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PROJECT STATUS REPORT

Dynamic Forest Modeling Simulations of Russian Boreal Forests under Climate Change Conditions for Ecological, Geochemical, and Economic Analyses

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I. PROJECT INFORMATION

Progress to date with respect to proposed methodology

There has been significant progress with respect to the project entitled "Dynamic Forest Modeling simulations of Russian boreal forests under climate change". The Russian team, led by Dr. Isaev and Dr. Ershov, collected the necessary input variables needed to drive the FAREAST simulator for all areas throughout the federated territory of Russia. These variables included detailed soil information, hydrological parameters such as bulk drainage and porosity, slope and aspect information, as well as the elevation in meters. This data was formatted into grid cells of 20 by 20 kilometers and arranged in a geographic information systems database which was then used to generate over 23,000 different sites where FAREAST could be run. Climatic information was generated by taking data from 60 years of records from 223 weather stations across Russia and interpolating the results across the landscape. This interpolation procedure was performed by the Russian team in their GIS laboratory and the information was transferred electronically to the U.S. team. This information was also folded into site creation.

In addition to the creation of over 23,000 sites, detailed species range maps were integrated into each site. This information was taken from historically documented ranges of tree species. Range maps were necessary to constrain the results of the model such that species were restricted to their current locations. Precursory analysis showed tree species from southeastern Russia present in Northwestern siberia (particularly Betula ermanii), however, with the advent of species range maps, these issues were resolved and the results from each site only generated forest types that follow natural distributions. Range map construction was performed by the U.S. team.

Each site was run under climate patterns generated by the data from Russian weather stations. All 23,000 sites were run for a period of 300 years amongst the computers of the CRES network. This process required over 380 hours of computer processing time and generated a significant amount of model data. The model output was tested against biomass data for the Russian territory. The Russian CFEP team provided biomass, leaf area index, and classified land use data for these tests. This validation dataset was generated empirically from a combination of remote sensing and field sampling by the Russian team. Analyses of these results required data to be managed by database and GIS software as well as statistical processing in the SAS programming interface. Statistical analysis of the correlation between the model runs and remotely sensed data is nearly complete. The U.S. has completed its validation exercises while the Russian team is currently generating its final validation report.

The IGBP western Siberia transect which divides central Siberia was modeled under both normal and warmer climate conditions. Contrary to proposed methodologies, a 4°C increase to normal conditions was used to represent climate change conditions. This step was taken due to problems arising from the correct importation of PCMDI climate data as well as the desire to have prescribed temperature changes for sensitivity analyses. These runs simulated over 1800 different sites amongst the transect. Upon completion, canonical discriminant analysis was used to examine the future state resiliency to composition changes. In particular, the analysis attempted to determine if the leading edge, interior, or trailing edge of the Siberian boreal forest was most likely to transition into another forest cover type given significant warming.

Developments and Accomplishments:

To date, the U.S. team has constructed two detailed statistical analyses and reports of forest model output generated by this project. The first paper, entitled "Continental Scale Application of a Russian Forest Gap Model: Modeling Russian Temperate and Boreal Forests" is undergoing final editing and will be submitted to the journal Global Change Biology. This paper details the validation of FAREAST on a continental scale and notes the high regression statistics between its output and remotely sensed validation data. In this paper, analyses by the U.S. team found that for forests with a leaf area index greater than 3 (considered older-growth forests), the r^2 between the model runs and validation data across Russia was 0.781, which increased to 0.8721 when outliers were removed.

The Russia team's analysis suggested a more conservative r^2 of over 0.6 for several different forest types. Together, these analyses, while slightly different in methodology, suggest a rigorous validation experiment for FAREAST testing and imply that FAREAST is a capable and competent forest model, able to routinely generate acceptable forest simulation data for the Russian Federation.

The second paper, yet untitled, is in draft format and will be submitted to a scientific journal by the end of the calendar year. This paper documents the discriminant function analysis of model runs under climate change conditions and makes suggestions as to forest composition shifts in Siberia. Specifically, this paper documents how the leading edge of northern Boreal forests are particularly resilient to community composition shift, that community composition shifts in the interior of the forests do not occur until 100 years of a warming climate occurs and the stand undergoes a disturbance, and that it is unlikely that we will see changes in community composition in intact boreal forests for at least 25 years and likely for another 50 years until these stands breakdown. These two research articles will hopefully be accepted into the scientific literature. In addition to the contribution to the scientific literature, this project has also created output data for 23,000 sites across Russia and projections of forests throughout Siberia under varying climate conditions. The ability exists to test a wide range of climate conditions if the need arises.

Problems:

The major problems encountered through this project dealt with integrating PCMDI output into the site creation framework such that FAREAST could run sites populated with PCMDI climate data. In response, the team decided to use idealized and uniform increases in temperature to normal climate and precipitation information. This decision was seen as ideal in that it would provide more generalized results which could be used to show basic trends in forest cover and would be more applicable than a narrowly defined climate data set. Another problem was the modification of disturbance within the framework of the FAREAST model. Firstly, the dedicated student in the U.S. lab designated to integrate the bug model did not fulfill his obligations to the laboratory team. Secondly, computer technical support was lost due to the lack of appropriate laboratory funds necessary to hold the position. As such, disturbance was eliminated from the context of the model functioning and instead, the investigations mainly examined direct responses of ecological communities to climate change. Timber is in the process of being incorporated to the project, albeit in the form of a separate and independent economic model, so economic analysis will still exist in the final report of this project. Finally, in contrast to U.S. testing, the Russian CFEP team indicates that the relationship between FAREAST output and remote sensing data suggests that FAREAST needs adjustment to properly model biomass in a few forest type classes.

Future Plans:

Two significant studies are being constructed and will be completed by early in the next calendar year of 2011. Firstly, Mr. Lutz of the U.S. team is working with Dr. Mark White at the Macintire School of Commerce to integrate FAREAST model output into a carbon and timber harvest economic model. This model examines the economic trade-offs between different intensities of forest land use, between timber harvest and carbon sequestration for forestry carbon credit opportunities. This economic model has been used in the U.S. states of New Hampshire and Virginia, and its forest parameters will be driven by FAREAST output throughout Russia. In particular, the U.S. team will investigate the potential changes in economic returns for forest land owners in Siberia in different scenarios of warming.

Additionally, the U.S. team has recompiled the FAREAST model to generate climate runs with different episodic starting points in a forest's life cycle. These runs will be used to examine the effects of climate change on forests of different ages. While previous examinations of the effect of climate change looked at the response of bare ground areas and post-disturbance ecosystems for the effect of a warming climate, this study will suggest the fate of older and mature forests under different climate scenarios. The goal is to determine the break points where forests of specific ages will be vulnerable to stand replacement by other species. This kind of study will be applicable to forests of Russia and will give Russian land owners the ability to see the changes that may occur in their lands given the current species composition and the relative stand age of their plots. The results of this study will also be important for managers of biodiversity whom wish to know how species composition may change in mature stands in order to effectively preserve appropriate areas or manage forests for future species ranges.

Expenditures and Forecasted Budget:

David Lutz, member of the U.S. team, has received a stipend for his participation in this project. Of the budgeted funds, Mr. Lutz has received $10,010. The remaining $5990 will be awarded as a stipend through December, 2010. For the Russian CEPF team, Drs. A. Isaev and Yershov have logged 40 days of effort, while Dr. E. Sochilova has logged 30 days of effort. The Russian CEPF team have not received money from the CRDF for this reporting period.