



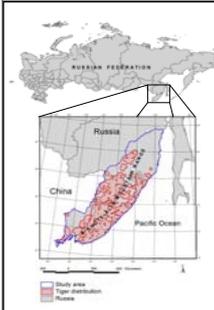
# Impact of Climate and Land Use Change on Fire Frequency and the Amur Tiger : Characterization of Fire regimes at the Regional Scale from Remotely Sensed Data



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## Introduction

Forests of the Russian Far East (RFE), designated by UNESCO as a World Heritage site and home to the critically endangered Amur tiger, are experiencing increasing pressure from growing demands for natural resources and the rising threat of large fire occurrence. The frequency and intensity of fire events in boreal forests are predicted to rise due to global warming. A conceptual Fire Threat Model (FTM) has been developed within this project to provide quantitative assessment of fire threat to the Amur tiger.



A reduced version of the model structure includes the major components of Fire Threat Modeling: Fire Danger - the most generic (but regionally specific) component and Values at Risk and Recovery Potential - both highly region specific and resource specific components.

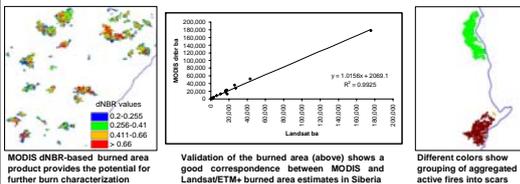
The large size and mountainous terrain of the study area and government control of data sources make remote sensing the only viable source of data for spatially explicit modeling. The remotely sensed data driven FTM is aimed at evaluating probability of wildland fire occurrence, its impact and recovery potential for a given resource. This study explores causes and distribution of fire in this ecosystem, conditions leading to significant fire events, impacts of these fires on the Amur tiger, and habitat recovery potential. The main goal of this project is to evaluate changes in fire threat to the Amur tiger with predicted climate and land use change in the region. Additionally, possibility of mitigating against rising fire threat by implementing changes in land use practices will be investigated.

## Data Sources and Methodology

**MODIS Active Fire Detections** reprocessed through the Fire Spread Reconstruction approach (Loboda and Csiszar, in press); Terra (2001, 2002) and Terra and Aqua (2003, 2004, 2005)

### Burned Area/Impact Severity

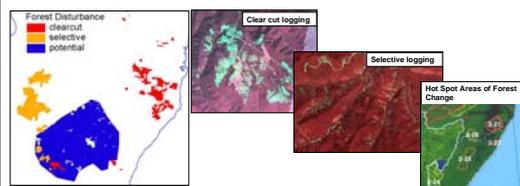
Automated dNBR based burned area product from MOD09A1 for the full-leaf-out period (May 1–Sept 6) and aggregated active fires for leaf-off period (Sept 7 – April 31)



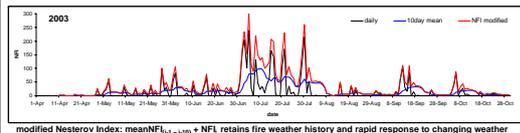
MODIS dNBR-based burned area product provides the potential for further burn characterization



**Forest Disturbance (logging)** created through visual analysis of Landsat/ETM+ imagery mosaic for RFE (1999-2002) and "Hot Spot Areas" of Forest Cover Change



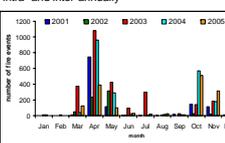
**Fire Weather Product (NFI<sub>mod</sub>)** calculated from NCEP-NCAR Reanalysis 4-times daily observation data and the Global Precipitation Climatology Project (GPCP) 1 degree daily rainfall data.



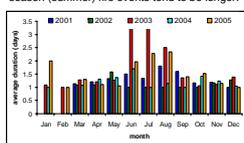
## Spatio-Temporal Patterns of Fire Occurrence

### Interannual Variability of Fire Occurrence

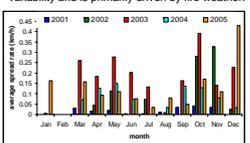
Number of fire events is highly variable both intra- and inter-annually



The majority of fire events are short-lived. Mid-season (summer) fire events tend to be longer.



