Impact of Climate and Land Use Change on Fire Frequency and the Amur Tiger

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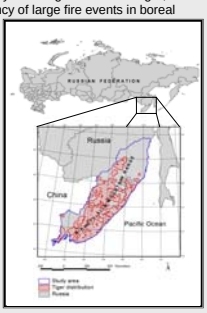
Project Background

Introduction

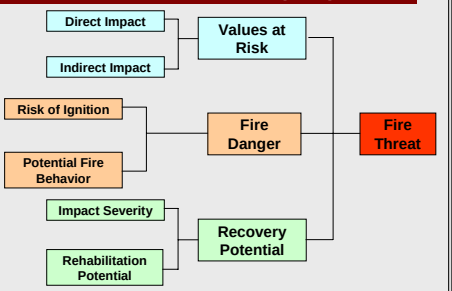
Forests of the Russian Far East (RFE), designated by UNESCO as a World Heritage site and home to the highly endangered Amur tiger, are threatened by wildland fires. The frequency of large fire events in boreal forests of the Northern Hemisphere is predicted to rise due to global warming. While fires are a natural component of the ecosystem, their occurrence has been modified by human impact. Fires contribute to the Amur tiger habitat reduction through destruction, degradation and fragmentation of forests. The current and future well-being of the tiger will partially depend on minimizing the effects of wildland fires on the area resources. The large size and mountainous terrain of the area and government control of data sources make remote sensing the only viable source of data for spatially explicit modeling.



Remotely Sensed Data Driven Fire Threat Model (FTM)

The FTM is a new tool aimed at identifying fire susceptible areas of highest importance for a given resource.

- fuzzy logic driven
- outputs spatially explicit and temporally dynamic maps of fire threat
- designed for resource management.
- provides a framework for developing quantitative assessments of various parameters and their contribution to the overall potential impact of fire on a given resource
- designed to be used for operational resource monitoring
- provides the possibility for predictive assessment of fire threat and evaluation of potential resource management scenarios aimed at minimizing the fire threat

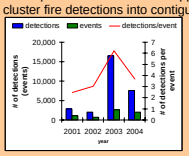


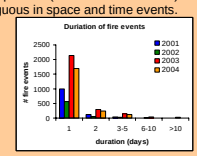
A reduced version of the model structure includes the major components of Fire Threat Modeling: Fire Danger - the most generic (but regionally specific) component and Values at Risk and Recovery Potential - both highly region specific and resource specific components.

Fire Danger: Spatio-temporal patterns of fire occurrence

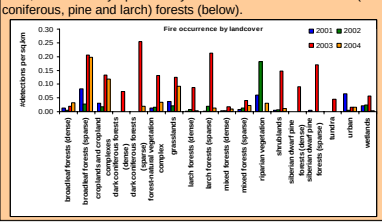
Developments of Fire events

MODIS active fire detections from Terra (2001, 2002) and Terra and Aqua (2003, 2004) satellites were reprocessed through the Fire Spread Reconstruction approach (Loboda and Csiszar) to cluster fire detections into contiguous in space and time events.





The 2001-2002 and 2003-2004 periods cannot be compared directly. However, more fire events occurred in 2003 (above left) with the largest number of long fire events (above right). During 2003, fire activity particularly increased in coniferous (dark coniferous, pine and larch) forests (below).

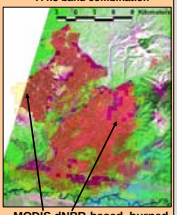


Burned area and its characterization

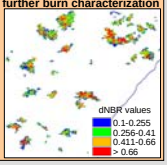
A new automated burned area product from Surface Reflectance 8-Day L3 Global 500m product (MOD09A1) was developed:

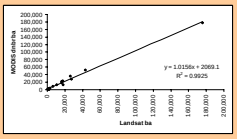
- burned area is mapped during the full-leaf-out period (May 25 – September 6)
- Normalized Burn Ratio (NBR) is calculated for MODIS bands 2 and 7: (Band2-Band7)/(Band2 +Band7)
- dNBR is calculated between the NBR values of the same compositing period for two consecutive years
- dNBR values above 0.099 are further evaluated against MODIS active fire detection locations

Landsat/ETM+ image path 111 row 25 from 05/18/2002 7:4:3 band combination



MODIS dNBR-based burned area product (above and below) retains the variations in the surface reflectance and provides the potential for further burn characterization

