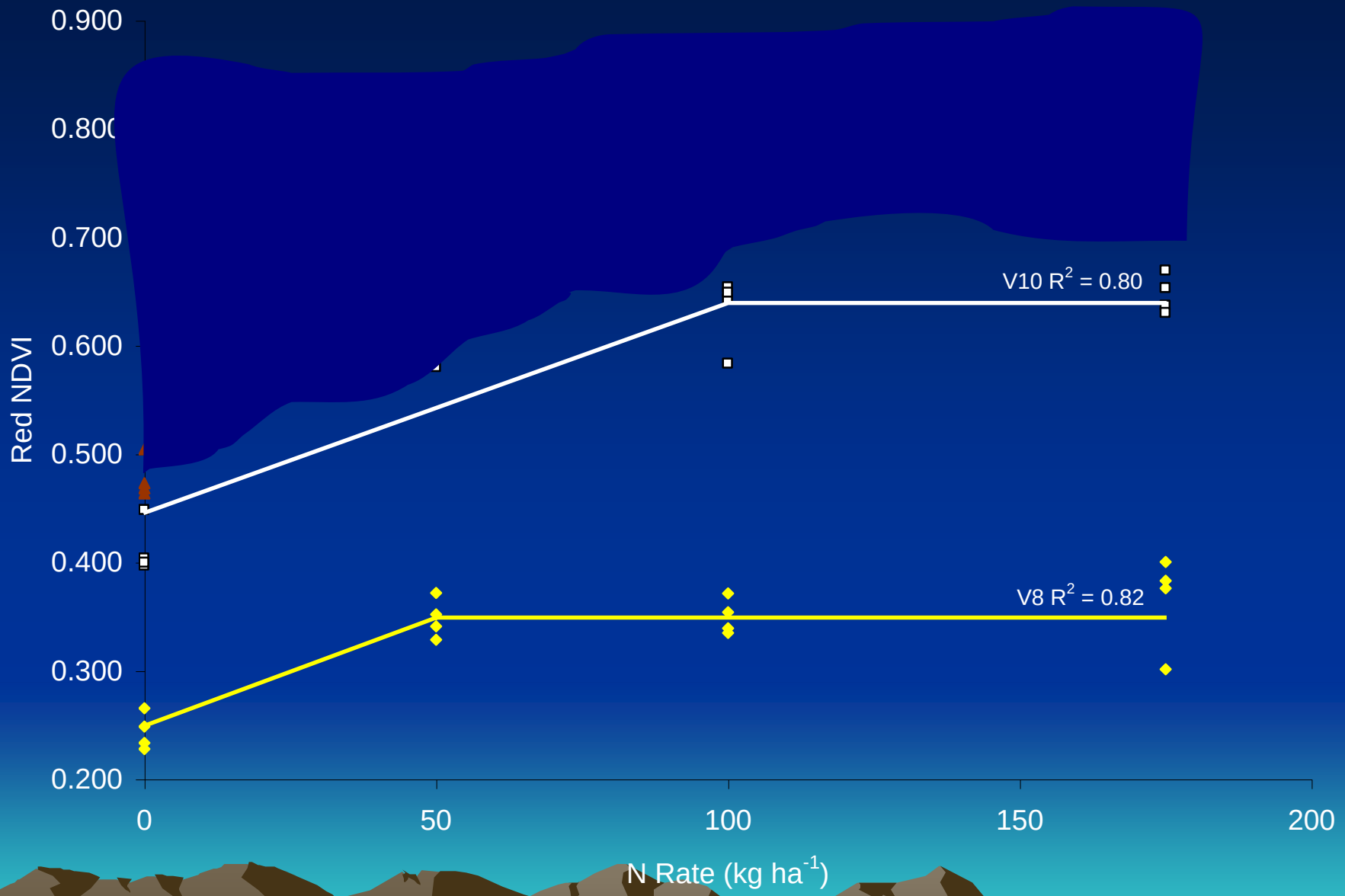

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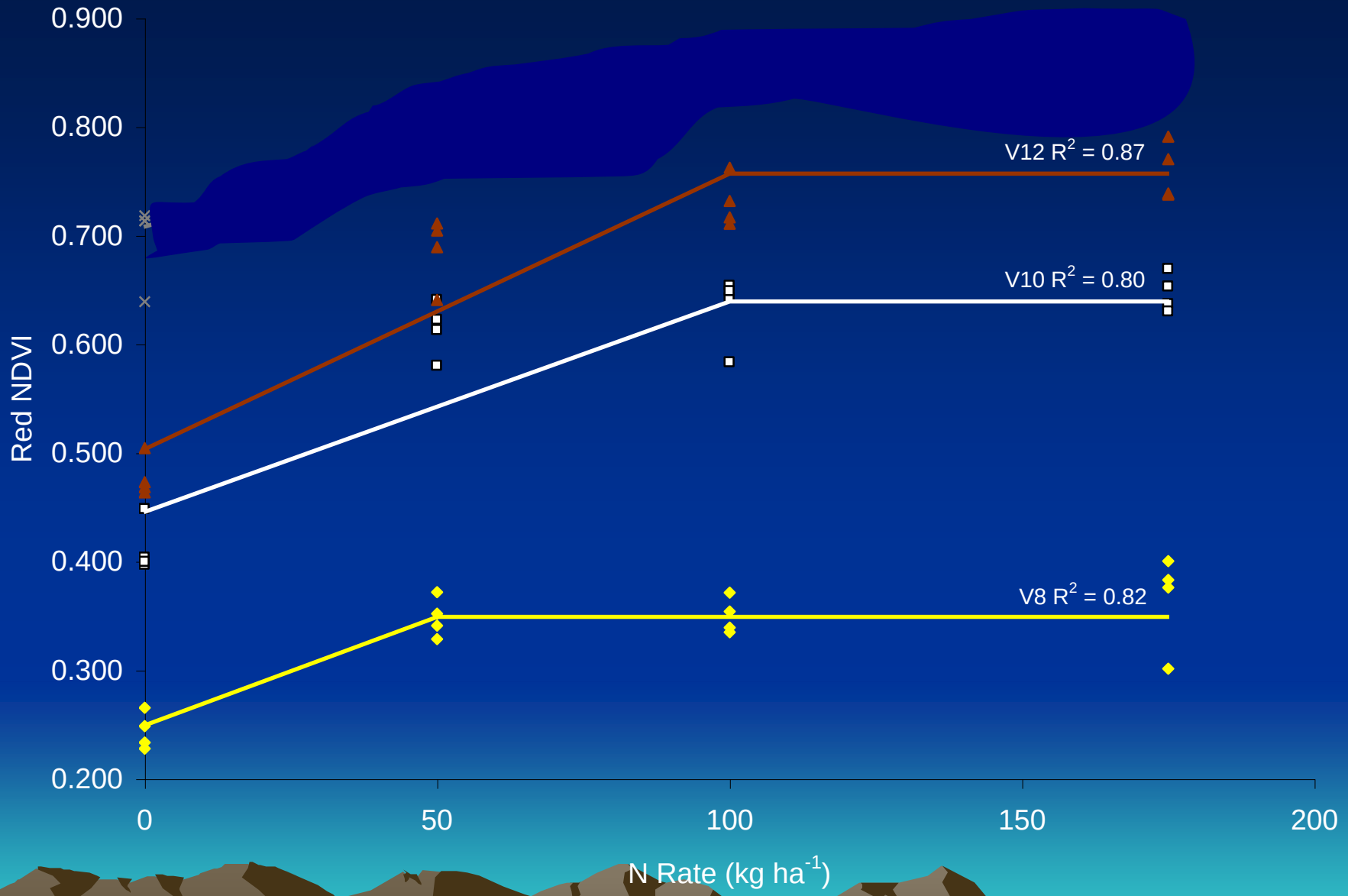

