Response to the NEON RFI

TITLE: Priest River Experimental Forest, the Northern Rocky Mountain core wildland site (Domain 12)

1. Submitting Domain: **Northern Rocky Mountain (Domain 12) (NoRMEO)**
2. RFI Response: **Core Wild land Site**
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1. Summary

Name(s) of the NEON domain represented:
Domain 12 or Northern Rocky Mountain Ecological Observatory (NoRMEO).
http://www.normeo.org/

The Northern Rocky Mountain Domain is among the most diverse in the United States, ranging in climate from maritime-influenced to continental, and in vegetation from seasonally dry coniferous forests to alpine meadows. It is also an area of rapid urban expansion, which directly impacts wildland areas. The challenge for NEON will be selecting a core site that is most representative of the climate, vegetation, and urban-wildland interactions in the entire domain. We offer to NEON the Priest River Experimental Forest (PREF) as the most representative site by each of these criteria in Domain 12. The PREF (N 48˚, 21', 06.341", Longitude: W 116˚, 50', 22.982") is located on the western slope of the Rocky Mountains in northern Idaho. *It is the only potential site in the Domain that contains forest communities dominated by each of the major tree species in the Domain.* This unique diversity is due to the elevation gradient, from 671 to 1798 m, and because the climate is intermediate between the two extremes in the region, maritime and continental. The area is also adjacent to an urban area that is among the fastest-growing in the Nation.

Critical to the western United States is the vulnerability of water resources for urban and agricultural areas. The snowpack is representative of the Domain because it is "at risk" (*sensu* Nolin and Daly, 2006). The forest receives substantial snow accumulations, but the snow is maintained at temperatures close to 0ºC. As a consequence, a relatively small change in temperature will melt snowpack at low elevations and significantly shorten the duration of snow cover at high elevations (Fig. 1). This susceptibility to climate change makes PREF an ideal candidate for the Continental Climate and Connectivity RFI's. The snowpack is a major driver of ecosystem function in these systems because summer rainfall is so rare. Snowmelt represents the primary mechanism of soil recharge in headwater ecosystems and the primary source of runoff for headwater streams. The relation between snowpack dynamics and runoff provides a key example of connectivity between snow in wildland areas and the water available for human use in downstream urban and agricultural areas of more arid, neighboring domains.

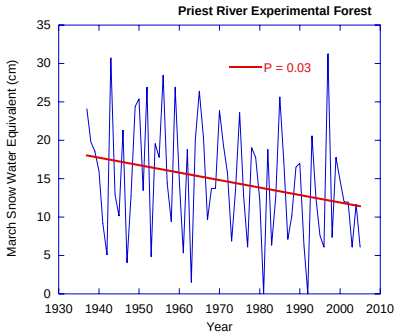

Figure 1. Long-term snow water equivalent data at Priest River Experimental Forest.

PREF has a long history of research directly related to the objectives of NEON. Continuous long-term records are available for weather (1911-current), snowpack (1937-current), tree growth (1914-current) and nearly continuous records for streamflow since 1938. The forest has been the site of long-term research on fire, hydrology, forest ecosystem ecology, and ecosystem processes. PREF has the infrastructure needed for a NEON Core Site, including a residential site with line power, office, lab, conference rooms, and excellent roads. There are two proposed sites for eddy flux. PREF contains two Research Natural Areas that can serve as controls for manipulative experiments. It is in close proximity to Spokane International Airport, the largest airport between Minneapolis and Seattle. For more details and pictures of PREF: http://forest.moscowfsl.wsu.edu/ef/pref/

In summary, PREF presents an extraordinary package: research and housing facilities, long-term datasets, easy access, recent research on NEON issues, the most common climate regime in the Northern Rockies domain, high species diversity, and high sensitivity to climate change. This package of conditions, facilities, and long-term data will make PREF a valuable addition to the Continental-scale network of NEON Core Wildland Sites.

