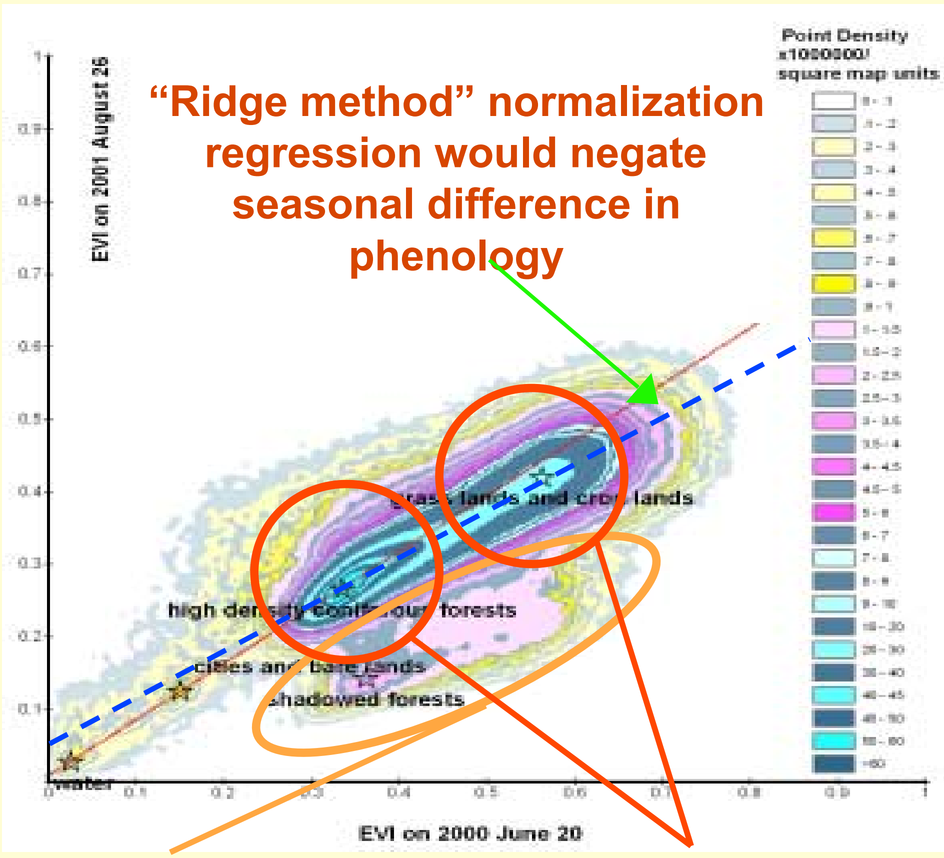
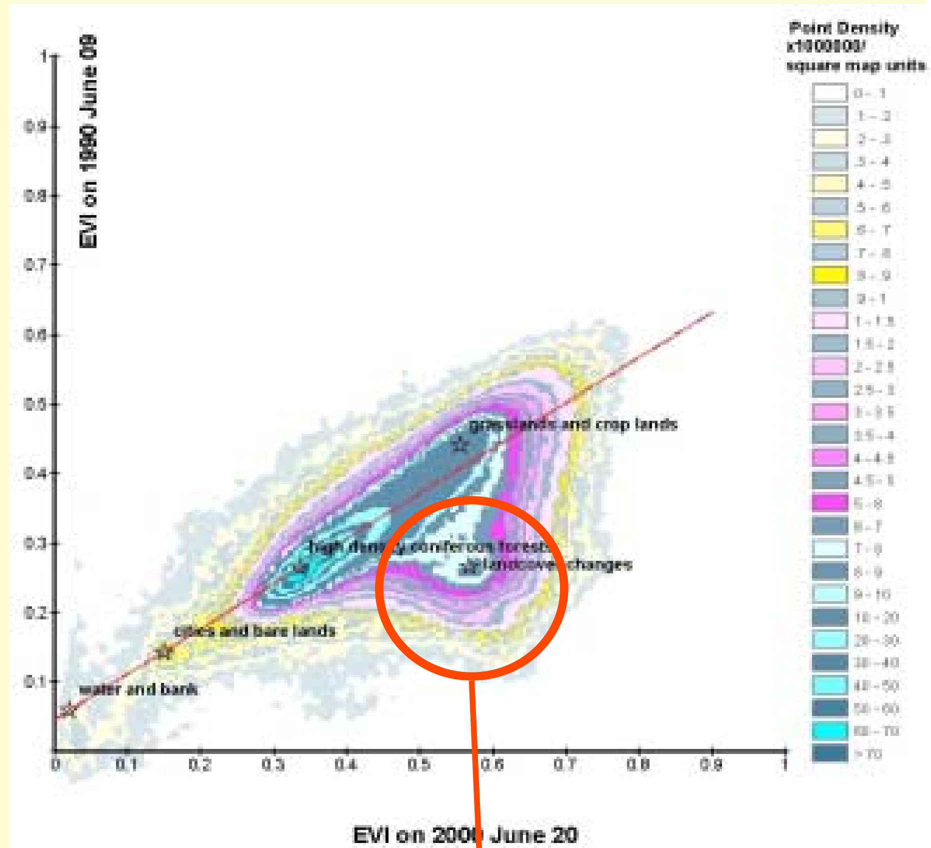
EVI-based normalization regressions

2001 image vs. 2000 image (both L7 ETM+)



1990 image (L4 TM) vs. 2000 image (L7 ETM+)