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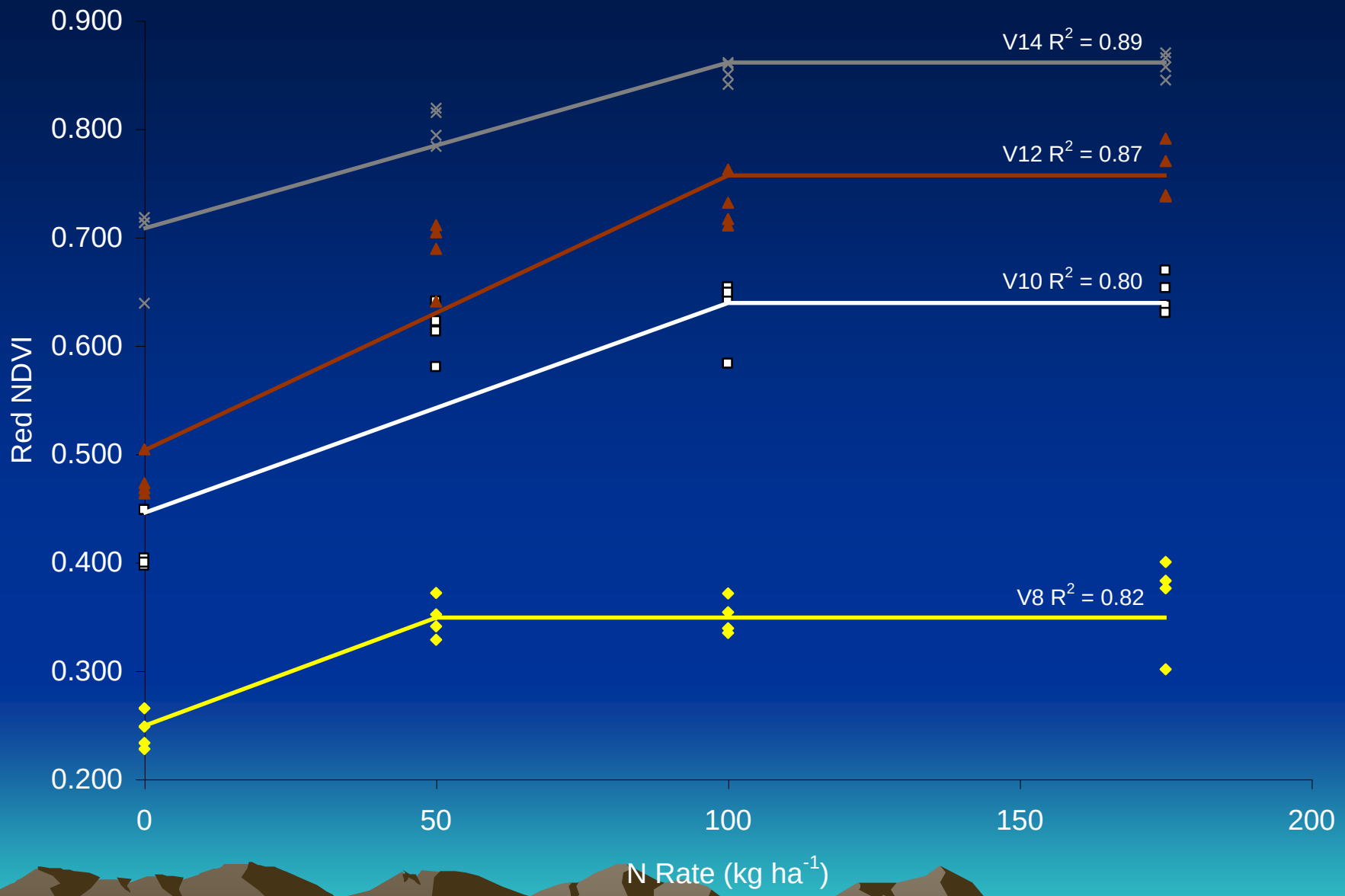
Red NDVI correlation with 4 fluid Nitrogen application rates (site year 1)



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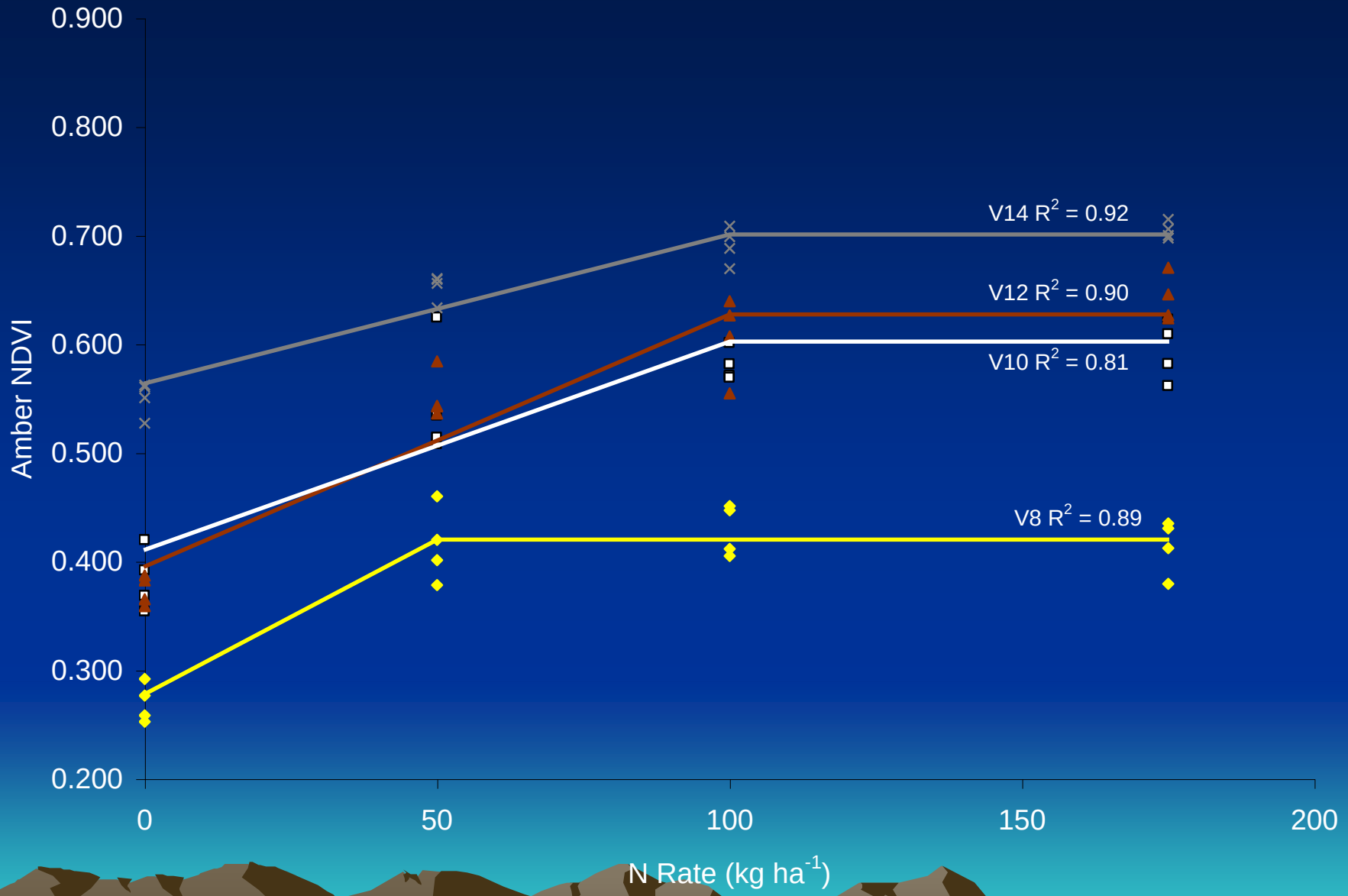
Amber NDVI correlation with 4 fluid Nitrogen application rates (site year 1)



