EFFECTS OF SCALE ON REMOTE SENSING ASSESSMENTS OF BURN SEVERITY IN A PONDEROSA PINE FOREST

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INTRODUCTION

With the past century of fire suppression in ponderosa pine (*Pinus ponderosa*) forests, there has been an accumulation of surface fuels and dense stands of saplings and seedlings. This has led to a decrease in understory vegetation cover *(1,2)* and an increase in fuel loads, increasing the potential of future high severity fires *(1,3)*. However, fire size and location can make it costly and unsafe to obtain ground measurements of understory vegetation cover and fuels *(4)*. Remotely assessing heterogeneity and ground cover components within a fire perimeter can contribute to monitoring of ecological trends post-fire and are often used to plan and prioritize fuel treatment implementation *(5,6)*. Landsat TM images are free, have a spatial resolution of 30 m^2, and have been used to assess burn severity since 1984 *(7)*. However, because of the spatial resolution of Landsat TM images, it is often difficult to distinguish between overstory and understory post-fire effects. The Quickbird sensor of Digital Globe Inc., however, is one of many fine scale sensors with a high spatial resolution of 2.4 m^2 for multispectral bands and 0.6 m^2 for panchromatic bands. The Egley Fire Complex of eastern Oregon prompted the forest planner of the Malheur National Forest to obtain panchromatic fused Quickbird coverage (0.6 m^2 resolution) of the entire fire complex.

OBJECTIVE

Determine if fine scale imagery (Quickbird, 0.6 m^2 pixels) correlates better to field measured surface cover variables than moderate scale imagery (Landsat, 30 m^2 pixels)

METHODS

- Study Area: Malheur National Forest, eastern OR, USA (Fig. 1A and B)
- Egley Fire Complex: 3 lightning-ignited fires , burned ~57,000 ha from 7 to 21 July 2007
- Landsat images analyzed (see Table 1) were radiometrically corrected, Quickbird images were delivered as a pan-fused product from Digital Globe Inc. and orthorectified

Table 1. List of satellite images used, and dates images were acquired

Satellite	Date acquired
Quickbird	July 26, Aug 08 and 13, 2007
Landsat 5 TM (one-year pre-fire)	July 18, 2006
Landsat 5 TM (Immediately post-fire)	Aug 22, 2007
Landsat 5 TM (one-year post-fire)	July 7, 2008

- The normalized vegetation difference index (NDVI) was calculated for each image

$$NDVI = \frac{(NIR - RED)}{(NIR + RED)}$$

- Field sites (n=70) were sampled between May and July of 2008 distributed across the burn severity gradient guided by a rapid response Burn Area Remote Classification (BARC) map (Fig. 1A, Fig. 2)
- Each site consisted of five, 1 m^2 plots (Fig. 1C and D, Fig. 2) where tree canopy cover and ground surface components: understory green, non-photosynthetic vegetation (NPV), rock, soil, and char cover (%) were measured
- Because Quickbird pixels were smaller than field plots (Fig. 1D) and to determine if scale correlations to surface cover had a threshold, Quickbird images were averaged using focal statistic means in ArcMap at various window sizes (Table 2)
- NDVI values were then extracted to field plots within each window size and for Landsat images (left unaltered at 30 m^2 resolution)
- Only plot A variables (NDVI and surface cover variables were used for plot v site level analysis (Fig 4) where as, all plots were used for plot comparisons (Fig 5) and were averaged to site for site level analyses,(Fig 1)
- NDVI values from Quickbird window sizes and Landsat were then correlated with field measured variables using Spearman's correlations