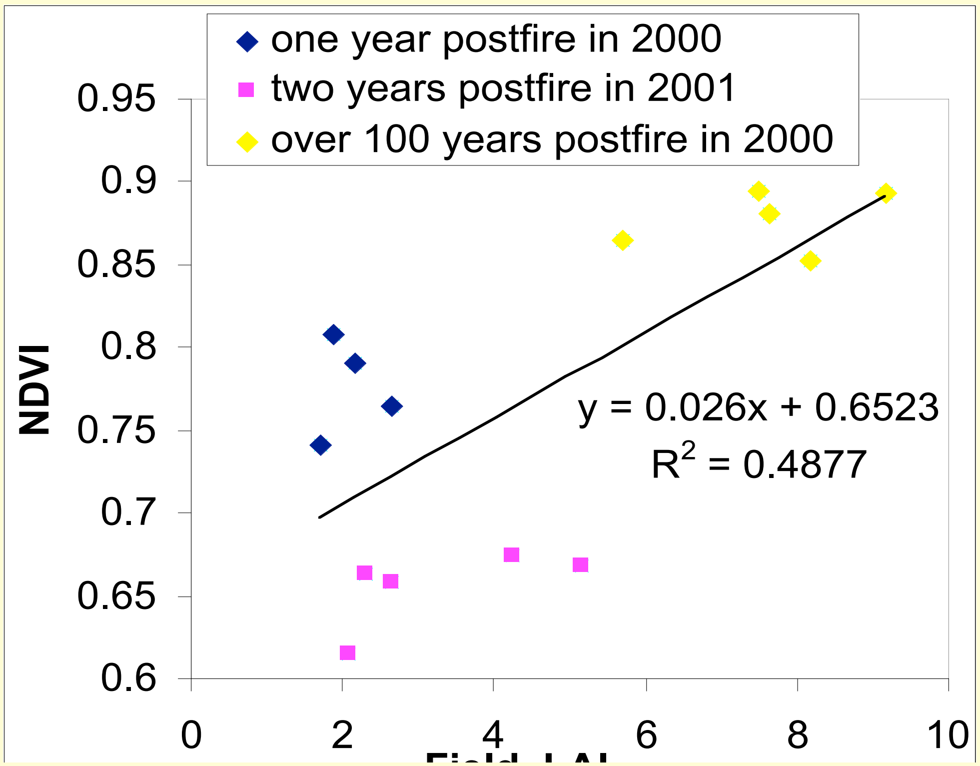


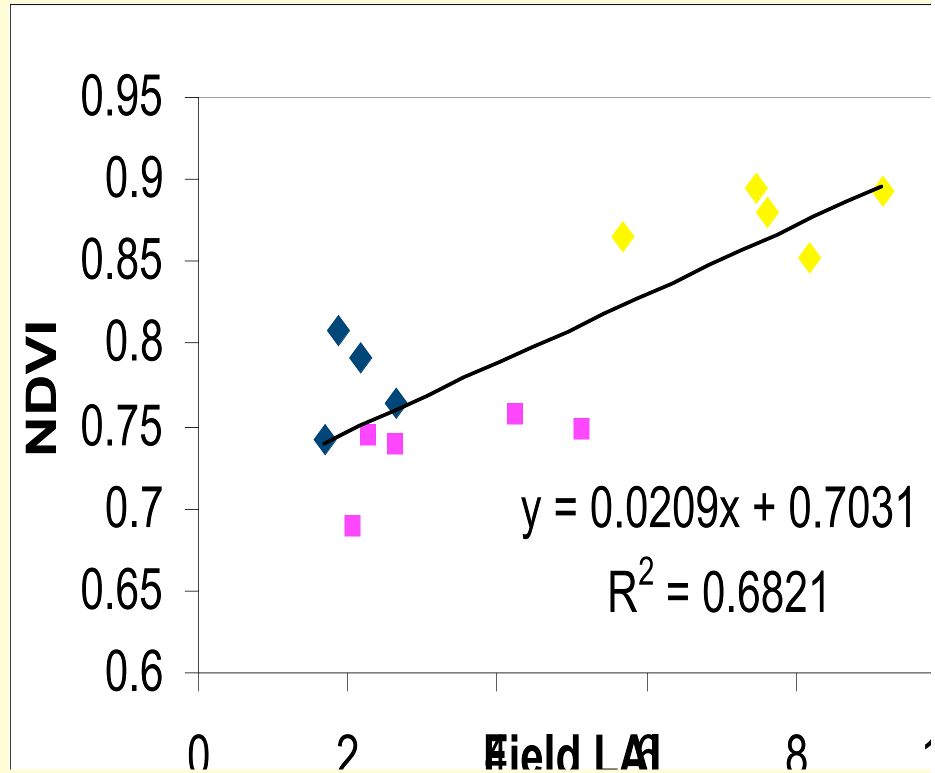
1. Shift in EVI due to cloud *shadowing* of vegetation (*not* due to cloud pixels themselves)

2. This is why EVI produces discernable separation of crop/grass (few shadows) from forest (high self-shading)

Landcover changes between 1990 and 2000 can now be specified as a shift from high density forest to crop/grass (not possible to do with NDVI)

Comparison of coniferous forest NDVI derived from ETM+ 2000 and 2001 with field collected LAI during those summers



