Annual Report for Year 2
Jan 6 2013 – Dec 31 2013
NASA Land Cover and Land Use Program
Funded under grant NNX12AD34G

LCLUC Synthesis: Forested land-cover and land-use change in the Far East of Northern Eurasia under the combined drivers of climate and socio-economic transformation

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Consultants

Consultants: Olga Krankina, Oregon State University*
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*recently switched to subcontract

Overall Project Timing

Summary about the project timing: The project award paperwork shows a start date of January 6 2012. However, Michigan began to receive the actual funding in March 2012. As soon as it was received, the prime institution worked quickly to get a prime budget in place by May 1. The subcontract institutions were notified that budget was set up in-house and their subcontracts had been formally initiated. Subcontracts to UVA and UMD had to be processed and established in the usual way which can take a couple of months. Additional time was required summer 2012 for all institutions to re-process the subcontracts after objections to and removing of certain references to China in their SOWs (a minor part) by the various entities involved in the process.

The prime (MI) started work in May 2012. UVA and UMD started research work in August/September 2012, although they and the team engaged in communications and planning prior to that time. In Year 2 OSU consultant Krankina asked to be converted to a subcontract and to delay significant involvement until that time. Thus as noted by the joint institutions, all project reports for “Year 1” cover a smaller time period than the official award start date would suggest and this varies somewhat between institutions due to the above timing constraints. Project reports for “Year Two” reflect a time period that is technically offset by 6-9 months due to the lagged project initiation as described above.

The remainder of this section of the report details activities at Michigan, Maryland and Virginia in separate sections.

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Statement of Work

Summary

During summer and fall 2012 six main research activities were carried out at Michigan. These were: 1) complete the majority of land-cover classification of a new case study site time series (4 dates) that was proposed to be added in Primorsky in the RFE (will also be an MS thesis), 2) addition of a second site also in Primorsky for which only clear-cuts will be mapped (almost complete), 3) classification of 2010 extension of the Landsat case study sites time series for existing UM case study sites in Irkutsk Krasnoyarsk and Tomsk (first two are now complete), 4) progress on time series GIS data on urban and roads change plus other needed ancillary GIS datasets, 5) collection of socio-economic and forestry statistics for Siberia and for the individual administrative units and completion of MS thesis, and 6) initiation of systems dynamics model planning. These are described in more detail below. Landsat work was carried out under supervision and planning of the project PI, assistance from MI Co-Is, and MI graduate students from the School of Natural Resources & Environment and the Center for Russian and East European Studies. In April the PI put together a talk co-authored by the project team for the 2013 LCLUC meeting and summarizing the aims of the project. The PI and consultant Hitztaler also spent time on the final stages of a paper on the Kamchatka site which has now been published in the NEESPI special issue on Northern Eurasia. A MS thesis was completed on statistical data.

Extension and Synthesis of Landsat Time Series for LCLUC

During Year two we completed most of the classification and work for this core objective for the UMich sites. We did the following: a) completed land-cover classification for the 2010 date for two of our three existing sites (Irkutsk, Krasnoyarsk). The 2010 date will bring the span of most sites from ~1975 up to 2010 at 4-5 time intervals; a) We selected the new "Primorsky" site, did the imagery preprocessing and began classification in summer 2013 with the expectation of completing this site in December 2013; c) We also selected a second Primorsky site and have done limited land-cover data extraction (clearcuts) on that site. A summary of the sites and data is provided in Table 1 below.

Table 1. The set of Landsat case study sites for synthesis, their WRS-2 location, dates of images previous classified and dates of the new augmentation classifications for 2010 plus one additional case site newly classified for all dates.

Site	WRS-2 path/row	Classified Dates	Augmentation Date/s
1.Tomsk: (UMich) westernmost, middle taiga & wetland, much Soviet-era logging, changing logging rates, patterns	P147r20	8-30-1975 9-7-1989 7-9-1999	9-1-2010
2. Krasnoyarsk: (UMich) west-central, middle taiga, much Soviet-era logging, changing logging rates, patterns	p141 r20	6-26-1974 7-7-1990 8-18- 2000	6-19-2010
3. Irkutsk: (UMich) just west of Lake Baikal, mixed/larch forests, changing logging rates, frequent fire.	p132 r 23	6-21-1975 8-21-1989 8-13-2001	8-30-2010
4. Chita: (NELDA) southern taiga, mixed/larch forests, fire, commercial logging, proximity to China border	p129 r 24	8-22-1976 5-28-1992 6-11-2000 8-7-2006	9-3-2010
5. Amur: (NELDA) boarder of Russia/China, southern taiga larch /n. deciduous, commercial logging, fire, different fire regimes from different national policies	p 122 r23	6-15-1987 5-15-2002 7-5-2006	9-2-2010
6. Primorsky South: (new, UMich) diverse temperate/boreal forests on varied topography, proximity to China border	p113r29	N/A (new)	6-30-76 9-09-89 5-29-98 9-21-99 8-31-09
7. Primorsky North: (new, UMich) diverse temperate/boreal forests on varied topography, proximity to China border	P113r28	N/A(new)	6-29-76 6-27-88 6-7-2001 9-12-2010
8. Sikhote-Alin: (NELDA) diverse temperate/middle-taiga forests on varied topography, commercial logging, extensive wildfire, proximity to China border	p111 r25	8-131990 5-18-2002 9-7-2005	9-2-2009
9. Kamchatka: (UMich) central river valley, old-growth larch, logging outpost in Soviet era, possible renewed logging	p99 r 21, p99 r22	7-23-2007	8-18-2000

