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LETTER

Specifying geospatial data product characteristics for forest and fuel management applications

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Abstract

One of the greatest challenges for land managers is to maintain a multitude of ecosystem services while reducing hazards posed by wildfires, insect outbreaks, and other disturbances accelerating due to climate change. In response to limited available resources and improved technical abilities, natural resource managers are increasingly using geospatial data to plan and evaluate their management actions. Large amounts of public resources are invested in research and development to improve geospatial datasets, yet there is limited knowledge about the specific data types and data characteristics that clients (e.g. land managers) prefer. Our overall objective was to investigate what geospatial data characteristics are preferred by natural resource professionals to monitor and manage forests and fuels across large landscapes. We performed an online survey and collected supplemental data at a subsequent workshop during the 2020 Operational Lidar Inventory meeting to investigate preferred data use and data characteristics of data users of the Pacific Northwest. Our online survey was completed by 69 respondents represented by managers and natural resource professionals from tribal/state, federal, academic, and industry/consulting entities. We found that metrics related to species composition, total biomass/timber volume, and vegetation height were the most preferred attributes, yet preference differed slightly by employment type. From the workshop we found that metric preferences depend upon which management priorities are central to the management application. There was preference for data with Landsat pixel-level (30 m) spatial resolution, annual temporal resolution, and at regional spatial extents. To maintain viable ecosystem services in the long term, it is important to understand the metrics and their data characteristics that are most useful. We conclude that our study is a useful way to understand (a) how to improve the data utility for the users (clients) and (b) the development and investment needs for the data developers and funders.

1. Introduction

Climate change is increasing the need for accurate information for land managers to overcome climate-induced challenges to sustainably manage our collective natural and cultural resources (Keenan 2015, Herold *et al* 2019). Recent focus has been on adaptive ecosystem management, in which decision-makers operate flexibly in the face of uncertainty, learning from their desired outcomes and unintended consequences, and adjusting practices accordingly (Gray 2000, Williams 2011). As research has mainly focused on impacts of climate change and assessment of vulnerabilities, multi-disciplinary approaches are

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emerging to improve decision making across different institutions, agencies, and stakeholders (Keenan 2015). However, to improve adaptive management and increase learning opportunities for natural resource managers, we need appropriate geospatial data that managers can utilize to evaluate management actions or constrain management alternatives. Managers include decision-makers of public land management agencies at federal, tribal, state, and local levels, as well as forest industry lands. Recent improvements in remote sensing (including data availability, analysis and accuracy, software development, and geographic information system (GIS) skills of natural resource managers) have led to opportunities to improve adaptive forest management (e.g. Andrus *et al* 2021). A key uncertainty, however, is information about the attributes and characteristics of the data that are most useful to managers or other data users.

Geospatial data products are commonly used for monitoring and managing landscapes. For instance, geospatial data products are used for monitoring vegetation cover (Sexton *et al* 2013), vegetation structure (Falkowski *et al* 2009), biodiversity (Gould 2000), fuel loads (Keane *et al* 2001), forest inventory (McRoberts and Tomppo 2007), and carbon stocks (Hudak *et al* 2020). In addition to monitoring, these data are also used for management applications, such as planning of fuel treatments, thinning projects, or invasive species control. Furthermore, multi-temporal remote sensing can be used for assessing change across the landscape related to disturbances (e.g., fire: Eidenshenk *et al* 2007; bark beetles: Meddens and Hicke 2014) useful for planning salvage logging, erosion control, and/or revegetation efforts. Remote sensing is a powerful tool to evaluate and assess management effectiveness for informing adaptive management (Camarretta *et al* 2020), due to regular revisit times and synoptic views (i.e., wall-to-wall information over large areas) (Lechner *et al* 2020).

Common data characteristics of geospatial data include the spatial resolution, temporal resolution, thematic resolution, and extent of the data. This is often based on the sensor(s) characteristics used to develop metrics (i.e., individual measurements (e.g. tree height)) from a dataset, but sometimes practical considerations, image fusion, and/or image enhancement techniques are used to improve spatial, temporal, spectral, and/or thematic resolution. There are multiple readily available global datasets such as carbon stocks (e.g. European Space Agency Biomass Maps; Santoro and Cartus 2019) and landcover (e.g. Copernicus Land Cover Data; Buchhorn *et al* 2020), and regional/continental datasets such as fire severity (e.g. MTBS data; Eidenshenk *et al* 2007) and vegetation/fuel characteristics (e.g. Landfire; Rollins 2009). Also, remote sensing scientists are constantly developing new products with higher spatial, temporal, and thematic resolutions over large extents. These characteristics of remotely-sensed data products traditionally have been limited by technical considerations, such as constraints of sensor characteristics (such as spectral resolution, spatial resolution, and temporal resolution; Key *et al* 2001) and computing storage and processing capabilities (Ma *et al* 2015). However, in recent years, advanced remote sensing equipment and computing technologies have allowed for an expanded range of data preparation and sharing (Kennedy *et al* 2009). In addition, natural resource managers are becoming more capable in using geospatial technologies (e.g. GIS and digital mapping software; Merry *et al* 2007), partly due to recently improved processing capabilities (e.g. Google Earth Engine) (Gorelick *et al* 2017, Stahl *et al* 2021). This situation presents a window of opportunity to consider the information needs of users and the data characteristics they desire.

Large amounts of resources are invested by federal science agencies (e.g. NASA and USGS), land management agencies (e.g. USFS and BLM), state agencies, and universities to collect and analyze geospatial data (e.g. NASA 2021), yet there is limited knowledge about the specific data characteristics that clients prefer. Furthermore, information regarding differences in data usage between clients (e.g. industry versus governmental natural resource professionals) or differences between management objectives (e.g. placing of fuel treatments versus timber harvest plans) can further specify data needs. Interactive social science techniques—for example surveys, workshops, and interviews (Patton 2002, Rodriguez-Franco and Haan 2015)—provide a novel approach to potentially improve data utility for desired applications (e.g. Martinez *et al* 2019, Feyisa *et al* 2020). Therefore, allocating funding to projects designed to include these interactive techniques might offer a good return on investment for agencies or institutions. We propose that in the long run, interactive techniques will allow agencies and institutions to expand knowledge to maximize the utility of remote sensing data, especially in areas where geospatial information is needed or desired. Here, we draw upon data collected through an online survey and a subsequent regional workshop that focused on preferred datasets and data characteristics of forestry professionals in the Pacific Northwest.

Our overall objective was to investigate geospatial data characteristics preferred by natural resource professionals to monitor and manage forests and fuels across large landscapes. We assess which individual data attributes (hereafter referred to as metrics) are the most useful for our stakeholders and subsequently assess desired characteristics of the geospatial data (i.e. spatial resolution, temporal resolution, extent, precision, and format). We draw upon data collected through an online survey and a subsequent regional workshop that focused on data attributes and data

characteristics preferred by forestry professionals in the Pacific Northwest, a region relatively rich in geospatial data types and where forest and fuel management issues are important ecologically, economically, and socially.

