Impact of Climate and Land Use Change on Wildland Fire Frequency and the Amur Tiger: background, hypotheses and methodology.

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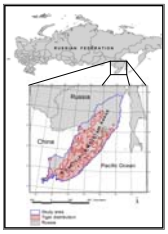
Introduction

Forests of the Russian Far East, designated by UNESCO as a World Heritage site and home to the highly endangered Amur tiger, are severely threatened by wildland fires. The frequency of catastrophic fire events in boreal forests of the Northern Hemisphere is predicted to rise due to the global warming trends. While fires are a natural component of the ecosystem, their occurrence has been modified by human impact. Fires strongly contribute to the Amur tiger habitat reduction through destruction, degradation and mainly fragmentation of forests. The current and future well-being of this biome and the tiger will largely depend on minimizing the effects of wildland fires on the area resources. 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.



Fire Threat Concept

Wildland Fire Science Concepts

Fire Behavior – modeling fire spread at a local scale for operational fire suppression efforts (e.g.- BEHAVE, FARSITE)

Fire Danger – modeling the probability of fire ignition and spread rate based on weather and fuel conditions at a regional scale (e.g. National Fire Danger Rating System (USA), Canadian Forest Fire Danger Rating System)

Fire Threat – modeling the probability of fire occurrence and the extent of fire impact on a particular resource within a specific region (e.g. - Wildland Fire Risk concept)

Goals, Hypotheses and Research Significance

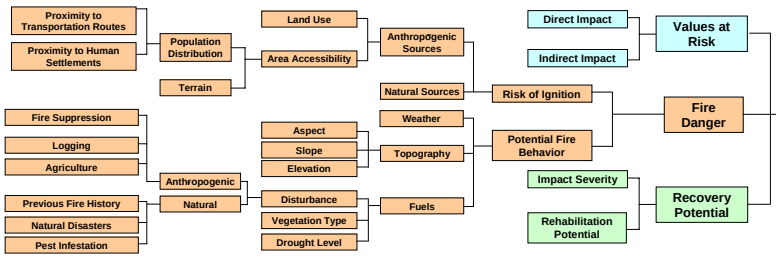
Goal: Evaluate the potential impact of climate and land use change on fire threat to the Amur tiger.
Hypothesis 1: Climate change will increase fire threat in the Amur tiger habitat.
Hypothesis 2: Changes in land use and management practices can mitigate against or enhance fire threat to the Amur tiger.
The proposed research presents a modeling initiative for developing scenarios of wildland fire impacts on the Amur tiger habitat from estimated climate change coupled with predictions of land use change. Its contribution to science includes:

- A dynamic widely applicable spatially explicit model of fire threat
- Incorporation of recovery potential into the model
- Modeling future changes in fire threat

Generic

- Highly generic – i.e. can be applied to various geographic areas, biomes and resources with proper parameterization
- Parameterized based on *a-priory* knowledge of fire occurrence and potential impacts on a particular resource
- Model inputs are weighted against each other and evaluated quantitatively according to fuzzy decision making logic

Conceptual Regional Fire Threat Model



Concept

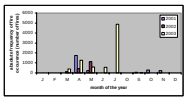
- Fire Danger is the most generic module of the FTM partially based on the fire danger forecasting approaches used by US Forest Service and Canadian Forest Service. The adaptation of the Fire Danger module to the regional specifics is achieved through proper parameterization and decision making rule assignment.
- Values at Risk and Recovery Potential modules are highly resource and region specific. The further development of these modules is required for specific resources.

Region Specific

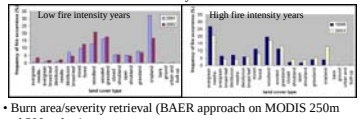
Characterization of Fire Regimes in the Russian Far East

Spatio-temporal dynamics of fire

- Spatio–temporal distribution of MODIS active fire product shows a shift in fire occurrence between high and low fire intensity years



- Distribution of fire occurrence by land covers



- Burn area/severity retrieval (BAER approach on MODIS 250m and 500m data)
- Recent fire history from MODIS active fires (UMD) and AVHRR (SFI) historic dataset

Drivers of fire occurrence

- Sources of fire ignition

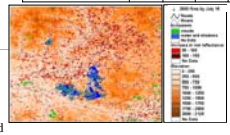
Risk of Ignition by transportation routes

year	2001	2002	2003	ave	koef	Danger level
% in 5km zone	85.81	81.19	73.41	80.14	1.94	VH
% in 5-10km zone	14.77	17.45	15.91	16.04	0.75	L
% in 10-15km zone	2.30	3.99	7.10	4.46	0.34	VL
total % outside buffers	2.21	3.42	8.81	4.81	0.20	VL