In pre-processing, work involved importing the images from GLOVIS into ERDAS IMAGINE, followed by calibration and atmospheric correction to surface reflectance. The latter was done two ways, using COST and also ATCORR. DEM data were needed for this so these data were processed. Documentation was created. In some cases more than one scene (only the primary scenes listed above) were needed to “fill” a case study site due to cloud issues; in this case several secondary scenes were processed as well. Scenes were clipped to a consistent study area over the multiple time series dates, and older data were reprojected to that of the 2010 data (UTM, WGS-84)

For image classification we used a hierarchical unsupervised-supervised approach for the new images to be classified. We identified all water and permanently bare features and masked them out of the imagery. We modified a wetland mask as we were only interested in permanent wetland changes, not minor year to year fluctuations due to wetness or dryness of a particular year. We used the urban GIS we created to guide identification and location of small towns and villages scattered over the sites (and difficult to identify only using spectral methods) and to mask these out. We then initiated supervised classification to map the major land-cover classes. using the same classification scheme for existing UMich sites that we used in the past. New accuracy assessment data were created for all UMich sites (all dates for Primorsky and 2010 for the other sites) based on independent interpretation of raw imagery, Google Earth and detailed topographic maps.

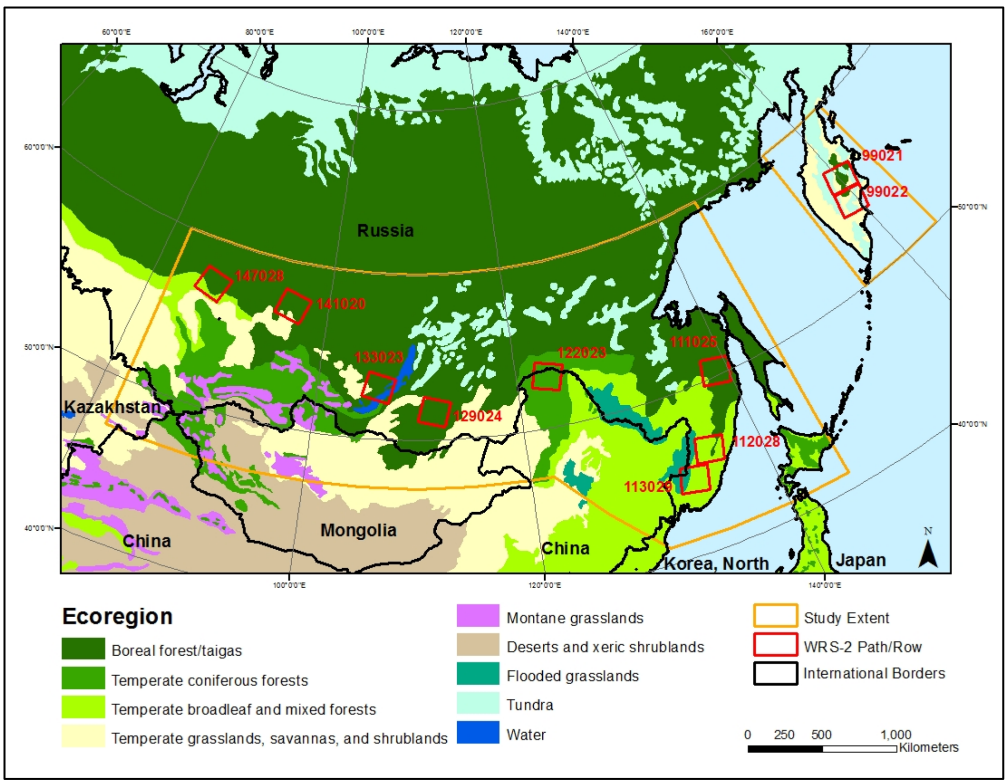


Figure 1. Location of all synthesis Landsat case study sites. Sites and their Landsat path/rows are shown also within the larger MODIS areas of interest.

Table 2. Land cover/land use statistics for UMich time series. Note that Irkutsk 2010 and Primorsky S. all years (shaded columns) are draft figures to date and are currently undergoing further work and revisions prior to completion
.

Land Cover/Land Use									
		Tomsk	Tomsk	Tomsk	Tomsk	Krasnoy.	Krasnoy.	Krasnoy.	Krasnoy.
Class Number	Class Description	1975	1989	1999	2010	1974	1991	2000	2010
1	Conifer Forest	11.73	10.82	10.20		16.70	10.92	8.01	10.34
2	Mixed Forest	31.72	29.04	28.70		41.26	38.89	36.73	32.52
3	Deciduous Forest	13.62	14.32	19.40		3.61	10.95	23.80	26.92
4	Young (Regeneration)	8.85	11.02	11.20		13.06	20.99	8.15	6.55
5	Logged/Cut	4.77	3.30	2.90		5.54	2.81	2.29	1.51
6	Burned	0.07	2.40	0.00		0.76	0.79	0.68	2.76
7	Insect (killed)	0.00	0.00	0.00		0.00	0.38	6.77	7.33
	Total Forest	70.77	70.91	72.40		80.94	85.75	86.44	87.93
8	Wetland	15.51	15.70	15.48		2.12	2.06	2.08	2.37
9	Agriculture	12.40	12.06	10.81		16.61	11.85	11.14	9.34
10	Urban	1.32	1.33	1.31		0.33	0.34	0.34	0.36
11	Bare	0.00	0.00	0.00		0.00	0.00	0.00	0.00
	Total Non-Forest	29.23	29.09	27.60		19.06	14.25	13.56	12.07
	Total	100.00	100.00	100.00		100.00	100.00	100.00	100.00

