**2.A. PRAGMA Biodiversity Expedition and Trust Envelopes**

The PRAGMA Biodiversity Expedition is designed to address compelling biology science questions related to the distribution of and adaptation to extreme environments. Mount Kinabalu (4095 m), in Sabah, Malaysia, is a biodiversity rich, yet extreme environment located in the northern part of Borneo. The mountain is marked by numerous ultramafic (serpentine) outcrops where the soil and substrates are high in iron, magnesium, nickel, and other metals, which creates an environment that is toxic to many plant and animal species. Studying biodiversity on Mount Kinabalu allows researchers to tackle what has been a broad scientific challenge –understanding how plants, animals, and microbes adapt to extreme environments, a changing climate, and toxic conditions. This year, the Biodiversity Expedition continued to address the technical issues posed by data and application-sharing among collaborators, began acquiring satellite imaginary from Mount. Kinabalu, and engaged a broader group of researchers in a dialogue about cyberinfrastructure in biodiversity research.

How do you share data and other elements of cyberinfrastructure with a virtual community when there are limitations or bottlenecks in moving the data? Such roadblocks might include sensitive data, licensing, and national and international restrictions limiting data distribution). PRAGMA Biodiversity Expedition members are collaborating with the PRAGMA’s Resource Working Group to examine and address some of these issues. A network trust envelope is one solution that increases data access security, facilitates data and software access across network firewalls, and provides a mechanism where those within the network have the same access to data, software, and other resources, even though they may be at distant nodes.

Over the last year, PRAGMA collaborators have focused on virtualizing the Lifemapper software application and cluster environment, developed by the KU Biodiversity Institute. This environment is used to model and predict the spatial distribution of species based on known occurrences of organisms, environmental data, and satellite imagery. The expedition extended Lifemapper’s computational ability from serving a dedicated cluster to enabling deployment on any high-performance computing platform. In addition to making computation more efficient and portable, the collaborators have expanded provenance information generated by Lifemapper and the compute environment and have used the Karma Provenance Tool from IU to more fully document the remote compute process.

The expedition team has completed an effort to port the extended application to a virtual environment and tested quick-and-easy spin-ups of the virtual cluster in the U.S. and Japan. These virtual clusters now join computational provenance information (e.g., hardware, software, time, error and other information) with experiment metadata (e.g., inputs, outputs, and processes for the simulations) to further document biodiversity research and enable scientific accountability. Our new ability to move the entire compute cluster to big geospatial data sets within a trust envelope (documenting processes along the way) is a big win. These efforts will allow collaborators greater ease in sharing information and resources in a controlled environment, which is essential for certain studies. Moreover, the provenance information will allow researchers to easily reconstruct the steps of a computational experiment.

In a parallel effort to build the data set, the Biodiversity Expedition team and its partners are working with recently acquired satellite imagery of ultramafic areas on Mount Kinabalu. The new acquisitions include partial scenes from two commercial satellite platforms, QuickBird and WorldView-2. The QuickBird imagery (Fig. X1) provides a high-resolution, 60 cm panchromatic (a single grayscale pixel represents ca. 60cm x 60cm on the ground) and four bands of 2 m data. In addition, two recently captured (June 2013) WorldView 2 scenes provide small, but cloud-free views of key areas of interest with eight multispectral bands at 2 m resolution. (Cloud free satellite data is notoriously difficult to obtain in the tropics.)

With these data, ultramafic vegetation and individual tree crowns are visible using a false color composite. Trees on ultramafic outcrops often have stunted growth forms, and these differences in canopy texture are readily detected with high resolution imagery. The team is employing quantitative analytical methods using Lifemapper, eCognition, and other GIS and remote sensing software –

along with plant specimen and ecological plot data – to model species distributions, as well as organism and ecosystem characteristics. These data will be linked to environmental factors, including elevation, climate, and soil chemistry. This represents an initial effort to build a body of biodiversity knowledge in a global biodiversity hotspot through detailed analysis of which plants grow where, particularly those that are able to adapt to extreme conditions. Ultimately, we wish to know how and why some species are able to adapt and evolve over time, leading to a better understanding of multiple species, genetics, and ecosystem conservation, as well as potential societal benefits.

Finally, the PRAGMA Biodiversity Expedition is building out its network of collaborators and partners. The mini-PRAGMA, hosted by the University of Indonesia in June 2013, included a one-day workshop on biodiversity research in Southeast Asia (see *Community Building*). The timing and location of the mini-PRAGMA also afforded a small group of PRAGMA members (Fig. X2) to travel to Mount Kinabalu, where they met with Sabah Parks representatives and local scientists to develop plans for further collaboration. In June 2014, Sabah Parks will host the International Conference of Serpentine Ecologists, and we are developing a plan for another mini-PRAGMA as a Special Symposium of the conference.

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