2. Methods

We organized an interactive session during the 2020 Operational Lidar Inventory (OLI) meeting that centered around data use and preferred data characteristics. The OLI meeting is a regional meeting that has been held annually for the last six years in Olympia, Washington since 2016 and is attended by federal, tribal, and state forest managers, forest industry professionals, consultants, and academics. Attendance has increased annually from approximately 35 people in 2016 to approximately 85 people in 2020. The OLI meeting focuses on the exchange of remote sensing techniques and ideas that have applicability in forest inventory and forest mapping applications. The main themes of the OLI 2020 meeting included discussions and presentations of the latest lidar technology in carbon monitoring, fuels mapping, and species mapping for forest management. Participants are tasked with developing, delivering, and/or utilizing geospatial data for forest management purposes in their profession and attend the OLI meeting to learn about novel (lidar) remote sensing techniques and state-of-the-art forest inventory methodologies.

In preparation for our interactive session prior to the 2020 OLI meeting we sent out an online survey to meeting registrants with initial questions about people's professional background (e.g. employment sector) and their preferences for geospatial data characteristics for forest and fuel management applications. The pre-workshop survey was packaged as an element of the meeting registration form, which contributed to a high response rate (94.5%; 69 out of 73 registrants completed the survey). Subsequently, we used the preliminary survey data to develop an interactive session centered around six questions during the interactive session at the workshop.

2.1. Pre-workshop survey

The online survey—*Mapping vegetation structure and fuel attributes for natural resource management* (appendix A)—was designed to expand the understanding of the needs of natural resource managers regarding geospatial vegetation and fuel data characteristics. The first section of the survey (survey section 1) consisted of six questions about professional background, including employer type (e.g. academics, industry, state agency, federal agency, non-profit, tribal, and other), length of time in profession, job responsibility, geospatial data use, forest growth model use, and use of fuel and fire modeling. The second section of the survey (survey section 2) posed ten questions about the usefulness of specific geospatial data sets (e.g. mean tree height, basal area, snag density) using a four-point Likert scale from 'not useful', 'somewhat useful', 'useful', to 'very useful'. Ten commonly used metrics were listed in the survey, namely: mean tree height, basal area, biomass, volume, crown base diameter, crown base height, coarse woody debris, fine woody debris, forest floor fuels, and snag density. Participants could also enter other useful geospatial metrics that were not listed. Participants were then asked about their preferences for spatial resolution, spatial extent, and measurement precision of the data sets. In the third and last section of the pre-workshop survey (survey section 3), the participants had an option to enter open-ended comments about the survey and/or how they would use the geospatial data.

2.2. Pre-workshop survey data analysis

We ranked the perceived usefulness of the geospatial metrics according to the survey participants and plotted the mean and standard deviation of the Likert scale (with very useful: 4, useful: 3, somewhat useful: 2, and not useful: 1. In addition to the provided metrics for which we had a Likert score, we also ranked the 'other useful geospatial metrics' that were entered more than once and ranked the number of times these additional metrics were listed. Furthermore, we calculated the standard deviation of the mean importance score for each employment type separately to investigate whether there were different preferences by occupational background. To generate four groups with a sufficient number of participants for comparison, we categorized the occupational backgrounds of professionals with similar land management duties and data application procedures into four categories (i.e. tribal/state agencies, federal agencies, industry/-consulting, and academics). A total of 159 individuals were directly invited (through email) to attend the OLI 2020 meeting and 73 individuals registered for the meeting. However, 4 individuals did not complete the entire registration/survey form, resulting in 69 respondents with approximate equal representation of tribal/state agencies (20%), federal agencies (14%), and academics (25%), and a higher proportion of industry/consulting (41%) employment type participants (figure 1). For each of the spatial resolution, data extent, and data precision characteristics, we standardized the responses as % relative preference by employment type and plotted the data as bar graphs to evaluate the general data characteristics preference and differences by employment type. With regard to the open-ended comments of survey section 3, the responses were coded and analyzed by type of

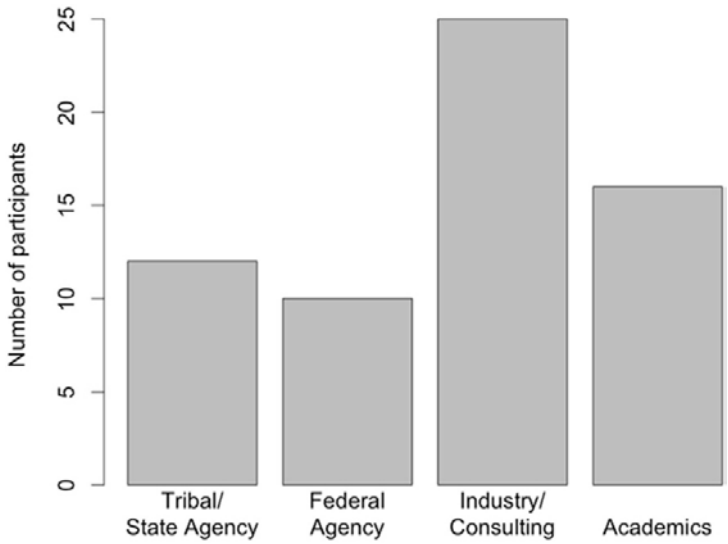

Figure 1. Number of online survey participants by employment type.

data characteristic preference. These data supplemented the closed-ended data of survey sections 1 and 2.

2.3. Workshop data

The interactive session at the OLI workshop was designed to further increase the understanding about the usefulness of geospatial metrics and their characteristics by facilitating a discussion of six pre-defined questions on a large poster (appendix B: *Utility of fuels and forest structure attribute data*). We used the outcomes of the online survey and included additional metrics (possible geospatial datasets) and other aspects that were learned from the online survey. The participants were randomly divided into six groups of 6–8 persons by placing a colored sticker on their nametag, with the color showing the group they belonged to. A total of 46 professionals participated in this interactive session and each of the groups had an assigned facilitator. The six questions revolved around data preferences and the questions were more targeted to specific management objectives (e.g. timber, fuels, wildlife, biomass). Each group was asked to discuss the questions, and participants voted for their preferred data characteristic by placing small colored stickers onto the poster. Participants were provided a limited number of stickers to indicate their preferences with respect to the objectives indicated in each question (appendix B). The votes of participants were then recorded for later analysis.

2.4. Workshop data analysis

The data collected during the interactive component of the workshop were analyzed to provide insight into the preferences of participants. For the geospatial metrics, spatial resolution, and temporal resolution, we analyzed the data as follows: We first summed the number of selections (i.e. each sticker represents one selection) separately by management objectives (i.e. timber, fuels, wildlife, and biomass) for each group. Next, we divided the number of selections by the total number of selections per category (e.g. species composition, vegetation height, etc) and multiplied that fraction by 100 to obtain a percentage (preference %). We then calculated the mean, standard deviation, and standard error for each category and management type across the six groups. For the desired spatial extent and data type we calculated the average preference (%) across the different categories as these questions were not split by management type. The data were plotted as bar graphs for interpretation and to assess differences in preferences of groups of workshop participants. In some instances, participants did not register a response for a particular data preference characteristic ('non-response'). Consequently, the number of responses varies by data preference characteristic.