Land Cover/Land Use									
		Irkutsk	Irkutsk	Irkutsk	Irkutsk	Prim._S	Prim._S	Prim._S	Prim._S
Class Number	Class Description	1975	1989	2001	2010	1976	1989	1999	2009
1	Conifer Forest	19.46	15.77	15.46	23.66	3.19	4.21	2.96	3.19
2	Mixed Forest	29.19	31.25	25.43	23.20	54.31	53.25	56.64	51.93
3	Deciduous Forest	7.75	8.23	11.87	7.34	7.46	2.87	4.93	6.40
4	Young (Regeneration)	1.39	1.39	1.50	3.12	0.06	0.98	0.91	1.19
5	Logged/Cut	0.79	2.28	0.60	0.45	0.48	0.64	0.12	0.30
6	Burned	0.18	0.32	2.53	6.85	0.00	0.00	0.00	0.00
7	Insect (killed)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total Forest	58.76	59.25	57.37	64.62	65.50	61.95	65.56	63.01
8	Wetland	19.69	18.80	23.62	14.01	14.25	14.62	11.36	14.69
9	Agriculture	15.16	15.33	13.05	17.01	18.57	21.55	21.33	20.51
10	Urban	0.44	0.63	0.40	0.30	1.68	1.88	1.75	1.79
11	Bare	5.95	6.00	5.55	4.06	0.00	0.00	0.00	0.00
	Total Non-Forest	41.24	40.75	42.63	35.38	34.50	38.05	34.44	36.99
	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

We initiated discussion with UMD and OSU on how to bring our respective datasets into congruence and in particular to meet the needs of systems modeling component of the project. That component is focused on land-use, especially logging activity and so clear-cuts and regeneration will be land-cover classes of particularly high interest.

Table 3. Land-Cover/Land-Use classification scheme for Landsat data.

Category Number	**Landsat Class**	**Forest and Land-cover/Land-use**
1	Conifer	Spruce/fir forest, upland Spruce/fir/Scots pine forest, lowland Siberian pine forests Scots pine or Scots pine-larch forests Korean pine Other high altitude conifer forests
2	Mixed	Mixed pine-birch/aspen forests Mixed pine-larch-deciduous forests Mixed spruce/fir/oak forests
3	Deciduous	Deciduous forests Birch-aspen (usually early successional)
4	Young	Post-cut or post-fire with deciduous or conifer regeneration Regeneration from agriculture
5	Cut	Fresh cuts
6	Burn	Fresh fire scars
7	Insect	Insect infestation
8	Wetland	Wetlands, flood-lands Bog
9	Agriculture	Agriculture (crops, hay, pasture, meadow)
10	Urban	Built-up areas
11	Bare	Bare ground
12	Water	Water

Customization of GIS Urban and Roads Time Series for LCLUC

We have initiated several GIS datasets. Some (DEM) are needed for image processing. There are several GIS themes that are central to the LCLUC trends we expect to synthesize and which are also needed for mapping and/or modeling (e.g. roads and urban areas). Others will help support a number of purposes. For mapping urban sites we imported all of the Russian topographic maps and digitized the urban locations to polygons, classifying them by size. We expect these represent the situation mostly in the 1970s-1980s. We then updated them to what was observed on later images. We did not expect to see much change, but were interested to confirm that expectation. This layer is also aiding image classification. Some statistics for four sites are listed below in Table 2. Urban data has been shared with UMD/OSU for purposes of aiding their Landsat classification refinements and updating.

Currently we are also completing the same procedure for roads: initial digitization from topographic maps, classification of different road types, and then updating the roads to represent later eras via comparison with the Landsat data.

Table 4. Extent of urban areas at four dates in one site (Irkutsk) in E. Siberia. These statistics are typical of our case study sites. Urban areas in the Landsat case sites are primarily small towns/villages.

Study site	Irkutsk				
Years	1975	1990	2000	2010	Number of urban area
Area of large cities (111)	0	0	0	0	0
Area of small cities (112)	0	0	0	0	0
Area of towns (113)	11.476643	11.47664	11.476643	11.476643	1
Area of villages (114)	269.2049	271.1865	275.35253	277.52839	156
Total area in km2/number	280.681543	282.6631	286.82917	289.00503	157