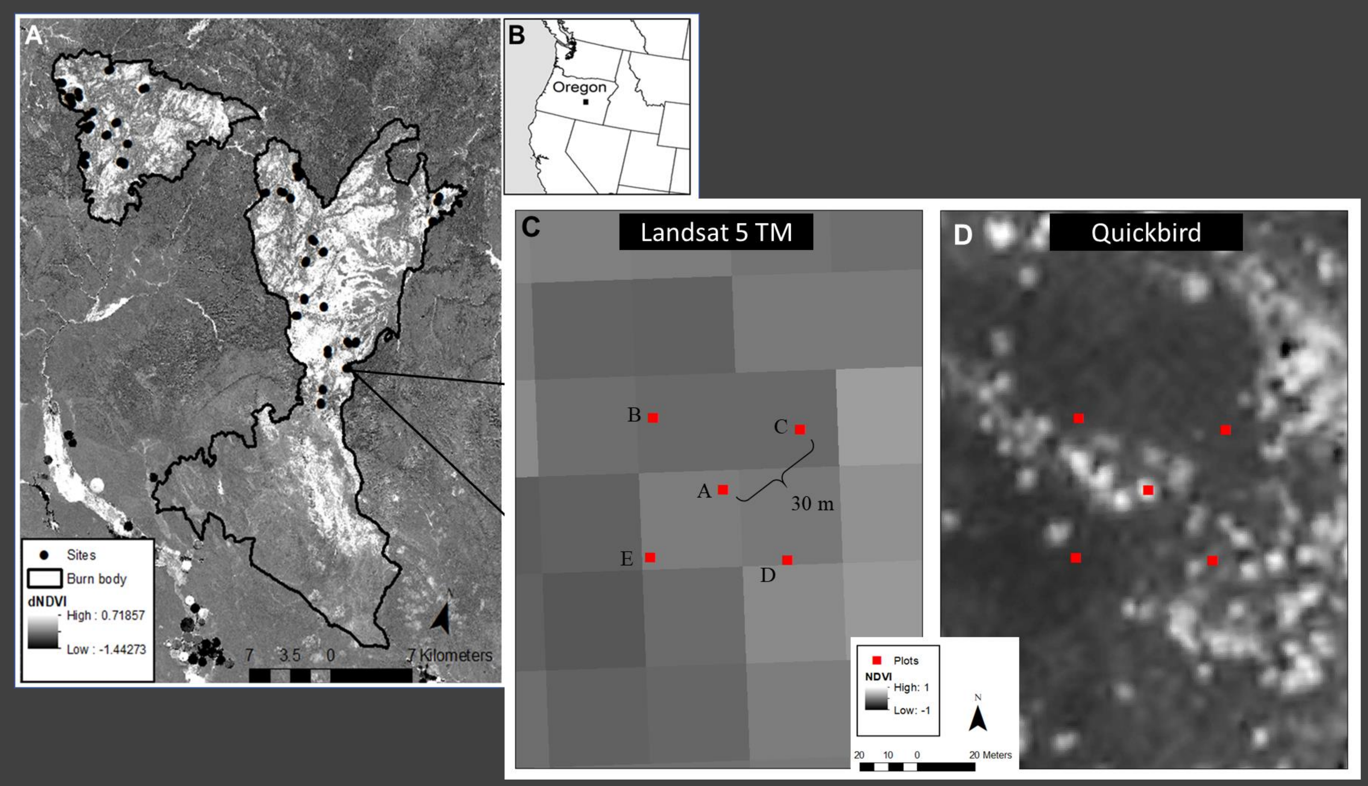

Fig. 1. Egley Fire Complex (2007) of eastern Oregon, USA, showing (A) the gradient of burn severity represented by dNDVI (pre-fire NDVI – immediate post-fire NDVI), (B) location of study area in Oregon, USA, (C) site layout over Landsat 2007 NDVI image, and (D), site layout over Quickbird 2007 NDVI image.

Table 2. Quickbird window sizes used for scale differences and their corresponding meter by meter (m^2) size.

Window size	m^2	Scale Similarity
1x1	0.6	
3x3	1.8	
5x5	3.0	
8x8	4.8	
17x17	10.2	
25x25	15.0	
50x50	30	Landsat
83x83	49.8	
167x167	100.2	
417x417	250.2	MODIS