2. Domain Characteristics

2.1. Vegetation

One criterion for a core site in NEON is that it be representative of the domain; the Priest River Experimental Forest includes examples of every major forest type in the Northern Rockies. These include species that are not found in the southern part of Domain 12 or in the southern Rockies, e.g., western larch (*Larix occidentalis*), western red-cedar (*Thuja plicata*), and western hemlock (*Tsuga heterophylla*), as well as species distributed throughout the west, e.g., ponderosa pine (*Pinus ponderosa*), Douglas-fir (*Pseudotsuga menziesii*), and lodgepole pine (*Pinus contorta*). At high elevations, the forests are similar to those in southern Rockies, dominated by Engelmann spruce (*Picea engelmanni*) and subalpine fir (*Abies lasiocarpa*), grading into alpine meadows dominated by beargrass (*Xerophyllum tenax*). The understory likewise includes a mixture of species with coastal affinities, e.g., devil's club (*Oplopanax horridum*), as well as species distributed across the continental interior, e.g., bluebunch wheatgrass (*Agropyron spicatum*).

About 60 % of PREF is covered in pristine mixed-conifer forest dominated by trees 120 to 140-years old. The remaining 40 % is dominated by vegetation that has reestablished on harvest units and burns with rare stands over 200 years old. Canopy heights approach 50 m (Fig. 2). Projected leaf area index (LAI) ranges from 0 m^2/m^2 on talus slopes at high elevations to 10 m^2/m^2 in the larch/cedar forests growing in alluvial bottoms; LAI averages approximately 5 m^2/m^2.

2.2. Climate

The NoRMEO domain is among the most climatically diverse of the 20 NEON domains, containing at least five of the twenty-five NEON climate regimes (Fig. 3). However, the mixture of climates at PREF is the most representative of Domain 12, representing about 40% of the total area. This mixture is dominated by a regime that is characterized as cool, moist montane. The most common climate regime in NoRMEO, it represents approximately one quarter of the total domain area. At PREF, this regime grades into a cool, moist valley climate at lower elevations. These regimes are transitional between the northern Pacific coastal and continental regimes. The Pacific influence increases winter cloudiness, precipitation, and temperatures compared with areas east of the continental divide. Summer is characteristically sunny and dry (Finklin, 1983). These conditions occur almost exclusively in NoRMEO and might be considered the "type climate" for the Northern Rockies domain.

2.3. Edaphic Factors

The PREF lies on the westward slope of the Rocky Mountains. Elevation varies from 671m at the Priest River on the west to 1798m on the ridgeline 9 km to the east. Mountainous land dominates the domain and occupies approximately 90% of PREF. The area is dissected by five first-order streams, meeting one of the primary criteria of the NEON ISEP. They join into two second-order streams flowing from east to west, leaving ridges separated by 1 to 2 km. The linear valleys provide excellent lines of sight for telemetry and sensor networking. The soils of the mountain slopes are underlain by granites, gneiss and schist. Soil surface horizons have formed in aeolian loess and volcanic ash. Surface textures are mostly silt loams, relatively fine-textured soils with low rock contents and high water-holding capacity.

Soil moisture limits productivity and decomposition during late summer and on south-facing slopes at lower elevations. The stream terraces and fans of Benton and Canyon Creeks have lateral water subsidies from side slopes, and fertility and productivity are high in these areas. Fertilizer experiments have demonstrated that nitrogen and, on metamorphic bedrocks, potassium deficiencies, may co-limit productivity. Soils of the high elevations are too cold, too thin, and too infertile to support the higher productivity observed at lower elevations. In these

characteristics, the soils of PREF are similar to those in forestlands across a broad swath of northern Idaho, southeastern British Columbia, and northwestern Montana.

2.4. Aquatic

Domain 12 is dominated by low-order streams in rugged terrain. This is well-represented at PREF; there are five first-order and two second-order streams with their headwaters in PREF (Fig. 4). Canyon Creek drains into the East River, a fourth-order river on the north side of the forest. Benton Creek drains into the Priest River, a fifth-order stream that drains Priest Lake to the north and forms the western boundary of the forest. Priest River drains into the Pend Oreille River, which flows into the Columbia River near the Canadian border.

Canyon Creek has a v-shaped valley and 4-6% gradient. Stream width is 2-5 m and the sinuosity index is 1.3 (average), with many debris dams caused by windthrown trees. This riffle-pool stream had a pH of 7.3 and temperature of 7.2 °C in late September. Forty macroinvertebrate taxa were found in the Research Natural Area. These data yielded a relatively low biotic index, indicating that the macroinvertebrate community may be quite sensitive to environmental change. Benton Creek has a gauging station (Fig. 4) with nearly continuous data since 1938.