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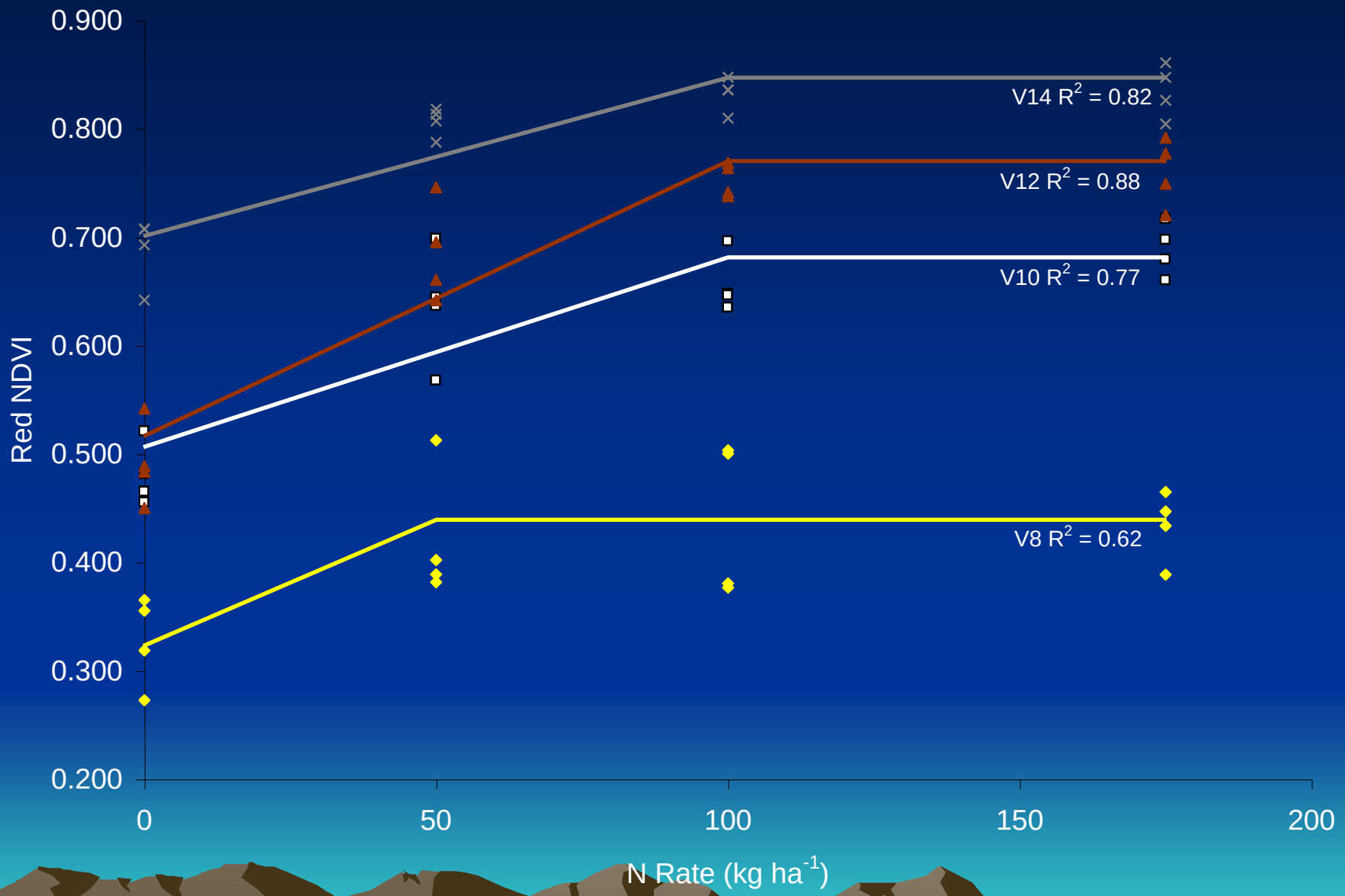
Red NDVI correlation with 4 fluid Nitrogen application rates (site year 2)



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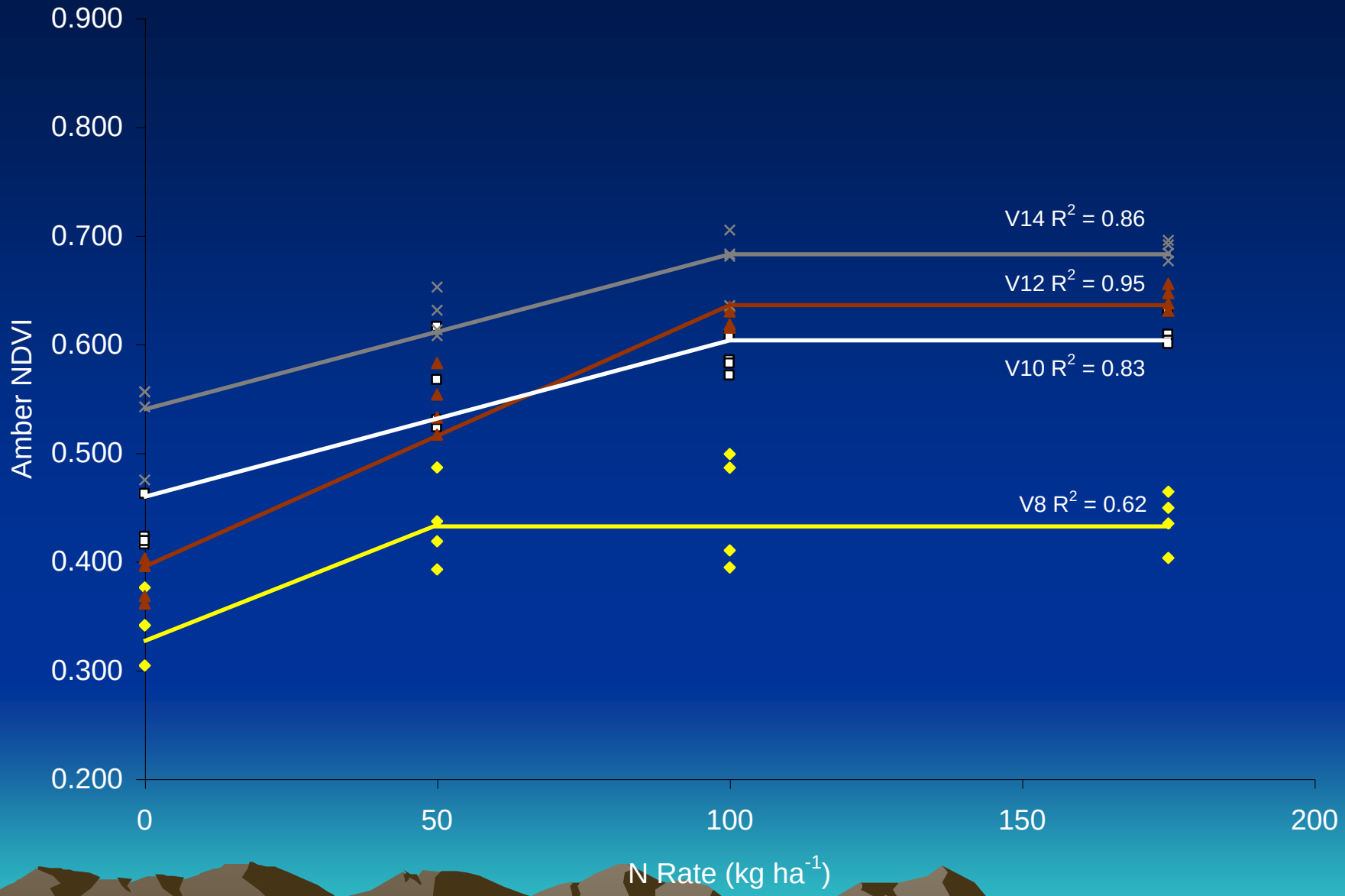
Amber NDVI correlation with 4 fluid Nitrogen application rates (site year 2)