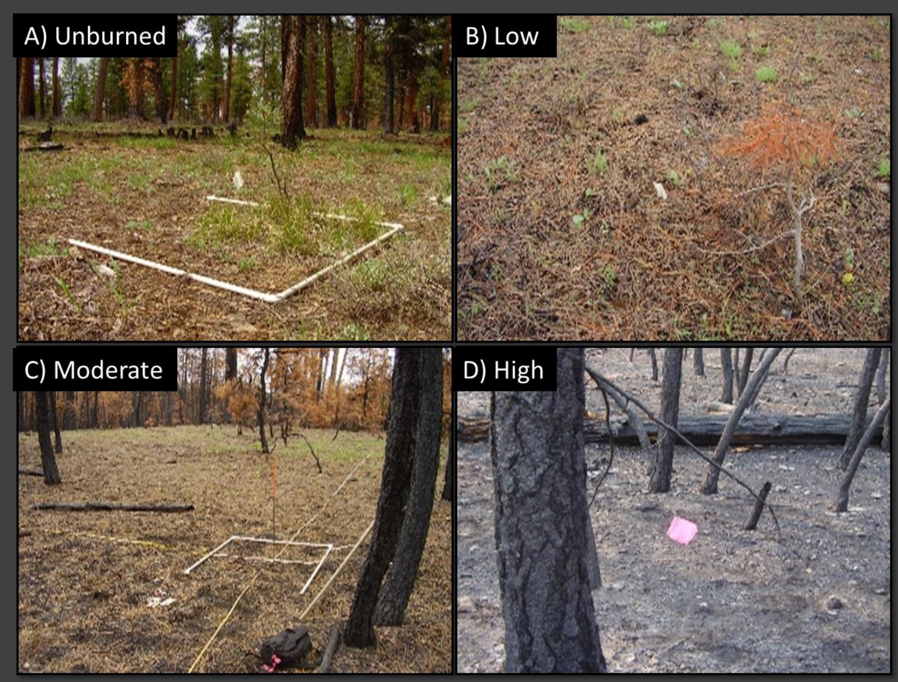

Fig. 2. Plot level field photos (2008) of an (A) unburned site, (B) low burn severity site, (C) moderate burn severity site, and (D) a high burn severity site within the Egley Fire Complex (2007) of eastern Oregon, USA.

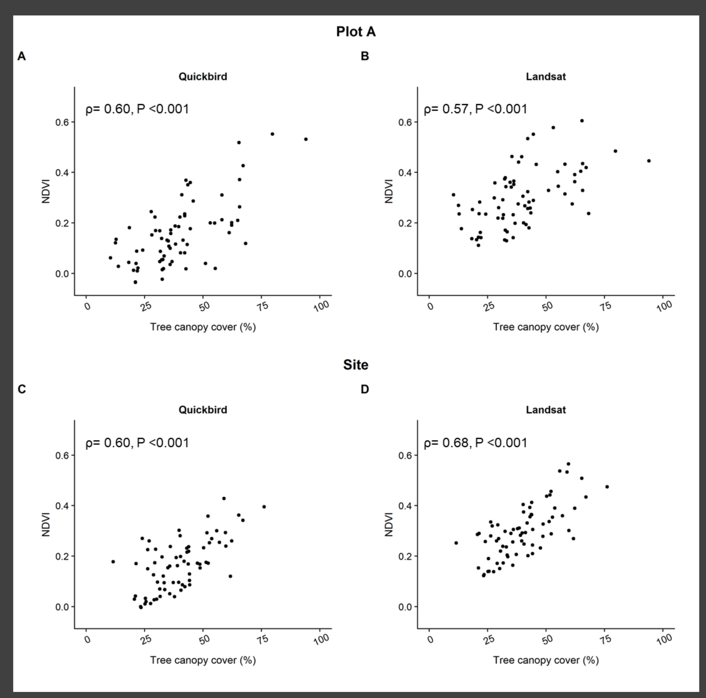

Fig. 3. Plot A Spearman's correlations (ρ) between unaltered Quickbird NDVI (A) and Landsat 2007 NDVI (B) along with site level Spearman's correlations between unaltered Quickbird NDVI (C) and Landsat 2007 NDVI (D) with tree canopy cover (%).