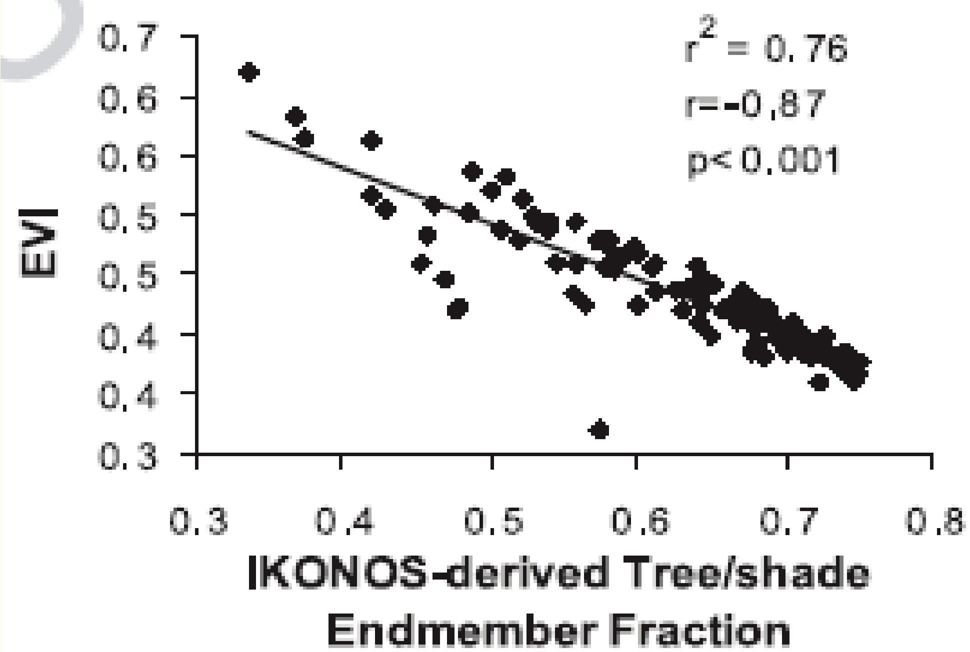


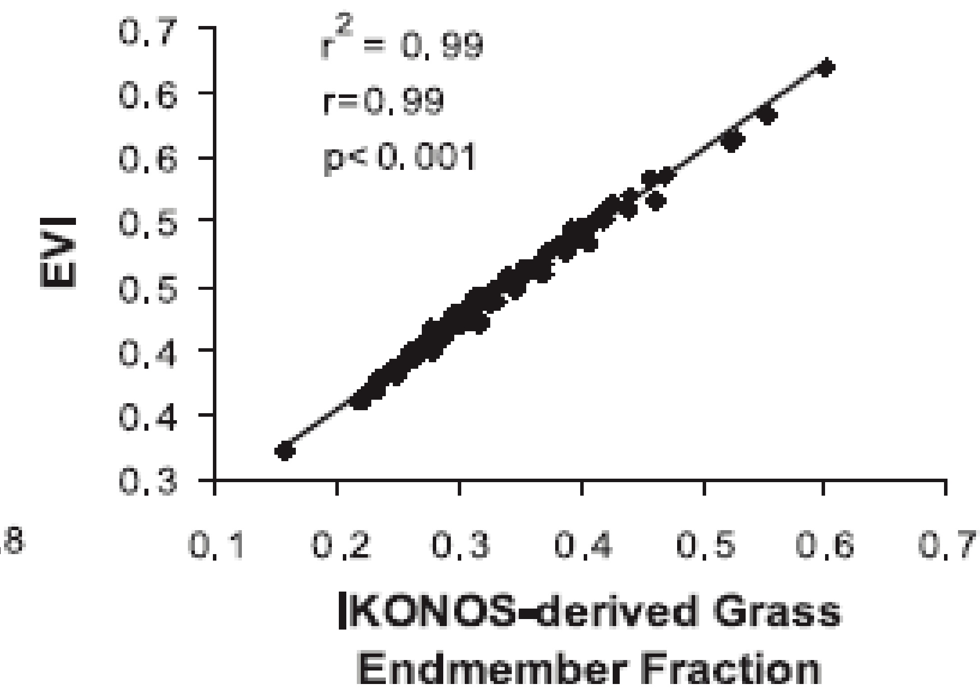
Before Normalization

After Normalization

Although EVI was more useful for separating vegetation cover types than NDVI, the LAI normalized correlation was poorer for EVI (r^2=0.49) than for NDVI (r^2=0.68). *Why is this the case?*

Likely Answer:
“Cancellation Effect” of EVI in mixed conifer-grass pixels

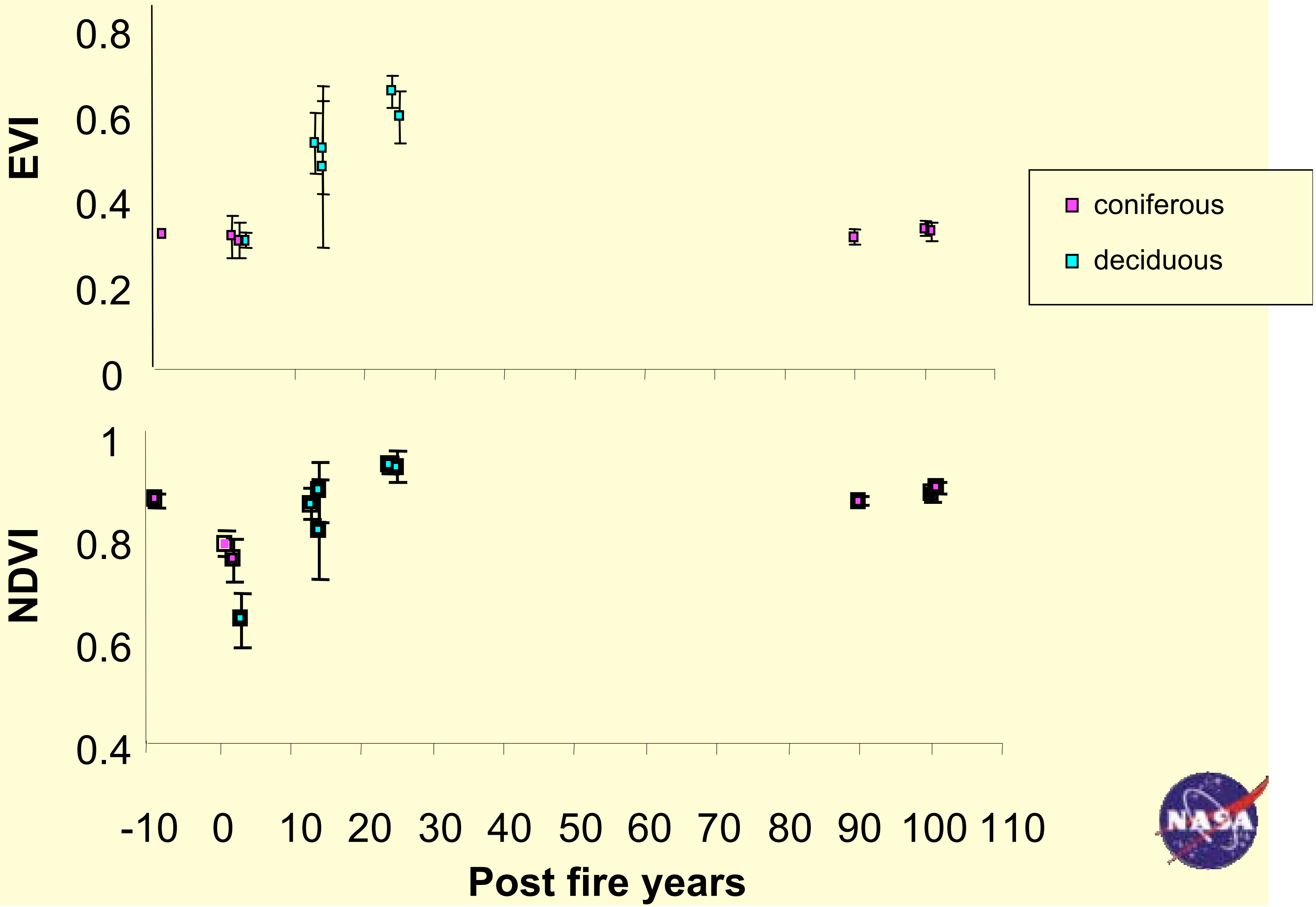




EVI decreases as shading within the canopy increases; allows for tree canopy and understory endmember fractions to be well discriminated, yet degrades the correlation between total pixel (tree+understory) LAI and EVI

(X. Chen, L. Vierling, E. Rowell, and T. DeFelice, 2004. *RSE*, in press.
Data from ponderosa pine forest in Black Hills, SD.)

