USFS-NASA Pitch Fest

Book of Abstracts

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What is the USFS-NASA Pitch Fest?

There is incredible potential for Earth observation data to support and advance the work of land management agencies such as the US Forest Service (USFS). The tremendous volume and diversity of data available today combined with the power of analytics and creative thought presents a watershed moment for this area of work. **The USFS-NASA Pitch Fest provides a platform to share ideas and spark new collaborations around using NASA data products and tools to meet pressing land management needs.**

During the pitch fest, representatives from NASA and the USFS will highlight key opportunity areas for increased NASA-USFS coordination and collaboration to support sustainable natural resource management. Participants will share and vote for ideas to pilot NASA technology to help address priority land management issues. Top ideas will be selected based on participant votes with the goal of coordinating support in the form of expertise, tools, and knowledge.

Pitch Fest finalists will have the chance to refine their idea for integrating NASA data and to establish connections and sustained support for developing the tools and methods needed to operationalize the data. Their progress will be highlighted during the **2020 USFS-NASA Joint Applications Workshop (September 1-3, 2020 / location: Salt Lake City, Utah)**.

Our goal is to enhance connections and strengthen partnerships between NASA, USFS, and the broader resource management community in order to solve research and operational resource management challenges through careful integration of NASA Earth observation data. The Pitch Fest will be a space for creativity, innovation, and collaboration. We welcome your contributions!

Who Planned this Interagency Meeting?

- **Everett Hinkley**, US Forest Service
- **Sabrina Delgado Arias**, Science Systems and Applications, Inc., NASA Goddard
- **Raha Hakimdavar**, US Forest Service
- **Kim Locke**, NASA Goddard
- **Erik Johnson**, US Forest Service
- **Mahesh Pun**, NASA Goddard
- **Edil Sepulveda Carlo**, NASA Goddard
- **Stephanie Granger**, NASA JPL
- **Birgit Peterson**, USGS
- **Peggy O'Neill**, NASA Goddard
- **Batu Osmanoglu**, NASA Goddard
- **Cynthia West**, US Forest Service
- **Aurora Cutler**, US Forest Service
- **Andy Hudak**, US Forest Service
- **Matt Reeves**, US Forest Service

Idea Abstracts

1. Using dynamic remote sensing for early detection of forest stress in the Sierra Nevada Mountains.

Ben Soderquist, Troy Magney, Nick Parazoo (USFS Office of Sustainability and Climate, UC Davis, NASA JPL)

Resource managers with the U.S. Forest Service need to rapidly assess forest responses to increasing drought stress, insect outbreaks, and forest disease driven by climate change. Advances in dynamic remote sensing techniques now allow scientists to rapidly detect physiological changes in forest vegetation in response to environmental stressors before visible effects can be detected. Using data collected from NASA and European satellites, members of our team have recently developed a method to monitor solar-induced chlorophyll fluorescence (SIF) at high spatial and temporal resolutions (500m2 weekly, 5km2 daily). Their work has shown that SIF is a strong predictor of forest productivity and can be used to track daily shifts in photosynthesis and vegetation stress across California's diverse forest ecosystems. High-resolution and rapidly available SIF datasets have many potential applications and can be used to identify vulnerable species and locations, prioritize prescription treatments, and monitor the effectiveness of forest management actions. To facilitate the application of dynamic remote sensing data in forest management, our team will collaborate with NASA, the USFS Geospatial Technology and Applications Center, and the USFS Pacific Southwest region to initiate scientist-manager partnerships across the Sierra Nevada to develop interactive tools that allow managers to quickly assess forest stress and identify response strategies that can be informed by SIF products.

Expected Management/decision support outcomes:

- Web-based tool that allows resource managers whose work is dependent on the condition of terrestrial vegetation (e.g. silviculturists, watershed program managers) to view regularly updated shifts in SIF, forest productivity, and other complementary NASA products across Sierra Nevada forests.
- Communication and educational materials (e.g. webinars, fact sheets, story maps)
- A peer-reviewed document synthesizing sensitivities of forest ecosystems to drought, rapid drought response strategies and tactics developed from science-manager partnerships, and recommendations for the application of remotely sensed forest productivity.

- The state of California will also need to quantify carbon for use in its cap-and-trade system in the coming years. The state's scoping plan for natural and working lands is aiming to remove 20 million metric tons of CO_2 equivalent into soil and vegetation sinks by 2030. Achieving this level of ambition will require assessment tools to verify best carbon management practices and analysis of risks and vulnerabilities of different carbon stocks.

EO Data: Landsat, MODIS, OCO-2 and OCO-3 NASA carbon observatories for SIF detecting. We also plan to use additional NASA products like MODIS and Landsat for comparative analyses and forest stress assessment

Keywords: **Forest health, Climate and drought, Carbon emissions and flux**

2. Habitat for tree that have been displaced by pathogens and insects

Christopher Dionigi (USDA APHIS PPD)

With the development of genetically engineered (GE) varieties of native trees that are resistant to forest pathogens and insects, it may be possible to replant species that have been largely removed from forests due to high mortalities. An example is GE blight-resistant American chestnut. Insect resistant ash that are less vulnerable to emerald ash borers might also be possible. These advances could make large scale repopulation efforts technically feasible. However, where plants should be planted and what impacts they may have on forests and T&E species are significant questions. NASA could help by remote surveys seeking possible habitat for GE American chestnut. They would also form base-line data for future monitoring efforts should these trees grow and spread. Remote sensing data are valuable for understanding the current extent of forest pathogens and their impacts, but they could also provide valuable data to guide forest restoration.

Expected Management/decision support outcomes: Integration of NASA data into forest restoration plans and models.

EO Data: Uncertain - looking for guidance

Keywords: Forest health, Vegetation mapping, Forest restoration and T&E species.

3. Operational Tool for Producing Near Real-Time Land Surface Phenology Product at 10-30m Pixels by Fusing Landsat, Sentinel-2, and VIIRS Observations for Land Management

Xiaoyang Zhang (South Dakota State University)

Land surface phenology (LSP) data from historical satellites (^{3}500m) are critical for reconstructing the record of vegetation dynamics and making predictions about biological responses to future environmental scenarios. A near real-time (NRT) LSP product would have even greater importance in assisting foresters and land managers for detecting forest disturbances (related to human activities, forest pests, and disease outbreaks), reforestation, species invasion, and climate change influences. Development of an operational tool to generate NRL-LSP product becomes applicable with the recent availability of multiple spatial and temporal operational satellites. Particularly, NASA VIIRS land products operationally provide 375m-500m surface reflectance daily. Recently, NASA Harmonized Landsat and Sentinel-2 (HLS) product provides surface reflectance observed by the Operational Land Imager (OLI) aboard Landsat-8 and Multi-Spectral Instrument (MSI) aboard Sentinel 2A and 2B satellites. The HLS offers 10-30m observations with an average revisit interval of 3-5 days. Thus, the operational tool is able to generate daily 10-30m HLS-VIIRS land surface reflectance by fusing time series HLS data with temporal shape calculated from VIIRS observations. It further produces an NRT-LSP product at 10-30m pixels by blending the fused HLS-VIIRS time series and climatological LSP data. The NRT-LSP will produce the timing and magnitude of seasonal dynamics in forests and other vegetation.

Expected Management/decision support outcomes: An operational tool and products of near-real time vegetation phenology dynamics

EO Data: Landsat, Sentinel-2, MODIS, VIIRS

Keywords: Wildfire impacts, Forest health, Climate and drought, Vegetation mapping, Rangeland management

4. Tree Structure Damage Impact Predictive (TreeS-DIP) Model/Product

Renee Jacokes, Brad Quayle, Andrew Molthan, Christopher Hain, Bonnie Stine, Bill Burkman (USFS, NASA MSFC)

As the frequency of large-scale natural events increases such as hurricanes, floods and ice storms, the Forest Service and its partners requires tools, models and products that enable them to respond more rapidly, accurately, and consistently. These events along with droughts, fire and large-scale infestations clearly represent a risk for timber security for our Nation. The lack of a common understanding of the general location, distribution, and severity of the impact immediately after an event increases the risk for timber insecurity and a major economic loss to local communities, states and our Nation.

The Forest Service and the Southern Group of State Foresters (an association of southern states) have agreed to explore the development of tools, protocols, and guidelines for a more coordinated, consistent and common operating procedure to efficiently respond to these events. Models and products that can predict the impact to tree structure immediately after an event at a regional landscape scale currently do not exist. The Forest Service and the Southern Group needs products that can quickly and consistently provide a range of predictive damage to tree structure in the early morning hours (or near real time results) after an event.

Expected Management/decision support outcomes: This product will be used by the Forest Service and the Southern Group Alliance as a tool for strategic management to allocate ground resources to the field immediately following the event.

EO Data: RADAR, Land Information System (LIS) Soil Moisture

Keywords: Fuel loading, Wildfire impacts, Soil moisture, Vegetation mapping, Resource Hazard Response

5. Landscape conditions for adaptive management and adaptation in a rapidly changing landscape

Jason Sibold, Clay Speas, Carlyn Perovich, Michael Battaglia, Jake Ivan (Colorado State University, USFS GMUG and Rocky Mountain Research Stations, Colorado Parks and Wildlife)

Climate change is creating ecosystem management challenges that require frequently updated, landscape-scale data to achieve multiple management objectives in an ever-changing environment. Recent increases in extreme weather events since the early 2000s in the Rocky Mountains have resulted in increased rates of forest disturbances. The Grand Mesa, Uncompaghre and Gunnison National Forests (GMUG) in Colorado has experienced both record-setting cool-wet and warm-dry conditions in recent years that have resulted in large avalanche cycles, high-severity wildfires, extensive bark beetle outbreaks and widespread drought-induced forest mortality. In response, the GMUG initiated a long-term adaptive ecosystem management project, the Spruce Beetle Epidemic and Aspen Decline Management Response Project

(SBEADMR), which integrates GMUG managers, scientists and citizens in management planning of timber harvest, ecosystem restoration, habitat conservation, fire-hazard reduction and long-term adaptation to warming at the landscape scale. This first of its kind management project, which is the model for US Forest Service adaptive management nationwide, needs updated information on landscape conditions to decrease uncertainty for decision making and planning. The goal of the proposed collaboration with NASA is to use remote sensing data in combination with existing robust field data to identify ways to provide frequently updated landscape condition information for the SBEADMR Project.

Expected Management/decision support outcomes: Updated information on landscape conditions will help with near-term planning decisions such where aspen restoration treatments will be most effective, where salvage treatments will have the largest influence on reducing fire hazard in bark beetle killed forests, and how critical habitat for Canada lynx is changing at the landscape scale. Developing the capacity for ongoing updated landscape conditions will allow for adaptation, which is the central focus of the SBEADMR Project, based on changing conditions and treatment outcomes.

EO Data: Landsat, High spatial resolution R-G-B-NIR, LiDAR, Uncertain - looking for guidance

Keywords: Wildfire hazard, Fuel loading, Forest health, Climate and drought, Vegetation mapping

6. Remote sensing of black carbon (BC) inputs from wildland fires: refining estimates of BC production and improving landscape C simulation models

Mac Callaham, Joseph O'Brien, Louise Loudermilk, Dexter Strother, Steve Flanagan, Kevin Hiers, (USFS Southern Research Station, Tall Timbers Research Station)

Black carbon (BC) is an important component of the terrestrial carbon cycle and is formed during every single wildland fire event. The majority of remotely sensed spectral data relating to BC has been focused on detection of aerosols in the atmosphere, but there are clear applications for evaluating BC on terrestrial surfaces. Surface BC production rates are being studied at the plot scale, and important relationships to fuel characteristics have recently been elucidated for frequently burned pine systems in the US South. However, at the landscape scale, and for the multitude of ecosystems where fires occur, understanding of how BC is produced in relation to fire behavior (associated with fuel, topography, climate, etc.) is not well known at any reasonable level of resolution. Remote sensing imagery is used to determine "burned area severity" and this is based on surface spectral characteristics including detection of white ash deposits among others. We propose to use remotely sensed spectral characteristics of soil surfaces to estimate BC production rates for both prescribed and wildfires. Detecting the range of values encountered on burned surfaces, followed by calibration of these values to BC concentrations, has potential to vastly improve our understanding of BC production in wildland fires, and thus to inform landscape scale C-cycle simulation models.

Expected Management/decision support outcomes: Improved understanding of fire effects on carbon cycles. Results could influence prescriptions for prescribed fires in terms of how different conditions influences C storage in the form of long-term pools like char.