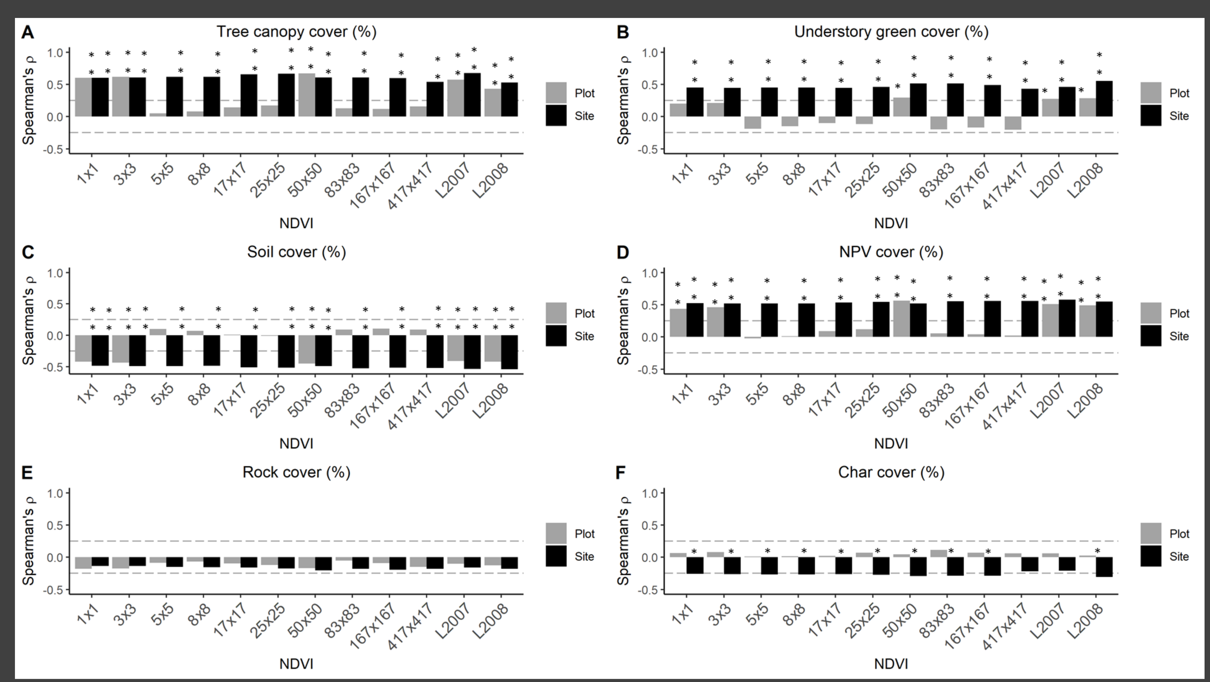

Fig. 4. Spearman's correlation (ρ) vs scale of NDVI for (A) tree canopy, (B) understory green, (C) non-photosynthetic vegetation (NPV) cover, (D) soil, (E) rock, and (F) char cover (%) by plot A (Plot) and site. Landsat 5 TM NDVI values are denoted as "L." Correlations with P ≤ 0.05 are denoted as "*" and P ≤ 0.001 are denoted as "**".