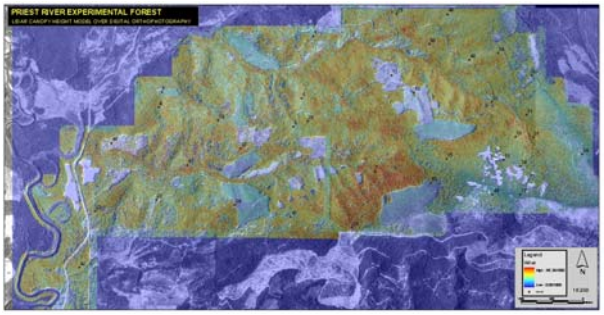

Figure 2. LIDAR image of the Priest River Experimental Forest, showing canopy heights. PREF is shown with a star.

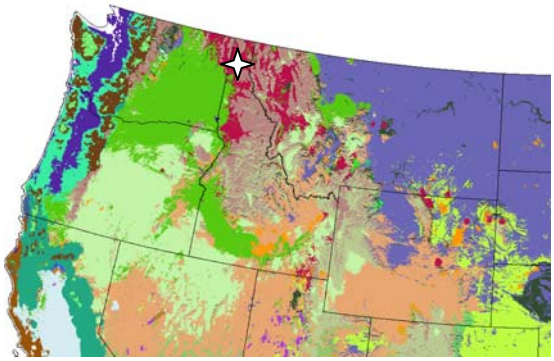

Figure 3. Climate regimes over the northwestern U.S. mapped by W. Hargrove. The location of

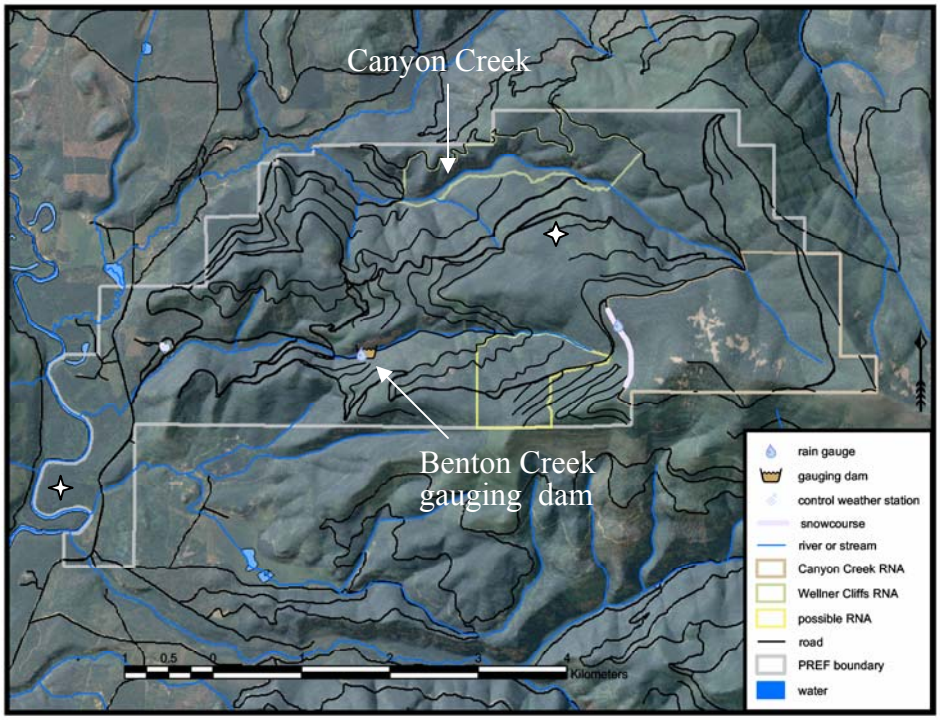

Figure 4. Map of PREF showing watercourses and roads. Potential sites for eddy covariance towers are shown as stars.

3. Ownership, and accessibility and use constraints

3.1. Ownership status of the site (e.g., private, institutionally owned, leased, trust)

The PREF is within the Priest Lake Ranger District of the Idaho Panhandle National Forest. It is owned by the USDA - Forest Service. Research is the primary use of PREF.