EO Data: Uncertain - looking for guidance

Keywords: Fuel loading, Wildfire impacts, Carbon emissions and flux, Prescribed fire impacts

7. Remote sensing for more accurate estimates of area burned in sub-canopy prescribed fires using char related spectral signatures

Mac Callaham, Joseph O'Brien, Louise Loudermilk, Dexter Strother, Steve Flanagan, and Kevin Hiers (USFS Southern Research Station)

Current estimates of active fire and burned area typically are around 1 km resolution and are overpass dependent. There are several recognized issues with this approach, including that smaller fires, fires occurring under live canopy (most prescribed fires in the southern US), and fires not long enough in duration may not be detected. We propose that in spite of canopy obscuration of surface fire effects, there should be detectable changes in surface spectral signatures due to production of char in forests with relatively open canopies (particularly pine forests). We propose to use imagery to detect subtle differences in surface reflectance where canopy greenness is unchanged. This will require finer-resolution data – likely from Sentinel-3 or equivalent. This approach should allow for improved accounting of burned area in regions where prescribed fires are small and of short duration. Better estimates of area lead to improved estimates of emissions and other pools in the carbon cycle such as production of char. Recent work on surface char at plot-scale revealed important relationships between char and fuel characteristics in frequently burned pine systems, but at landscape scale, we have limited understanding of char production in relation to prescribed fire behavior. The ultimate objective for this work is to take more accurate estimates of area burned to develop more accurate BC production estimates and inform regional-scale terrestrial process models dealing with carbon.

Expected Management/decision support outcomes: Vastly improved reporting of area burned in prescribed fires. Improved data on emissions, and carbon cycling, including char production.

EO Data: Uncertain - looking for guidance

Keywords: Carbon emissions and flux, Prescribed fire extent and effects

8. Strategic SMAP soil moisture products downscaling for integration with current USFS wildfire and prescribed burning prediction models, systems, and tools

Grant Snitker, Joseph O'Brien, Mac Callaham, Matt Levi (University of Georgia, USFS Southern Research Station)

Soil moisture is directly linked to fire occurrence, spread, and intensity, but is currently underutilized in USFS tools for understanding wildfire risk and prescribed fire management. NASA's Soil Moisture Active Passive (SMAP) mission offers a frequently updated (every 2-3 days), 36-km resolution gridded soil moisture product, but its low spatial resolution limits its use in local and regional fire management. Recent SMAP downscaling efforts have produced CONUS-extent soil moisture maps at 1-km resolution, but validation studies demonstrate mixed results. Statistical measures indicate downscaling performs well in open, sparely vegetated areas or agricultural/pastureland, but poorly in density vegetated areas, such as forests and shrub-lands. We propose strategic downscaling of SMAP soil moisture products targeting forested regions of CONUS, with a feasibility study focused in the Southeast US where approximately 6.5 million acres undergo prescribed burning annually. This work will utilize NASA remote sensing vegetation products (MODIS), gridded soil data, and elevation data (SRTM) to accommodate for local drivers of soil moisture. Field validation studies will be carried out to compare measured soil moisture and live/dead fuel moisture within modeled regions. Final downscaled soil moisture products will be designed for integration with current USFS modeling and assessment tools to help practitioners develop capacity for integrating soil moisture into planning activities.

Expected Management/decision support outcomes: Adapt existing NASA remote sensing dataset (SMAP) to a scale useful for supporting wildfire risk assessment and prescribed fire management.

- Integrate soil moisture into to suite of datasets and tools used by the USFS in wildfire and prescribed burning planning activities.

- Focus SMAP downscaling efforts on forested regions of the United States most vulnerable to wildfire, but with the least number of in-situ soil moisture monitoring stations.
- Increase the capacity for predicting soil moisture and fuel conditions that may lead to dangerous conditions during wildfire or prescribed fire scenarios.

EO Data: MODIS, SMAP, SRTM

Keywords: Wildfire hazard, Climate and drought, Soil moisture

9. Coarse-scale 3D fuel mapping for operational use in next-generation fire-atmosphere fire behavior models

E. Louise Loudermilk, Andrew Hudak, Steve Flanagan, Scott Goodrick, Joseph O'Brien, Kevin Hiers (USFS, Southern and Rocky Mountain Research Stations, Tall Timbers Research Station)

Land managers across the country are faced with novel climate and ecosystem conditions that affect vegetation composition and interacting disturbance regimes. For wildland fire, multi-scale fuel characteristics directly impact fire behavior and fire effects. Fuels are often poorly represented in new state of the art physically based fire models that require heterogenous fuel inputs to produce realistic fire behavior simulations. QUIC-Fire (Linn et al. 2020) is designed for fire management practitioners, where they can compare, evaluate, and design burn plans based on input ignition patterns. This model works best with 3D fuels inputs. There is a need for more complete fuel map coverage across regions, particularly contiguous areas within, e.g. National Forest Systems, where either sampling is difficult or unrealistic, but is imperative if these newer models are to be run effectively. As USDA Forest Service scientists, we propose to integrate our data and knowledge of these finer-scale attributes with NASA’s remote sensing capabilities to 1) create wall-to-wall 3D maps of canopy fuels, by linking sparse and coarse-scale 3D datasets to inform on more contiguous 2D datasets, 2) in select areas, create surface fuel maps of sub-canopy vegetation by linking coarse-scale canopy maps with field data and ancillary fire data, 3) utilize state-wide datasets of ALS for cross-validation, 4) test and validate data within QUIC-Fire, and 5) streamline the process for continuous mapping.

Expected Management/decision support outcomes: This project and datasets would be useful to kickstart the utilization of next-generation fire behavior models that have been newly introduced and are being tested in the field.

EO Data: Landsat, Sentinel-1, Sentinel-2, MODIS, VIIRS, ICESat-2, LiDAR, Uncertain - looking for guidance, GEDI

Keywords: Wildfire hazard, Fuel loading, Wildfire impacts, Vegetation mapping

10. Microwave and optical remote sensing for fire detection

Sujay Kumar, John Bolten (NASA GSFC)

Recent work at the hydrological sciences lab at NASA GSFC has demonstrated the viability of using modeling, remote sensing, data assimilation, and machine learning with the NASA Land Information System (lis.gsfc.nasa.gov) for the detection, recovery, and impacts of fires. The demonstrated techniques include a use of a combination of both optical and microwave remote sensing. While the optical remote sensing measurements provide high resolution coverage, they are limited by sensing limitations under cloud cover and infrequent temporal revisits. The use of microwave remote sensing data can effectively mitigate these issues, enabling timely detection of fire events.

Expected Management/decision support outcomes: Timely detection of fire events

EO Data: Sentinel-1, Sentinel-2, MODIS, VIIRS, ECOSTRESS, SMAP, SRTM

Keywords: Wildfire hazard, Wildfire impacts, Forest health, Soil moisture, Vegetation mapping, Carbon emissions and flux

11. Quantifying canopy bulk density and downed coarse woody fuels via optical and SAR satellite sensor data to enable wildfire modeling and risk management

Peter Wolter, Brian Sturtevant, Jeffrey Kroll, Patty Johnson (Iowa State University, US Forest Service, Rhinelander, Kawishiwi Ranger District and Superior National Forest)

L-band SAR data are needed to compliment optical satellite data for (1) improving space-ground calibration of "burnable" canopy bulk density (CBD) and (2) extending spatial and compositional accuracy of standard fire behavior fuel models by accurately modeling forest surface fuels (sensu Wolter et al. 2017, and Wolter et al. 2012). Canopy fuels are correlated with forest basal area, which L-band SAR is best suited to map, which provide a view of canopy components not currently possible using optical satellite and lidar data (Engelstad et al. 2019). SAR sensor data at both C- and L-bands will also enable accuracy and spatial resolution improvements to bolster existing standard fire behavior fuel models (Scott and Burgen 2005, Wolter et al. 2017).

USFS recently funded research to improve forest structure mapping. Field data and Lidar were combined to model several structure parameters; all but CBD were modeled successfully (Engelstad et al. 2019). Low CBD accuracy remains a vexing problem. Efforts to map CBD using optical sensors is problematic because overstory conceals understory biomass. A need remains for approaches that include active satellite sensor data that may offer a better view of understory fuel structures, such as radar (Keane et al. 2006).

We propose NASA serve as a JAXA and CONAE liaison for the acquisition of PALSAR-2 (10m FP fine or DP fine) and SAOCOM-1A (FP L-band) for regional CBD and fuel model mapping to enable improvements to fire risk management.

Expected Management/decision support outcomes: Improvements to accuracy and spatial resolution of CBD and surface fuel models will enable more accurate accounting of forest fuels, which will enable two USFS outcomes: (1) improve wildfire behavior modeling and (2) improve fire risk management efforts by identifying and targeting vulnerable fuel areas for fuel reduction treatments.

EO Data: Landsat, Sentinel-1, Sentinel-2, PALSAR-2 and SAOCOM-1A

Keywords: Wildfire hazard, Fuel loading, Wildfire impacts, Forest health, Vegetation mapping

12. Scalable surface fuels mapping using three-dimensional remote sensing

Jonathan Greenberg, Leland Tarnay, Matthew Dickinson, Eric Rowell, and Carlos Ramirez (University of Nevada, Reno, USFS, Tall Timbers Research Station)

Fires spread, primarily, via surface fuels which are notoriously hard to quantify at scale using most forms of remote sensing technologies. Attempts to map surface fuels are limited given that most remote sensing technologies are not sensitive to subcanopy conditions, so the maps are largely imputed rather than directly measured. Three-dimensional technologies such as LiDAR and structure-from-motion derived point clouds provide promising datasets that may be able to quantify surface fuel conditions directly, but even these technologies have been largely underutilized. Our proposal is to leverage ground- and low-altitude remotely sensed data (terrestrial laser scanning and UAV-derived SFM point clouds) to provide scalable training data on surface fuel conditions to calibrate and validate airborne and spaceborne three dimensional analysis tools (e.g. voxel and ray-tracing techniques) to produce landscape maps of surface fuel conditions.

Expected Management/decision support outcomes: Landscape maps of fuels are not a new thing, however, these landscape scale maps currently don't have the accuracy to support project scale work either in the operations or in the planning side of fire, fuels, and forest management. The proposed work would bridge this gap and, once vetted, would be able to support both fire planning, fire modeling, and fire operations in the USFS with unprecedented skill and specificity, particularly in dry forests where specific 3D arrangements of tree and stand scale forest structure determines fire resilience.

EO Data: Landsat, ECOSTRESS, High spatial resolution R-G-B-NIR, LiDAR, GEDI

Keywords: Wildfire hazard, Fuel loading, Wildfire impacts

13. Introducing Spatially Distributed Fire Danger from Earth Observations (FDEO) using Satellite-based Data in the Contiguous United States

Alireza Farahmand, Natasha Stavros, JT Reager (NASA JPL, Raytheon)

Wildfire danger assessment is essential for operational allocation of fire management resources. Traditional studies focus on meteorological forecasts and fire danger index models (e.g., National Fire Danger Rating System—NFDRS) for predicting fire danger. Meteorological forecasts, however, lose accuracy beyond ~10 days. While some recent studies have statistically related hydrologic parameters and past wildfire area burned or occurrence to fire, no study has used these parameters to develop a monthly spatially distributed predictive model in the contiguous United States. Thus, our idea is to introduce Fire Danger from Earth Observations (FDEO), which uses satellite data over the contiguous United States (CONUS) to enable two-month lead time prediction of wildfire danger. FDEO uses satellite observations of land cover type, vapor pressure deficit, surface soil moisture, and the enhanced vegetation index, together with the United States Forest Service (USFS) Fire Program Analysis (FPA) data to develop spatially gridded probabilistic and cetegorical predictions of fire danger, defined as expected area burned as a deviation from "normal". The results show that the model predicts spatial patterns of fire danger with 52% overall accuracy over the 2004–2013 record, and up to 75% overall accuracy during the fire season. This demonstrates the potential utility of using diverse observational data sets for use in operational fire management resource allocation in the CONUS.

Expected Management/decision support outcomes: National Interagency Fire Center (NIFC) generates one to four months' significant wildland fire potential prediction maps for the US every month. While expert knowledge has shown to help wildfire prediction, it is associated with a wide range of limitations, including careful matching of experts to application, lack of transparency, and repeatability, determining how to best aggregate multiple expert responses and linguistic uncertainty. With overall high performance of FDEO in both probabilistic and categorical fire danger forecast, FDEO is a promising framework for assessing wildfire danger in the entire CONUS, which relies on near real-time remote sensing observations and leverages lead time desired for resource allocation management.