3. Results

3.1. Online survey results

The meeting had a strong contingent of both industry and academic participants (41% and 25% respectively), with sizeable contingents of tribal and state (20%) and federal agencies (14%) (figure 1). The largest proportion of participants was mid-career employees (>10 years; 50% of respondents), with equal numbers of representing the moderately early-career employment classes (5–10 years, 1–5 years (24%)), and only 1% being new to the field (<1 year), thus overall suggesting substantial experience in this area by participants. Fifty-four survey respondents (78%) indicated that they used geospatial data *frequently* or *very frequently*, while only five survey respondents (7%) indicated that they used geospatial

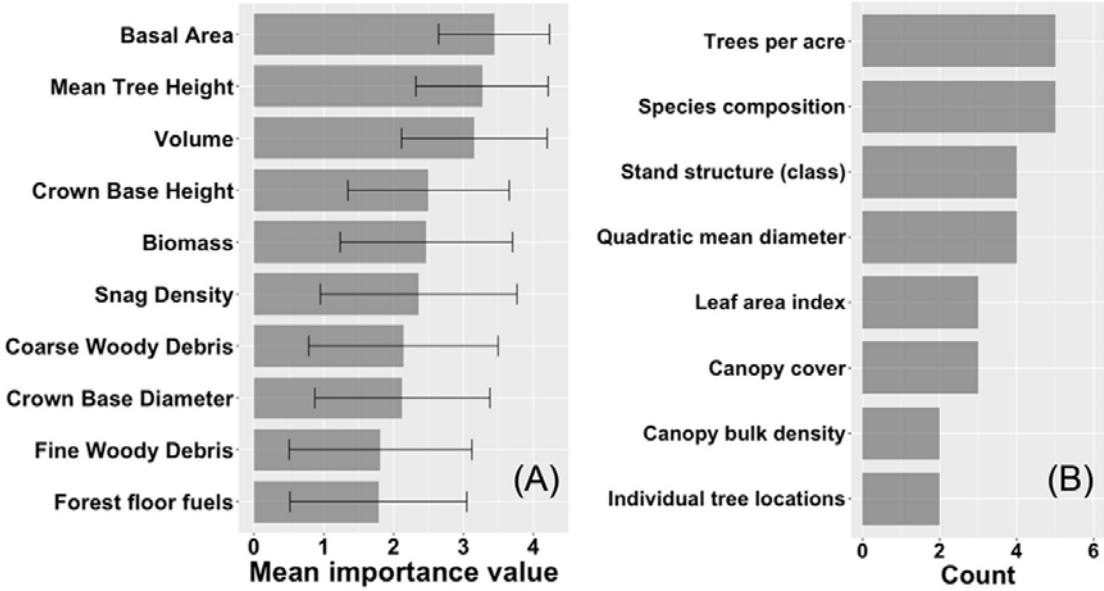

Figure 2. (A) Mean importance score (derived from a four-point Likert scale; error bars indicate standard deviation) for various geospatial metrics and (B) additional metrics identified in the survey by the participants. The metrics are ordered by importance from high to low.

data *little* or *never*. Use of forest growth models was more variable, with 30 (43%) indicating that they used forest growth models *frequently* or *very frequently*, while 22 (32%) indicated that they used forest growth models *little* or *never*. Finally, only a small proportion used fuel or fire models in their profession; 8 participants (12%) indicated that they used fuel/fire models *frequently* or *very frequently*, while 40 participants (58%) indicated that they used fuel/fire models *little* or *never*.

Basal area, mean tree height, and timber volume were the three geospatial metrics that received the highest mean importance scores, i.e. higher mean value of 3 (corresponding with a relative high Likert score) (figure 2(A)). Fine woody debris and forest floor fuels received the lowest mean importance scores, i.e. lower mean values than 2 (corresponding to a relatively low Likert score) (figure 2(A)). Of the optional additional geospatial metrics (metrics that were not provided in the survey), trees per acre and species composition were entered 5 times (18%), while stand structure class and quadratic mean diameters were entered 4 times (14%) (figure 2(B)). Several other metrics, such as leaf area index and individual tree crown location were selected as well, but less than 4 times.

In the mean importance score by employment type, we see slight differences in some metrics (figure 3). For instance, federal agency employees indicated that biomass is more important as compared to the other employment types. Academics indicated that timber volume was less important, and industry/consultant professionals indicated that snag density was less important as compared to the other employment types. All employment types registered 'important' for mean tree height and basal area, whereas all sectors scored 'less important' for fine woody debris and forest floor fuels.

Across all the employment types there was a clear preference for stand-level (0.5–5 acre) spatial resolution data, although more of the industry/consulting and academics participants indicated interest in higher resolution data (i.e. plot-level (1/10th acre) and pixel-level (30 m) data (figure 4(A)). Participants had a more variable response to the preferred data extent question, with all employment types indicating preference for larger extents, including national, regional, and/or national forest-level extents above a smaller project-level extent (figure 4(B)). More than 80% of state agencies and industry/consultant employment groups indicated the strongest preference for data with RMSE < 25% (i.e. *very precise*), while relative preference of federal agency and academics included a more mixed response, indicating that both data with RMSE < 25% or data with RMSE 25% or more but smaller than 50% (i.e. *precise* 25%< RMSE < 50%) fit their preferences and needs (figure 4(C)). None of the participants was interested in data with RMSE > 50%.

3.2. Workshop-derived data results

Mean preference for geospatial metrics—as calculated by the mean percentage of votes across groups—showed large variability by management objective (i.e. timber, wildlife, fuels, biomass) (figure 5). Species composition, total biomass, and vegetation height were the metrics that had the highest overall (mean of the 4 management objectives) preference (%), whereas fine woody debris, tree location, and leaf area index had the lowest preference (%). For