Fire spread rate has strong interannual variability and is primarily driven by fire weather.



**Seasonal Specifics of Spatial Distribution of Fire:** Three distinct seasons of fire occurrence were identified during burned area mapping:

### early season (Jan 1 – Apr 30)

- primarily occur in agricultural landscapes and broadleaf forests
- very similar in spatial distribution
- burn through dead litter
- do not have significant/ lasting impact



### mid season (May 1 – Sep 6)

- primarily occur in coniferous forests, wetlands and grasslands
- differ in spatial distribution
- have significant/lasting impact on land cover



### late season (Sep 7 – Dec 31)

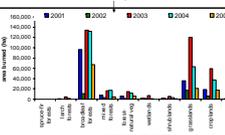
- occur in agricultural landscapes, grasslands and broadleaf forest
- burn through dead litter
- do not cause significant/lasting impact



### Fire Occurrence and Burned Area by Land Cover Types

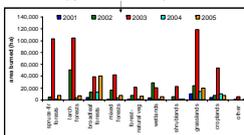
#### early season (Jan 1 – Apr 30)

Early season fire events are mainly concentrated in croplands. However, the largest fire events occur in broadleaf forests prior to leaf-out season.



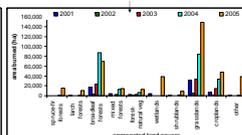
#### mid season (May 1 – Sep 6)

May fires are found in croplands, grasslands and wetlands. June-August fires are concentrated in coniferous (spruce-fir and larch) forests.



#### late season (Sep 7 – Dec 31)

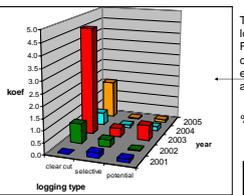
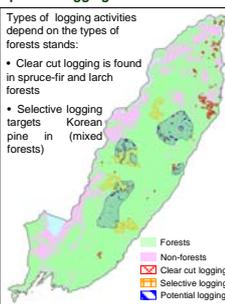
Late season is characterized by low intensity surface fires in grasslands and broadleaf forests.



## Impact of Logging on Fire Occurrence and Spread

Types of logging activities depend on the types of forest stands:

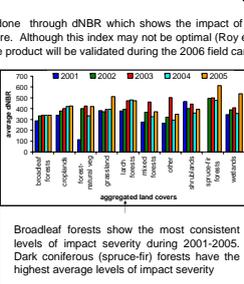
- Clear cut logging is found in spruce-fir and larch forests
- Selective logging targets Korean pine in (mixed forests)



The importance of land cover disturbance through logging rises with the increase of forest fire activity. Fire occurrence in logged areas (particularly clear cut) increases dramatically during 2003 – the year of extreme fire activity. Koef represents values per unit area and is calculated as:

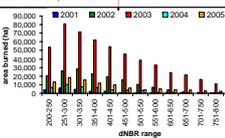
$$\% \text{fire in a given zone from all fires in the forests} / \% \text{area occupied by the zone from total forested area}$$

Fire spread rates in logged areas are generally higher than in all forested areas (2002-2004). In 2001 and 2005, fires occurred mainly in broadleaf forests which experience little disturbance from logging.

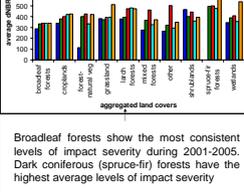


### Impact of Severity Assessment

was done through dNBR which shows the impact of fire on living vegetation. The dNBR retains the variability of surface reflectance signature post fire. Although this index may not be optimal (Roy et al., 2006), it was linked to field measurements of burn severity (van Wageningen et al., 2004). The product will be validated during the 2006 field campaign.



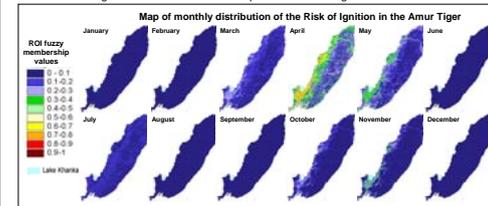
Needleleaf forests (spruce-fir and larch) have considerably higher percentage of severely damaged area compared to other land covers.