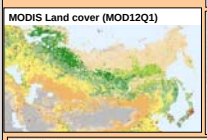


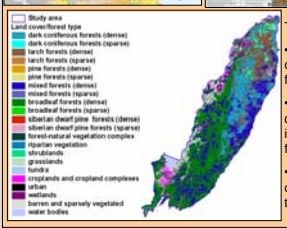


Preliminary validation of the burned area (above) shows a good correspondence between MODIS and Landsat/ETM+ burned area estimates in Siberia

Land cover

Land cover/Forest type coverage of the study area was created by combining 2 independent 1km^2 satellite land cover products (SPOT-VGT based landcover of Northern Eurasia and Boston University MODIS based land cover) and a map of Russia's forests.





The coverage:

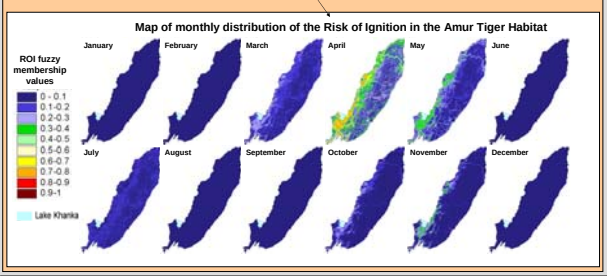
- has higher confidence levels for forested areas
- provides more detailed information on forest types
- retains all land cover classes for the entire area

Fire Danger: Drivers of fire occurrence

Fire ignition

The analysis of the FSR processed points of ignitions derived from MODIS active fires show:

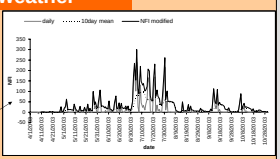
- a strong connection between human presence and fire ignitions
- common use of fire for crop residue management in spring and fall
- few fire events are initiated during summer months, however, these are the fires which tend to grow and spread for longer time-periods
- an increase in the number of fire ignition points in areas with steep slopes in June and July indicates a potential increase in contributions from natural fire sources, such as lightning
- risk of ignition shows a considerable intra-annual variability and should be evaluated within fire danger modeling initiatives as a dynamic parameter

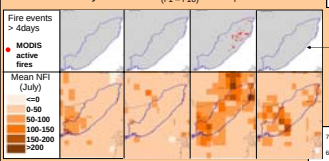


Climate and weather

The Nesterov Fire Index (NFI) was calculated from NCEP-NCAR Reanalysis1 4-times daily observation data and the Global Precipitation Climatology Project (GPCP) 1degree daily rainfall data. Daily NFI coverage of RFE was produced for the period of 2001-2004.

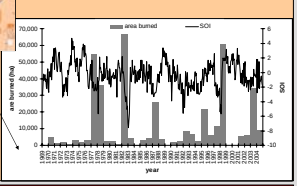
We modified the Nesterov Fire Index to retain fire weather history: mean$NFI_{(i-1\ -\ i-10)}$ + NFI_i



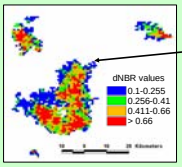


Maps of mean monthly NFI for July 2001-2004 show the correspondence between unusually high NFI values and an increase in large fire occurrence in the RFE.

The longer-term record of fire occurrence in Primorsky Krai of the RFE was obtained from the Russian Aerial Forest Protection Service "Avialesookhrana". 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.



Fire Threat



Recovery potential

- Impact severity will be assessed through the dNBR values of the burned area product (validation in 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)

Jack pine seedling sprouting following a fire, Wisconsin © Jeri Brandenburg / Minden Pictures

msbu.cz/~bozek/obrazky/Animals/index.php

Values at Risk

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

www.amosklasterec.cz/zvirata-index.html

www.eskimonedia.co.uk/Wildlife%20Page.html

Climate change impact on Fire Threat: Outputs of the FTM based on Climate Model Scenarios available at International Panel on Climate Change (IPCC) or higher resolution regionally parameterized climate models will be used to assess future fire threat to the Amur tiger.

Modeling Current and 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. Outputs of the FTM based on these scenarios will be evaluated to assess potential changes in fire threat due to land management.

Mitigating potential impact of climate change on fire threat through land use management practices: The FTM outputs incorporating both land use and climate change scenarios will be evaluated. To develop a set of land use scenarios aimed at minimizing anthropogenic influence on wildland fire.

Acknowledgements

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