3.2. Entity who currently owns the property.

Overall administration of PREF is by the USDA Forest Service - Rocky Mountain Research Station (RMRS), Fort Collins, CO. The local administrators are stationed at the Moscow Forestry Sciences Lab on the nearby campus of the University of Idaho.

3.3. Restrictions on the use of or access to the site.

Only 18% of the PREF has limited research restrictions. Canyon Creek and Wellner Cliffs RNA's (520ha out of 2758ha) are dedicated to non-destructive research, thus making them outstanding controls for manipulative or intensive instrumentation. The existing road network will reach most other areas in PREF. Short spur roads could be constructed to facilitate access to tower sites. The forest roads beyond the headquarters site are accessible by over-snow vehicles when necessary. Through close coordination between NEON and the RMRS the long-term research program of the RMRS and its cooperators will be augmented with state-of-the-art infrastructure and data processing capabilities.

3.4. Existing easements on the site.

None

3.5. Long term (30+ years) accessibility and availability.

There are no restrictions in regards to long-term availability or access. Should PREF be selected, a memorandum of understanding (MOU) between NEON Inc. and RMRS would be required to protect and preserve the interests of both parties. Most of the land surrounding PREF is administered by the State of Idaho, which manages its holdings for timber production. There are no anticipated land use changes in the foreseeable future.

3.6. Restrictions on the feasibility of running experiments on the site.

The only major restrictions for manipulative experimentation are in the Research Natural Areas. Currently, a committee of Forest Service and University of Idaho researchers meets to maintain records of past and current studies and to resolve potential conflicts due to overlapping uses of the same areas.

3.7. Potential sites for eddy covariance

Feasibility issues also arise due to potential use of eddy covariance on the site. Like the rest of the Northern Rockies domain, PREF is dominated by mountain slopes. For NEON, this forces a critical decision: should core sites be located where there is flat, "fluxable" terrain, or in more representative mountainous area? The key controls over carbon sequestration in complex terrain are likely to be fundamentally different from those with less topographic variability. If true, restricting measurements and analyses of carbon dynamics to "fluxable" terrain would seriously compromise our ability to predict carbon fluxes in forests of the Western U.S. The continental scope of NEON, and its combination of models and dense sensor networks, creates an ideal opportunity to evaluate explicitly the impact of topography on ecosystem function, and to ask whether ecosystem response to climate change is significantly affected by topography. In our

core site nomination for Domain 12, we will collaborate with nominators from Domains 16 and 13 to propose deployment of NEON infrastructure in mountainous terrain with enhancements that will allow the development of new flux measurement technology that accounts for advective fluxes in hilly and mountainous terrain. This would be genuinely transformational.

Recognizing that these issues are unresolved, we have proposed two potential sites for the advanced towers. The lowermost is in a loop of the Priest River within the boundaries of PREF, in a mixed conifer forest of uniform fetch on a flat section of the valley floor. Line power could easily be run the 500 m from transmission lines that parallel the road to the east. This low-elevation site could be made accessible year-round and would be close to the headquarters. This lower site would provide the conditions appropriate for eddy flux with relatively little filtering required. The uppermost site is on a uniform slope of 20% in a patch of mixed, low-elevation forest of uniform fetch, on the north-facing slope above the headwaters of Canyon Creek. This site would present pronounced advection due to katabatic winds associated with nightly cold air drainage, requiring empirical corrections based on ancillary measurements. It would also require that line power be delivered almost 5 km from the headquarters site. We present it recognizing the advection issues, but noting that such sites are the rule, rather than the exception, in the Northern Rockies. We hope that NEON will choose between these sites based on the criteria they eventually choose.

3.8. Environmental assessment.

Environmental Assessments (EA) are routinely performed for activities at PREF. The most recent was for the Canyon Creek research project and the EA resulted in a Finding of No Significant Impact, December 2002; there were no challenges to this finding.

3.9. Site characteristics that are environmentally sensitive.

There are several plant and animal species currently listed as threatened that are found within the PREF. A detailed archaeological survey of PREF was conducted in 1978 and is on file at the Moscow Forestry Science Lab; the buildings within the headquarters site are listed on the National Register of Historic Places, and the Gisborne fire lookout is listed on the National Historic Lookout Register.