EO Data: MODIS, AIRS, GRACE

Keywords: Wildfire hazard, Fuel loading, Water and aquatic resources, Climate and drought, Soil moisture, Vegetation mapping, Wildfire Danger

14. Evaluating Performance of Icesat-2 ATL08 Product for Vegetation Structure Characterization in Various Vegetation Environments In the USA

Lonesome Malambo, Sorin Popescu (Texas A&M University)

NASA's Land Water Vegetation Elevation product (ATL08) product is providing terrain and canopy height estimates at unprecedented fine spatial scales, enabling improved prospects for the assessment of forest condition. However, there is a great need to validate these data to determine their usability for vegetation condition studies across diverse ecosystems (e.g. deciduous, evergreen, savanna environments). We aim to validate the ATL08 terrain and canopy height estimates in multiple ecosystems by leveraging available discrete return airborne lidar from the U.S. Geological Survey's 3D Elevation Program (3DEP), currently covering two-thirds of conterminous US. We expect such validation studies to contribute to bridging the development phase bottleneck, highlighted in the previous USFS/NASA workshop, to allow expedient application of NASA's EO data to support monitoring activities and management decisions.

Expected Management/decision support outcomes: Provide guidance or recommendation for the utilization of ICESat-2 data for vegetation condition monitoring in USFS programs.

EO Data: Landsat, ICESat-2, LiDAR

Keywords: Vegetation mapping, Forest vertical structure

15. Flash and burn: Connecting ignition sources to wildland fires in time and space

Joseph O'Brien, Louise Loudermilk, Steve Flanagan, Kevin Hiers, Dan Jimenez, Andy Hudak, Cynthia Fowler, Grant Snitker (USFS Southern and Rocky Mountain Research Stations, Tall Timbers Research Station, Wofford College, University of Georgia)

Ignition of wildfires occurs from two primary sources: people and lightning. Understanding the spatial and temporal distribution of these sources is critical for effective fire management, be it suppression, prescribed fires, or understanding fire regimes. In some areas, human ignitions dominate but the link between human activity and fire starts is poorly understood. Even less well understood is the connection between lightning flashes, ground strikes, ignition and fire spread. To better understand the source and timing of ignitions, we propose to use a variety of space-borne sensor platforms to connect lightning or the lack of it to wildland fires. For example, we would explore the links among data from the GLM on GOES-R and MODIS and VIIRS fire detection. Many hurdles need to be overcome. For example, ground strikes must be separated from cloud-to-cloud lightning. Also, there is an unknown lag between a lightning strike and subsequent fire detection that is influenced by many factors. Detecting human ignitions is difficult from satellite observations because of their often-small size and short duration, however, these fires add up to millions of hectares. We will overcome these hurdles by also exploiting data collected on the ground, focusing on areas with good data on fire occurrence, size, vegetation, and climate. This combined with sociocultural data would provide a deep and powerful understanding of the role ignition sources have in driving wildland fire dynamics.

Expected Management/decision support outcomes:

1. Systematically identify the dominant ignition source for wildland fires across the US and globe.
2. Identify the lag between lightning detection and fire detection and explore mechanisms driving lightning ignition.
3. Examine where and when human ignitions dominate wildland fires and explore links among vegetation, climate and sociocultural drivers both for wildfires and prescribed fires.
4. Examine the relationship between ignition source and suppression effectiveness, also patterns of fire growth.
5. Explore the spatial occurrence of prescribed fire, locate and identify predictors of successful implementation of managed fires.
6. Link changes in seasonality of fire ignition to ignition type, connect to expected climate change scenarios

EO Data: Sentinel-1, Sentinel-2, MODIS, VIIRS, Uncertain - looking for guidance, GOES-R Geostationary Lightning Mapper

Keywords: Wildfire hazard, Wildfire impacts, Climate and drought, Prescribed Fire

16. Enhancing Fire Management with Earth Observations

Mary Ellen Miller, Nancy French, Matt Dickinson, Sam Batzli (Michigan Tech Research Institute, USFS, University of Wisconsin-Madison)

Before the flames, earth observations are used for mapping fuels and monitoring fire danger. Thermal imagery during a wildfire is critical for understanding fire location, intensity, and spread rates. Post-fire land management depends heavily on earth observations to help predict flooding, erosion, slope stability and tree mortality. Earth Observations are clearly a vital component of fire management. However, the high stakes and rapid decisions needed to suppress unwanted wildfire and manage its effects often prevent the rapid adoption of newer datasets and techniques. We are proposing to explore integrating two new sensors ECOSTRESS and GEDI into fire management and developing additional applications for thermal imagery from VIIRS and MODIS. Evaporative Stress Index products from ECOSTRESS have great potential for improving maps of pre-fire danger and enhancing predictions of post-fire emissions that rely on fuel moisture. GEDI waveforms can enhance fuel structure and help measure post-fire consumption and emissions. Thermal information from multiple sensors such as VIIRS, MODIS and GOES can be fused to provide clues to soil and vegetation heating that impact post-fire effects on vegetation mortality and hydrology. Developing new tools and datasets is not enough; we will also need to adapt datasets to the needs and formats used by fire managers.

Expected Management/decision support outcomes: Improved spatial information on fuel moisture for emissions modeling and fire danger mapping. New formats and products for thermal imagery to support fire effects modeling.

EO Data: Landsat, Sentinel-1, Sentinel-2, MODIS, VIIRS, ECOSTRESS, ICESat-2, LiDAR, GEDI

Keyword: Wildfire hazard, Wildfire impacts, Water and aquatic resources, Vegetation mapping, Carbon emissions and flux

17. NIROPS imagery for calibration and validation of satellite fire products

Luigi Boschetti, Andrew Hudak, Vince Ambrosia, (University of Idaho, USFS, NASA AMES)

Airborne infrared scanners currently operated by National Infrared Operations (NIROPS), located at the National Interagency Fire Center, have the capability of delivering geolocated, GIS ready active fire detection maps at very high spatial resolution, with incident management teams as the primary user. This short proposal highlights the potential benefits of improved access to IR airborne imagery for the fire sciences community. This initiative would require a modestly priced investment to (a) perform absolute radiometric calibration of the IR imagery and (b) archive, document and distribute the data. This data would meet several outstanding demands of the satellite fire community:

- the validation and calibration of satellite products from polar orbiting and geostationary satellites requires contemporaneous measurements, that are extremely challenging due to the spatially and temporally changing nature of fires. In particular, there is a strong need for measurements at an intermediate scale between ground measurements (IR sensors mounted on towers) and the coarse resolution of the satellites used for fire detection. This is a high priority both for the detection of actively burning fires, and for the estimation of the Fire Radiative Power (FRP), which requires absolute calibration of bi-spectral IR measurement.
- The initiative would result in an extensive dataset of fire observations to inform the requirements of future airborne and satellite missions.

Expected Management/decision support outcomes: Since the 1960 the Forest Service has been using Infrared (IR) Imagery acquired by airborne platforms to operationally support fire suppression efforts. Airborne infrared scanners are currently operated by National Infrared Operations (NIROPS), located at the National Interagency Fire Center, have the capability of delivering geolocated, GIS ready active fire detection maps at very high spatial resolution, with incident management teams as the primary user. Whilst maintaining incident management as the primary focus of the NIROPS acquisitions, this short proposal highlights the potential benefits of improved access to IR airborne imagery for the fire sciences community. The acquisition of calibrated IR measurements from NIROPS would provide a reference standard for future missions and would allow for the generation of an extensive dataset to drive the simulation of the performance of future sensors.

EO Data: Landsat, Sentinel-2, MODIS, VIIRS

Keywords: Wildfire hazard, Wildfire impacts, Active Fire Mapping and Fire Radiative Power Estimation

18. National Canopy Height Layer (1m) and Dataset of Individual Tree Objects

Jim Ellenwood (USFS R&D IMAR/MRS&GAR)

Creating and maintaining a nation-wide 1-meter canopy height model layer based upon available Lidar data, digital photogrametric high-resolution imagery, interferometric radar, etc. The construction of the canopy height model from a DSM and DTM is not without issues. NASA Goddard has developed processing routines to assist in creating a reasonable CHM layer through various routines that filters data anomalies. Additional routines have been created by University of Vermont. This product would need to be designed to incorporate multi-temporal datasets where a given pixel can have multiple sources at different times. Individual tree objects can help to stabilize the temporal issues.

Expected Management/decision support outcomes: Several agencies need canopy height. Forest Service R&D would benefit from this product to support direct relationships with the permanent ground inventory. This product would support 1) small area estimation, 2) enhance timber products monitoring, 3) improve carbon and biomass estimates, 4) allow for more precise land cover and change estimates, and 5) allow for more precise urban inventory estimates and enable synthetic estimates for urban areas which have not been measured. Additional agency support may facilitate the development of high-resolution geospatial layers that may form the basis for mapping needed for assessment, plan development, and monitoring phases of the 2012 Planning Rule framework.

EO Data: ICESat-2, High spatial resolution R-G-B-NIR, LiDAR, UAVSAR

Keywords: Wildfire hazard, Fuel loading, Wildfire impacts, Forest health, Vegetation mapping, Carbon emissions and flux

19. Seeing the Buildings, Forests, and Trees: Mapping WUI Environments and Losses After Wildfire Events

Miranda H. Mockrin, Volker C. Radeloff, Todd Hawbaker, Sebastian Martinuzzi (Northern Research Station, University of Wisconsin, United States Geological Survey)

The Forest Service, along with state and community partners, faces a mounting challenge in wildfire management as the wildland-urban interface (WUI) continues to expand (Radeloff et al. 2018): more than 20,000 buildings were destroyed by wildfires in 2018, despite nearly $5 billion spent in suppression each year. Unfortunately, our ability to learn from these losses, and better understand when and where buildings are destroyed to wildfire is currently limited. We rely upon on the ground post-fire surveys of building loss and fuel characteristics to document buildings destroyed and fuels around them (e.g., Syphard et al. 2019). Such surveys typically occur only for high-profile fires, rarely assess buildings that survived, and are necessarily limited in their assessment of vegetation and fuels, as they are carried out post-fire. Despite significant advances in remote sensing of vegetation and fire risk modeling, our best existing vegetation products (e.g, LANDFIRE) and models do not capture fine-grained vegetation around homes or extend into urban areas. However, recent advances in remote sensing offer new opportunities to map both buildings and vegetation in WUI areas. The USFS is currently collaborating with the University of Wisconsin and the USGS to create a high-resolution map of the WUI using Microsoft's national-scale database of building footprints, which were identified from high-resolution imagery using a convolutional neural network (CNN). Expanding and integrating such techniques with remote sensing of vegetation density and structure around homes will allow us for the first time accurately assess the conditions leading to wildfire loss and survival, directly generating enhanced recommendations for wildfire mitigation on the ground. Our goals are to 1) map all buildings within wildfire perimeters (before and after fires), applying the CNN pipeline to high-resolution imagery, 2) map pre-fire vegetation density near buildings using existing lidar data, and 3) develop predictive models of wildfire outcomes.

Expected Management/decision support outcomes: This framework will significantly advance our ability to assess wildfire impacts, and our enhanced knowledge will help the Forest Service and communities strategically allocate mitigation resources to reduce future losses. In a time when wildfire extent and losses continue to expand, such research is increasingly vital to reduce wildfire risk across ownerships.

EO Data: LiDAR, high-resolution imagery (WorldView, GeoEye, Planet).

Keywords: Wildfire hazard, Fuel loading, Wildfire impacts, Vegetation mapping

20. Disturbance/Recovery Forecasting

Nathan Pugh, Claire Simpson, Rob Vaughan (USFS-GTAC)

Create greenest pixel mosaic to look at healthiest veg and run a forecasting model to determine if and when areas will return to healthiest state (or predicted difference from "base state" in 5 years, 10 years, etc.). Alternatively use a forecasting model on only pre-2015 imagery and see how well current vegetation trends are predicted by historical data – which areas are greener/drier than expected and what does this mean for future trend analysis?

Expected Management/decision support outcomes: Support various on the ground applications as well as overall forest planning and monitoring applications affecting plans for things like harvests, planting, recreation and grazing to name a few.