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Findings:

- The highest correlations (NDVI vs N application rates) were observed at growth stages V12 and V14 for site year 1 and V12 for site year 2.

- Growth stages V12-V14 are most likely be the best opportunity to acquire in-season NDVI readings for the most accurate determination of crop vigor and in-season N management

- The amber (crop circle) and red (Green Seeker) NDVI correlations with N application were not significantly different.

Findings:

- Green seeker sensor appears to saturate sooner (high NDVI values) and may limit its application under thick crop canopy covers

- Overall both sensors performed equally well under field conditions

Study Justification:

Based on findings of our previous work in Green House (i.e. amber & red sensors determine N variability equally well in corn)

Next logical step for us was to develop an N recommendation algorithm that could optimize N application.

A field study was conducted to determine sensor performance for field use and with an NDVI based N algorithm.

Objectives:

To evaluate two NDVI sensors in field:

-NTech's GreenSeeker™ (red)
-Holland Scientific's Crop Circle™ (amber)

To determine:

-Sensor performance across N rate and growth stage.
-If ancillary variables used in conjunction with NDVI increases effectiveness

To Develop:

-An N recommendation algorithm.

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Methods:

Sensors:

-NTech's GreenSeeker™ red unit

-Holland Scientific's amber Crop Circle™

Sites:

-2 site years near Fort Collins, Colorado

NDVI Readings:

-V8, V10, V12 and V14 growth stages

N rates (lb ac^{-1}):

-0, 50, 100 and 175

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Supplemental Sampling:

Ancillary data was collected at each sensor reading

- - Soil NO_3 (0-8 in depth)
- - Plant flag leaf total N concentration (10 locations)
- - SPAD Chlorophyll (10 locations in each plots, 4 reps)
- - Plant height (5 locations)
- - Corn grain yield (plot combine with yield monitor)

Results:

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Amber and Red NDVI correlation with nitrogen application rates across site years.

Multiple Regressions:

No ancillary variables substantially increased the R^2 of NDVI with grain yield.

Ancillary samples can be destructive to the plant, difficult to obtain, and/or time consuming.

-Soil Samples
-Plant Samples
-Plant Height
-SPAD Chlorophyll

Algorithm Development:

NDVI Response Index:

A response index (RI) is generally used in NDVI algorithms.

$$RI = NDVI_{Reference} / NDVI_{Target}$$

This is an indication of N deficiency in the Target area compared to the Reference area.

This index can be used to determine the amount of N needed to make up this deficiency based on NDVI readings.

Algorithm Development:

Algorithms were developed using the RI concept:

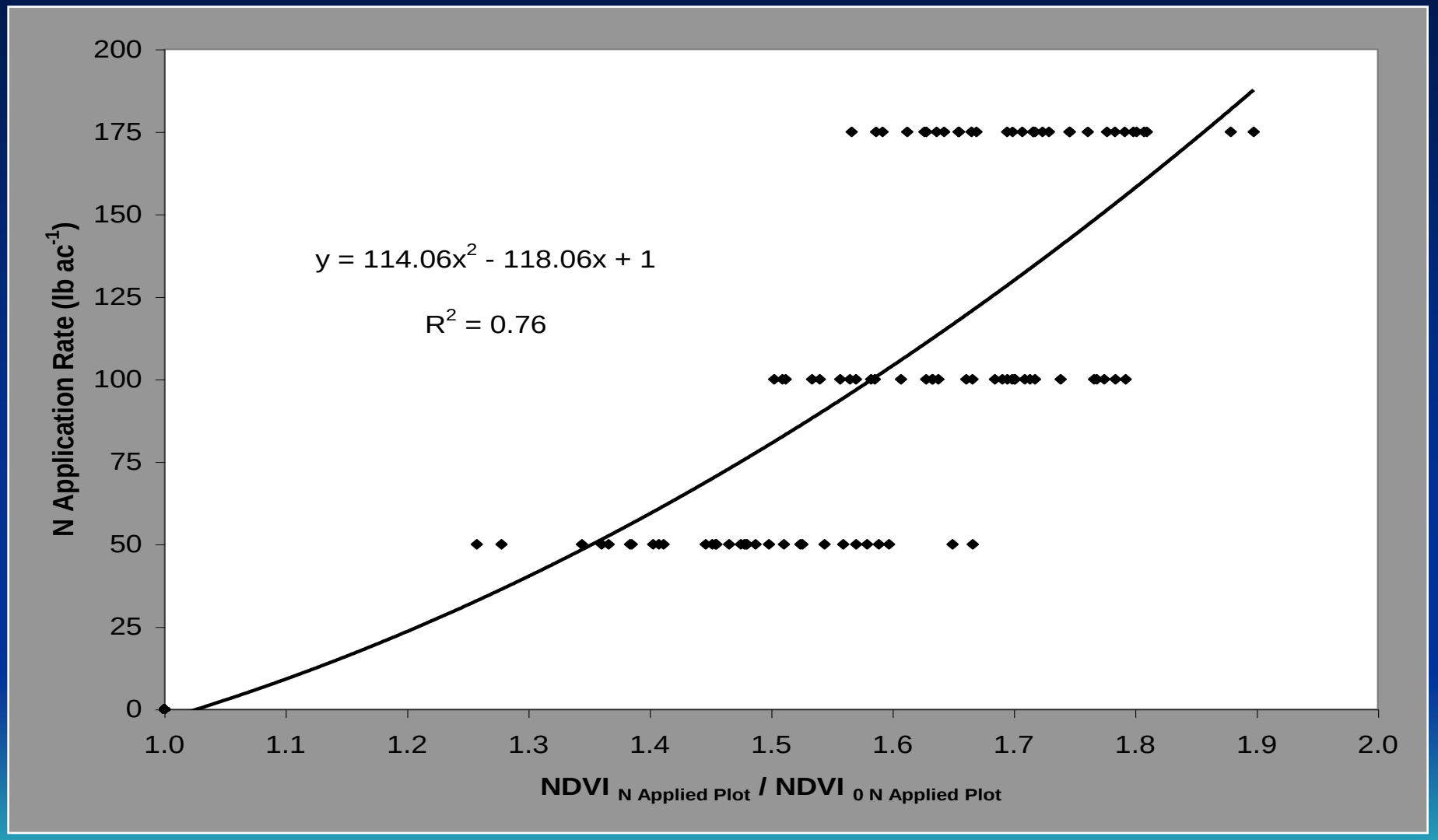
$$RI_{Algorithm} = NDVI_{N\ Applied\ Plot} / NDVI_{0\ N\ Applied\ Plot}$$