Broadleaf forests show the most consistent levels of impact severity during 2001-2005. Dark coniferous (spruce-fir) forests have the highest average levels of impact severity

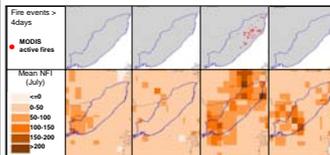
## Drivers of Fire Occurrence

**Risk of Ignition** based on the FSR processed points of ignitions derived from MODIS active fires show a strong connection between human presence and fire ignitions.

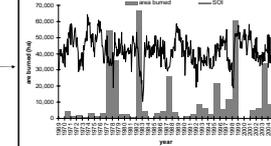


- spring and fall fires are initiated in close proximity to transportation routes and agricultural areas
- an increase in the number of fire ignition points in areas with steep slopes in June and July indicates a potential increase in contributions from natural fire sources, such as lightning

### Climate and Weather



The longer-term record of fire occurrence in Primorsky Krai of the Russian Far East Protection Service "Avialesokhrana". The comparison of trends in fire occurrence and the Southern Oscillation Index (SOI) show that the amounts of area burned correspond with El Nino occurrence.



## Future Work

### Fire Danger Mapping/Modeling

- Fire Danger Module of the FTM will be parameterized based on the coefficients developed during the characterization of fire regimes
- The model performance will be tested during the 2006 fire season

### Recovery Potential Assessment/Modeling

- dNBR based impact severity will be validated during 2006 field campaign
- Vegetation re-growth:
  - Approximate duration of rehabilitation to the pre-burn conditions (literature)
  - Vegetation replacement – connect burn severity with vegetation replacement and tree cover restoration – field observations (2006)

### Values at Risk Mapping



Potential fire impacts on the Amur tiger and its main prey will be evaluated through:

- fire spread rate vs. species/their young mobility
- land cover ranking according to tiger and its prey habitat preference
- fluctuations in prey densities with the emergence of edge habitat

### Modeling Current and Future Fire Threat to the Amur Tiger

- **Climate change impact on Fire Threat:**
  - IPCC Climate Model Scenarios or higher resolution regionally parameterized climate models will be used to assess future fire threat to the Amur tiger

### Land use change impact on Fire Threat:

- A set of land use change scenarios for the RFE will be developed and applied to assess potential changes in fire threat due to land management

### Mitigating potential impact of climate change on fire threat through land use management:

- The FTM outputs incorporating both land use and climate change scenarios will be evaluated.
- A set of land use scenarios aimed at minimizing anthropogenic influence on wildland fire will be developed

## Acknowledgements

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RAD Space Research Institute. 5) MODIS land cover; 6) MODIS land cover; 7) MODIS land cover; 8) MODIS land cover; 9) MODIS land cover; 10) MODIS land cover; 11) MODIS land cover; 12) MODIS land cover; 13) MODIS land cover; 14) MODIS land cover; 15) MODIS land cover; 16) MODIS land cover; 17) MODIS land cover; 18) MODIS land cover; 19) MODIS land cover; 20) MODIS land cover; 21) MODIS land cover; 22) MODIS land cover; 23) MODIS land cover; 24) MODIS land cover; 25) MODIS land cover; 26) MODIS land cover; 27) MODIS land cover; 28) MODIS land cover; 29) MODIS land cover; 30) MODIS land cover; 31) MODIS land cover; 32) MODIS land cover; 33) MODIS land cover; 34) MODIS land cover; 35) MODIS land cover; 36) MODIS land cover; 37) MODIS land cover; 38) MODIS land cover; 39) MODIS land cover; 40) MODIS land cover; 41) MODIS land cover; 42) MODIS land cover; 43) MODIS land cover; 44) MODIS land cover; 45) MODIS land cover; 46) MODIS land cover; 47) MODIS land cover; 48) MODIS land cover; 49) MODIS land cover; 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