EO Data: Landsat, Sentinel-1, Sentinel-2, MODIS

Keywords: Forest health, Climate and drought, Vegetation mapping, Rangeland management

21. Using ICESat-2 and Landsat to Map Forest Aboveground Biomass in the Southern US

Lana L. Narine, Sorin C. Popescu, Lonesome Malambo, and Meng Liu (Auburn University and Texas A&M University)

One of four key research areas highlighted at the first USFS-NASA Joint Applications Workshop was vegetation condition, with functional areas that included vegetation structure and function, forest health and carbon monitoring. With NASA's ICESat-2 capturing measurements over vegetated areas, indicators of ecosystem health and a key surrogate of carbon, forest aboveground biomass (AGB), can be derived. Previous studies with simulated ICESat-2 data emphasized the synergistic relationship between ICESat-2 and Landsat for characterizing vegetation structure, and initial findings with actual data support this approach. Our idea proposes the use of available data provided by ICESat-2 and Landsat to map AGB over the southern US. We also propose the integration of airborne lidar data from USGS 3D Elevation Program (3DEP) and available field inventory data, such as FIA data. The goal of 3DEP is to provide nationwide coverage of lidar, with current coverage at approximately 67% of the US. Thus, leveraging the capability of existing airborne lidar, which has been shown to accurately estimate field measured AGB, we propose a multi-source, multi-scale scale approach for achieving regional coverage. Methods would entail using airborne lidar to estimate ground AGB, processing ICESat-2 data and relating metrics from the processed data with airborne lidar-estimated AGB. Machine and deep learning algorithms would then be investigated for integrating with Landsat to achieve wall-to-wall AGB.

Expected Management/decision support outcomes: Up-to-date maps of AGB density and distribution (at 30-m resolution) for the southern US and potential source of information for reporting on vegetation condition, including vegetation structure and carbon monitoring.

EO Data: Landsat, ICESat-2, LiDAR

Keywords: Vegetation mapping

22. Sub-pixel Analysis of Flaming and Smoldering Combustion

Chris Elvidge (Colorado School of Mines)

There are two widely recognized combustion phases: flaming and smoldering. Flaming is hotter and produces more complete combustion. Smoldering is cooler and produces more smoke and partially oxidized trace gases. The flaming radiant emissions are shifted to shorter wavelengths (Wein's Displacement Law). Our approach is to model the flaming phase Planck curve with near infrared and shortwave infrared radiances. The flaming phase radiances are then modeled for the remaining VIIRS bands and subtracted from the observed radiances. The smoldering versus background Planck curves are then derived from the residual radiances.

Expected Management/decision support outcomes: EOG has one more year of funding for this development from the JPSS Proving Ground program. We plan to begin near-real time VNF+ production later this year. We are looking for opportunities to validate results. We anticipate that the USFS could find the additional information content useful for fire and smoke management.

EO Data: Nighttime Landsat, Nighttime VIIRS

Keywords: Wildfire hazard, Wildfire impacts, Fire and Smoke Management

23. Facilitating the use of Remote Sensing for Rapid Detection of Deforestation and Fire and Monitoring Carbon Sequestration

Matthew Dickinson, Carlos Alberto Silva, Andy Hudak (USFS Northern Research Station)

New sources of remote-sensing data are needed to support governments and NGOs in rapid detection of deforestation and fire and in monitoring carbon sequestration, but the data need to be readily available and easy to use at national and local scales. A combination of passive and active remote sensing has shown great promise for rapid detection of illegal deforestation for cattle ranching that is occurring throughout the Mesoamerican tropics, but active data are hard to use and need local calibration. Fire is an integral part of pasture establishment and there are disparate sources of remote-sensing data that are useful for fire detection. However, the MODIS and VIIRS sensors are typically the only ones used, resulting in missed fires, delayed detection (high latency), and other uncertainties. As with deforestation detection, a combination of passive and active remote sensing (esp. space-based LiDAR) show promise in quantifying carbon sequestration. In contrast to a global approach to detecting deforestation and fire and carbon monitoring, NASA could support national and local-scale efforts by (1) providing more highly-processed data from more sensors through a single portal, (2) developing tools that would support application, (3) supporting national and local ground calibration campaigns, and (4) supporting training and demonstration activities.

Expected Management/decision support outcomes: USFS International Programs, the USGS, international NGOs, and government agencies in Mesoamerica are working throughout the region on nature conservation, social and economic development, reducing illegal logging, and carbon sequestration. A multi-country focus for the last several decades has been protecting large areas of habitat and the corridors that connect them from South to North America. Countries must develop their own national programs to meet requirements of the United Nations Program on Reducing Emissions from Deforestation and Forest Degradation and, thereby, benefit from carbon sequestration within their borders. Greater and more effective use of remote-sensing data at national and local scales would support these efforts. For deforestation and fire detection and carbon monitoring, systems designed to provide information at global scales will provide limited value for these national and local programs. As such, NASA should consider tailoring their support to these national and local needs.

EO Data: Landsat, Sentinel-2, MODIS, VIIRS, LiDAR

Keywords: Wildfire hazard, Wildfire impacts, Carbon emissions and flux, Conservation

24. Integrating NASA and USFS datasets for a high-resolution annual forest carbon monitoring system

Alex Rudee, George Hurtt (World Resources Institute, University of Maryland)

Integrating remote sensing data from NASA with the Forest Inventory and Analysis (FIA) dataset could provide USFS with a high-resolution annual forest carbon monitoring system suitable for greenhouse gas inventory applications. As attention from policymakers and the public builds around natural solutions to climate change, there is a significant unmet need for robust data on forest carbon stock changes at multiple spatial scales. Providing a sophisticated forest carbon monitoring product would position USFS and NASA as key stakeholders for the national, state and local agencies that are currently struggling to produce data of sufficient quality to inform policy and land management decisions. This monitoring product would also enable USFS to seamlessly incorporate carbon sequestration into management plans and agency decision-making for public lands. This product would represent a leap forward relative to FIA-based annualized estimates of carbon stock change by leveraging NASA products to assess the spatial structure of forests and map annual forest area change, producing spatial estimates of aboveground carbon, canopy cover, and ecosystem carbon sequestration and storage over time. Importantly, the integration of remote sensing and field-based datasets would allow for robust annual updates to these estimates, giving the monitoring system a temporal and spatial resolution that is ideal for greenhouse gas inventories.

Expected Management/decision support outcomes: Developing a spatially explicit annual inventory for forest carbon stock change would allow USFS and other agencies, including at the state and local levels, to more fully and precisely evaluate trends in carbon sequestration at multiple spatial scales. Potential applications include:

- Providing data to state and local greenhouse gas inventories in order to inform better forest policy and management decisions at all levels of government
- Creating an annually updated interactive national map of forest carbon stock changes linked to the National Greenhouse Gas Inventory, which could be used for academic research and serve as a template for forest carbon inventories in other countries
- Informing a catalog of restoration needs on public lands by identifying where wildfire or other natural disturbances have caused significant year-over-year carbon losses

- Improving forest management plans by targeting activities such as thinning or invasive species control to forest areas that are sequestering less carbon than comparable areas with similar forest types and environmental conditions
- Tracking spatial changes in carbon sequestration over time as forest age and composition changes, including in response to climate change
- Communicating the value of Forest Service lands and management activities for carbon sequestration to other agencies, Congress, and the public

EO Data: Landsat, LiDAR

Keywords: Carbon emissions and flux

25. Mapping tree crown areas & height of forests the 50 cm scale using machine learning

Compton Tucker (NASA GSFC)

My NASA group is processing large volumes of commercial satellite data at the 50 cm scale. We have executed this for millions of km2 of sub-Saharan Africa and enumerated the crown-area of billions of individual tree crowns using machine learning. We are now associating tree height with our tree-crown mapping, also derived from commercial satellite data, to move to biomass. While most of this work was done for discrete trees, we have also dealt with clumped trees and can disaggregate continuous canopies into individual tree crowns. We would welcome the opportunity to work with the US Forest Service on problems of shared interest.

Expected Management/decision support outcomes: Tree enumeration inside and outside of forests in terms of crown area and crown height at the 50 cm scale; biomass estimates at the object level of individual trees; and ecological metrics using distributions of tree crown area.

EO Data: Landsat, Sentinel-2, MODIS, VIIRS, High spatial resolution R-G-B-NIR, Imaging Spectroscopy

Keywords: Wildfire hazard, Fuel loading, Wildfire impacts, Forest health, Climate and drought, Vegetation mapping, Carbon emissions and flux

26. A deep learning approach for modeling forest structure and classifying disturbance across ecotypes and time

Tony Chang, Ty Barry Wilson, Karen Schleeweis (Conservation Science Partners, USFS)

This project proposes an analysis of the performance of a deep learning model for forest structure and classification estimates across the entire US over a variety of ecotypes and a 20-year time period. Although many techniques have been developed thus far to detect disturbance at the Landsat 30-m pixel level, classification for fine grain data over large areas, often it is difficult to determine the transition of a forest in terms of loss, and accurately represent the difference between a sparse forest canopy that is fully burned or a dense forest canopy that is partially burned. This is because a pixel-based analysis depends only on the spectral signature and not on an object-based detection of the number of trees or percent canopy cover present. We propose performing an object-based analysis using the sub-30 m pixel dataset from the National Agriculture Imagery Program (NAIP) and the Copernicus Sentinel-2 sensors and temporal Landsat 4/5/7/8 data, to train a multi-sensor recurrent convolutional neural network model to classify forest type and continuous forest metrics simultaneously. For this project, we will be building on a recently published deep learning model called 'Chimera' (https://www.mdpi.com/2072-4292/11/7/768) that was training and tested in the Sierra Nevada region. We hope to expand the utility of this model by training it across various ecotypes in the United States for forest disturbance detection.

Expected Management/decision support outcomes: More accurate and continuous measurements of forest gain and loss that could impact forest ecosystem health, fuel loading, and wildfire behavior across various ecotypes within the US.

EO Data: Landsat, Sentinel-2, High spatial resolution R-G-B-NIR

Keywords: Wildfire hazard, Fuel loading, Wildfire impacts, Forest health, Vegetation mapping, Carbon emissions and flux

27. Predicting forest mortality by integrating genetics and remote sensing

Benjamin Blonder, Suzanne Marchetti (UC Berkeley, Forest Service - R2 Forest Health Protection)

Predicting species response to climate change is often done via environmental predictors. However, species are comprised of multiple genotypes, some of which may be better suited to novel conditions. Predicting responses can be improved by identifying ‘winner’ and ‘loser’ genotypes under novel environments, i.e. by determining interactions between a genetic mosaic and an environmental mosaic across space. Such work has been limited by the need for time-intensive DNA sequencing work.

This project will investigate whether remote sensing (multispectral imagery) and artificial intelligence algorithms can map genotypes across space. Genotypic variation should drive phenotypic variation, which should affect spectral reflectance of canopies, which should then be separable using appropriate algorithms. Remote sensing of genotypes is a frontier for upscaling biodiversity conservation and predicting mortality/stress (e.g. NASA's ECOSTRESS).

This project will assess quaking aspen, a dominant species experiencing high drought mortality. Aspen can occur in diploid or triploid genotypes, impacting its physiology. We will determine whether hyperspectral or multispectral imagery can map ploidy level across thousands of square kilometers, then will use these AI-inferred maps and topographic data to forecast mortality risk. The work will be carried out with the US Forest Service and will support on-the-ground conservation efforts. Advances would be applicable to many other species.

Expected Management/decision support outcomes: We could create a predicted forest mortality map for the year 2050 covering all of western North America. The map will be similar in construction to a species distribution model (Franklin 2013), but will incorporate additional genetic predictors, consistent with recent calls to incorporate genetic information in conservation planning and biogeography (Fitzpatrick & Keller 2015). The map will be used to further assess areas beginning to show signs of mortality, or in areas explicitly identified by US Forest Service partners as being of concern. This work will directly extend and significantly improve extant US Forest Service efforts to forecast the future distribution of aspen forests in North America (Rehfeldt et al. 2015).

EO Data: Sentinel-2, ECOSTRESS, Imaging Spectroscopy

Keywords: Forest health, Climate and drought, Vegetation mapping

28. Testing ICESAT2 data for Supporting Tree Canopy Cover Data

Kevin Megown, Stacie Bender, Karen Schleeweis, Mark Finco, Bonnie Ruefenacht (USFS)

ICESAT2 offers a unique perspective in both space and time towards characterizing tree canopy cover data for CONUS, and Coastal and Interior Alaska. We look to test the ICESAT2 data for use in the development of the 2021 and future Forest Services National Tree Canopy Cover data development which uses landsat as a basis for modeling. The current FS TCC product is found at: https://data.fs.usda.gov/geodata/rastergateway/treecanopycover/index.php. The FS TCC data aims to track and support broadscale monitoring of TCC through space and time and believe the ICESAT2 data will directly support expanding the product to improve timeliness and frequency of TCC data iterations.

Expected Management/decision support outcomes: To determine the effectiveness and application of the ICESAT2 data for use in development of the Forest Service Tree Canopy Cover data.