Where: N Applied Plot = 175, 100 and 50 lb ac^{-1}
0 N Applied Plot = 0 lb ac^{-1}

This RI was then plotted against the N application rate that created each particular RI.

The resulting equation was forced through 1 as this RI means no additional N would be required.

Amber N Algorithm:



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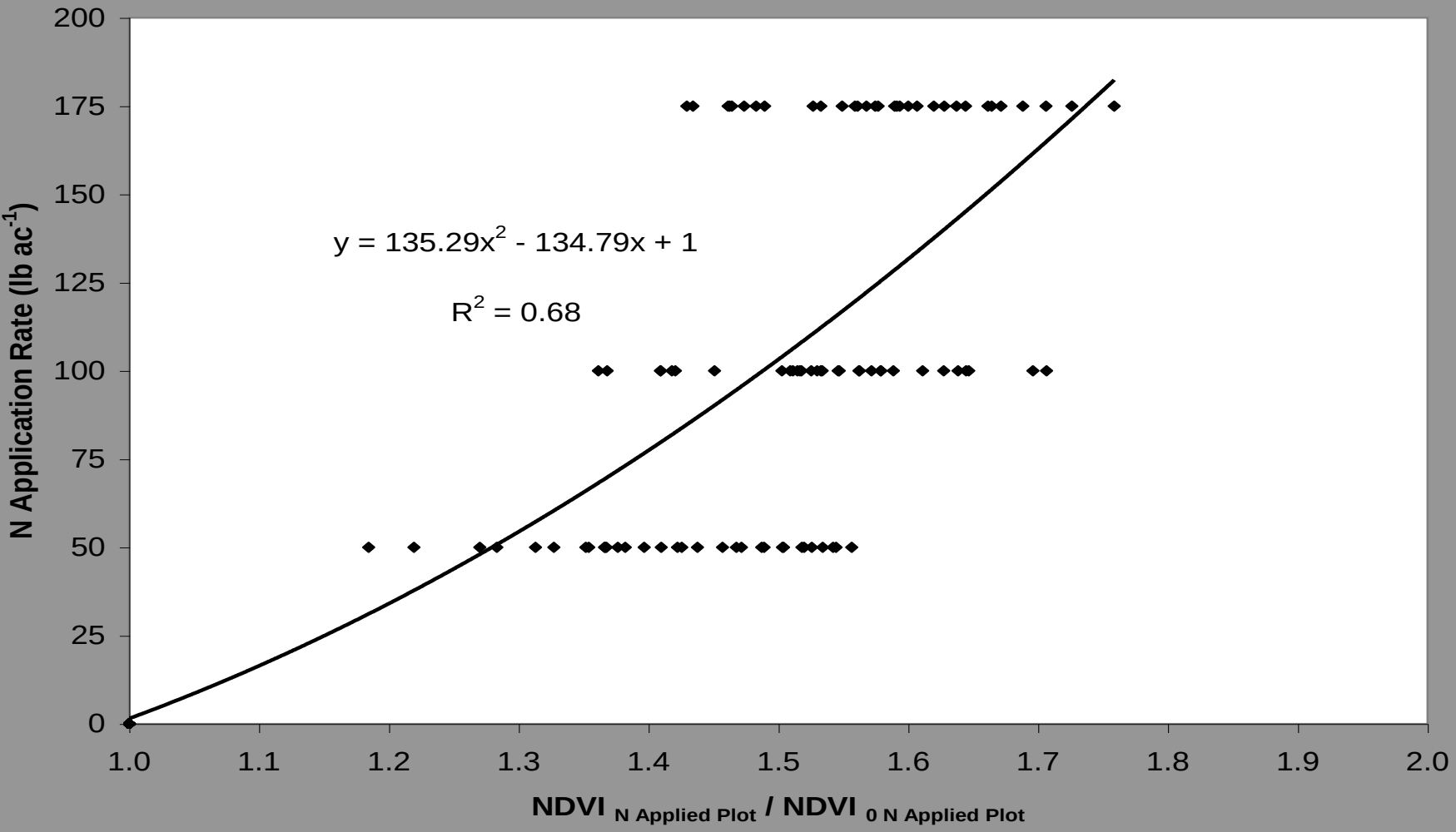
Red N Algorithm:



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Amber & Red Algorithms:

Amber Sensor N Algorithm:

$$N\ Rate\ (lb\ ac^{-1}) = (114.1 \times (NDVI_{Reference} / NDVI_{Target})^2) - (118.1 \times (NDVI_{Reference} / NDVI_{Target})) + 1$$

Red Sensor N Algorithm:

$$N\ Rate\ (lb\ ac^{-1}) = (135.3 \times (NDVI_{Reference} / NDVI_{Target})^2) - (134.8 \times (NDVI_{Reference} / NDVI_{Target})) + 1$$