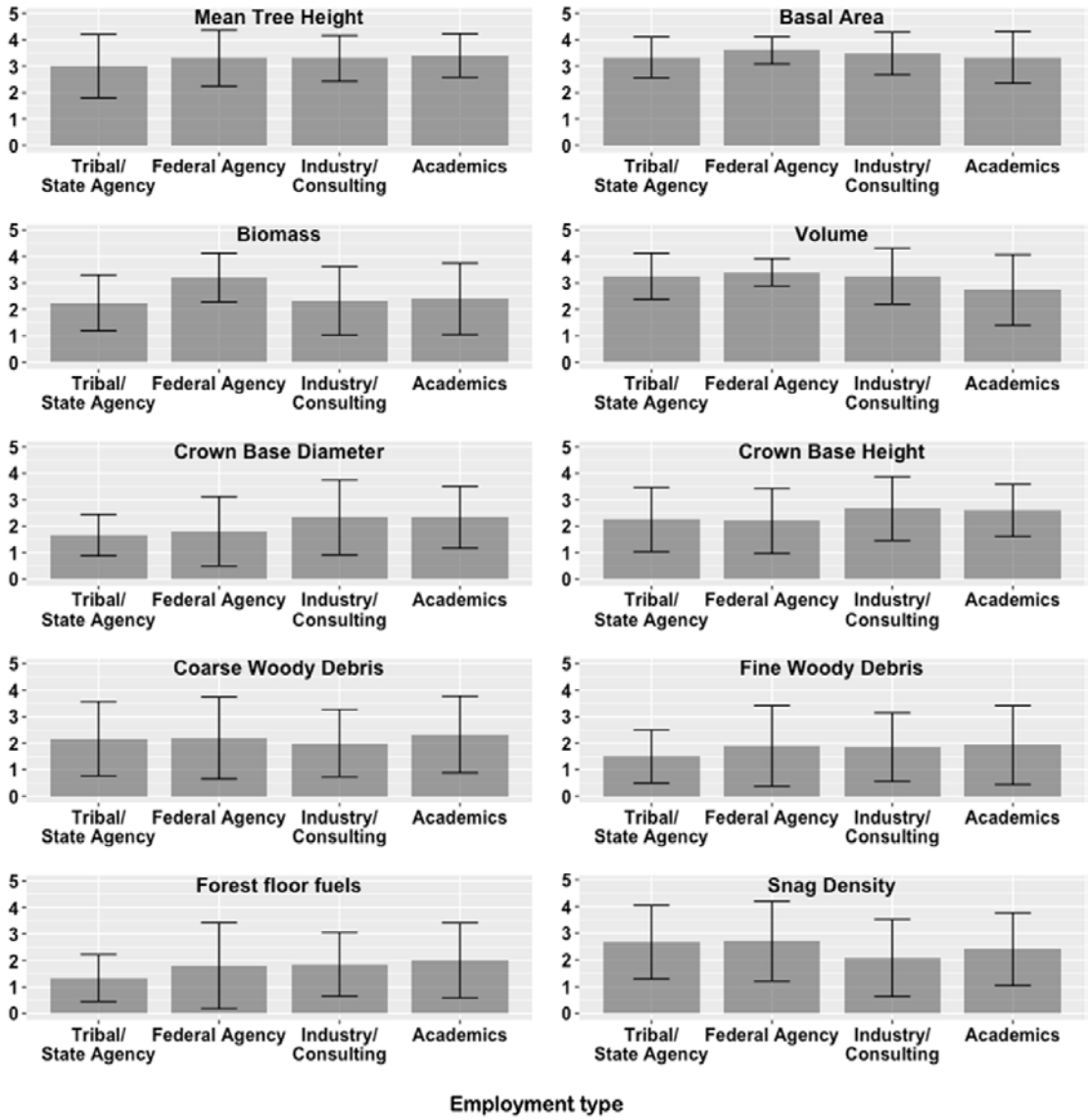

Figure 3. Mean importance score (derived from a four-point Likert scale; error bars indicate standard deviation) for various geospatial metrics by employment type of the participants.

the preference of the spatial resolution of data, there was more consistency across management applications, with the 30 m, sub-meter, and county-level spatial resolutions having the highest preference (%) (figure 6). According to the combined preference (%), there was a slight preference for fuels data having higher spatial resolution (e.g. the 3 m spatial resolution for the fuels application: ∼30% (figure 6)) as compared to the other management objectives. The preference for temporal resolution was more consistent across management objectives. Overall, there was a clear preference for annual data, with >40% across all management objectives. There was little interest in more frequent data for timber, biomass, and wildlife as compared to the fuels management objective, where there was some interest in daily data (figure 7). At least some people were interested in all data extents, but the middle extent ranges were the most popular, with regional extent (equivalent to a western US national forest) being by far the most popular extent with 33% of the votes. There was a large amount of variation in participant's interests in data extents, with regional data proving the most popular (figure 8). Vote proportions for standard raster or vector file formats, i.e. GeoTiffs (56%) and Shapefiles (25%), were substantially higher than proprietary file formats such as ERDAS, ENVI or ESRI grids or multidimensional file formats, i.e. netCDF (figure 9).

4. Discussion

To inform adaptive management for maintaining viable ecosystem services in the long term, it is important to understand which metrics and data characteristics are most useful to natural resource professionals (Kennedy *et al* 2009). We conducted an online survey and organized a subsequent interactive workshop to explore and improve the understanding