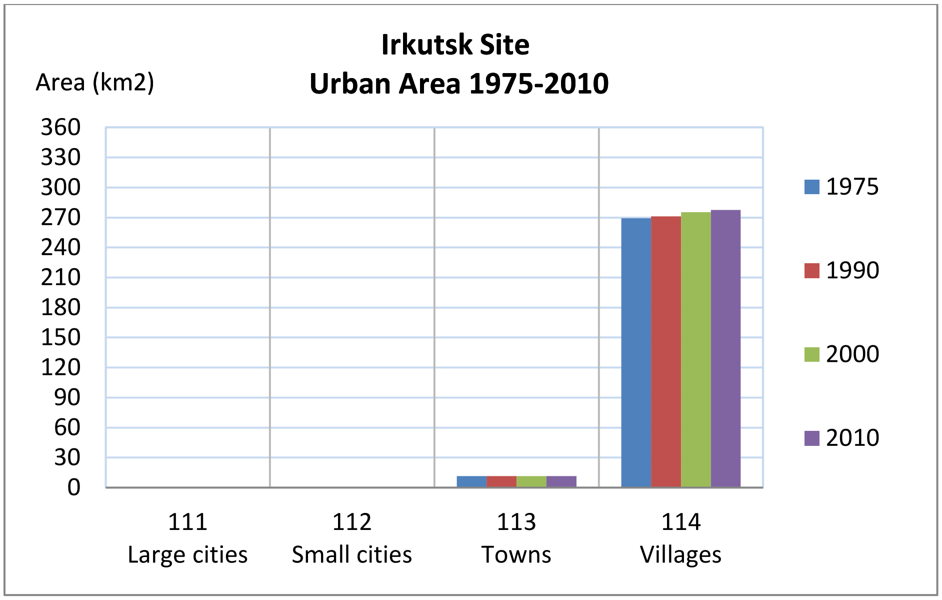


Figure 2. Irkustk site urban data in graph forma.

Collection and Analysis of Statistics Time Series for RFE administrative units for input to Model

One project aim for this sub-objective is to assemble statistical data on socio-economic variables deemed to be important. This has two purposes: 1) to compare with Landsat case study site LCLUC trends, and 2) for eventual use in a systems model. Towards this end we have collected data for each administrative unit in which our case sites fall and also for Russia as a whole, wherever possible. We discussed variables of interest at a level likely to be reported, and have been able to locate data for most and over timeframes either from 1975-present or from 1990-

present, depending on availability. A number of considerations make this complex – different reporting groups, changing definitions over the years, inconsistent statistical surveys, etc. We have also identified a set of data for which we will need some assistance from our Russian partners. Figure 3 shows a selection of two variables for which time series were collected and plotted.

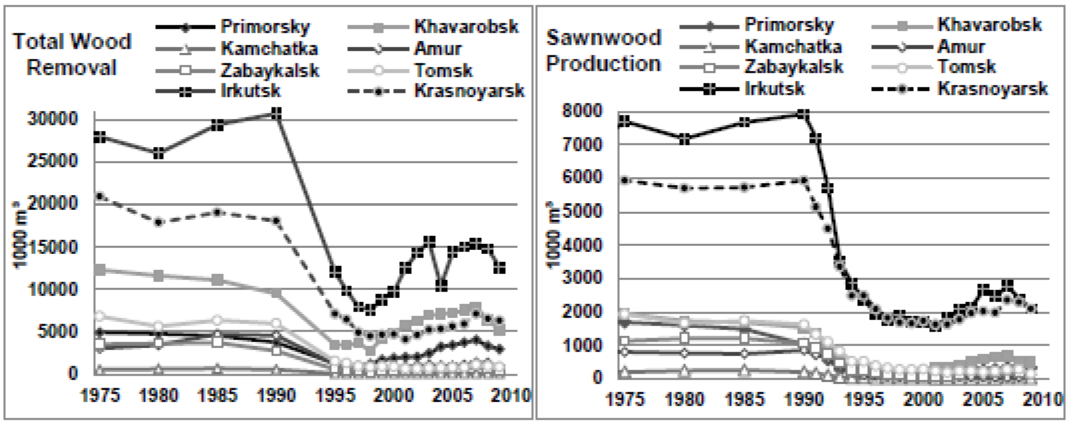


Figure 4-1. Timber industry metrics of total wood removal and sawnwood production in the study sites 1975-2009.