3.10. Airspace Restrictions

None

4. Existing infrastructure

4.1. Existing / potential housing facilities

The headquarters site at PREF consists of an office and lab building, three residential buildings, a bunkhouse, mess hall, conference building, and a shop. A fourth residence is occupied by a PREF employee. All residences were constructed by the Civilian Conservation Corps between 1934 and 1939 and are listed in the National Register of Historic Places. The conference building, with a capacity of 50, was constructed in 1998. During the field season, PREF averages 1000 days use by Forest Service and other research personnel. The residential buildings and bunkhouse have a capacity of 27 beds. During the winter months, a cabin and the bunkhouse/mess hall are shut down, reducing bed space to 18. All residential buildings have full kitchens and linens are provided.

4.2. Existing / potential laboratory capabilities

The office/lab building has 400 ft^2 of office space available on the first floor. The second floor has 1000 ft^2 dedicated for lab space. In addition, there is a full basement. At this time, the office

building is shut down during the winter months, with the exception of the Superintendent's office. With a modest investment, the building could be renovated for year-round use. There is an abandoned seedling nursery that would be useful to conduct smaller scale manipulative experiments. The fenced, irrigated, 7-ha site is flat and has been used to conduct research on tree genetics, tree competition and endophytic fungi.

4.3. Electrical, gas and other necessary power

Avista Utilities provides line power to the headquarters site; natural gas is not available in this area. Domestic water is provided by a deep well on the site and provides water for housing, labs and irrigation. There is no other infrastructure beyond the headquarters area.

4.4. Existing computer resources and cyberinfrastructure

A T1 line is currently being installed and is expected to be operational by January 2007. The climatic, hydrological, and atmospheric data sets collected at PREF are public domain. Data resulting from a partnership between NEON Inc., NoRMEO, and the RMRS at PREF would also be considered public domain. Raw data is archived at PREF and the Moscow Forestry Science Lab and is also available to the public.

Control Weather Station (CWS): Data (11/27/1911 to 12/31/2005) is available from several websites, under Priest River Experimental Station, ID # 107386:

University of Idaho: "Interactive Numeric & Spatial Information and Data Engine" is a comprehensive source, having daily observations of min/max temp, precipitation, snowfall, etc. See: http://inside.uidaho.edu/asp/dates.asp?stations=107386.

Western Regional Climate Center: has monthly averages and station metadata. See: http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?idprie.

Snow Pack: (WY 1937 to present) are available for the Benton Meadow (elev. 2380 ft, 725 m) and Benton Spring (elev. 4775 ft 1455 m):

Natural Resource Conservation Service (NRCS): has the full record for both snowcourses, see: http://www.wcc.nrcs.usda.gov/cgibin/state-site.pl?state=ID&report=snowcourse and select the snow course of interest (Benton Meadow or Benton Spring).

Atmospheric Chemistry: A National Atmospheric Deposition Network (NAPD) site was established in PREF on December 31, 2002. The site reference is ID02. Data can be found at the NAPD web page at: http://nadp.sws.uiuc.edu/sites/siteinfo.asp?net=NTN&id=ID02 .

Benton Spring (elev. 4725 ft, 1440 m), monthly observations available as Excel spreadsheets from 1961 to present.

Benton Cr. gauging dam (elev. 2640 ft, 805 m), recording rain gauge stripcharts and spreadsheets of monthly totals, beginning from 1961 to present.

Hydrographs from Benton Cr. gauging dam: Digitized gauge heights from 1955 to 1964, and 1976 to 1997. Electronic data has been collected from 1997 to the present. Efforts are now underway to complete the digitizing of all available paper records from the dam, precipitation gages and climate variables from the Benton Creek watershed.

Tree growth data: available from permanent growth and yield plots, 1914 to present.

4.5. Road Access

Road access to PREF is by State Highway 2 from Spokane, Washington to Priest River, Idaho. Within PREF, the entry and forest roads are surfaced with gravel or native soils. Road access is available year round to the housing and labs. The forest is 65 miles from Spokane International Airport, the largest airport between Minneapolis and Seattle in the northern United States. Spokane International Airport is served by most major airlines in the US.