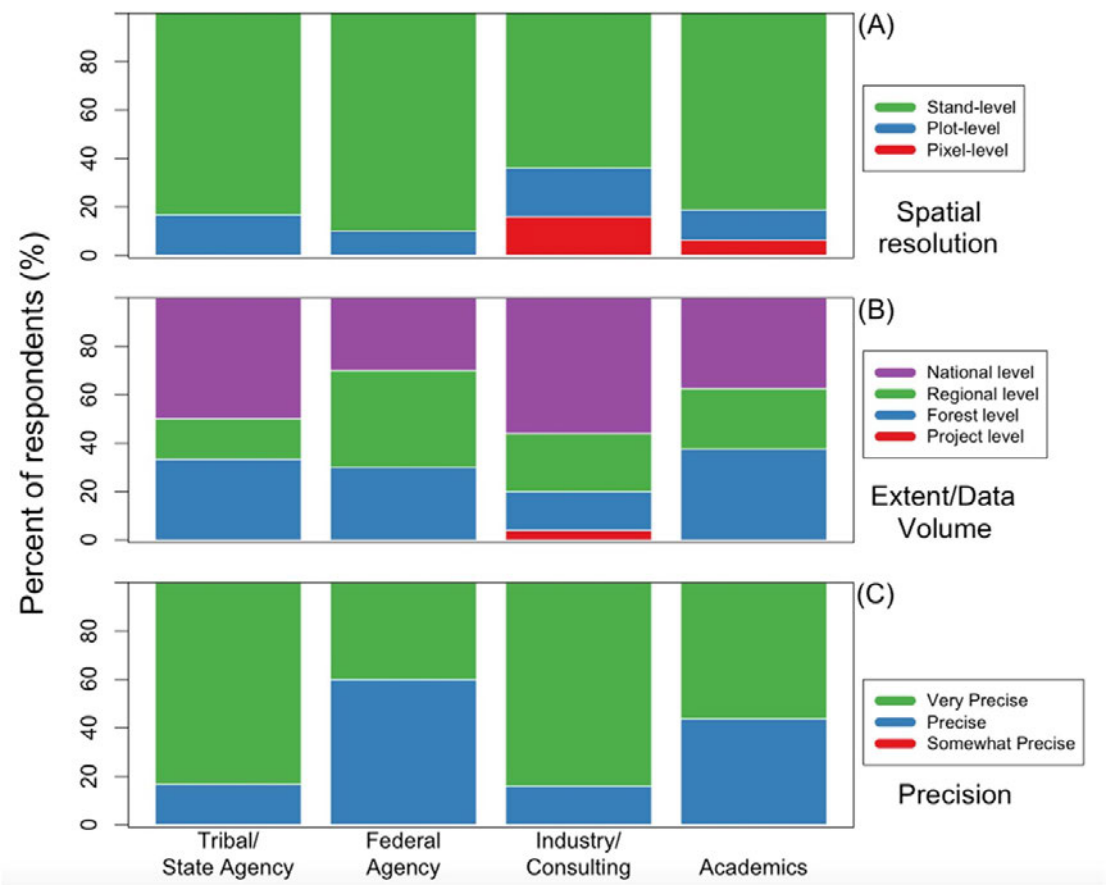

Figure 4. Percent of respondents (%) indicating preference for (A) spatial resolution, (B) data extent, and (C) precision geospatial data characteristics by employment type of the participants.

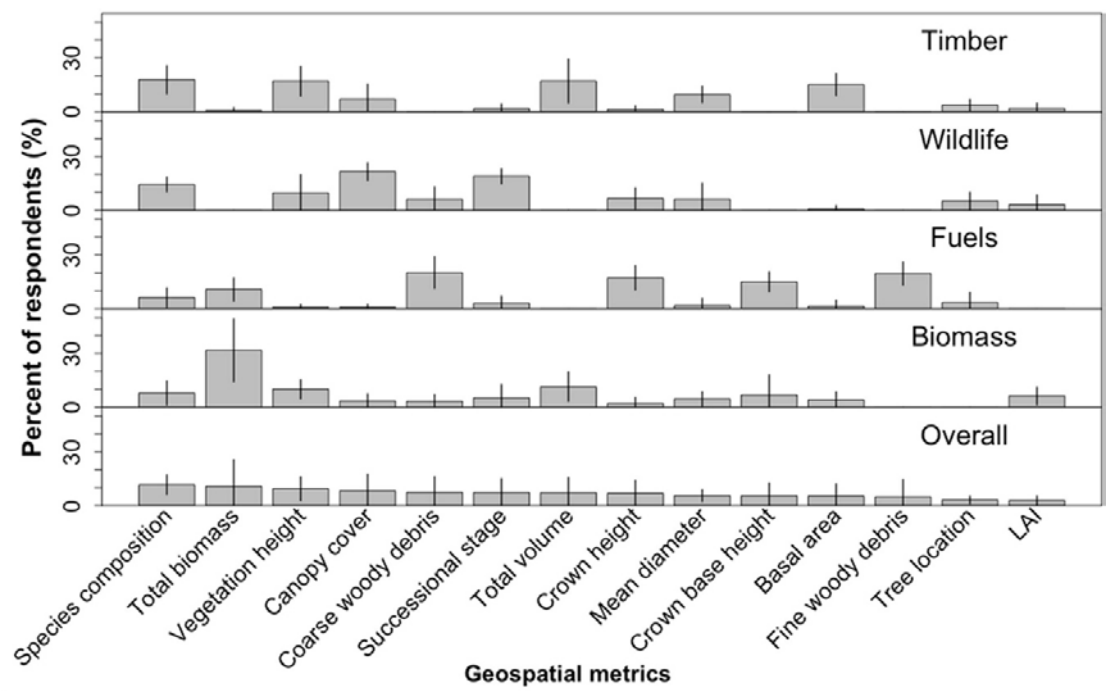

Figure 5. Mean percent of respondents (%) indicating preference for geospatial metrics split by four different management priorities (i.e. timber, wildlife, fuels, and biomass). The results are the mean and standard deviation of six different focus groups. The metrics are ordered by overall importance from high to low.

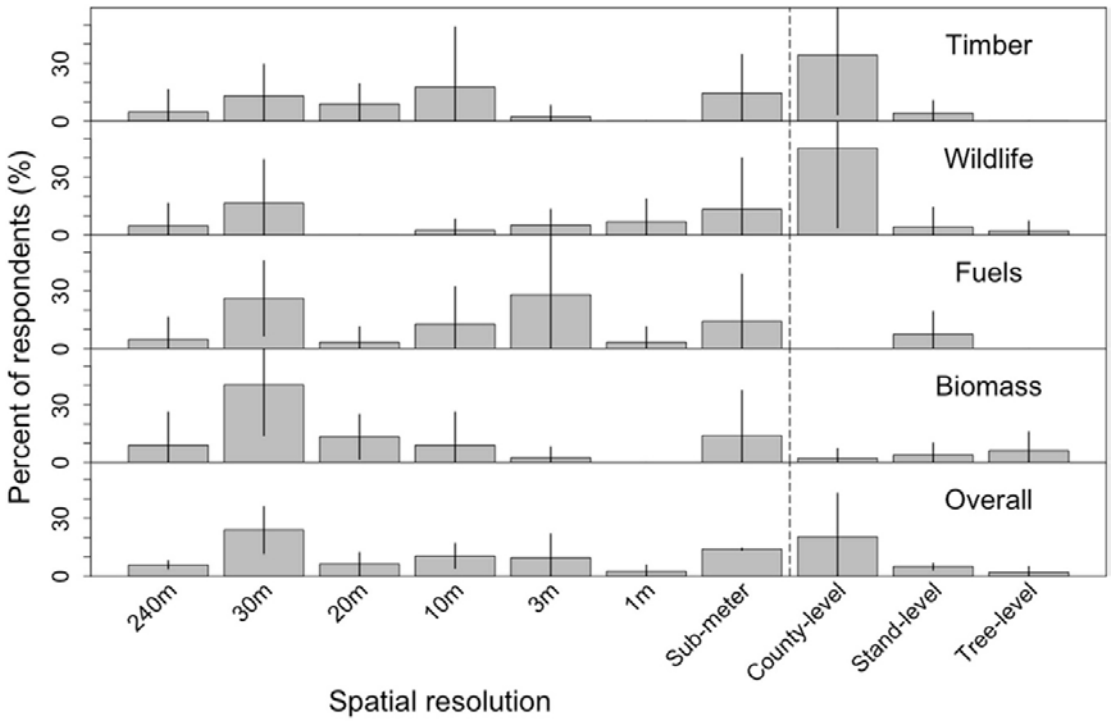

Figure 6. Mean percent of respondents (%) indicating preference of the desired spatial resolution of geospatial data split by four different management priorities (i.e. timber, wildlife, fuels, and biomass). The results are the mean and standard deviation derived from six different focus groups.