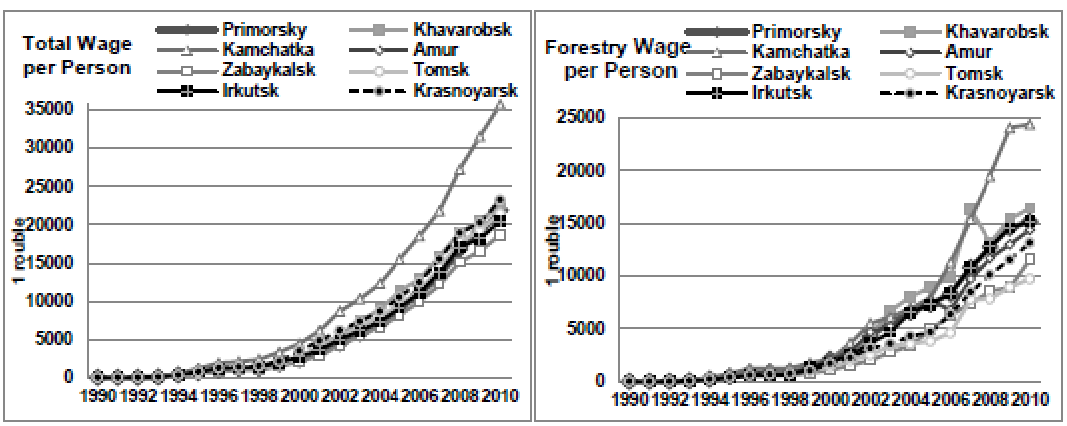


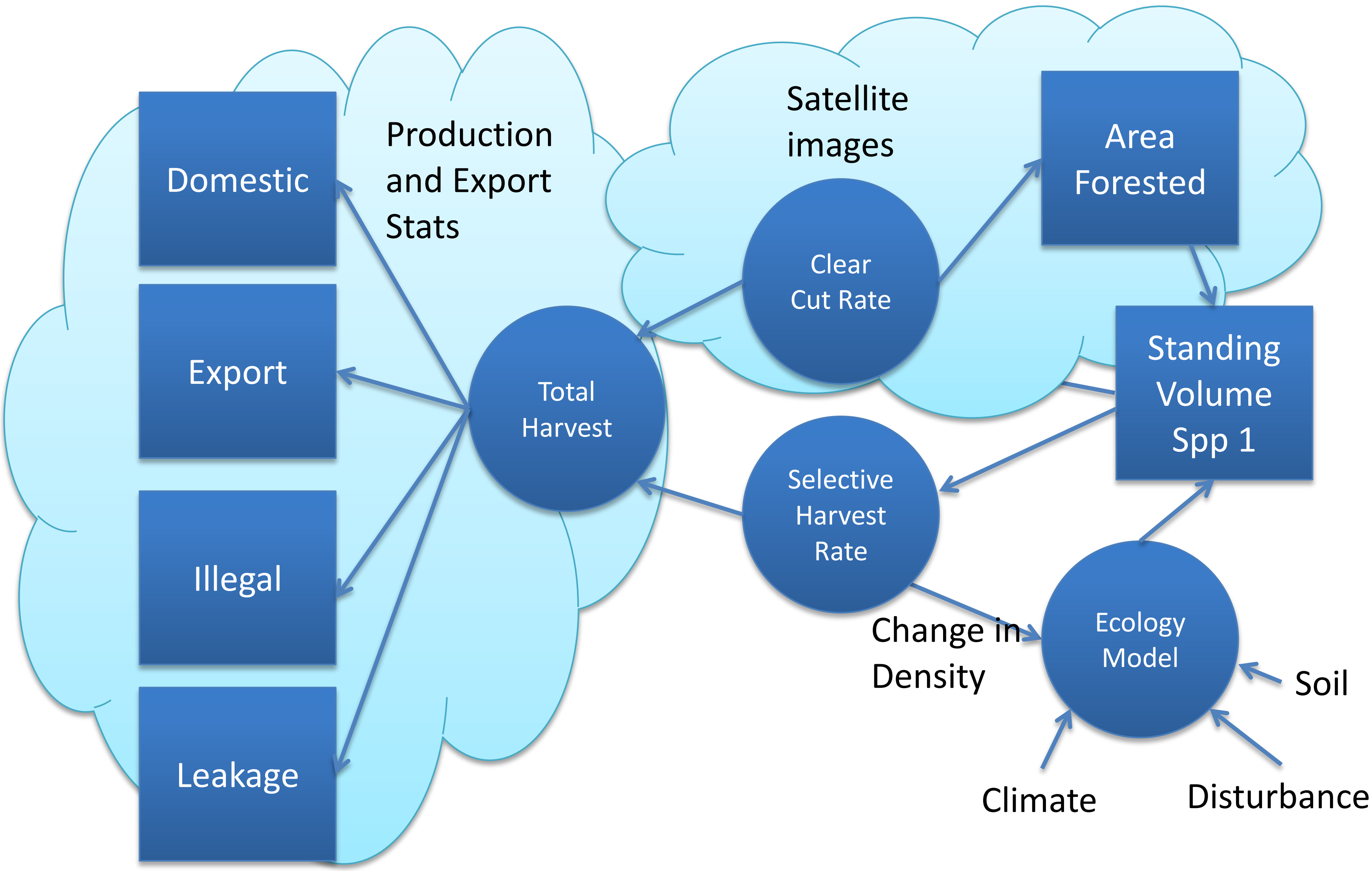
Figure 4-5. Metrics of total wage and forestry wage in the study sites 1990-2009.

Figure 3. Two selections of compiled time series data for study region.
(Source: Park, examples from Kwangkeun, MS Thesis 2012, University of Michigan

In addition, Co-I Newell is currently collecting and processing data on export and customs related to trees/harvest for RFE, particularly Primorsky.

Initiation of systems modeling planning

We have begun discussions toward developing the systems modeling component of the project. The following is a diagram of the initial synthesis conceptual model. Figure 3. Draft conceptual model.



Project publications and presentations

Publications

Hitztaler, S. and K. Bergen. 2013. Mapping Resource Use over a Russian Landscape: An Integrated Look at Harvesting of a Non-Timber Forest Product in Central Kamchatka. Environmental Research Letters, 8: 045020.

Bergen, K., Hitztaler, S., Kharuk, S., Krankina, O., Loboda, T., Zhao, T., Shugart, H., Sun, G. 2012. Human Dimensions of Environmental Change in Siberia. Chapter 7 in G. Gutman and P. Groisman, editors, Regional Environmental Changes in Siberia and Their Global Consequences. New York, Springer. 357 pp.

Groisman, P. Y. G., Garik. Shvidenko, Anatoly Z. Bergen, Kathleen M. Baklanov, Alexander A. Stackhouse Jr., Paul W. 2013. Introduction: Regional Features of Siberia. In G. Gutman and P. Groisman, eds, Regional Environmental Changes in Siberia and Their Global Consequences. New York, Springer, 1-18 pp.