EO Data: Landsat, High spatial resolution R-G-B-NIR

Keywords: Fuel loading, Forest health, Water and aquatic resources, Climate and drought, Vegetation mapping, Rangeland management, The FS TCC data supports a number of FS business needs (ex. post stratification) and is available to the public (https://www.mrlc.gov/)

29. Improving forest structure monitoring with GEDI

Ray Davis, Sean Healey, David Bell, Zhiqiang Yang (USFS National Forest System, Pacific Northwest Region)

The Northwest Forest Plan (NWP) has governed federal forest management in the Pacific Northwest for more than 25 years. A key effectiveness metric under the Plan has been maintenance of forest structure capable of supporting late-successional associate species such as the northern spotted owl. Regional mapping of target structural conditions makes use of an innovative imputation approach which relies on time series of Landsat imagery, calibrated with extensive inventory data. This work, and ties to NASA, are described here: https://earthobservatory.nasa.gov/images/145979/spotting-the-spotted-owl-30-years-of-habitat-change. We believe that the dense sample of full waveform lidar now coming from NASA's GEDI instrument might radically improve our differentiation of key forest structures. With millions of structure observations compared to thousands, and direct representation of canopy structure that is not available with plot measurements, we see an opportunity to enhance assessments included in the next 5-year NWFP Effectiveness Report. We propose to work with current GEDI researchers and perhaps the LP DAAC to include this new data source in our monitoring system.

Expected Management/decision support outcomes: Remote sensing has provided key context for Northwest Forest Plan monitoring since the 1990s. Combined with forest inventory methods, the mapping that is targeted for improvement is a foundational asset for periodic (5-year) assessments of Plan effectiveness.

EO Data: Landsat, LiDAR, GEDI

Keywords: Vegetation mapping, Habitat, endangered and sensitive species

30. Landsat-era LAI data for studying declining water resources in Oregon's Harney Basin

Margaret Matter and Bailing Li (Oregon Department of Agriculture, NASA GSFC, University of Maryland)

Fresh water resources in the Western U.S. have been declining for decades. These changes coincided with significant decreases in precipitation and SWE, warmer temperatures and increases in forest density/expansion. Efficient, effective management of water and forest resources depends on fully understanding individual and combined roles of factors in influencing freshwater resources both historically and in the future.

Leaf Area Index (LAI) data provide information on land cover change, including forests. Currently, MODIS-based LAI products are available at 500 m spatial resolution, for 2002-present. This dataset is not long enough to study the intertwined effects of changes in forest s and climate, both of which have changed slowly over several decades. LAI has also been derived from Landsat surface reflectance data (e.g., Ganguly et al. 2012), but no official products extending beyond the MODIS LAI period are available for climate related studies. We propose to derive LAI data from Landsat missions, beginning in 1972, and assimilate the LAI data into a land surface model embedded in the NASA Land Information System (LIS) system to study water storage changes. The atmospheric forcing fields driving the model reflect climate change, thus the LAI data assimilation allows us to tease out impacts of climate from that of vegetation changes. The LIS modeling framework also serves as a bridge between NASA data and USFS tools which may be unable to use LAI data directly.

Expected Management/decision support outcomes: This study will benefit the USFS and Oregon by providing needed information in the following areas:

- Relative impacts due to the individual climate and anthropogenic forcings over time on surface water and groundwater resources
- combined effects of interactions between and among the climate and anthropogenic forcings over time on water resources
- Projections of future impacts of climate as well as the combined effects of climate and anthropogenic factors on forest and water resources.

The increased understanding that will result from such a study will help address water and forest resource challenges in the near-term, and will be critically important to informing decision-making, monitoring of conditions and impacts of policies and resource management actions, and in adaptively managing forest and water resources efficiently and effectively.

EO Data: Landsat

Keywords: Wildfire hazard, Forest health, Water and aquatic resources, Climate and drought, Soil moisture, Vegetation mapping

31. Developing an improved biomass inventory system for U.S. mangrove forests using remote sensing and LiDAR-based field sampling techniques

Todd Schroeder, Carl Trettin, Mark Brown, Temilola Fatoyinbo, Mark Simard (USFS Southern Research Station, Goddard Space Center, Jet Propulsion Laboratory)

Biomass is the foundation of the valued ecosystem services that are widely recognized from mangroves. However, information about the condition of mangroves including biomass is limited because they are notoriously difficult forests to access and traverse. Accordingly, the application of remote sensing data to estimate structural attributes and biomass is an attractive alternative. Canopy height can be used as basis for estimating forest biomass, however inclusion of another metric that is sensitive to stand density or stocking could provide a more robust basis for inventorying mangrove biomass. Another source of uncertainty in the quantification of mangrove biomass is the accuracy of allometric equations that are used, which then are inextricably linked to the remote-sensing models that are built to estimate forest biomass. Accordingly, improvements in the allometric equations would improve the accuracy of both field and remote sensing based biomass inventories. The goal of this project is to develop a robust model for estimating mangrove biomass in US and territorial waters. The project would have two components: (1) application of high resolution radar and Lidar data (airborne and / or space) to provide the basis for robust model to estimate forest structural components (e.g., height, stand density), and (2) development of improved allometric functions based on terrestrial Lidar. This work would have wide-spread interest from governments in national reporting.

Expected Management/decision support outcomes: The project improve capabilities within the national forest inventory for reporting mangrove biomass at state / territory and national scales. It would also enhance applications in numerous other countries where mangroves exist.

EO Data: Landsat, Sentinel-1, Sentinel-2, MODIS, High spatial resolution R-G-B-NIR, LiDAR, UAVSAR, Uncertain – looking for guidance

Keywords: Forest health, Water and aquatic resources, Vegetation mapping, Carbon emissions and flux, forest inventory

32. Developing improved forest soil moisture estimates from in situ, satellite and land-surface models

Steven Quiring, Trent Ford (The Ohio State University, University of Illinois Urbana-Champaign

The goal of this project is to develop national-scale soil moisture products that accurately represent soil moisture conditions in forested environments. These products will be developed by integrating multiple, diverse sources of soil moisture information to support USFS management and decision making.
With funding from NOAA and NIDIS we have developed and deployed a series of national soil moisture products based on in situ measurements, remote sensing (NASA SMAP) and land surface models (NLDAS-2). These products are provided in near-real-time at: <nationalsoilmoisture.com>. The methods used to develop these products have been evaluated and published in the peer-reviewed literature. However, the assessment of the accuracy of these products has primarily been in agricultural and grassland environments because this is where most in situ measurements are located. Therefore, the goal of this project is to improve the accuracy of our soil moisture in forested environments. Specifically, we plan to:

1. Identify and gather in situ soil moisture data from forests and rangelands

2. Evaluate different methods for combining the in-situ measurements with model-derived soil moisture (and satellite-derived soil moisture in rangelands)
3. Develop soil moisture products specific to forests and rangelands
4. Evaluate the accuracy and utility of these products for supporting USFS management and decision making.

Expected Management/decision support outcomes: As outlined in the summary of the USFS-NASA Joint Applications Workshop, improved soil moisture data will: 1) Improve plant stress early warning, 2) Improve consistency of soil moisture information across scales, 3) Drought detection, 4) Improve water supply maximization strategies, 5) Provide inputs for ecological, disease and pest modeling, 6) Support decision making regarding accessibility of recreation trails (e.g., ATV)

EO Data: SMAP, To date we have evaluated SMAP, AMSR-E, and TRMM TMI, but other satellite-derived soil moisture products could also be used

Keywords: Forest health, Water and aquatic resources, Climate and drought, Soil moisture

33. Linking Snow-Soil-Fuel Moisture To Manage Wildfire Hazards in Complex Terrain

Adrian Harpold, Erin Hanan, and Manuela Girotto (University of Nevada, Reno, UC Berkeley)

Understory fuel moisture is a critical control on fire spread and fire planning in montane regions. Fuel moisture products could help optimize prescribed burning schedules and monitor forests fire conditions. No product is available at the spatial scales needed in complex terrain. Our research team will integrate several remotely sensed datasets that take at advantage of the physical connections that snow provides in recharging soil moisture and maintaining fuel moisture using a physical model and data assimilation approach:

1. Spatial estimates of snow disappearance that controls soil and fuel moisture timing (via MODIS, Landsat, Sentinel-1 and -2) and lidar.
2. Spatial estimates of land surface temperature that can be used to estimate surface vapor pressure deficit (via ECOSTRESS, Landsat, or MODIS), a primary determinant of fuel moisture.
3. Spatial estimates of soil moisture (via SMAP and Sentinel-1) could inform distributions in shallow mountain soils.

Our novel approach will downscale (when necessary) and assimilate these remote sensing datasets into an ecohydrological modeling platform (i.e. RHESSys), with the goal of developing a daily fuel and soil moisture product at ~30 m scale over mountainous USFS lands. The ecohydrological model allows forest growth and fire spread simulations, which could assess the long-term benefits of forest restoration strategies intended to reduce severe fire risk.

Expected Management/decision support outcomes: Wildfire prediction, soil moisture monitoring, and hydrologic monitoring

EO Data: Landsat, Sentinel-1, Sentinel-2, MODIS, ECOSTRESS, SMAP, SRTM, LiDAR

Keywords: Wildfire hazard, Wildfire impacts, Water and aquatic resources, Soil moisture

34. Use of remote sensing to monitor the condition and biogeochemical processes in managed forests

Andrew Chris Oishi, Devendra Amatya (USFS Southern Research Station)

The ability to monitor environmental conditions that affect biogeochemical processes in forests is critical to understanding the interactions of land management practices and the provision of ecosystem services. Advances in sensor technology and resolution of remote sensing data suggests opportunity for developing tools specific to biogeochemical processes that are inextricably linked to ecosystem services, thereby providing the capability for large-scale assessments, as well as providing a basis for validating conditions inherent to earth system models. This initiative would consider the development of applications utilizing remote sensing data to assess the changes in the water and carbon balance in managed pine forests. Over 2 million acres of forest in the southeastern US are expected to be "restored" to long leaf pine; a major goal for federal, state, and private lands, with benefits accruing with respect to carbon sequestration and water yield. The project would focus a paired watershed study where one watershed is being converted to long leaf pine using three common silvicultural prescriptions. Field based monitoring of CO_2 and energy flux, soil moisture, ground water, stream discharge, vegetation composition and growth, provides an excellent platform for developing remote sensing – based tools; suggestions include: estimation of evapotranspiration, soil moisture, changes in above-ground biomass, tree and understory species composition, change in forest structure.

Expected Management/decision support outcomes: The project could provide field validated tools for assessing changes in water and carbon balance in managed watersheds. Correspondingly, the tools would also provide the basis for large scale modeling applications.

EO Data: Sentinel-1, Sentinel-2, MODIS, ECOSTRESS, SMAP, High spatial resolution R-G-B-NIR, LiDAR, Imaging Spectroscopy, Uncertain – looking for guidance

Keywords: Fuel loading, Forest health, Water and aquatic resources, Soil moisture, Vegetation mapping, Carbon emissions and flux

35. Delineation of Terrestrial - Blue Carbon Boundary in Coastal Waters of the U.S.

Carl Trettin, Temilola Fatoyinbo, Mark Simard (USFS Southern Research Station, Goddard Space Center, Jet Propulsion Laboratory)

Blue Carbon includes coastal ecosystems at the interface between land and deep marine waters. Specifically, blue carbon refers to vegetated wetlands that are tidally influenced, including sea grasses, saltwater marshes, mangroves, freshwater marshes and forests. The terrestrial extent of these ecosystems are freshwater tidally influenced wetland forests and marshes. Accordingly, tidal freshwater wetlands occur at the land / sea interface, which is recognized as critical hot spot for biogeochemical processes and ecosystem services that are affected by land use, climate change and sea level rise. Unfortunately, there are huge uncertainties about extent and distribution of freshwater tidal wetlands; this is attributable to imprecise delineation of tidal extent and inaccuracies in the National Wetland Inventory. The woefully inaccurate data about the distribution of these wetlands is an impediment to research and policy, and it precludes information that is needed to accurately represent the landscape in earth system models. This initiative focuses on the integration of remote sensing data to delineate the boundary between terrestrial and blue carbon ecosystems. The project would utilize representative areas in the Atlantic, Gulf, and Pacific coastal plains. The approach would include optical sensors for delineating the wetland vegetation types and Lidar or radar data for imputing tidal reach. This work would provide a basis for continental and global applications.

Expected Management/decision support outcomes: The project would provide new information on the distribution and characteristics of coastal wetlands that are required for land management planning, resource assessment and national reporting purposes. The results of this project would facilitate the a continental-scale assessment, which is needed.