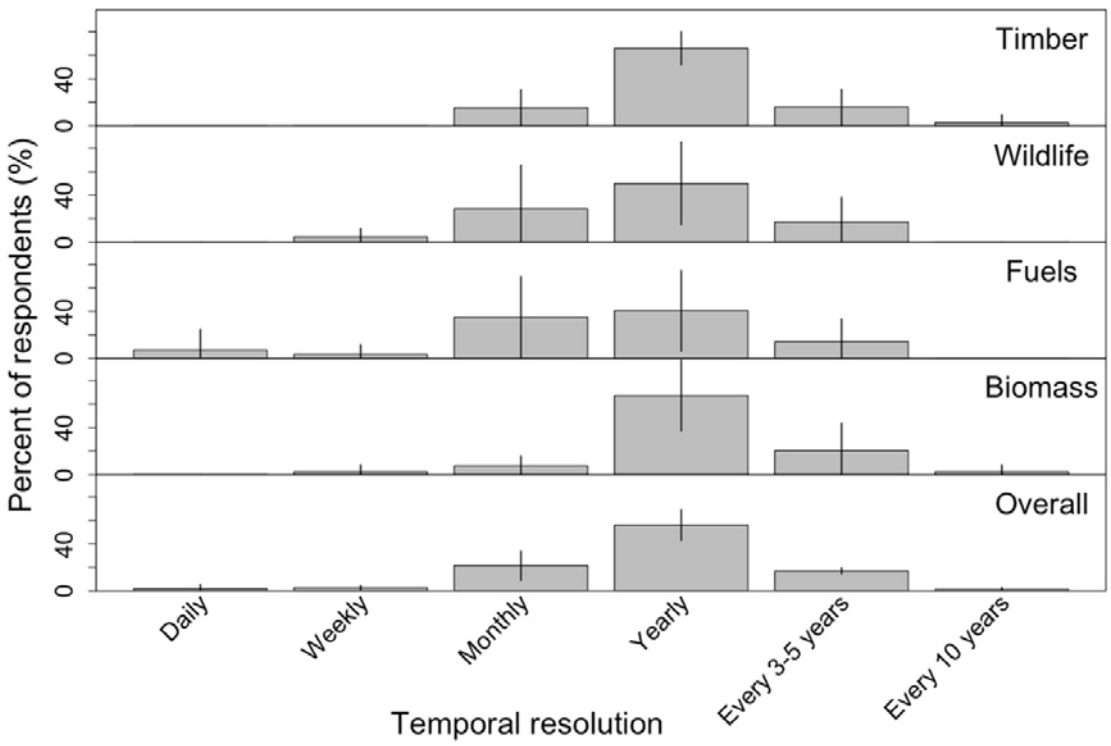

Figure 7. Mean percent of respondents (%) indicating preference of the desired temporal resolution split by four different management priorities (i.e. timber, wildlife, fuels, and biomass). The results are the mean and standard deviation derived from 6 different focus groups.

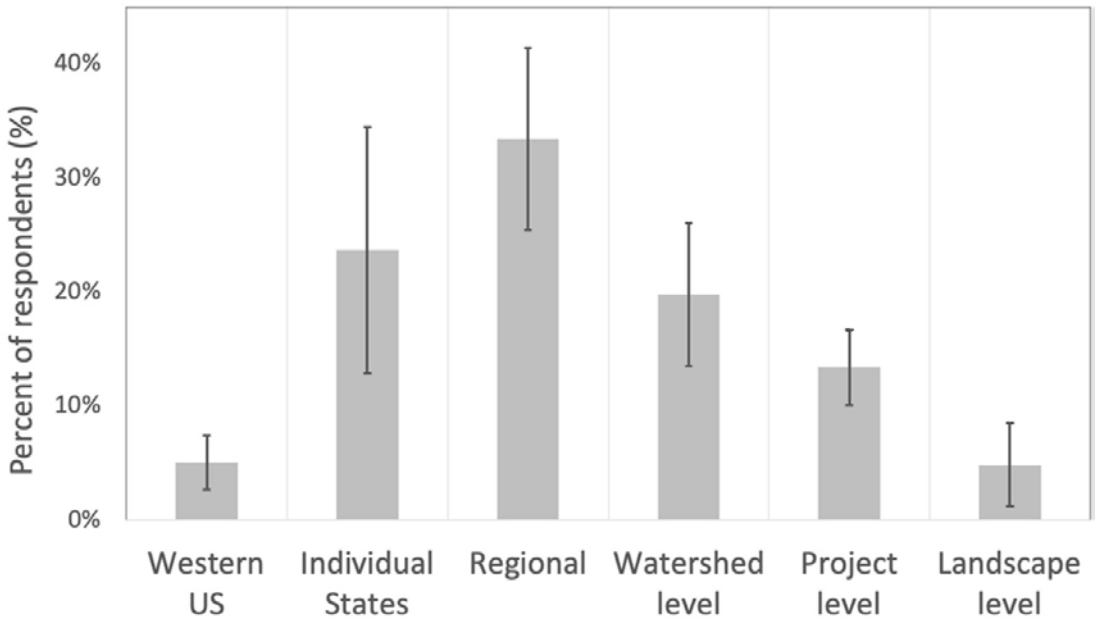

Figure 8. Mean percent of respondents (%) indicating preference of the desired spatial extent for management purposes. The results are the mean and standard deviation derived from six different focus groups.

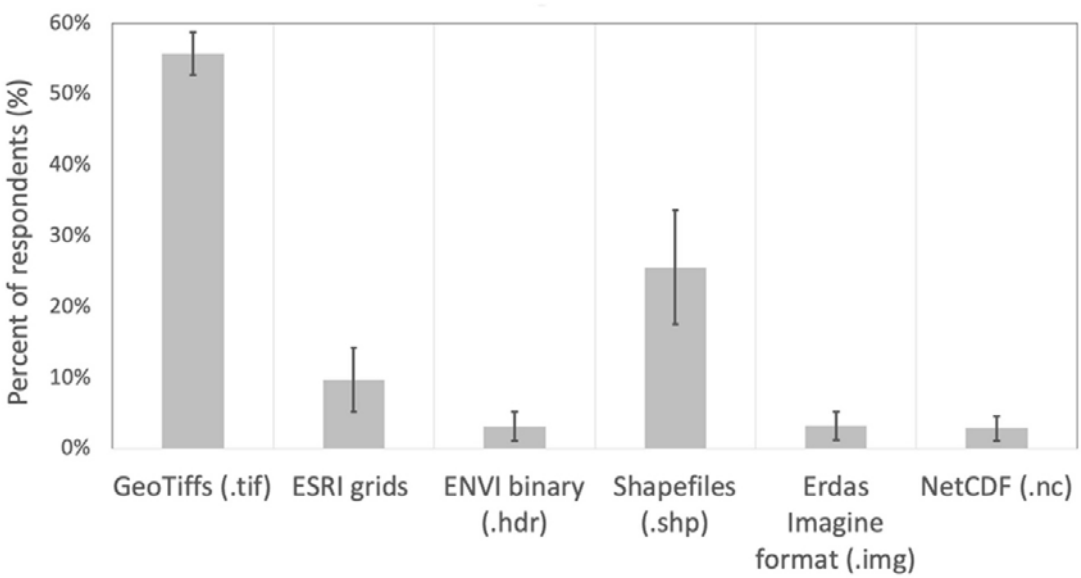

Figure 9. Mean percent of respondents (%) indicating preference of the desired geospatial data type for management purposes. The results are the mean and standard deviation derived from six different focus groups.