Gutman, G. G., Pavel Ya. Gordov, Evgeny P. Shiklomanov, Alexander I. Shiklomanov, Nikolay I. Shvidenko, Anatoly Z. Bergen, Kathleen M. Baklanov, Alexander A. 2013. Summary and Outstanding Scientific Challenges for Research of Environmental Changes in Siberia. In G. Gutman and P. Groisman, eds, Regional Environmental Changes in Siberia and Their Global Consequences. New York, Springer, pp. 347-354.

Presentations

Bergen, K., Loboda, T., Shugart, H. Sun, G., Newell, J., Brown, D., Shuman, J., Krankina, O., Hitztaler, S. LCLUC SYNTHESIS: Forested Land Cover and Land Use Change in the Far East of the Northern Eurasia Under the Combined Drivers of Climate and Socio-Economic Transformation. Invited Featured Presentation: NASA Land-Cover/Land-Use Change Program annual meeting, Rockville, MD, 2013.

Bergen, K., Kharuk, V., Loboda, T., Shugart, H. Sun, G., Newell, J., Brown, D., Shuman, J., Krankina, O., Hitztaler, S. *Poster*. LCLUC SYNTHESIS: Forested Land Cover and Land Use Change in the Far East of the Northern Eurasia Under the Combined Drivers of Climate and Socio-Economic Transformation. NASA Land-Cover/Land-Use Change Program annual meeting, Rockville, MD, 2012.

Work schedule

The 2013 – 2014 and to end of project activities will be aligned with the overall project timeline and will focus in the following areas:

- January – May 2014: Complete the mapping and accuracy assessment of the UMich and Primorsky Landsat 2010 scenes to extend existing time series. Complete GIS analysis of urban and roads. Complete statistical time series and analysis for important variables. Complete time series validation and correction.
- January 2014 – August 2014: Work with UMD (who will be completing their extension of Landsat-based assessments of the land cover change at previously identified sites) to ensure comparability of results.
- January 2014 – end of project: Develop and implement systems model. Work with project collaborators to integrate remote sensing and statistical results into modeling frameworks.
- October 2014 – end of project: Finalize project results, prepare and submit manuscripts to peer-reviewed journals.

Annual Report for Year 2
Dcember, 2012 – November, 2013
NASA Land Cover and Land Use Program
Funded under grant NNX10AF41G:

LCLUC Synthesis: Forested land cover and land use change in the Far East of Northern Eurasia under the combined drivers of climate and socio-economic transformation

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Statement of Work

During the second year the UMD team focused on two major activities. First, we introduced major modifications to the past disturbance mapping project with specific focused improvements in Eastern Siberia and the Far East. Second, we extended Landsat classifications for our NELDA sites (2 completed and 1 in progress) to update land cover change to the 2010 era. In addition, we continued our collaboration with the project participants in developing approaches for merging the remote sensing and forest modeling components and discussion on an overall modeling framework for socio-economic assessment.

Reconstruction of past disturbance history in the RFE from the present-day MODIS record

In year 2 we made major improvements to the MODIS-based disturbance record dataset. First, we have increased the density and amount of Landsat training data particularly in Siberia and the Russian Far East (Figure 1). The majority of dense stacks in the training set were developed in the previous year, however, our initial accuracy assessment and validation indicated that additional training data, particularly for Eastern Siberia, is critical to improve the performance of the algorithm. Overall we have produced a Landsat-based disturbance training dataset for 49 Landsat image stacks picking out nearly all

Figure 1. Distribution of training and validation Landsat data stack across Russian forests. D denotes “dense” stacks of Landsat imagery (> 3), and S denotes “sparse” stack (<= 3).

available multi-year Landsat images for Eastern Siberia. In addition, a disturbance record from complete Landsat records for the area south of Khabarovsky and Primorsky Krais, developed during previous efforts, was added to train the MODIS-based tree classifier. Figure 2 shows the beta version of the stand age distribution product which is currently undergoing accuracy assessment and fine-tuning. Our initial assessment using the Landsat-based NELDA sites shows a notable improvement in product accuracy in Eastern Siberia.