Siberian Pre/post-fire VI dynamics
using normalized Landsat images from 1990, 2000 and 2001



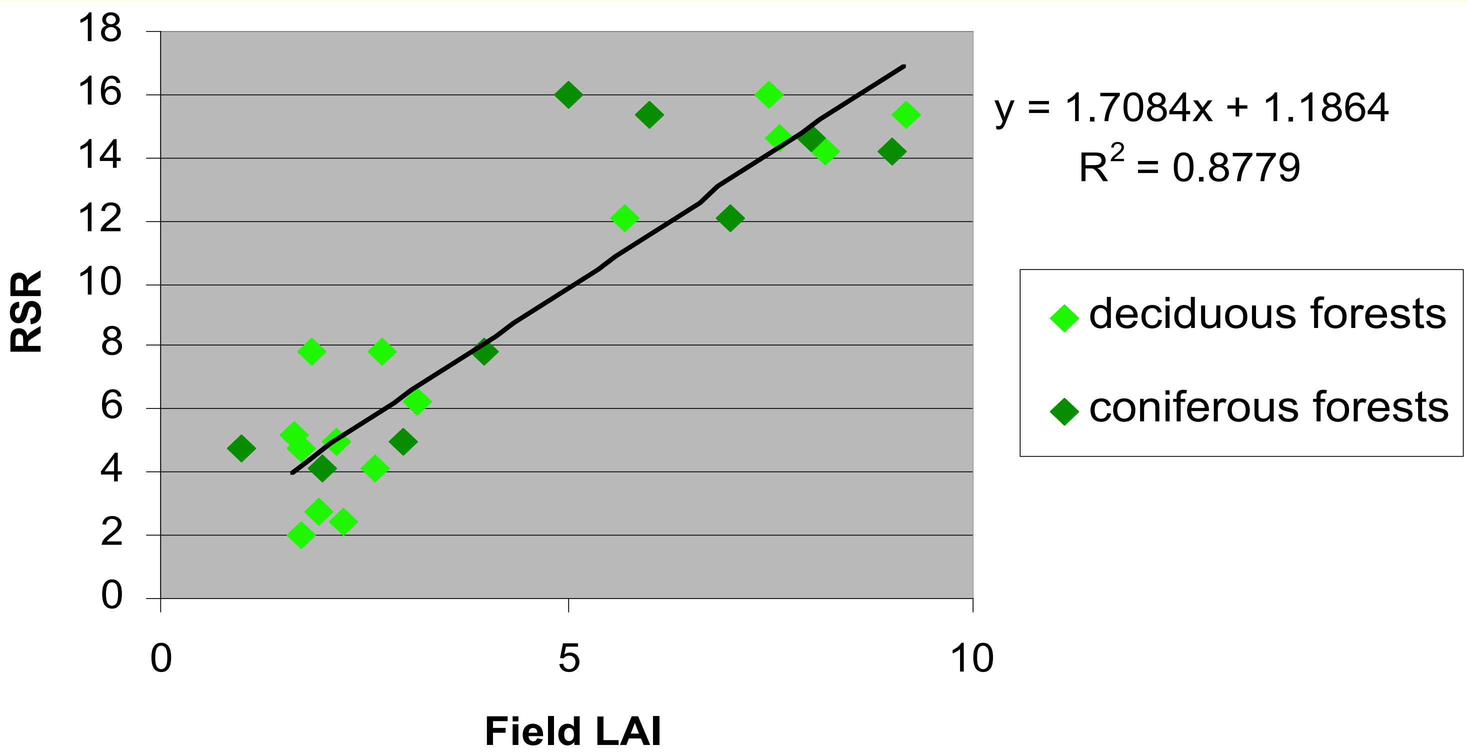
Remote Sensing Research Highlights

- Development of a "Temporally Invariant Cluster" normalization method to improve change detection using multi-temporal, cross-platform imagery
- Elucidation of NDVI and EVI (Enhanced Vegetation Index, Huete et al. 1997) applications for remote sensing of vegetation structure (including LAI and canopy shadowing effects) along burn chronosequences
- Investigation of the RSR (Reduced Simple Ratio; Brown et al. 2000) relationship with LAI in fire chronosequences
- Development of a relevant scaling approach for relating IKONOS and ETM+ imagery to MODIS imagery in post-fire landscapes, including investigations of spatio-temporal variation in MODIS data
- Improvement in how canopy-specific calibration coefficients (necessary to calculate LAI in needleleaf forests) must be used when investigating recently disturbed forests

Reduced Simple Ratio (Brown et al., 2000)

$$RSR = \frac{\rho(\lambda_{NIR})}{\rho(\lambda_{red})} * \left(1 - \frac{\rho(\lambda_{SWIR}) - \rho(\lambda_{SWIR\,\min})}{\rho(\lambda_{SWIR\,\max}) - \rho(\lambda_{SWIR\,\min})}\right)$$

The RSR correlates very well with field LAI data at both the Siberia and Black Hills sites.



e.g. for Siberia ETM+ data, correlation between VI's and field LAI:

VI	r^2
EVI	0.49
NDVI	0.68
RSR	0.88 (see graph)