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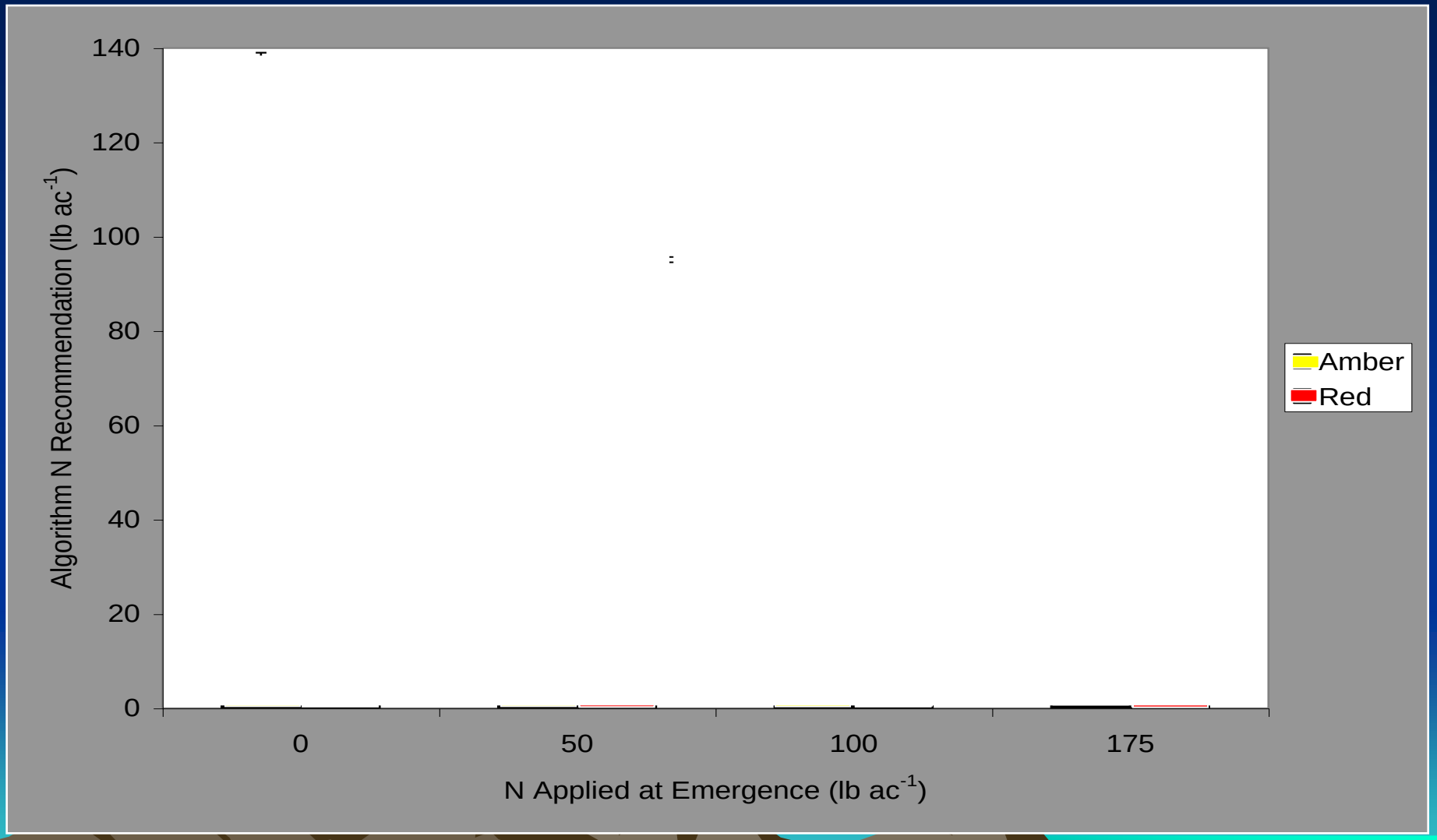
Site Year 1 N Recommendations:



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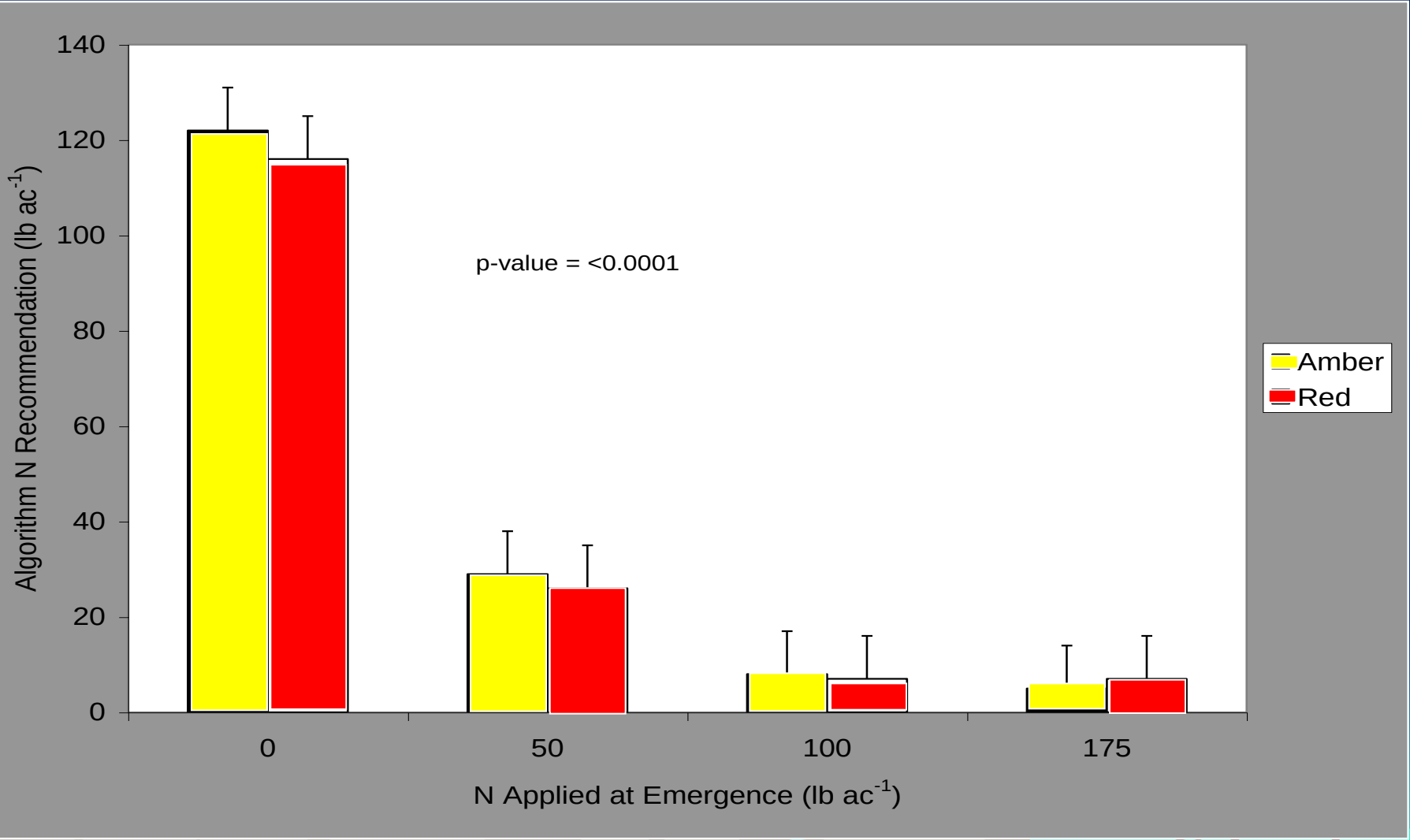
Site Year 2 N Recommendations:



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Site Year 1 N Algorithm Bias:

	-----N applied at corn emergence (lb ac $^{-1}$)-----			
	0	**50**	**100**	**175**
Amber Algorithm				
N Recommendation	130	28	13	6
95% Confidence Interval	134 / 125	32 / 24	16 / 10	8 / 4
% of Bootstrapped Samples Within CI	96	89	95	96
Red Algorithm				
Algorithm N Recommendation	124	28	14	8
95% Confidence Interval	129 / 120	32 / 23	17 / 11	10 / 6
% of Bootstrapped Samples Within CI	96	97	96	92

† 100 Bootstrapped Random Samples per N Application Rate

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Site Year 2 N Algorithm Bias:

	-----N applied at corn emergence (lb ac $^{-1}$)-----			
	0	**50**	**100**	**175**
Amber Algorithm				
N Recommendation	122	29	8	5
95% Confidence Interval	126 / 117	33 / 25	11 / 6	6 / 4
% of Bootstrapped Samples Within CI	90	97	94	95
Red Algorithm				
Algorithm N Recommendation	116	26	7	7
95% Confidence Interval	122 / 111	29 / 22	8 / 6	9 / 5
% of Bootstrapped Samples Within CI	94	95	93	91

† 100 Bootstrapped Random Samples per N Application Rate

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Summary:

- ✓ Sensors distinguished N variability equally.
- ✓ Sensors related highly with N rate ($R^2 > 0.89$).
- ✓ Optimum NDVI readings at the V12 to V14 growth stages.
- ✓ Amber and red algorithms did not recommend significantly different amounts of N.
- ✓ Algorithms proved to be unbiased in their N recommendations.