Risk of Ignition by distance from human settlements

year	2001	2002	2003	ave	koef	Danger level
% in 5km zone	28.76	23.03	25.86	25.88	3.56	VH
% in 5-10km zone	46.50	43.56	37.28	42.44	2.68	H
% in 10-15km zone	20.42	21.55	18.68	20.22	1.38	M
% in 15-20km zone	7.77	8.89	6.77	7.81	0.69	L
total % outside buffers	7.09	12.66	20.96	13.57	0.27	VL

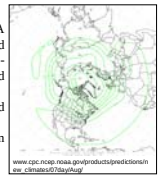
- Natural and Anthropogenic disturbance:
  - Fire suppression (Russian fire protection service data)
  - Logging (red reflectance from MODIS 250m data)
  - Agriculture (land cover data)
  - Previous fire occurrence (historic AVHRR and MODIS)
  - Pest infestation (Land Resources of Russia + MODIS 250m NDVI)
  - Natural disasters (literature and press + MODIS 250m and 500m data)



Drop in red reflectance due to the charring on the burned area provides an opportunity for burned area mapping.

Conditions enhancing fire spread

- Climatic Drivers:
  - 500hPA (NWSCPC). A correlation has been established between the condition of the mid-Troposphere and the area burned in the boreal forests of Canada.
  - Long term fire records and teleconnections (NWSCPC)
  -NDVI and GVMI (MODIS 250m and 500m imagery)



- Meteorological conditions:
  - The Nesterov fire index (from TOVS and AIS) will be evaluated in terms of fire weather characterization for the Russian Far East. The simplicity of its retrieval combined with the possibility of its calculation from the remotely sensed data make this fire index the best option for fire weather danger evaluation.

Resource Specific

Fire Threat Modeling for the Amur Tiger

Application

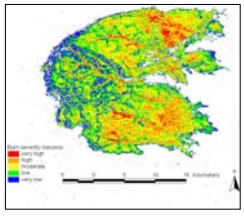
Immediate impacts on the Amur tiger

- **Tiger:**
  - Fire spread rate vs tiger cubs' mobility
  - Land cover ranking according to tiger habitat preference

- **Prey (wild boar, red deer)**
  - -Fire spread rate vs species/ their young mobility
  - Land cover ranking according to prey habitat preference
  - Fluctuations in prey densities with the emergence of edge habitat

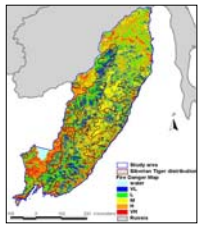
Area rehabilitation potential

- Impact severity (BAER approach)
- Vegetation re-growth:
  - Approximate duration of rehabilitation to the pre-burn conditions (literature)
  - Vegetation replacement – connect burn severity with vegetation replacement – field observations (Summer 2006)
  - Tree cover restoration (VCF or field observations 2006)



Current fire threat to the Amur Tiger

- Compilation and parameterization of FTM for the Russian Far East and the Amur Tiger based on the data collected during the previous steps. The output of the model will be presented in a GIS format with spatially explicit levels of fire threat at the regional level. The example shows an output for preliminary potential fire danger modeling for the Russian Far East.
- The input values will be weighted based on a set of fuzzy logic decision ratings of the relative to each other importance
- Outputs of FTM for 2001 - 2005



Future Scenarios

Climate and Land Use Change Impacts on Fire Threat to the Amur Tiger

Policy Making Support

Climate change impact on fire threat to the Amur Tiger

- Outputs of FTM based on Climate Model Scenarios available at International Panel on Climate Change (IPCC). A search for higher resolution regionally parameterized climate models for the Russian Far East will be continued.
- Comparison between these FTM outputs and FTM outputs for 2001 - 2005

Land use change impact on fire threat to the Amur Tiger

- Development of a set of possible Land Use change Scenarios within IDRISI environment
- Outputs of FTM based on the Land Use Change Scenarios and their comparison with FTM outputs for 2001- 2005

Minimizing fire threat through Land management practices

- Outputs from FTM based on scenarios of both climate and land use change
- Development of a set of land use scenarios (IDRISI) focused on minimizing human driven fire occurrence
- Outputs from FTM based on the newly developed scenarios of land use management and climate change

•Significance

- Fire Threat Model (FTM) will **improve** our **understanding of wildland fire impact on the Amur tiger** beyond the current range of experience
- Characterization of fire threat to the Amur tiger as the top predator reflects on the **fire threat to the ecosystem sustainability**
- FTM will provide **ecological forecasting** for the Amur tiger in terms of fire impact
- Future fire threat scenarios will create the **scientific basis for broad scale decision and policy making** processes underlying tiger conservation work and enable resource managers to create **a long-term disaster prevention plan**

•Conclusions

- The Amur tiger is a symbol of ecosystem sustainability of the Russian Far East
- Tiger habitat is reduced and fragmented by wildland fires
- This research will:
  - Improve our understanding of fire impact on the tiger
  - Provide spatially explicit and dynamic information on changes in fire threat to the tiger
  - Allow for testing management scenarios
  - Provide the basis for preparing management policies and tactics minimizing wildland fire impacts on the tiger

Acknowledgements

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