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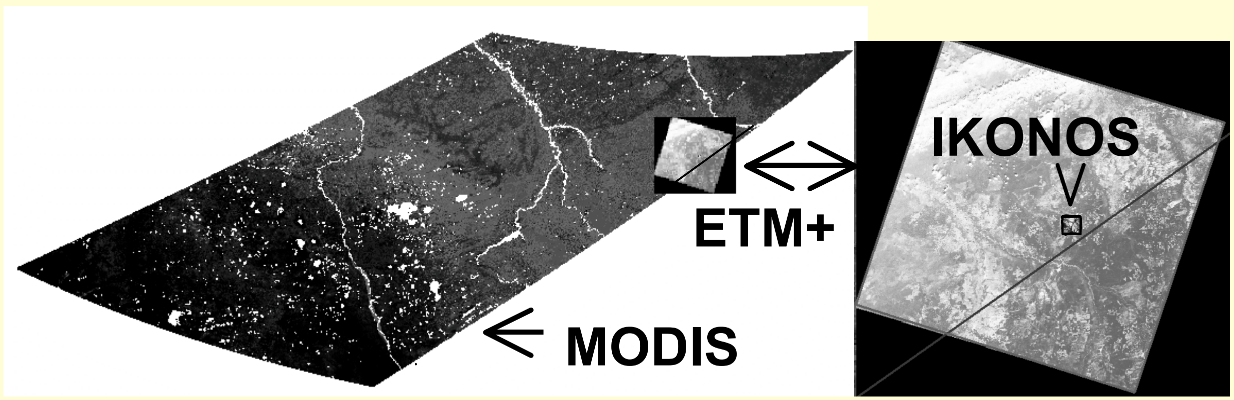
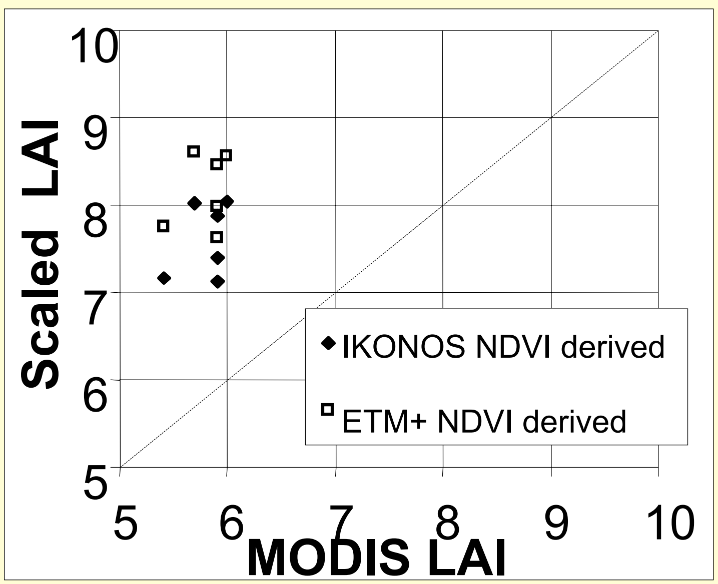
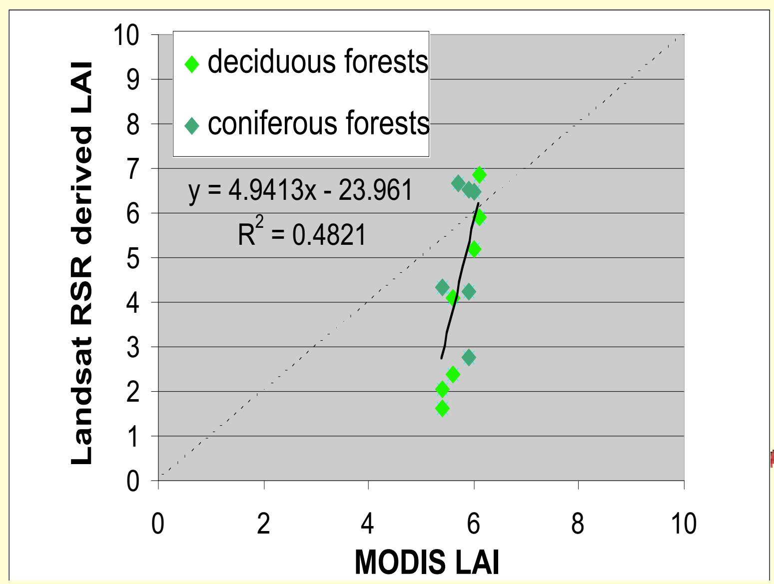
Landsat-to-MODIS Scaling

- Cross-platform NDVI correlation is poor (r^2=0.37); EVI correlation is better (r^2=0.85) *View angle (i.e. atmosphere) artifact?*



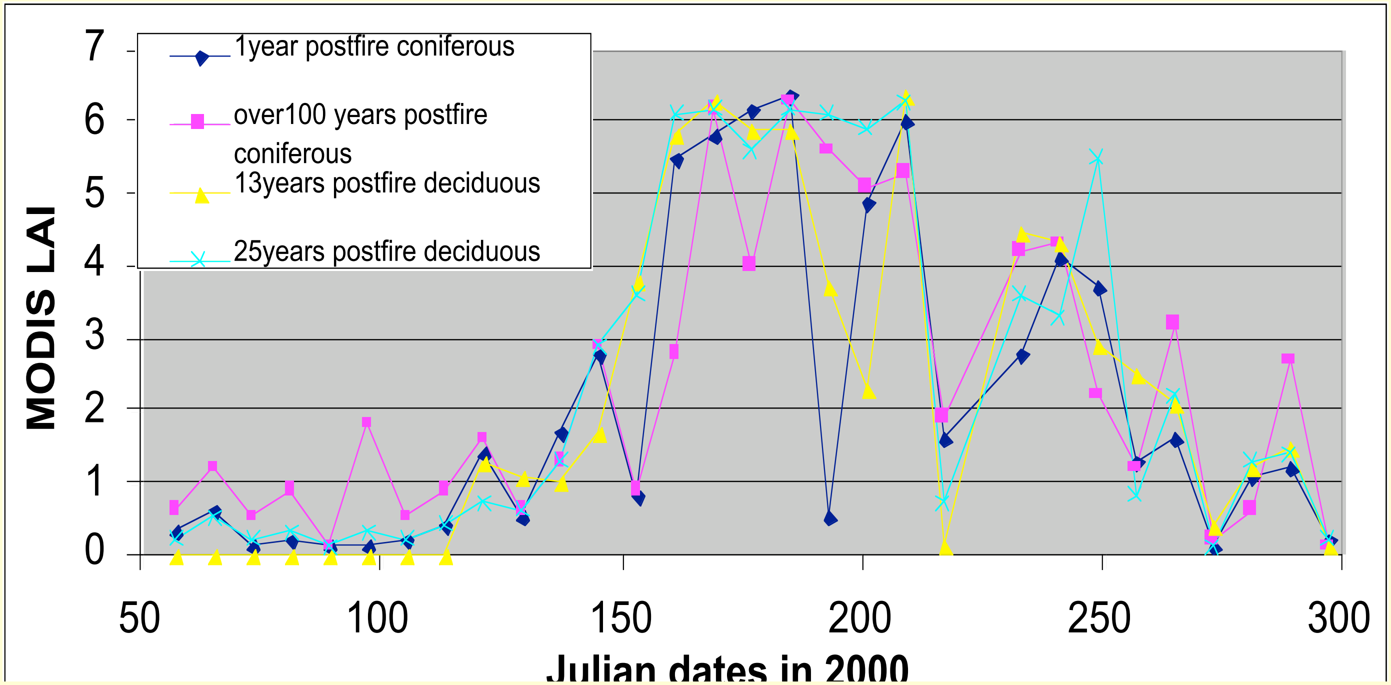
- MODIS LAI shows significant compression relative to IKONOS and ETM+ derived LAI





Additional MODIS Consideration

• Potential problems with LAI product at high-latitude sites in the wintertime



Possible cause: illumination and/or background snow effects

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Determination of Conifer LAI

effective LAI

$$LAI = L_e (1 - \alpha) \gamma_s / \Omega_E$$

woody-to-total area ratio

needle-to-shoot area ratio

Clumping index *(via TRAC)*

**What adjustments can be made to find the best match (or fit) between satellite retrieved VIs and field measured LAI?*

$\alpha = 0.27$

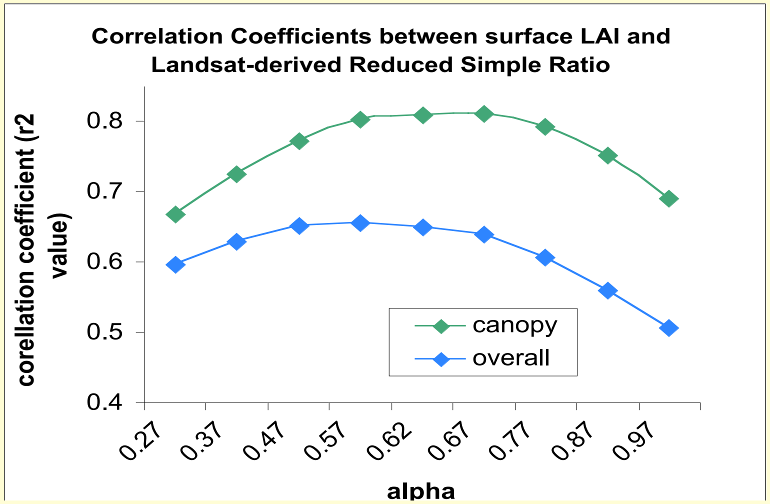
$\gamma = 1.25$

Law et al. (2001), Chen et al (1997)