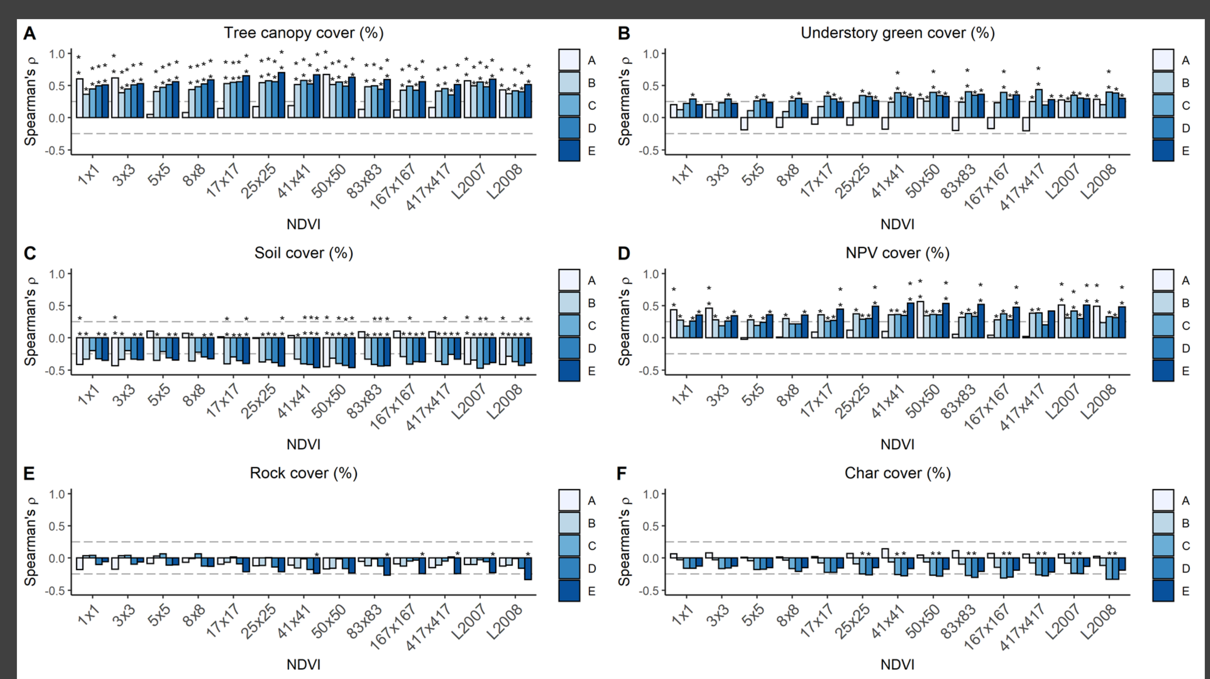

Fig. 5. Spearman's correlation (ρ) vs scale of NDVI for (A) tree canopy, (B) understory green, (C) non-photosynthetic vegetation (NPV) cover, (D) soil, (E) rock, and (F) char cover (%) by all plots within a site. Landsat 5 TM NDVI values are denoted as "L." Correlations with P ≤ 0.05 are denoted as "*" and P ≤ 0.001 are denoted as "**".

RESULTS/DISUCCION

- Quickbird 1x1 window NDVI correlations to surface covers were relatively similar to Landsat 2007 and 2008 NDVI correlations to surface covers (Fig.3 and 4) at both the plot and site
- Plot A Quickbird NDVI from 1x1, 3x3, and 50x50 windows and Landsat 2007 and 2008 NDVI correlated significantly with tree canopy (all P < 0.001), NPV (all P < 0.001), and soil cover (%, all P < 0.001, see Fig. 3 for Spearman's correlations)
- Quickbird 1x1 and 3x3 cell sizes are more similar in scale to the 1 m^2 plot (Table 2)
- At the site level, all NDVI measurements correlated with all surface cover variables except rock cover and char cover at the Quickbird 1x1 window, 417x417 window, and Landsat 2007 level (all P< 0.001 for tree canopy, understory green, NPV, and soil cover correlations with NDVI, all P ≤ 0.031 for char, Fig. 4)
- Landsat correlations to surface cover variables were similar to Quickbird correlations to surface cover variables at the site level
- Plot trends varied among the different plots, though generally NDVI from all window sizes and Landsat correlated significantly with tree canopy, soil, and NPV cover (%, Fig 5.)
- Understory green and char correlations at the plot level generally became more significant the larger the window size (Fig. 5)
- The larger the window size, the more NDVI values are being averaged, which may lead to stronger correlations

CONCLUSIONS

Site level correlations were much stronger than at plot level, demonstrating the importance of matching pixel size of remote sensing images to ground scale.

Quickbird and Landsat NDVI correlations to surface cover variables at the site level were remarkably similar, even at different Quickbird window scales, for this study.

FUTURE RESEARCH

- Quickbird and Landsat NDVI values will be correlated with surface variable covers within treated areas and untreated areas to determine if treatment effects can be detected at finer scales
- Quickbird and Landsat NDVI values will also be correlated to surface variable covers within tree canopy cover groups (low, moderate, and high) to determine if Quickbird imagery correlates to surface variables better than Landsat in areas with low canopy cover (i.e. rangelands)

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