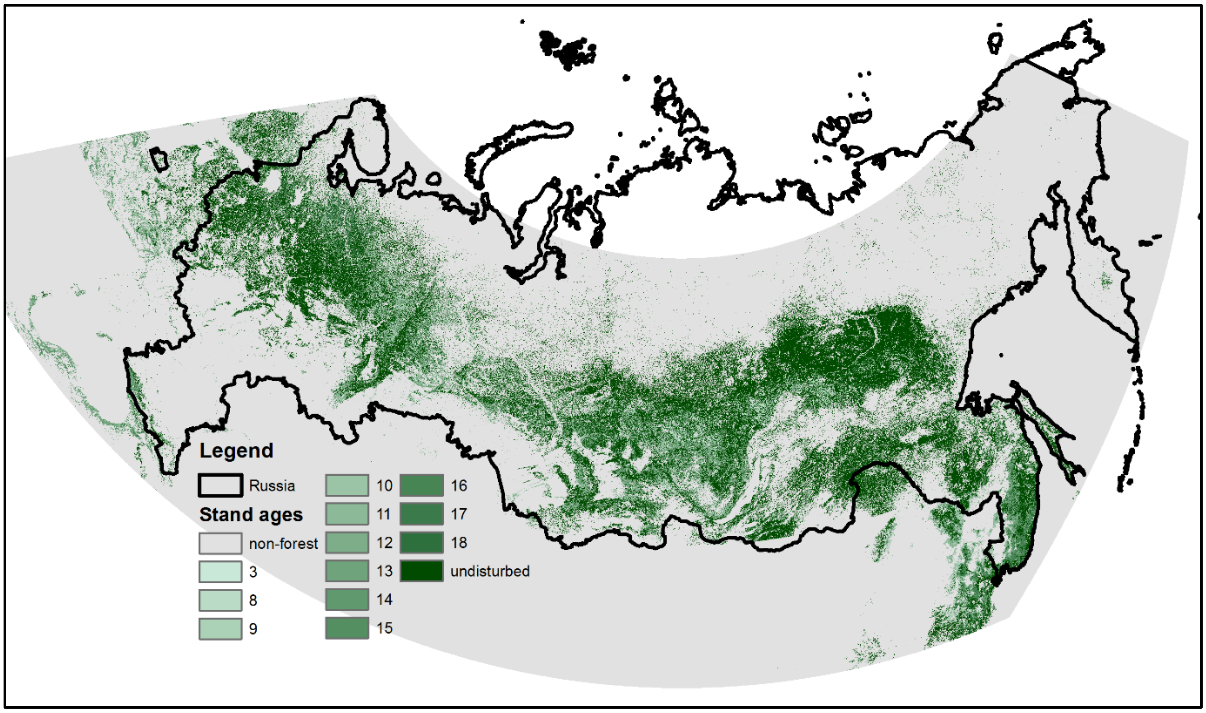


Figure 2. Stand-age distribution for year 2001 (beta version)

We intend to release the Landsat-based disturbance training dataset to the broader scientific community and are currently preparing a manuscript describing the methodology and product accuracy. A MODIS-based product will also be released after it undergoes a complete accuracy assessment. We will include all NELDA and other Landsat-based assessments used within this project in combination with historical forestry records to provide the validation datasets for the stand age distribution map. We aim to make both products available though the Oak Ridge DAAC.

Landsat-based mapping of land cover and land cover change at selected sites

Our second major priority for year 2 was in extending the Landsat-based land cover record in three of our previously existing NELDA sites. Land cover mapping for two of the three sites has been completed to 2010. These sites are currently undergoing accuracy assessment. Figure 3 shows the land cover mapping differences between 2000 and 2010 in the Chita site (NELDA). The results show transition of mixed forests to more mature larch-dominated stands as well as overall recovery of past burns. The extreme fires of 2003, however, did not leave a long-lasting impact on the Chita forests. While very large, 2003 fires occurred in late May and thus primarily were limited to low intensity surface fires. These fires did not cause notable mortality in mature forests and thus their impact is not noticeable in the 2010 classification.

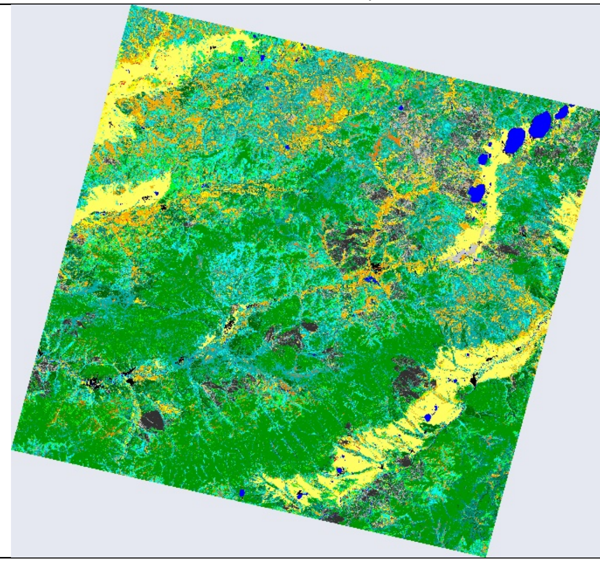
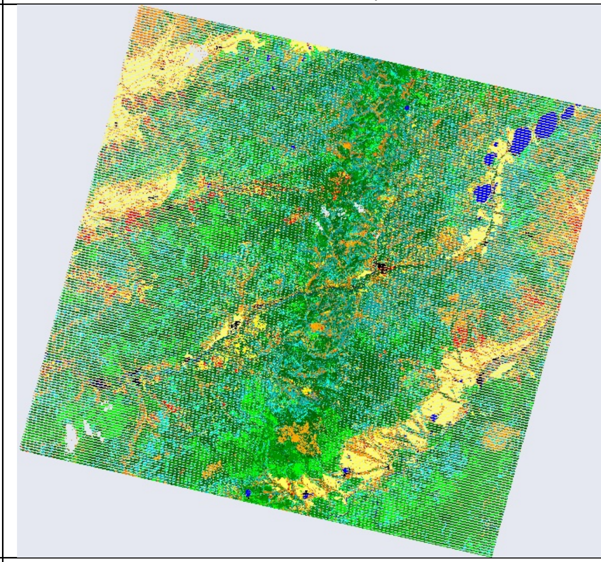
Percent Cover	**Chita** June 11, 2000 	**Chita** June 23, 2010 
Tree.needleleaf.deciduous.closed	5.31 %	24.33 %
Tree.needleleaf.deciduous.open	6.76 %	7.83 %
Tree.mixed.closed	25.81 %	16.43 %
Tree.mixed.open	17.28 %	10.50 %
Tree.broadleaf.deciduous.closed	5.47 %	6.41 %
Tree.broadleaf.deciduous.open	9.18 %	7.88 %
Total	69.81 %	73.38 %

Figure 3. NELDA Chita site land cover classifications and tree-dominated land cover proportions for 2000 and 2010.