"Tuning" _ in partially burned forests is very important for deriving accurate canopy LAI

Woody-to-total area ratio (_) is highly heterogeneous where a burn has removed varying amounts of green needles from individual trees

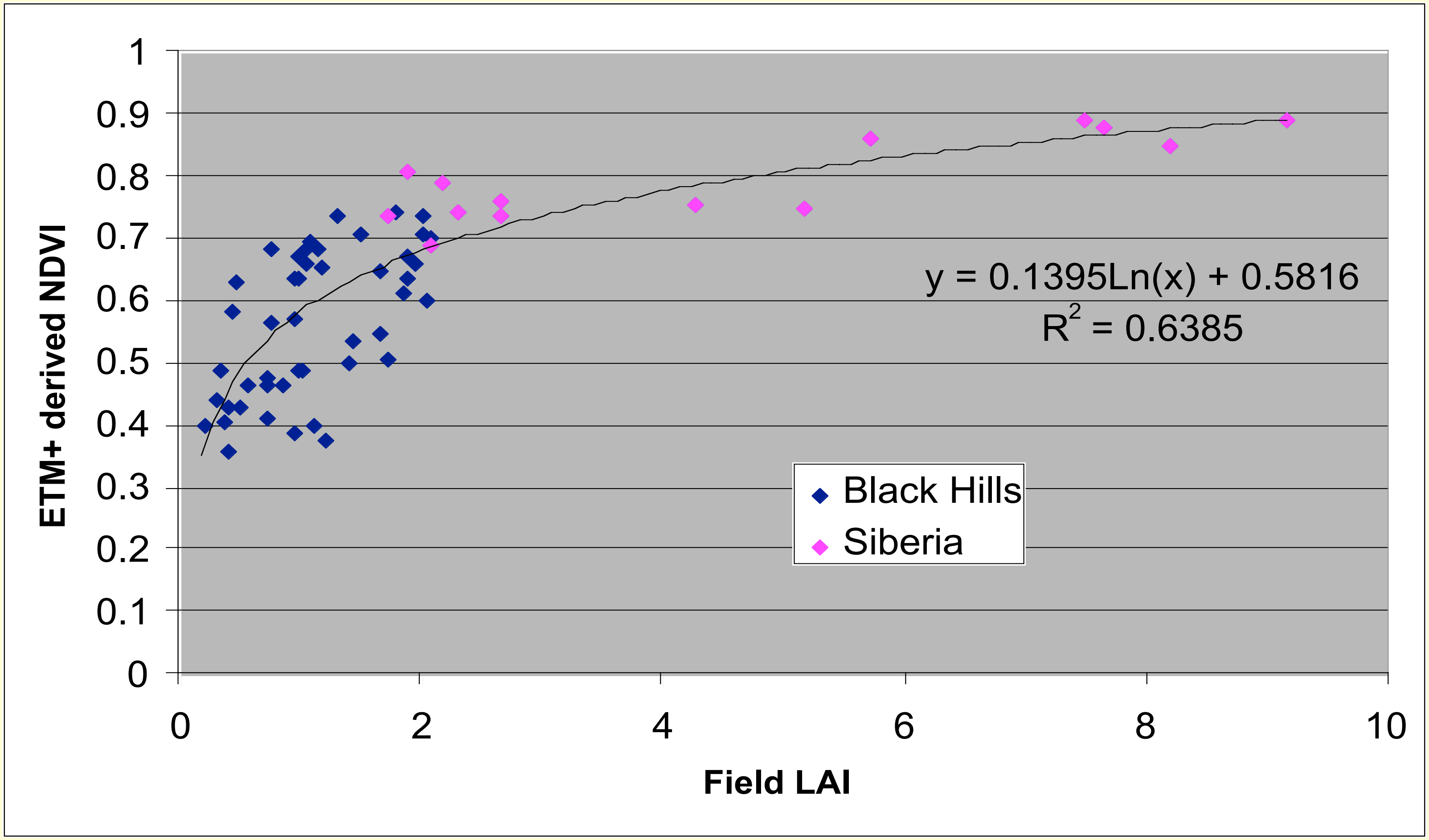
The goodness-of-fit between LAI and remotely sensed VIs reflect how critical _ value assessments are for disturbed forests (right).