4.6. Security

A full-time employee resides on the site, providing security and maintenance for the headquarters buildings. There are no other measures in place to protect outlying equipment or installations. However, a long tradition of cooperation with local residents of the area has resulted in a minimum of vandalism. For example as part of a recent sap-flux study we had over 45 marine batteries, 9 solar panels and 5,000 m of wire placed throughout the Benton Cr. watershed for three years with no vandalism or animal damage.

5. Supplementary Information

5.1. Existing gradients at the site

The PREF is characteristic of the strong gradients in elevation, climate, and vegetation found in Domain 12. A land-use gradient exists between the urban areas of Coeur d' Alene/Spokane and the wildland and managed lands found on PREF. Land uses along this gradient include; suburban, exurban, pasture and intense forest management. A distinctive feature of this gradient is the similarity in elevation between the urban areas and the base of the PREF. This offers the opportunity to observe impacts of land use not confounded by elevation. Should PREF be chosen as the Core Site, we plan on placing our moveable towers across this land use gradient (See appendix for more details). The University of Idaho and Washington State University both have branch campuses in the urban area to facilitate this effort.

5.2. Site History

There are long-term data sets of daily weather (1911), snowpack (1937), tree growth (1914) and streamflow (1938). PREF became a monitoring site of the National Atmospheric Deposition Program (NADP) in 2003. LIDAR and GIS layers of PREF are available, as are soil and geologic maps, and recent species lists of flora and fauna, both terrestrial and aquatic. The major forest disturbances on PREF have included fire, disease and insects. The fire return interval ranges from approximately 20 to 200 years. The major tree diseases are root rot and the exotic white pine blister rust, which was introduced in the 1920's. This rust fungus has sharply reduced the amount of western white pine on the forest, and is in the process of reducing the amount of whitebark pine.

5.3. Recent and ongoing research and monitoring activities relevant to NEON Science Challenges.

For the past decade, the Priest River Experimental Forest has been a center of carbon balance research in the Rockies, where the work focused first on elevation and species differences, then on CO_2 effects, and more recently on tree height and foliar N effects. For parameterization of biogeochemical models, there have also been extensive studies of allometric functions, vertical trends in leaf mass per area, leaf turnover, leaf area index, and water dynamics. Recent work has included extensive analyses of canopy transpiration (sapflux) across a range of canopy height classes, tree species and slope position, influence of cold-air drainage on nocturnal transpiration, isotopic mass balance of soil water, LIDAR and hyperspectral remote sensing. In addition, significant progress has been made in developing the mechanistic understanding of headwater hydrology, including snowpacks.

5.4. Institutional diversity

NoRMEO represents a diverse group of academics from the University of Idaho, Idaho State University, Washington State University, the University of Montana, Montana State University and the University of Wyoming. Also, the USDA-Forest Service and the RMRS fully support this endeavor. Specifically, faculty members from the nearby University of Idaho and Washington State University have long-standing research programs at PREF and both campuses provide a research base to support activities at PREF. Both Universities have strong and cooperative programs in ecology, hydrology, and atmospheric sciences. The WSU Laboratory for Atmospheric Research provides support for the atmospheric measurements. The joint Palouse Isotope Consortium between the University of Idaho and Washington State University also provides stable isotope facilities for this NEON effort, and is currently co-teaching courses on stable isotope theory and methods.

5.5. Human diversity and training

The geographic area surrounding PREF has very large Native American population; the Colville, Spokane, Flathead, and Coeur d'Alene reservations effectively surround it. There is also a large Hispanic population in southern Idaho and central Washington. There are no HBCU's, Hispanic-Serving Institutions, or Tribal Colleges in our immediate area but several of our PI's work with the tribal foresters in the region. The PI's support and have taken advantage of aggressive efforts by their respective universities to recruit under-represented minorities and women. At Washington State University, the Graduate School at Washington State participates in the McNair program to recruit at Colleges and Universities that have high numbers of under-represented minorities. At the undergraduate level, WSU has several bilingual admissions counselors and an Associate Dean who target agricultural areas in Washington with a predominantly Hispanic population. They also recruit at several meetings including the Society for the Advancement of Chicanos and Native American in Science (SACNAS) and the Annual Biomedical Research Conference for Minority Students (ABRCMS). The University of Idaho has documented its diversity policies (2004), specifying that it shall "through legally appropriate affirmative action and other means supported by law…recruit, enroll, retain, and graduate a diversified student population" Support for this goal has been provided by funding from the NSF-EPSCoR program, which focuses on coupled carbon and water balances. Likewise, NSF REU and IGERT programs have supported many minority students and provided resources for recruiting more. Finally, the investigators in this proposal have already demonstrated their ability to recruit and train members of under-represented groups. We will strive to not only maintain, but improve our records in this area.