EO Data: ICESat-2, SRTM, High spatial resolution R-G-B-NIR, LiDAR, UAVSAR, Uncertain - looking for guidance

Keywords: Water and aquatic resources, Climate and drought, Vegetation mapping, Carbon emissions and flux, Sea level rise

36. Identifying and leveraging synergies with the remote sensing community to improve the next generation of the SNOTEL ground observation network and NRCS water supply forecasting system for the US West

Sean Fleming, Brian Domonkos, Jolyne Lea, Chris Brown, Karl Wetlaufer, Gus Goodbody (USDA NRCS)

USDA's Natural Resources Conservation Service (NRCS) operates SNOTEL, a long-term network of telemetered, high-frequency, near-real-time mountain snow and climate monitoring stations at over 700 sites in the western US. The annual value of these data is billions of dollars, mainly reflecting their use in predicting seasonal river runoff; NRCS also operates the largest stand-alone water supply forecast (WSF) system in the US West. Even marginal WSF improvements can offer over $100 million in benefit every year for a single basin, motivating continued improvement in watershed hydrology models and input data. Our pitch is for a study assessing capabilities, gaps, and opportunities for remote sensing (RS) as it relates to SNOTEL and WSF, centered around two themes. (1) What can RS do for WSF? Satellite and airborne RS for snow water equivalent is tremendously promising, but theoretical and practical challenges remain in leveraging these data to improve operational WSF modeling skill. (2) What can SNOTEL do for the RS community? SNOTEL and related networks, like SCAN with its soil moisture observations, enable building and ground-truthing RS products, and there is opportunity to add or modify sensors to better meet the needs of the RS community. Our goal is to learn where the RS community's efforts stand, what activities are ongoing or planned, how NRCS can capitalize on these outcomes, and where NRCS can help fill in gaps and provide additional suggestions or capabilities.

Expected Management/decision support outcomes: We expect this project to have significant impact on design and operation choices around the SNOTEL network, improving its usefulness to the remote sensing community; and on management decisions around remote sensing products employed for snowmelt runoff and water supply forecasting across the western US.

EO Data: Uncertain - looking for guidance

Keywords: Water and aquatic resources, Climate and drought, Soil moisture, Snowpack, hydrology, and water supply prediction

37. Detection and attribution of a recent, unexpected hydrologic change

Mark Green, Scott Bailey, and John Campbell (Case Western Reserve University and USFS Northern Research Station)

Small catchments have served as sentinels of forest ecosystem responses to changes in air quality and climate. The past decade of water budgets at the Hubbard Brook Experimental Forest in New Hampshire have indicated a hydrologic change that is consistent with an approximate 25% increase in evapotranspiration (ET) relative to the long-term mean. The magnitude of this multi-year ET deviation far exceeds others in the 60-year Hubbard Brook record. This hydrologic signal is based on the difference between precipitation and stream flow in small catchments, requiring additional measurements and analysis to isolate the role of ET from any change in subsurface water storage. While we are using ground-based measurements such as groundwater monitoring since 2007 to understand this hydrologic change, the ECOSTRESS and SMAP remote sensing products would likely help us determine what is driving this unprecedented shift in forest water balance. If this dramatic change in ET is occurring more broadly across the region, it would have substantial impacts on water resources and land-surface energy balances, with broad-ranging implications for forest productivity and management. Our Hubbard Brook team would like to partner with remote sensing experts who are interested in helping understand hydrologic change in our catchments, and possibly tracking whether the changes we are observing are occurring at broader scales.

Expected Management/decision support outcomes: Hydrologic monitoring protocols that integrate ground-based and remotely sensed data.

EO Data: ECOSTRESS, SMAP

Keywords: Water and aquatic resources

38. Riparian areas vegetation classification

Sinan Abood, Linda Spencer, Nathaniel Gillespie (USFS)

Riparian area's extent, shape, size, and land cover composition are important parameters in any successful watershed management plan. The Watershed, Fish, Wildlife, Air & Rare Planet staff and Vegetation Management & Rangeland Ecology staff successfully developed a multiscale framework for delineating riparian area's extent, shape, and size at a 10-meter spatial resolution for all NHD streams at 24K scale. The new national riparian areas base map lacks the land cover composition parameter instead we utilize NLCD land cover products at the 30-meter spatial resolution to extract riparian land cover composition. Using this newly developed riparian dataset and NASA observation satellites and technology especially Sentinel-2 multi-spectral bands this gap could be filled with a land cover composition for delineated riparian areas with a matching 10-meter spatial resolution. here I am proposing two ideas; first developing classification algorithms for google earth engine with a simple built GUI to classify a user-selected riparian area of interest riparian on the fly where Sentinel-2 imagery available with land cover change application if possible, second classify riparian area's land cover for the national forests utilizing overlapped riparian base map extent and Sentinel-2 imagery at 10-meter spatial resolution.

Expected Management/decision support outcomes: riparian areas land cover inventory.

EO Data: Sentinel-2, High spatial resolution R-G-B-NIR, LiDAR, Uncertain - looking for guidance

Keywords: Wildfire impacts, Forest health, Water and aquatic resources, Vegetation mapping, Rangeland management

39. Using thermal imagery acquired with the UAVSAR platform to identify and delineate groundwater dependent ecosystems (GDEs)

Tim Stroope, Donna Shorrock, Karri Cary (USFS)

Sub-meter thermal imagery of GDEs acquired by sUAS demonstrates high potential for the identification and delineation of these features. It has also demonstrated the greater potential of long-endurance fixed-wing UAS based thermal systems with comparable resolution. SAR and optical imagery have been used to identify GDEs with varying degrees of accuracy but, can be limited by resolution and the need for time series imagery. Land managers working at small scales (e.g. timber sale units and sections of riparian corridors) and short time frames (e.g. months) require accurate, high resolution data that requires minimal post-processing. GDEs are generally stable features on the landscape and groundwater is generally thermally stable with respect to the surrounding landscape. These attributes could allow for the identification and delineation of these features without the need for time series imagery. NASA's UAVSAR program would be an ideal candidate to test the ability of thermal imagery to identify GDEs in a more efficient manner than uSAS and without the resolution limitations of satellite-based instruments. Thermal imagery acquired by UAVSAR flights over NFS lands could be processed and utilized by land managers and potentially applied within months of acquisition. By developing the methodology to identify GDEs through thermal and SAR imagery from UAVSAR, we can expand GDE inventory techniques to more broadly available high-resolution satellite imagery in the future.

Expected Management/decision support outcomes: Managers will use UAVSAR data to complement and prioritize field operations. Having these data will improve NEPA efficiency by increasing the accuracy and extent of available information, thereby lessening the chance of adversely affecting resources that were unidentified due to incomplete ground inventories.

EO Data: Landsat, Sentinel-1, Sentinel-2, Imaging Spectroscopy, UAVSAR

Keywords: Forest health, Water and aquatic resources, Climate and drought, Soil moisture, Vegetation mapping, Carbon emissions and flux, Rangeland management

40. Designation and recovery tracking of an emergency priority watershed using EO

Raha Hakimdavar, *other names to come* (USFS)

The 2018 Farm Bill requires USFS to develop criteria for designating an emergency priority watershed following significant wildfire events. Priority watersheds are HUC12 watersheds where restoration efforts and investments are prioritized. The new special emergency designation requires that USFS develop criteria to qualify a watershed as such following a significant wildfire and a way to monitor/evaluate recovery following restoration work and investments. We propose developing a decision support tool that uses the Normalized Burn Ratio calculated from Landsat, Sentinel-2, and potentially ICESat-2, coupled with a simple rainfall-runoff model developed using GPM-IMERG, PRISM, and USGS streamflow gauge data, to help USFS (1) more systematically decide which HUC12 watersheds warrant the "emergency priority watershed" designation (as one of the criteria to be met), and (2) track watershed recovery 1-3 years following the special emergency designation, when all fire-related restoration work on the watershed is expected to be completed. A NASA DEVELOP team conducted a related proof of concept study on the Gila National Forest. We anticipate building on that work by scaling it up to a national application and using the methods developed to address a slightly different need than the case with the Gila project.

Expected Management/decision support outcomes: (1) Helping USFS meet a requirement in the 2018 Farm Bill. (2) Helping USFS prioritize watersheds for emergency restoration work following significant wildfires. (3) Helping USFS monitor medium-term watershed recovery following a significant wildfire.

EO Data: Landsat, Sentinel-2, ICESat-2, GPM-IMERG

Keywords: Wildfire impacts, Water and aquatic resources

41. Estimation of Rangeland Yield from Soil Moisture Active Passive (SMAP) Data Products

Mahesh Pun and Matt Reeves (NASA GSFC & USFS)

The United States Forest Service (USFS) and Bureau of Land Management manage about 200 million acres of rangelands. Among other activities, these agencies regulate livestock grazing (permits, herd size, allotments, season of use) to improve or maintain rangeland conditions that meet the increasing demand for multiple uses. In addition, monitoring rangelands helps managers respond to, and prepare for, impacts from wildfire, drought, and climate change. Estimating rangeland yield (or fuel yield) from soil moisture data, as a covariate with the other data, is important for providing feedback essential to making informed management decisions and evaluating their results. However, field observations of soil moisture and annual production are sparse, which challenges the use of soil moisture information in estimating rangeland yield.

Publicly available satellite-based soil moisture maps, Soil Moisture Active Passive (SMAP) data from NASA may help overcome the challenges of sparse field observations of soil moisture. The SMAP observations of L-band passive microwave T_b are highly sensitive to surface soil moisture and temperature. NASA provides SMAP L4 RZSM product which is generated using a land data assimilation system that combines the advantages of the SMAP T_b measurements, precipitation observations, and land surface modeling. Application of this soil moisture product which are spatially refined could be very helpful in estimating rangeland yield in a regional scale. In addition, working directly with managers and reviewing past management decisions such as turn-out date may enable calibration of soil moisture conditions to appropriate range-readiness factors to increase communication between managers and permittees.

Spatially refined soil moisture product SMAP L4 RZSM from NASA and available rangeland yield data from USFS will be used for this project. The relationship between soil moisture and rangeland yield data will be analyzed, and the accuracy of this relation will be estimated. We will examine the spatial and temporal relations between SMAP and yield and between SMAP and turn-out date. We will need 6 – 12 managers to co-develop this product with. Regions 3 and 4 (Southwest and Intermountain West) will likely be the most cooperative in this endeavor based on prior experience.

The test relations between SMAP and yield we will test a variety of Vegetation Indices from MODIS or VIIRS at monthly time steps combined with SMAP. In this process we will pay close attention to and test for lag effects which are always present. For the range readiness process, we will examine records of turn out date for specific pastures under both BLM and USFS jurisdiction and compare these records with SMAP information. This has never been done before. Perhaps in doing this we can develop soil moisture guidelines and forward-looking statements.

Expected Management/decision support outcomes:

- Analysis on how SMAP product from Earth Observation can provide feedback essential to making informed management decisions and evaluating their results in the field of rangeland management
- A tool for estimating rangeland yield (or fuel yield) from SMAP soil moisture data
- Analysis of spatial and temporal relations between SMAP and rangeland yield
- Analysis of relationship between SMAP data and pasture turn-out date

EO Data: Soil moisture product SMAP L4 RZSM, MODIS, VIIRS, Landsat

Keywords: Rangeland yield, Soil moisture, SMAP

42. Real Time remote viewing technical assistance

Robert Gubernick (USFS)

The biggest obstacle I face supporting the field is time limitations due to travel. For example, since I work nationally on infrastructure / water related problems a site visit may take only 1 days work but requires 3 total days due to travel. If I had a technology like facetime or zoom on my phone and the field person had one, I could go for a site inspection and provide directions on where to take measurements remotely.

Satellite phones capability or linkage is needed since many sites do not have cell phone connectivity. A typical travel trip to these sites range between $1000 and 2000 dollars per trip. If the sites with lower risk can be supported in this remote fashion it would reap a huge savings in travel costs each year. It will also allow me to help more Forests do work each year since I will have a time savings on travel. This tool could be used widely for technical assistance in the agency and yield a significant cost savings and increase productivity.

Expected Management/decision support outcomes: They would be very supportive of saving money

EO Data: Uncertain - looking for guidance, Phone or other technology that can uplink a phone thru satellites for real time remote observation with field crews

Keywords: Forest health, Water and aquatic resources, Rangeland management, Infrastructure design and inspection

43. Post-Harvest Recovery Prediction

Nathan Pugh, Claire Simpson, Rob Vaughan (USFS-GTAC)

Create a tool to predict time to recovery after harvest with x characteristics at site with y features (e.g. elevation, climate) using LandTrendr/CCDC→ use historical data to get harvest date/info, look at timeseries trends to get validation data for recovery duration and look at remote sensing-based impact factors for site. Goal would be a UI for land managers to input information about a proposed harvest and get quantitative prediction of site recovery trends/uncertainty. Could also do some sort of space-time substitution to try to extend current recovery trends using similar-environment pixels e.g. how have similar areas recovered historically to similar disturbance.