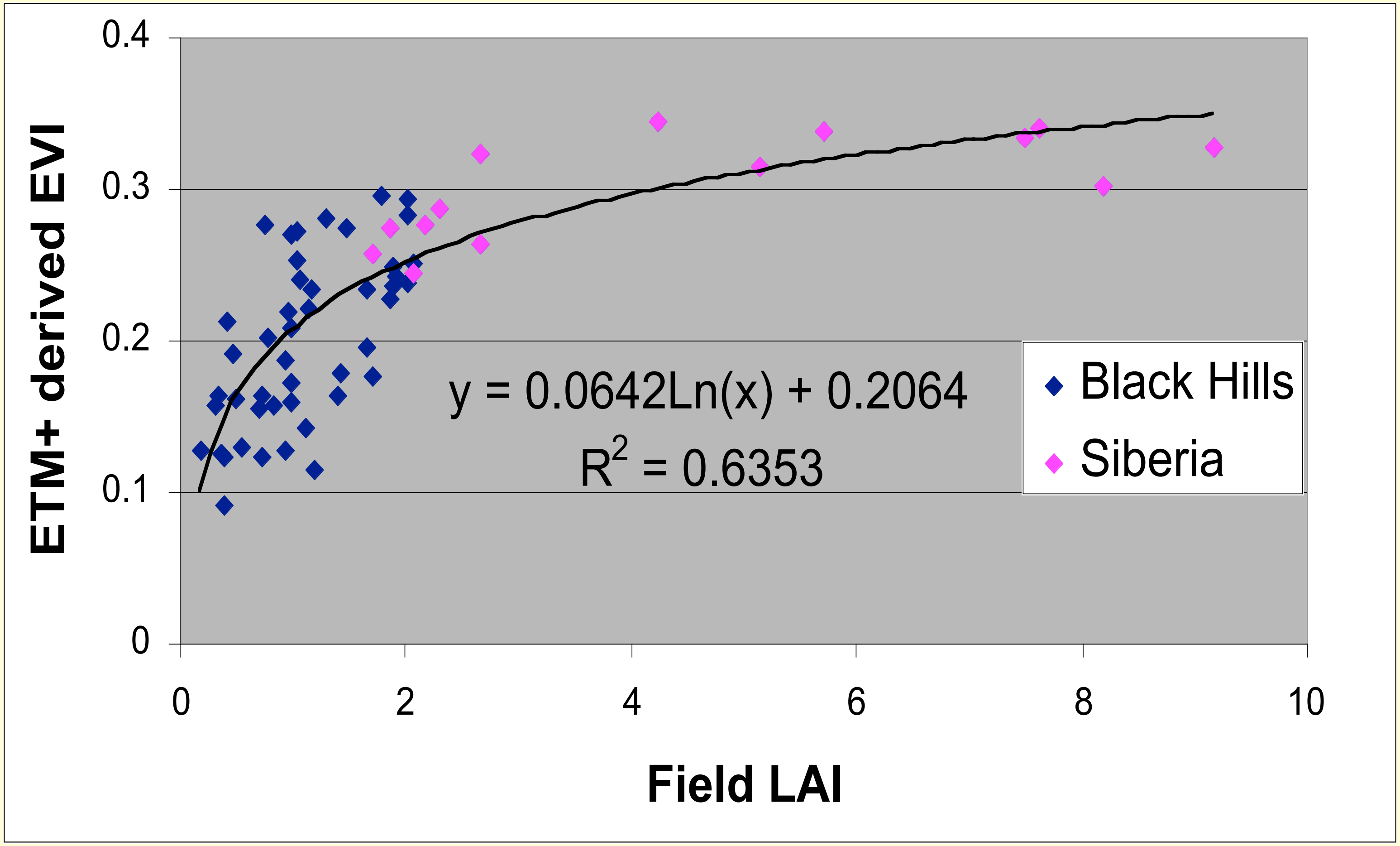
Has implications for retrieving LAI in areas affected by fire, drought, insect/pathogens, and other disturbances.

Combination of Siberia and Black Hills into VI vs LAI Analysis

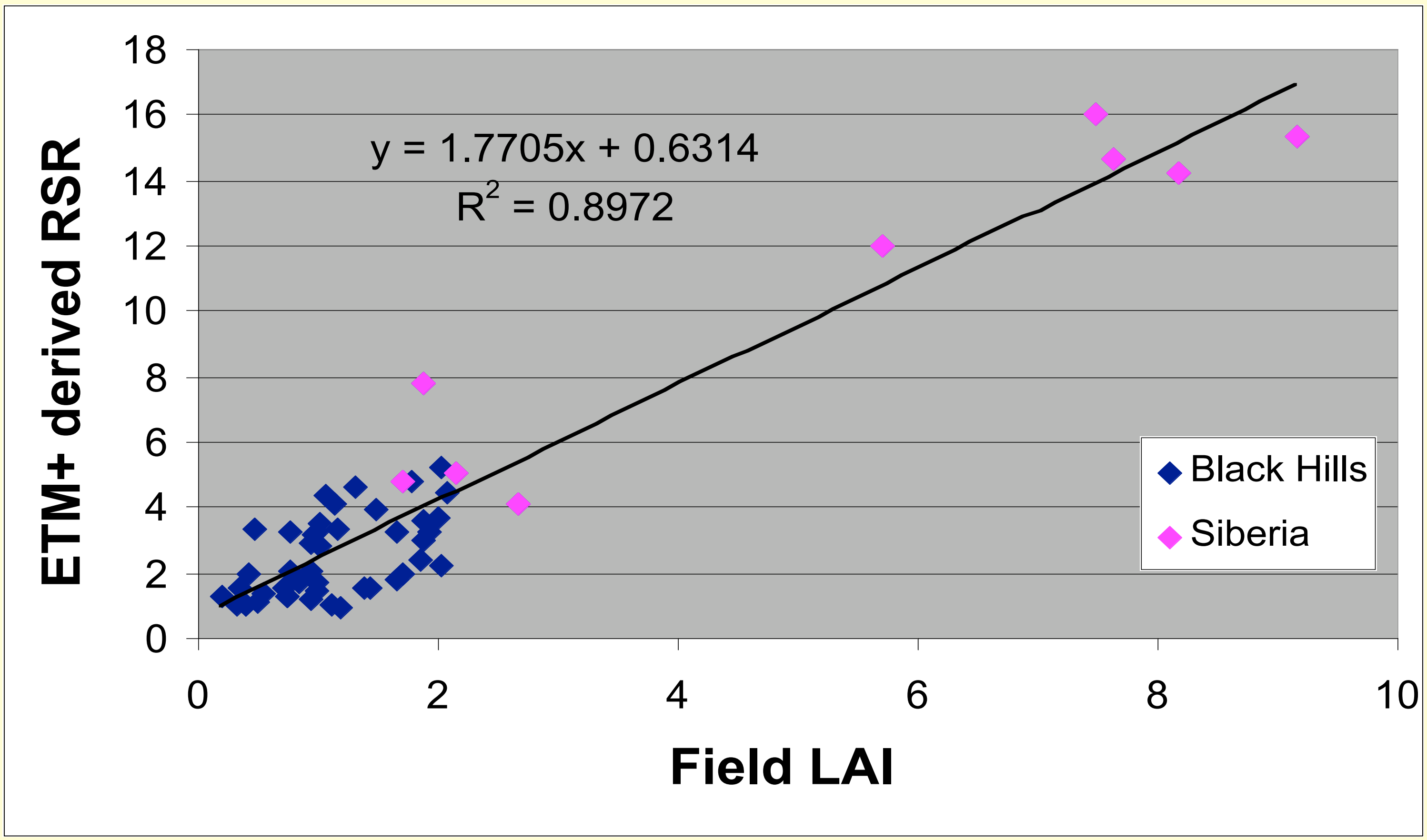
NDVI VS. Field LAI



EVI VS. Field LAI



RSR VS. Field LAI



Summary of RS Research Highlights - I

- Newly developed "Temporally Invariant Cluster" normalization method improves change detection using multi-temporal, cross-platform imagery
  - Improved relationships between VI's and LAI