Acknowledgment

We would like to thank the Fluid Fertilizer Foundation for their continued support of this study.

Thank You

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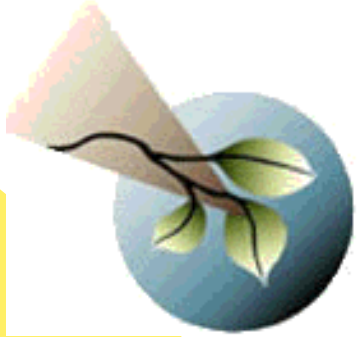
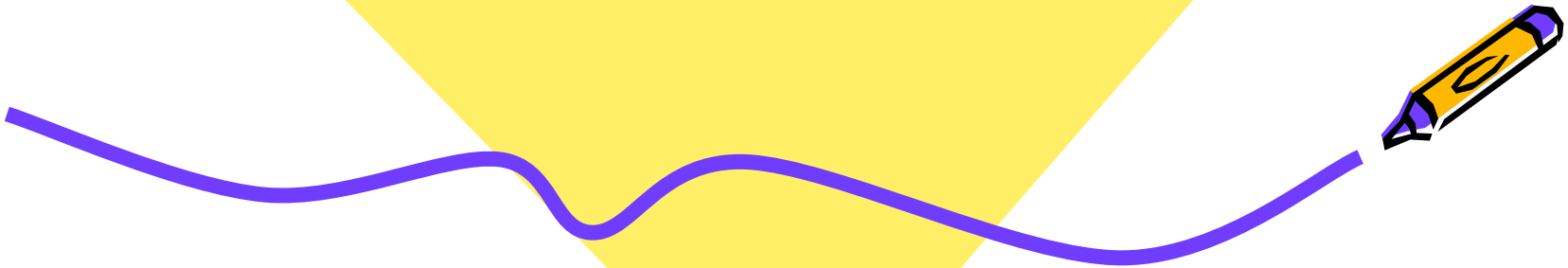


10th International Conference on Precision Agriculture



10th ICPA

- The 10th ICPA conference will be in Denver, Colorado.
- The dates of the ICPA conference are July 18th - July 21st, 2010.

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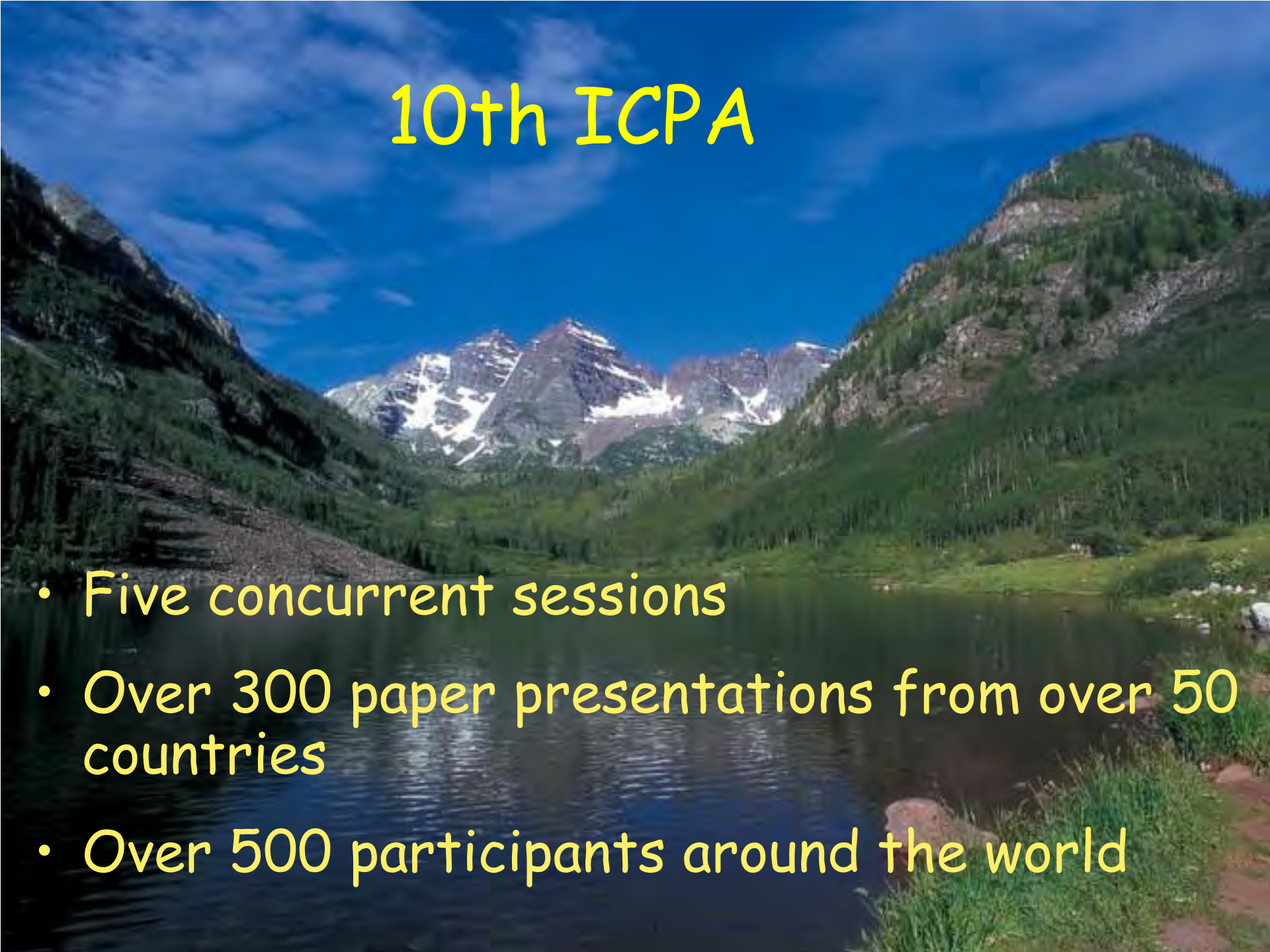
Knowledge to Go Places

10th ICPA

- Location: Denver Tech Center, Denver
- Conference Hotel: Hyatt Regency

10th ICPA



- Five concurrent sessions
- Over 300 paper presentations from over 50 countries
- Over 500 participants around the world

10th ICPA

- Over Forty Exhibitors / industry / sponsors
- Dedicated session for practitioners (A to Z)
- Excursion/tours for companions/family members

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Conference brochure

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JULY 18–21, 2010 · Hyatt Regency Tech Center Denver Colorado USA

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10th International Conference on Precision Agriculture (ICPA) • July 18–21, 2010 • Hyatt Regency Tech Center, Denver, Colorado, USA.

To register or to submit abstracts, visit www.icpaonline.org

Welcome Message

Dear International Precision Agriculture Community:

It is a great pleasure for me to announce the **10th International Conference on Precision Agriculture (ICPA)** to be held at the Hyatt Regency Tech Center in Denver, Colorado, USA from July 18th to July 21st, 2010.