Expected Management/decision support outcomes: Goal would be a UI for land managers to input information about a proposed harvest and get quantitative prediction of site recovery trends/uncertainty.

EO Data: Landsat, Sentinel-1, Sentinel-2, MODIS

Keywords: Forest health, Vegetation mapping, Harvest Planning and Management

44. A FIESTA Bridge: Spanning the gap between NASA products and forest inventory data

Gretchen Moisen, Tracey Frescino, Kelly McConville (USDA Forest Service, Rocky Mountain Research Station, FIA)

FIA needs interactive web apps through which users can easily create statistically defensible estimates and analyses, with automated reports, of forest attributes within user-specified polygons and time periods anywhere in the conterminous US. Work is currently underway that taps the extensive FIA plot network along with national remotely sensed data layers to produce estimates using published and widely accepted model-assisted and small area estimation methodologies. It leverages a decade's worth of statistical and computational research on FIA's flexible estimation engine, FIESTA, and provides a vehicle through which other scientists and analysts can share their own tools and analytical processes. Needed is a better understanding of which NASA data products to use to improve forest inventory estimates, which NASA data products might offer new vehicles for carrying and conveying inventory information on-the-fly, and which NASA tools might enhance this effort. NASA expertise could also assist in computing resources for computationally demanding small area and model-assisted estimators and addressing data security issues in an interactive web environment.

Expected Management/decision support outcomes: This project enhances FIA's ability to provide foundational data in an interactive environment. It supports forest management's need for defensible estimates on relatively smaller ecological units encountered in Forest planning, NEPA analysis, terrestrial condition assessments, forest management treatment projects, and post-fire vegetation analysis.

EO Data: Landsat, MODIS, Uncertain - looking for guidance

Keywords: Fuel loading, Wildfire impacts, Forest health, Vegetation mapping

45. NASA GLOBE Observer Trees Tool for Mobile Tree Height, ICESat-2, and Open Altimetry

Brian Campbell, Peder Nelson (NASA Wallops Flight Facility and GST, Inc., Oregon State Univ.)

The NASA GLOBE Observer Trees Tool allows citizen scientists to measure tree height for as many trees as the observer wants. You can track the growth of trees over time and even take observations at the same time the NASA Ice, Cloud, and land Elevation Satellite-2 (ICESat-2) is taking measurements of tree height from space. During your observation of tree height, you can also measure the tree circumference. Tree height is the most widely used indicator of an ecosystem's ability to grow trees. Observing tree height allows NASA scientists to understand the gain or loss of biomass which can inform calculations of the carbon that trees and forests either take in from or release into the atmosphere. Using the Open Altimetry online tool, anyone can compare the GLOBE tree height data to the tree and tree canopy data from ICESat-2. The GLOBE data can provide a second level of data comparison and serve scientists in their research. The pitch would be a demonstration of how to do comparisons between the GLOBE tree height data and ICESat-2 tree height and tree canopy data using the GLOBE Visualization System, NASA GLOBE Observer App, and Open Altimetry

Expected Management/decision support outcomes: The NASA GLOBE Observer Tree Height Data is available for researchers of all ages and there are GLOBE tree height observations in over 120 countries.

EO Data: ICESat-2, NASA GLOBE Program

Keywords: Forest health, Vegetation mapping

46. Building Capacity to use NASA data For Forestry Management

Ana I. Prados (NASA GSFC)

An important step in use of NASA data, is building the capacity for stakeholders at the local, regional and national level to access and analyze existing resources and apply them to USFS management activities. This can take the form of online or in-person training in technical capacity building. Using NASA's ARSET program as an example, this session will discuss existing activities, gaps in training at the USFS, and plans moving forward

Expected Management/decision support outcomes: Increased use of NASA data for decision support related to forestry management

EO Data: Landsat, Sentinel-1, Sentinel-2, MODIS, VIIRS, SMAP, ICESat-2, SRTM

Keywords: Wildfire hazard, Wildfire impacts, Forest health, Water and aquatic resources, Climate and drought, Soil moisture, Vegetation mapping

47. Satellite data based Virtual Nature (Forest)

Rainer Ressl, Florian Hruby (CONABIO)

Virtual Reality based on real satellite derived information can serve to provide Virtual nature ecosystems and help to visualize and model changes over time. Satellites can provide data on forest cover/distribution, forest type, height, density, together with additional data such as topography, satellite data classification for other ecosystems, climate data, hydrology etc, which serve as input data for the development of local or regional virtual ecosystems (VR-Nature). Models can be applied to visualize changes over time, e.g. impacts of forest cover/distribution due to climate change or fires within an immersive environment (Oculus; other devices). This technology can be used for quantitative and qualitative analysis of forest decision makers and shows in addition far higher potential for raising awareness of the general public with respect to forest related issues than traditional 2-dimensional static maps and/or common statistics. An example of satellite data based Virtual Nature development can be seen for a Virtual Coral Reef in Mexico (area 3 km x 3km). Bathymetry derived by WorldvIew-2 data, as well as the benthic habitats. www.biodiversidad.gob.mx/geoviz DOI: 10.1007/s41064-020-00107-y

Expected Management/decision support outcomes: e.g. Modelling climate change towards forest impacts (disease or fire risk), Distribution and forest composition changes over time; Help forest decision makers for awareness raising of general public through immersive environments

EO Data: Depending of scale and type of information to be visualized (optical satellite data and Radar data)

Keywords: Wildfire hazard, Wildfire impacts, Forest health, Climate and drought, Carbon emissions and flux

48. [Withdrawn]

49. The potential for near-term iterative forecasting to advance USFS land-management and decision support

Michael Dietze, Quinn Thomas, Shawn Serbin, Melissa A Kenney, Eric V. Lonsdorf (Boston University, Virginia Tech, Brookhaven National Lab, University of Minnesota, Ecological Forecasting Initiative)

Imagine a future where NASA and USFS monitoring data are used to drive real-time forecasts that continually update our understanding of the state of US forests and rangelands and dynamically project responses to land-management options so that we can better maximize human health, ecosystem services, and economic growth (Dietze et al. 2018 PNAS). The science to support the development of such a system is already in place. First, USFS has long employed models to support land management, fire risk, and forest health decision making. Process-models provide inherent advantages when it comes to extrapolation into new conditions, running management scenarios, and fusing data across scales and processes. Second, we have developed approaches for assimilating remotely sensed observations (hyper- and multi-spectral imagery, lidar, thermal, SIF, etc.) into process-models, providing a mechanism for real-time updating of observed and inferred system states. Third, we have prototype automated workflows (e.g. PEcAn, DART, FLARE) running every day that ingest new data and produce ensemble forecasts (e.g. vegetation drought status, carbon and water stocks and fluxes, water quality). Finally, in partnership with practitioners, we have experience assessing stakeholder needs and translating forecasts into indicators, quantifying ecosystem service, and developing and testing decision-support tools. The time is ripe to scale up to integrated, operational forecast systems.

Expected Management/decision support outcomes: Decisions are fundamentally based on what we think will happen in the future given different actions or scenarios. Forecasts embody our best scientific hypothesis of what we expect to happen in the future based on our current understanding and observations, and thus forecasts can be designed to directly support decision making. Iterative forecasts, in particular, are deeply synergistic with adaptive management approaches -- these forecasts are updated as new information becomes available which can identify decision rules by which land-management decisions ought to be revisited to increase the likelihood of the desired future outcomes. Examples of decision-relevant iterative forecasts that could be scaled-up and developed into land-management and decision support include: projections of vegetation drought stress and soil & fuel moisture in response to weather variability and different management interventions (e.g. irrigation, thinning, harvest); predictions of recruitment/regeneration success in response to weather, planting date and density; predictions of forest growth, carbon storage, and fuel loading under different management scenarios; predictions of how aquatic resources (e.g. stream, lake and reservoir water quality) respond to changes in the watershed; predictions of forest pest and pathogen outbreaks and spatial spread under the status quo and management interventions.

EO Data: Landsat, Sentinel-1, Sentinel-2, MODIS, VIIRS, ECOSTRESS, SMAP, ICESat-2, High spatial resolution R-G-B-NIR, LiDAR, Imaging Spectroscopy, UAVSAR

Keywords: Wildfire hazard, Fuel loading, Wildfire impacts, Forest health, Water and aquatic resources, Climate and drought, Soil moisture, Vegetation mapping, Carbon emissions and flux, Rangeland management, Early Warning

50. Wildfire mitigation and emergency response: Connecting NASA data, models, and tools to USFS decisions using concept maps and machine-assisted discovery

Bill Teng, Brian Wee, Arif Albayrak (NASA GES DISC, Massive Connections, LLC)

There are existing national interagency programs for wildfire mitigation and response, including the Burned Area Emergency Response (BAER) program and Community Wildfire Protection Plans (CWPPs). The BAER program is used to assess the characteristics of wildfires, their immediate and downstream impacts, and actions that mitigate the risks of hazards like flooding and debris flow after heavy precipitation. The CWPPs are used to inform wildfire mitigation strategies for at-risk communities. We are in the initial phases of using concept maps to document science-informed, data-driven workflows related to BAER and CWPPs. Concept maps are ideal for capturing the transdisciplinary, fire management processes that involve multiple organizations, science disciplines, policies, and jurisdictions. We intend for these “data to decisions” concept maps to facilitate transdisciplinary engagement and machine-assisted “context-aware” knowledge discovery. The resulting transdisciplinary knowledge base can then support existing or new technologies that enable the reuse and adaptation of existing BAER reports and CWPPs for USFS wildfire management decision support. This reuse and adaptation will be traceable to, and leverage, NASA GES DISC (and other NASA DAACs) data, models, and tools, as well as our existing relationships with NASA and Goddard Applied Sciences Programs.

Expected Management/decision support outcomes: Enhanced reuse and adaptation of existing BAER reports and CWPPs for USFS wildfire management decision support that are traceable to, and leverage, NASA GES DISC (and other NASA DAACs) data, models, and tools. For BAER, we expect our proposed approach will augment existing knowledge curated in document repositories, like the BAER reports database at the Moscow Forestry Sciences Laboratory.

EO Data: Landsat, Sentinel-1, Sentinel-2, MODIS, VIIRS, SMAP

Keywords: Wildfire hazard, Fuel loading, Wildfire impacts, Water and aquatic resources, Climate and drought, Soil moisture, Vegetation mapping

51. NASA Operational Data Extractor Service (NODES)

Andrew Lister (USFS Northern Research Station)

NASA has hardware, software, knowledge, and data resources to create useful satellite timeseries datasets. USFS has vector data like inventory plots and forest stand boundary polygons with associated ground data. What is lacking is an operational system in which USFS staff can, securely, upload these shapefiles and obtain clean, operationally ready (OR) timeseries data for each feature in the shapefile, such as temporally smoothed values for various sensors (Landsat, Sentinel, and MODIS), band combinations, and pre-computed spectral indices. For example, clean OR datasets could be used by the FIA program to quickly identify FIA plots that have likely changed, in order to avoid visiting (in the field or with photos) "no-change" plots, and more cost-effectively perform mid-cycle updates of forest area status. Multivariate indices associated with the OR data (clean time series and other temporal signature metrics) could be used to characterize plots or NFS stand polygons in order to better predict forest attributes at these locations. We would break the "wall-to-wall map" paradigm and embrace the "OR data per meaningful feature" paradigm, making OR data easier to use than it would be in map form. If NASA-USFS prepared a secure, cloud-based system to return OP data from USFS shapefiles, it could benefit from potentially using the USFS data for cal/val of their modeling work. Both agencies would benefit, and there would be a large return on NASA and US data investment.

Expected Management/decision support outcomes: USFS will be able to operationally extract and use processed NASA data in a standardized way, facilitating incorporation of the data into business processes. NASA will benefit from potentially being able to use the USFS vector datasets use for the extraction for their own cal/val activities. The agency has tended to rely on maps in the past, which are unwieldy and less versatile than clean, timeseries data attached to vector features of interest, like FIA plots or NFS stands. Having access to a versatile, OR dataset will facilitate modelling and other uses of NASA data that have heretofore been left to remote sensing scientists.

EO Data: Landsat, Sentinel-1, Sentinel-2, MODIS, Any sensor from which timeseries data can be generated for large areas

Keywords: Wildfire hazard, Fuel loading, Wildfire impacts, Forest health, Water and aquatic resources, Climate and drought, Soil moisture, Vegetation mapping, Carbon emissions and flux, Rangeland management, Any USFS application where OR data could be attached to specific locations of interest, like stream sampling sites or specific habitat patches.