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7. Appendix I. Deployment Strategy: Northern Rocky Mountains Domain (NRM)

NRM straddles the Continental Divide and is characterized by north-south tending mountain ranges that influence subcontinental climate patterns such that the western portion of the Domain has a warmer, wetter maritime climate with most precipitation in winter, and the eastern portion has a drier, colder continental climate with summer precipitation. Local orography modifies these patterns with gradients from warmer and drier valley bottoms to colder and wetter mountain tops. As a consequence, vegetation grades from wet temperate coniferous forests in the west to valley bottom grasslands and cold temperate montane forests to the east. Fire regimes vary in severity and frequency with these regional and local climate and vegetation patterns. The deep mountain snowpacks feed the headwaters of the three major river systems of western North America (Snake-Columbia, Missouri-Mississippi, and Colorado). The region is unique in the lower 48 states in having all native terrestrial vertebrates present. Human populations and land use are in transition from small communities focused on agriculture, timber and mining to thriving small cities and surrounding exurban sprawl. This growth is especially focused in valley bottoms and lower-elevation treeline, setting up conflicts with wildlife and natural resource management.

NEON's continental-scale questions involving climate change, land use change and invasive species are also important within this Domain. The effects of climate warming are already apparent with snowmelt and spring runoff peaking about two weeks earlier than in the 1950s, and significant fall rains coming about 10 days later. This translates into earlier growing seasons, longer periods of summer drought, and lower streamflows in a region where water is limiting. The low streamflows constrain human water access, threaten native aquatic species, and favor expansion of aquatic invasives. In terrestrial systems, changes in climate and land use such as irrigation and exurban development have altered the spatial and temporal patterning of NPP. Severe stand-replacement fires are now occurring in lower treeline forests which are adapted to frequent ground fire, threatening the high levels of native biodiversity and putting expanding exurban development at risk. The modification of NPP has also resulted in herbivores shifting their range to irrigated valley bottoms, with attendant increases in population and enhanced spread of disease. Such changes in aquatic and terrestrial ecosystems have strong potential feedbacks that could negatively affect many ecosystem and economic components. In brief, the region provides a great opportunity to understand interactions of these changes and derive ways to mitigate negative effects on ecosystems and human well being.

Given the overlap of issues and questions both within-domain and across all western domains, we propose to establish three transects from urban to wildland sites that span the Domain (Fig 1). Along each transect, sites will be selected to characterize four or five land-use types: urban, exurban, agricultural/managed, and wildland (Fig 2). The spatial extent of the Domain will be sampled continuously via permanent tower installations at the wildland sites of each transect. The relocatable installations will be deployed at sites in different land-use classes, sampling three different land-use classes in the initial installation. Funds will be sought to maintain the initial wildland tower installations, with new towers added at the appropriate land-use positions along each gradient. If funds are not obtained, the relocatable towers will be repositioned at sites along the transects on 2- to 3-year time periods. (Fig 3). The simultaneous deployment of the land-use towers to different land-use classes will allow early model parameterization. As more land-use classes are sampled in successive time periods, parameterization will improve.

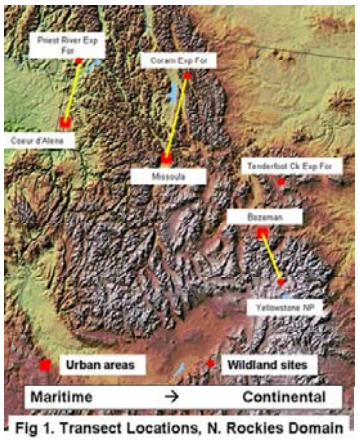

Fig 1. Transect Locations, N. Rockies Domain

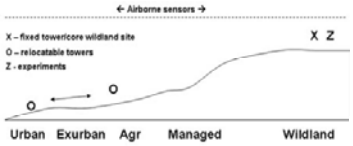

Fig 2. Urban to Wild Transect

Fig 3. Moveable Deployment of Towers