of the types of data and data characteristics that are preferred for forest and fuels resource management applications (e.g. planning and evaluation of management activities). We found that metrics related to species composition, total biomass/timber volume (e.g. basal area and aboveground biomass), and vegetation height are most preferred. Besides a consensus on the usefulness of certain metrics, there were differences in perceived usefulness between other metrics depending upon the purpose or management application for which the data were used (figure 5). Furthermore, we found slight differences in the preference of some metrics by employment sector (figure 3). For instance, federal agency employees indicated a higher preference for a variety of metrics, including biomass and snag density, as opposed to other employment types. This is probably related to federal mandates and multi-purpose management strategies (Manning *et al* 2018, Spies *et al* 2018) as opposed to other organizations that might be more concerned with a narrower range of management goals, such as wildfire prevention, habitat preservation, or timber production.

This study provides geospatial data developers with information, disaggregated by employment sector and management objectives, about the preferences

and needs of the users of their products. This information is a valuable reference to improve the development of new remote sensing data products. At the same time, geospatial data developers may find this study useful to bear in mind the variability among data users and may be conscientious about whether a particular product is designed to meet the needs of a particular employment sector or multiple employment sectors. If geospatial data developers have the flexibility to aim for the highest spatial and temporal resolution, largest extents, and provide many attributes, the products can be resampled, clipped, and subset to meet a broad variety of needs—although this will impose additional resource demand (cost, staff time) than coarser, smaller extent datasets with fewer attributes. The findings here can aid in targeting compromises in data configurations to best meet the greatest number of stakeholders needs with finite resources.

From the online survey, we found that there was a consensus in the need for precise to very precise data that span larger extents. The finding that data users prefer precise data with RMSE < 25% (or data with reduced uncertainty) aligns with an earlier study, in which the majority (>55%) of digital elevation model (DEM) users indicated that uncertainty is 'very' or 'somewhat' important (Wechsler 2003). Even though we found that precision is important for data users it is still unclear to us what scale of precision data is useful to the users. Precision (or uncertainty) is often communicated through a (global) measure of fit (e.g. an R^2, RMSE, or overall accuracy). While it is possible for many data developers/modelers to quantify the uncertainty at the pixel-level (e.g. Mauro *et al* 2016), most available geospatial data do not have this associated spatially explicit uncertainty data (but see Hudak *et al* 2020). More research is needed on the particular metrics (e.g. standard deviation, confidence intervals, # of votes from a randomForest model) and scale (e.g. global or pixel level) of uncertainty that data clients/users prefer and how this uncertainty data influences decision making. In addition, more information is needed to understand what kind of trade-offs users are willing to accept (e.g. receiving data with higher spatial resolution at smaller extents versus coarser spatial resolution data at larger spatial extent) is an important topic for future research.

The workshop responses provided further information and showed slight differences in preference of spatial and temporal resolution for different management applications. For instance, we showed that there was a slight preference for higher spatial and temporal resolution for forest fuel data applications compared to most other metrics. We note that we intentionally broadly defined the management applications; for instance, the fuels application was not further defined into more specific categories, such as suppression, emission, or fire prevention. Future research could further specify data use within a specific target group (e.g. fuels managers) and further investigate the use and needs of geospatial data for more specific uses.

By combining two interactive techniques (an online survey and an in-person workshop) we could provide additional context to improve our understanding of natural resource professional preferences, which would not have been possible when using just a single interactive technique. These novel interactive techniques can improve the fit between product development and user needs by expanding insights related to data use and preference on one hand and possible development of novel datasets by scientists (e.g. university collaborators) and funding-agencies (e.g. NASA) on the other hand. For instance, we found that species composition is regarded as an important metric (e.g. Hudak *et al* 2009); however, many remotely sensing methods at moderate resolution (i.e. ∼30 m pixel resolution) are not able to resolve individual tree species within mixed conifer forests. This points to a need to develop tree species-specific maps and this research topic might thus be a strategic investment choice for funding agencies leading to accelerated data development with improved precision.

This study focused on stakeholder data needs with respect to spatial data products related to a recently completed NASA-sponsored project (Hudak *et al* 2020) that is currently expanding to other themes including forest structure (e.g. tree height and cover), volume, carbon, and forest fuels. We did not, for example, include inquiries into the usefulness of the many landcover products and other data types that may be available and useful (e.g. land ownership, wildland urban interface, DEMs, disturbance maps). We further note that by focusing on a specific meeting (i.e. the OLI 2020 meeting), we did not sample across a representative group of natural resource managers across the entire northwestern U.S. The meeting participants, and hence our respondents, are weighted towards professionals who have a positive outlook on remote sensing technologies and are already familiar with them since the emphasis of the meeting is on OLI (the name of the meeting) and related technologies. Our data does not represent the forest analyst community at large, yet it provides a quantitative characterization of the preferences of analysts who are most likely to make use of geospatial data products. We further note that by combining the online survey with the workshop registration and including an interactive section in the meeting itself, we were able to achieve very high response rates. These rates are tempered somewhat by the fact that the meeting has a mailing list of 159 participants, and these participants are individuals who already have an interest in this topic and generally some familiarity with the meeting organizers. Further work is needed to understand the forest analyst community at large.

5. Conclusion

This study quantified the data characteristics of geospatial data preferred by natural resource professionals with an interest in remote sensing forest monitoring methods. To our knowledge, previous research has not documented user perspectives on remote sensing preferred characteristics. We found that metrics related to species composition, total biomass/-timber volume, and vegetation height were the most preferred by the participants in this study, with differences in perceived usefulness between other metrics depending upon the purpose or management objectives for which the data were used. In addition, we found differences in the preference of some metrics by employment sector. These results suggest that geospatial data developers have an opportunity to improve adaptive management by developing or improving products with these metrics or characteristics. At the same time, data developers should acknowledge variability among data users. As such, developers should have better insight into how to meet needs for a particular management objective or employment sector—or target multiple management objectives/employment sectors and develop a suite of products useful to a broader set of applications. Funders of data development may also consider tracking the relationship between stated preferences, such as those indicated in this study, and in outcomes or actual use in practice. These findings are useful for geospatial modelers, data developers, and funding agencies and show a desire for data-driven management decisions to improve assessments of forest productivity, ecosystem health, and fuel dynamics.

Data availability statement

The data that support the findings of this study are available upon reasonable request from the authors.

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Appendix A. Survey: ranking the importance of vegetation structure and fuel attributes for natural resource management

Note: This version was adapted to fit the online registration form of the OLI 2020 workshop.