52. Soil salinization detection, projection, mitigation adaptation for agriculture and forest lands

Steven McNulty (USDA Climate Hubs)

There are two products that we are looking for NASA to provide as part of our collaboration. The first is extent (remotely sensed imagery) of currently impacted coastal saline soils. This will vary due to storm (surge) activity and precipitation flushing of storm surge water. Sea level rise is the long-term driver of soil salinization so the second product would be a geospecific prediction (I guess you could call it a predictive map) of areas of saltwater intrusion in 10, 20, and 50 years. This will be a function topography, rate of sea level rise and soil type. As an ecologist, I will assist NASA in the development of a prediction algorithm. The Southeast hub is developing a salinization mitigation and adaptation manual to assist agriculture and forestry cope with sea level rise in the region. If NASA can provide the location of current and projected salt impacted soils, the climate hubs can provide the land manager guidance to mitigate or adapt to the salinization. **Expected Management/decision support outcomes:** Improved current and future coastal forest, range and agricultural land management and productivity

EO Data: Uncertain - looking for guidance

Keywords: Forest health, Rangeland management, Soil salinization mitigation, agricultural crop production, forest productivity

53. Semi-Automated National Forest Landslide Mapping via LiDAR

Noel Ludwig (USFS Rocky Mountain Region)

Mapping of existing landslides, which tend to be the areas at highest risk of future slope instability, is challenging and time-consuming, especially on national forests faced with access and soil data limitations. Traditional mapping techniques include manual surveying and photogrammetry; these tend to have insufficient spatial coverage, ground visibility, or consistency to inventory landslides on a landscape scale and ensure best available science is used to protect resources and lives. New semi-automated methods developed by academic institutions (e.g., Oregon State University and Universities of Oregon and New Mexico), state governments (most notably Oregon and Washington), and other federal agencies (primarily USGS) have been tested on nearby national forests, with mixed but promising results. These methods utilize DEMs derived from high-resolution bare earth LiDAR to consistently map landslide deposits on a landscape scale, by focusing on features such as slope and curvature of landslide scarps and deposits. Such maps can reveal key topographic features including hummocks, benches, tension cracks, scarps, horsts and grabens, and irregular drainage patterns. Such algorithms can include input from available soil and geology maps and can associate identified landslides with age classes and landslide types. Proposed here is a review of available methodologies and the application of one to broad-scale mapping of landslide deposits across NFS land in the western U.S.

Expected Management/decision support outcomes: Application of a consistent, NSF-wide, LiDAR-based semi-automated landslide mapping procedure

EO Data: LiDAR

Keywords: Soil instability and landslide hazard

54. Bare-ground trend forecasting

Nathan Pugh, Claire Simpson, Rob Vaughan (USFS-GTAC)

Bare-ground trend forecasting: Use RAP data or some other index of bare ground and use a model like ARIMA to predict the spread of bare ground.

Expected Management/decision support outcomes: Support various on the ground applications as well as overall forest planning and monitoring applications affecting plans for things like harvests, planting, recreation and grazing to name a few.

EO Data: Landsat, Sentinel-1, Sentinel-2, MODIS, VIIRS, ECOSTRESS, SMAP, ICESat-2

Keywords: Wildfire impacts, Forest health, Climate and drought, Soil moisture, Vegetation mapping, Rangeland management

55. Predictive Erosion Potential

Nathan Pugh, Claire Simpson, Rob Vaughan (USFS-GTAC)

Develop and validate a model to predict erosion potential or erosion control in a more concrete way, i.e. using specific units rather than relative erosion potential as the USPED model does

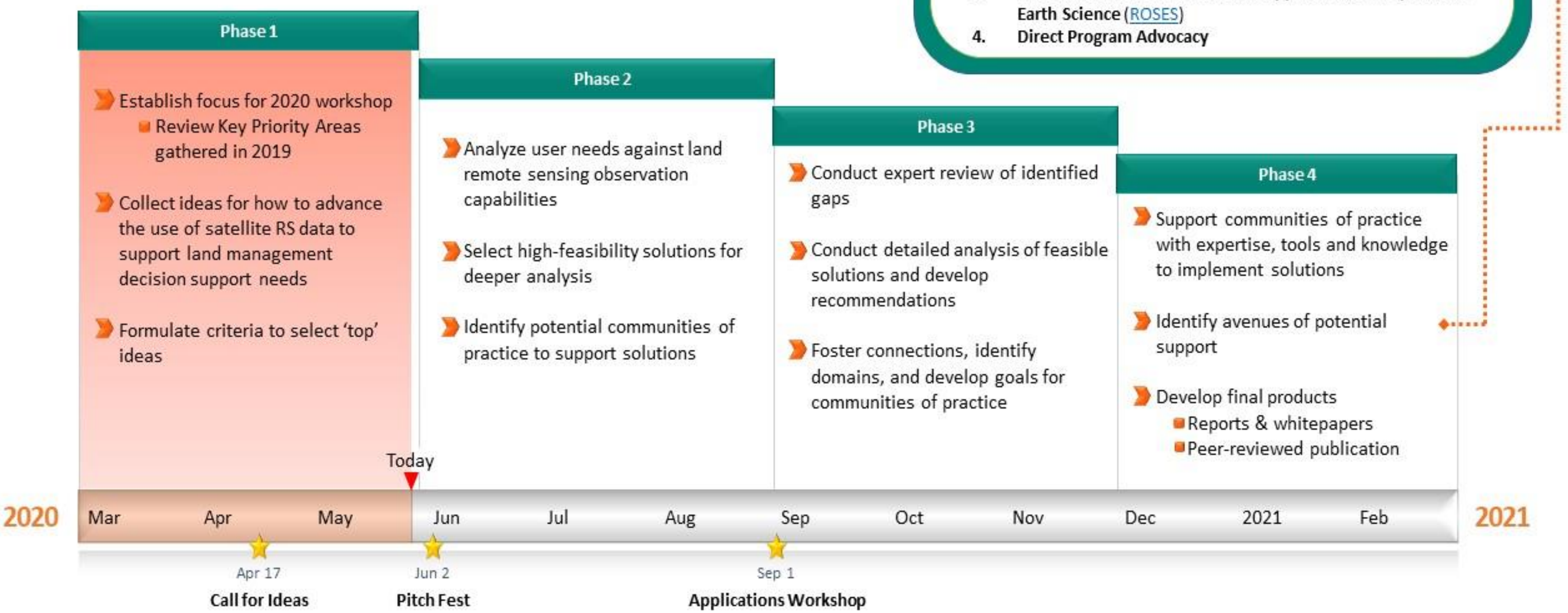
Expected Management/decision support outcomes: Support various on the ground applications as well as overall forest planning and monitoring applications affecting plans for things like harvests, planting, recreation and grazing to name a few.

EO Data: Landsat, Sentinel-1, Sentinel-2, MODIS, VIIRS, ECOSTRESS, SMAP, ICESat-2, SRTM, High spatial resolution R-G-B-NIR, LiDAR, Imaging Spectroscopy, UAVSAR, Uncertain - looking for guidance

Keywords: Wildfire impacts, Forest health, Water and aquatic resources, Climate and drought, Soil moisture, Vegetation mapping, Rangeland management

What happens next?

During the pitch fest, as participant you will help us prioritize ideas for piloting NASA technology to support land management operations. Your expert feedback and votes will help us select top ideas where NASA, the USFS and the broader community will coordinate support in the form of expertise, tools, and knowledge.



Withdrawn - Idea Abstracts

[Withdrawn due to lack of time] Predictive Erosion Potential Sky-to-Ground resilience mapping: Operationalizing thermal band imaging in direct support of Forest Service management scale actions and agency priorities

Samuel Prentice and Amarina Wuenschel (USFS National Forest System)

35, In water limited national forests of the Western US, water capture and provisioning via the soil sponge is the primary control on forest productivity as well as drought buffering directly through supplying water and indirectly via latent heat flux. Leveraging thermal IR bands to detect and discern near-surface moisture and slow flowpaths – "green water mapping" – is emerging as a powerful means of bridging remote sensing, nationwide agency priorities, and local management actions provided that the scale of resolution is operable for decision support. Preliminary finescale thermal IR acquisitions via sUAS on national forest projects are proving that worthiness in revealing Groundwater Dependent Ecosystems (GDEs) and forest resilience to sustainably accommodate increased forestry targets. In short, fine-scale thermal imagery is poised to fill a clear and present data gap that will act as a force multiplier in multiple NFS program areas. Such data also completes the spatial linkage between ground-based hydrologic field data and midscale thermal imagery from orbital platforms. Taken together, this multiscale suite of data – point based, sub meter, and midscale – can be explored to improve predictive downscaling. Accordingly, we propose a demonstration campaign of fine-scale thermal data capture across a set of semi-arid national forests spanning a precipitation-elevation gradient where thermal data would directly inform ongoing forest restoration assessment, planning and design.

Expected Management/decision support outcomes: Forest managers at all organizational levels can use these products to identify vulnerable and resilient forest systems at operable scales. Program areas that can immediately deploy the datasets include forestry products, water use, recreation, habitat for threatened and endangered species, and restoration. Additionally, mapping products will establish a baseline to monitoring changes in soil moisture patterns responding to a changing climate, directly enabling agencywide adaptive management directives and watershed condition classification.

EO Data: G-LiHT, or thermal from fixed wing UAS

Keywords: Forest health, Water and aquatic resources, Climate and drought, Soil moisture, Vegetation mapping, Carbon emissions and flux, Rangeland management

[Withdrawn due to lack of resources or readiness] Scaling NASA product pipelines for local use

Adam Moreno (California Air Resources Board)

NASA data products provide assessment of global ecosystem health. However, the US Forest Service must think more locally. The data used to make recommendation must be suited to the local environment. Applied scientists hesitate to use NASA data for recommendation making, as it is not designed for this level. However, NASA data pipelines that create global data suites, like MODIS products, allow for the insertion of regional data into the modeling algorithms. Altering NASA products for regional purposes by stepping back in the process chain, e.g. rerunning MOD17 with regional climate, is not easy and requires special knowledge to recreate the algorithms. For example, if an ecologist creates regional MODIS NPP, they have to rewrite MOD17, collect MODIS FPAR, landcover, and LAI data and rerun it. Additionally, they have to understand that they cannot include a new landcover map, as FPAR and LAI are calculated using the MODIS landcover data and would instead need to rerun MOD12 through MOD17. I propose a platform that allows users to rerun the NASA data processing pipeline, incorporating more locally relevant data and definitions. It will have the algorithms predetermined with a simple mechanism to define boundaries and insert local data. The result will be NASA-like products that are more regionally specific. locally specific data is required for policy makers and land managers and this will make NASA's products more accessible for their needs.

Expected Management/decision support outcomes: Platform to regionalize NASA data products

EO Data: MODIS, VIIRS, ECOSTRESS, SMAP, ICESat-2, SRTM, Imaging Spectroscopy

Keywords: Wildfire hazard, Wildfire impacts, Forest health, Water and aquatic resources, Climate and drought, Soil moisture, Vegetation mapping, Carbon emissions and flux, Rangeland management

[Withdrawn due to lack of time] Cloud-Based Web Map Tile Services with Encoded Z data

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As resource management professionals, we rely heavily on remote-sensing imagery products to make informed decisions about land. Access to imagery is typically made available to users via image server, web coverage service (WCS), or web map service (WMS) endpoints in GIS. These methods of serving data can be slow to load and difficult to conduct analysis on without making local copies of the imagery for the area of interest. This negatively affects user experience, especially in rural areas where internet bandwidth is low. Moreover, a vast majority of people using such products for land management purposes are only interested in pictures- not pixels.
In comes the alternative- a Web Map Tile Service (WMTS). This method of serving imagery is well suited for fast rendering in both web apps and GIS software. The raw imagery is split into pre-rendered tiles at various zoom levels and calls to the server are limited to only tiles in the current extent and zoom level. The downside of WMTS is that pre-rendered images don't contain environmental information- just R,G,B values. But what if we could satisfy all types of users by also encoding other environmental data (call it, "Z data") into the RGB color space? So, for example, if one clicks on the screen, they are provided access to any number of other data "behind the scenes"? Think: elevation, canopy height, bathymetry, temperature, and more...

Expected Management/decision support outcomes: A collaborative team of GIS and remote sensing professionals is formed to explore existing methods for encoding other types of data into RGB color space. A white paper is written that documents the process, advantages and limitations, and potential cost savings of implementing an "enhanced" WMTS vs traditional image service for one typical remote sensing product- LiDAR bare earth elevation data. The team would also document and explore existing alternatives that satisfy the same basic user needs.

EO Data: LiDAR, Potentially others, but would start with LiDAR Bare Earth products

Keywords: Wildfire impacts, Forest health, Water and aquatic resources, Climate and drought, Vegetation mapping, Information accessibility/User experience