We have identified a Landsat 8 scene to complete the Sikhote-Alin site. Our next priority is to extract disturbance categories from the full lengths of the NELDA Landsat stack records to match the needs of the project and allow for cross comparison of all Landsat-based forest change estimates.

Project publications and presentations:

Presentations (includes all presentations to date):

Chen D, Loboda TV, Hall A, Channan S, Weber CY (2013). Mapping stand-age distribution of Russian forests from satellite data. *Poster presentation* at the Fall meeting of the American Geophysical Union, December 2013, San Francisco, CA, USA.

Loboda TV, Chen D, Hight-Harf C (2012) Reconstructing a 40-year record of forest disturbance in Russia from contemporary satellite data. *Invited oral presentation* at the Fall meeting of the American Geophysical Union, December 2012, San Francisco, CA, USA.

Loboda TV, Hight-Harf C, French NHF (2012) Modeling risk of ignition as a function of landscape and human presence using satellite observations. *Oral presentation* at the Fall meeting of the American Geophysical Union, December 2012, San Francisco, CA, USA

Chen D, Loboda TV (2012). A decision-tree-based method for reconstructing disturbance history in the Russia boreal forests over 30 years. *Poster presentation* at the Fall meeting of the American Geophysical Union, December 2012, San Francisco, CA, USA.

Publications:

Chen D, Loboda TV, Hall A, Channan S (in preparation). Landsat-based forest disturbance sample dataset for boreal Russia. Intended for *Remote Sensing*.

Work schedule for year 3:

The 2013 - 2014 project activities will be aligned with the overall project timeline and will focus in the following areas:

- January – March 2014: Complete the mapping and accuracy assessment of the MODIS disturbance record and deliver the stand age distribution product to UVA for integration into the modeling of carbon stocks.
- January – June 2014: Complete Landsat-based assessments of the land cover change at all previously identified sites (Sikhote-Alin). Add identification of logging, burning, and agriculture classes to Landsat scheme to enable consistent assessment across NELDA and non-NELDA classification legends.
- May – September: preparation of MODIS- and Landsat-based disturbance datasets for delivery to the Oak Ridge DAAC including dataset formatting and development of accompanying user guides and metadata.
- June – December 2014: work with project collaborators to integrate remote sensing results into modeling frameworks and analyze the impact of climate change and socio-economic drivers on forest composition.
- July 2013 – December 2014: Finalize project results, prepare and submit manuscripts to peer-reviewed journals.

ANNUAL REPORT – J.K. Shuman and H.H. Shugart

Proposal Title: LCLUC SYNTHESIS: FORESTED LAND COVER AND LAND USE CHANGE IN THE FAR EAST OF NORTHERN EURASIA UNDER THE COMBINED DRIVERS OF CLIMATE AND SOCIO-ECONOMIC TRANSFORMATION

PI: Kathleen Bergen

Statement of Work

Forest age structure and disturbance
Disturbance reconstruction data will be provided by UMd for incorporation into the forest model at UVA. This disturbance data acts as an age correction factor which can be used to more accurately describe the successional state of the forest. UVAFME (UVA Forest Model Enhanced) simulates a mixed age forest, but inventory or disturbance data must be used to accurately classify each location according to time since last disturbance. UMd calculates stand age based on date since last disturbance which is then used to classify the age and forest composition according to the age since stand initiation in UVAFME. Inventory and simulated forest biomass data has been used to obtain regional carbon storage pools across Russia. Methods for incorporation of stand age as calculated by disturbance will be similar, but provide historical record at a detailed spatial resolution. The combination of detailed disturbance and stand age data provides a real time correction to the simulated forest output which can then be used in future projections evaluating land-cover response to future climate scenarios.

Connection between Forest model and Markov model
UVAFME (UVA Forest Model Enhanced) output will be post-processed for grouping according to forest state transitions for incorporation into the Markov model for synthesis of data from UMich, UVA, and UMd. UVAFME output has been adapted to allow grouping at the species or genus level. Using forest land-cover/land-use classifications, as defined by Bergen *et al.* (2008), UVAFME output is grouped according to these classifications to obtain forest state transition probabilities. UMich, UMd, and UVA participated in a conference call which continued discussion for the design and necessary elements of the synthesis model.

Project publications and presentations
Publications
Shuman JK, H H Shugart and O.N. Krankina. (2013). Assessment of carbon stores in tree biomass for two management scenarios in Russia. *Environmental Research Letters* **8** 045019 doi:10.1088/1748-9326/8/4/045019

Shuman JK, H H Shugart and O.N. Krankina. (in press). Testing Individual-based models of Forest Dynamics: Issues and an Example from the Boreal Forests of Russia. *Ecological Modelling*

Presentations
Shuman JK, K.A. Holcomb and H.H. Shugart October 2013 "Forest forecasting with an individual based model: examples from the boreal forests of Russia" International Boreal Forest Research Association, Natural Resources Canada, Edmonton, Alberta, Canada