It is an honor and a matter of pride for Denver, the mile high city that is nestled in the heart of the USA, surrounded by the Rocky Mountain National Park on the west to the Great Plains on the east, to once again host the ICPA conference in its technological hub "The Denver Tech Center."

Precision agriculture is growing and so is the precision agricultural community across the world. The 10th International Conference on Precision Agriculture is envisaged to be the largest ever, with more than 500 attendees from all over the U.S and over 40 countries (see program details, coming soon on www.icpaonline.org).

As with previous ICPA conferences, the **10th International Conference on Precision Agriculture** will provide a forum for presentations on the current state of precision agriculture research and applications. The conference will facilitate interaction among research scientists, producers, technology company representatives, equipment manufacturers, input dealers, agronomic consultants, software developers, educators, government personnel and policymakers.

The 10th ICPA conference will honor the achievements of a young and senior scientist with the "P.C. Robert Young and Senior Scientist Award." In addition, we plan to offer several awards in the graduate student category to recognize their work and encourage participation in the ICPA conference.

We are looking forward to seeing you at the **10th International Conference on Precision Agriculture** in Denver, Colorado, USA.

Sincerely yours,

Raj Khosla
Chair of the **10th International Conference on Precision Agriculture**
Colorado State University Monfort Professor

Call for Abstracts

Abstracts for the 10th International Conference on Precision Agriculture may be submitted online at www.icpaonline.org on or before the abstract submission deadline, October 30, 2009. Abstracts will be reviewed for suitability based on scientific content and clarity. Abstracts meeting these criteria will be accepted for presentation as either oral or poster presentations at the Conference. Abstracts are limited to no more than 300 words. Authors of accepted abstracts will be entitled to present their research at the Conference after payment of registration fees. They will also be entitled to submit full papers (more details later) for the Conference Proceedings in February, 2010.

Main Topics

- Sensor Application in Managing In-season Crop Variability
- Spatial Variability in Crop, Soil and Natural Resources
- Precision Nutrient Management
- Precision Conservation
- Precision Horticulture
- Remote Sensing Applications in Precision Agriculture
- Engineering Technologies and Advances
- Profitability, Sustainability and Adoption
- Emerging Issues in Precision Agriculture (Energy, Biofuels, Climate Change)
- Information Management and Traceability
- Education and Training in Precision Agriculture
- Guidance, Auto Steer, and GPS Systems
- Modeling and Geo-statistics
- Global Proliferation of Precision Agriculture and its Applications

Overview of the Program

Plenary sessions will set the stage for the conference with keynote speakers who will challenge us to use innovative techniques and technologies to expand our knowledge in production systems.

Concurrent sessions will feature researchers from across the globe. Each will present on their current studies into various aspects of precision agriculture. Six concurrent sessions will provide ample opportunity to hear presentations of interest to each attendee. One of the concurrent sessions "Precision A to Z Track for Practitioners," will be focused on practical advice for producers and professionals on key topics of precision agriculture.

Poster session will offer another forum for "one to one" interaction among presenters, scientists, students, and others in attendance to discuss their work in precision agriculture.

Exhibit hall will feature companies with the hardware and services that make technology in the field feasible. Companies with products specifically designed for researchers, practitioners and producers will be featured.

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Conference Coordination
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Conference website: www.icpaonline.org

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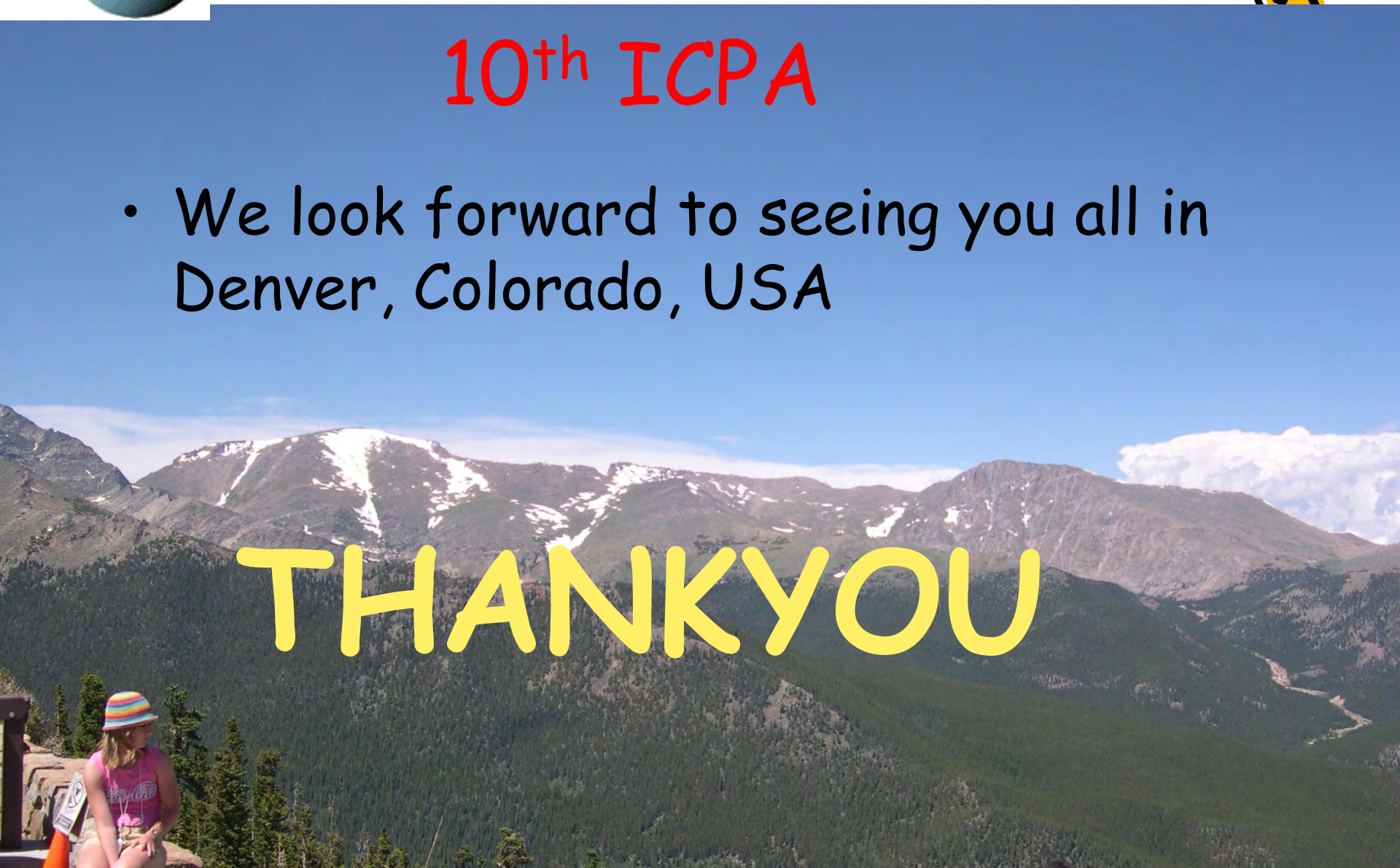
July 18-21st, 2010, Denver, Colorado

10th ICPA

- We look forward to seeing you all in Denver, Colorado, USA



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