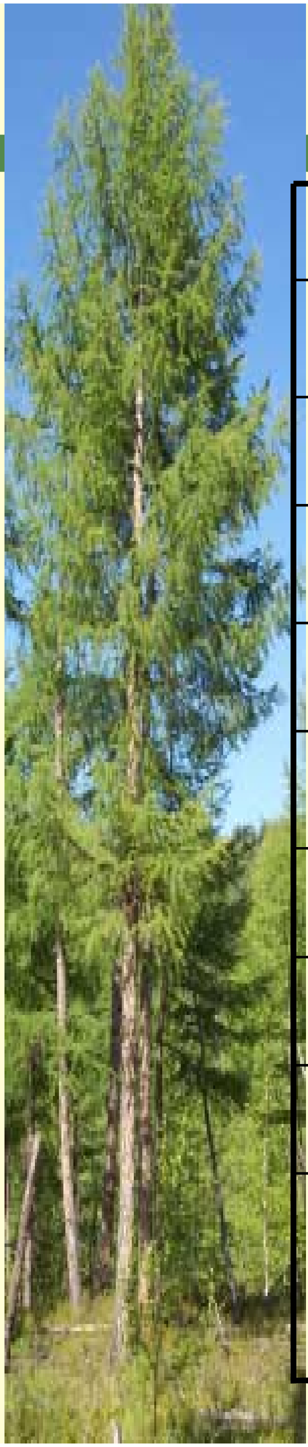
- EVI is sensitive to changes in canopy shading (be it self-shading or cloud shading) to better distinguish conifer forests from understory vegetation than does NDVI

- EVI is negatively correlated with fractional conifer forest coverage yet positively correlated with fractional green understory coverage; creates an EVI "cancellation effect" which degrades strength of EVI-LAI relationship for mixed pixels

- RSR is highly correlated with LAI due to added water-related _ information from SWIR bands

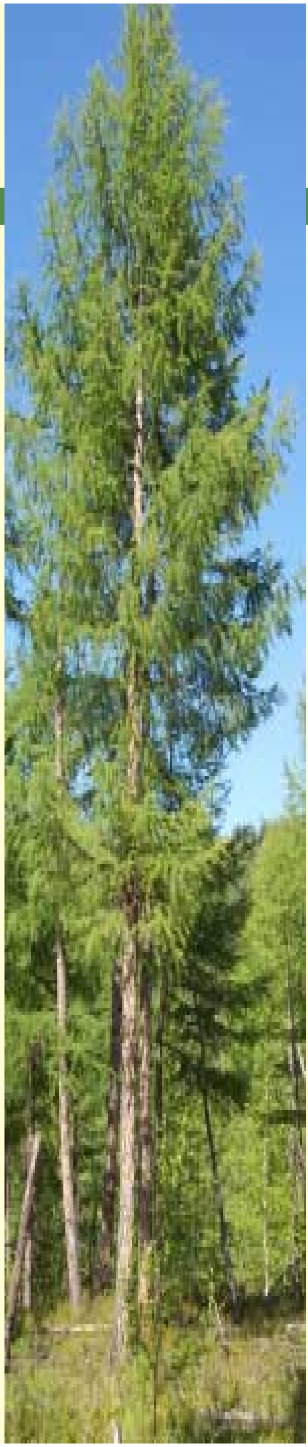
Summary of RS Research Highlights - II

- MODIS and ETM+ NDVI can be poorly correlated when field sites are near edge of MODIS scene (EVI is better correlated); more investigation is warranted
- Wintertime MODIS LAI retrieval problematic, possibly due to snow and/or low-angle illumination effects
- Tuning _ is necessary to account for partial needle loss in burned forests; can strengthen VI-LAI relationships
- Site water content can be well characterized using SWIR bands (interactions exist between SWC and LAI; Toomey and Vierling, *RSE*, in review)



Accomplishments

a priori Goals	Current Status of Results
Establish LAI for each post-fire age	Range of LAI determined for each post-fire age in the chronosequence
Compare direct and indirect LAI	Primary forest sites show saturation of indirect LAI
Produce LAI maps for a 3km x 3km test site	
Establish relationship between NDVI and LAI	Poor relationships between NDVI & optical LAI; *good relationships with EVI, RSR*
Investigate up-scaling of LAI to satellite data	New normalization techniques used to show reasonable correlation
Investigate use of BRDF to improve LAI derivation from RS data	
Establish relationship between spectral BRDF effects and LAI	
Model LAI for post-fire forests	Weather station set and data collected 3 yrs; no analysis
Provide support to EOS validation	**1.** Aeronet node installed and data provided since late 2000 **2.** LAI data: post on Siberian LAI website: http://ltpwww.gsfc.nasa.gov/bsb/lai/SibLAI.html



Potential Future Activities

- Extrapolate LAI across each site using surface and remotely sensed data
- Create site and regional maps using GIS
- Explore post-fire groundcover species
- Continue collaboration with graduate students at South Dakota School of Mines
- Investigate similar post-fire successional sites for LAI relationship in the more-unique (globally) Siberian Larch communities

Publications

- Kofman, G.B., Nelzina, A.G., Conley, A.H., Skripalschikova, L.N., Deering, D.W. **Methods to determine needle surface area**. *In Press* at Lesovedenie.
- Chen, X., and Vierling, L.A., **Using Lidar and Effective LAI Data to Evaluate IKONOS and Landsat 7 ETM+ Vegetation Cover Estimates in a Ponderosa Pine Forest.** *In Press* at Remote Sensing of Environment
- Leblanc, S. G., Deering D.W., Chen, J. M. and Conley A.H., **Extraction of plant canopy structure parameters from digital hemispherical photographs, Part two: methods comparison and application to boreal forests.** *TBS* to Agriculture and Forest Meteorology
- Conley, A.H., Deering, D.W., Nelzina, A.G., Kharuk, V.I., Leblanc, S.B., Kofman, G. B., Chen, J.M. **Leaf Area Index Across Post-fire Siberian Boreal Forests.** *TBS* to Agriculture and Forest Meteorology.
- Chen, X., Veirling, L.A., and Deering, D.W., **Remote monitoring of post-fire vegetation dynamics in Siberian Boreal Forests using MODIS and Landsat.** *TBS* to International Journal of Remote Sensing
- Chen, X., Vierling, L.A., Deering, D.W., Conley, A.H.,. **Local clustering of invariant features: a new relative radiometric normalization method for detecting landscape change.** *TBS* to Remote Sensing of Environment.
- Smith, R. and Vierling, L.A. **Improving remotely sensed LAI estimates in a burned ponderosa pine ecosystem.** *TBS* to Remote Sensing of Environment.
- Chen, X., and Vierling, L.A., **Seasonal variability in the Enhanced Vegetation Index and its relation to forest canopy LAI in Siberia and the Black Hills of South Dakota.** *TBS* to Remote Sensing of Environment.

IKONOS Data, June 2000

South Dakota Study Sites

Jasper Fire
(burned September 2000)

Black Hills Experimental
Forest Tower Site