Introduction: We have been funded by NASA to establish vegetation structure and fuel geospatial products for natural resource management. We are requesting your response to increase the understanding of the needs of the user community for this data. We really appreciate your cooperation!

Instructions: Please complete the questionnaire below by checking the appropriate box. The questionnaire is divided into 3 sections: (A) Professional background, (B) Metrics, and (C) Additional Information. You are invited to participate in this research project. Note that participation to this survey is entirely voluntary

(A) Professional background

Indicate your professional background:

Academics – Industry – State agency – Federal agency – Non-profit – Tribal – Other: ___

☐ ☐ ☐ ☐ ☐ ☐ ☐

How long have you been in this profession?

<1 years – 1 -5 years – 5-10 years – >10 years

☐ ☐ ☐ ☐

What is your primary responsibility in your job?

Management – Research – Product development – Reporting – Outreach – Other_____

☐ ☐ ☐ ☐ ☐ ☐

In your profession, do you analyze, and/or process geospatial data yourself (e.g., using ArcGIS)?

Never – A little – Somewhat – Frequently – Very frequently

☐ ☐ ☐ ☐ ☐

In your profession, do you use forest growth models (e.g., using Forest Vegetation Simulator (FVS))?

Never – A little – Somewhat – Frequently – Very frequently

☐ ☐ ☐ ☐ ☐

In your profession, do you use fuel or fire models (e.g., the FVS Fuels and Fire extension)?

Never – A little – Somewhat – Frequently – Very frequently

☐ ☐ ☐ ☐ ☐

(B) Fuel Loads and Forest Structure Metrics

Mean tree height (units: vertical feet)

Not Useful – Somewhat Useful – Useful – Very Useful

Basal area (units: ft²/acre)

Not Useful – Somewhat Useful – Useful – Very Useful

Total Dry Biomass (units: kg (dry biomass weight)/acre)

Not Useful – Somewhat Useful – Useful – Very Useful

Volume (units: cubic yards/acre)

Not Useful – Somewhat Useful – Useful – Very Useful

Crown Base Diameter (units: inches)

Not Useful – Somewhat Useful – Useful – Very Useful

Crown Base Height (units: vertical feet)

Not Useful – Somewhat Useful – Useful – Very Useful

Coarse Woody Debris (units: kg (dry biomass weight)/acre)

Not Useful – Somewhat Useful – Useful – Very Useful

Fine Woody Debris (units: kg (dry biomass weight)/acre)

Not Useful – Somewhat Useful – Useful – Very Useful

Forest floor fuels (litter & duff, units: inches (depth))

Not Useful – Somewhat Useful – Useful – Very Useful

Snag Density (units: number/acre)

Not Useful – Somewhat Useful – Useful – Very Useful

Other metric (please indicate): _____

Not Useful – Somewhat Useful – Useful – Very Useful

What would be your preferred spatial resolution of the data?

Pixel-level (e.g., 30m) – Plot-level (e.g., 1/10th ac. plots) – Stand-level (~ 0.5–5ac.) – Regional level

At what spatial extent do you need map products to do your job?

Project level Forest level Regional level National level

What would be the required (or desired) precision for the data (RMSE = root mean square error)?

Very Precise (RMSE<25%) – Precise (25%<RMSE<50%) – Somewhat Precise (RMSE>50%)

(C) Additional information (e.g., indicate how would this data be useful to you in your profession):

_____

_____

_____

Appendix B. Workshop poster for interactive session during OLI 2020

CMS Workshop #1: Utility of fuels and forest structure attribute data

Group No.: _____

Present question: ____

Workshop packet: Please work through the questions during the break-out session and report back to the group after 50 min.

Note: For the tables in Q1, Q2, Q3, Q4, and Q5 every group member gets to vote by posting stickers in the Table.

Question 1: Data sets

Introduction: Imagine that you are managing a tract of forest for the different management applications listed in the columns below. **Use the provided colored dots (12/person) to indicate which lidar/Landsat derived spatial metrics would be most useful for you and discuss your choices.**

Metric	Management application			
	Timber	Wildlife	Wildland fuels	Biomass
Mean vegetation height				
Basal area				
Crown bulk density				
Crown base height				
Mean diameter				
Total dry biomass				
Coarse woody debris (1000hr)				
Fine woody debris (1hr-100hr)				
Total Volume				
LAI**				
Tree location**				
Species composition**				
Canopy cover (%)**				
Successional stage**				
.....				
.....				
.....				

*** These metrics were identified as important during the questionnaire.*

Question 2: Spatial resolution

Introduction: We are going to prepare data at various spatial resolutions. 30 by 30m is the common pixel resolution of our data products, matching the Landsat spatial resolution. However, we also make use of aerial imagery (e.g., NAIP), higher-resolution lidar data, and high-resolution satellite imagery, making it possible to produce some data at much higher spatial resolution. On the other hand, we have the ability to aggregate data to stand level, county level as well.

Use the provided colored dots (4/person) to indicate which spatial resolution would be most useful for you and discuss your choices.

Spatial Resolution	Management application			
	Timber	Wildlife	Wildland fuels	Biomass
250m				
30m				
20m				
10m				
3m				
1m				
Sub-meter				
Tree-level				
Stand-level				
County-level				

Question 3: Temporal resolution

Introduction: We can prepare data at various temporal intervals. Often-times, lidar acquisitions are only acquired once, whereas Landsat imagery is acquired every 16 days. We currently generate annual fits from Landsat imagery, but we have the ability to produce data more or less often.

Use the provided colored dots (4/person) to indicate which temporal resolution would be most useful for you and discuss your choices.

Temporal Resolution	Management application			
	Timber	Wildlife	Wildland fuels	Biomass
Daily				
Weekly				
Monthly				
Yearly				
Every 3-5 years				
Every 10 years				

Question 4: Extent and data volume

Introduction: As part of our NASA Carbon Monitoring Systems project we can provide data in various formats, resolutions, and extents. However, sometimes we must make trade-offs on whether to either (a) make all data available over large extents once a project is complete or (b) make smaller subsets of data available earlier over smaller extents.

Use the provided colored dots (2/person) to indicate what ideal data extent and data volume would be most useful and discuss your choices.

Spatial Extent	Approximate data volume	Most useful
Western US	> 100 TB	
Individual States	~ 50 TB	
Regional (national forest, county level)	~ 10 TB	
Watershed level	~ 1 TB	
Project level	~ 10 GB	
Landscape-level	~ 1 GB	

Question 5: Data formats

Introduction: We can prepare data in various formats including geotiffs, esri grids, shapefiles, and/or ENVI binary files.

Use the provided colored dots (2/person) to indicate which format you would like to receive the data and discuss your choices.

Data format	Most useful
GeoTiffs (.tif)	
ESRI grids	
ENVI binary (.hdr)	
Shapefiles (.shp)	
Erdas Imagine format (.img)	
NetCDF (.nc)	

Question 6: The perfect data set

Introduction: We are interested in how to best serve our stakeholders into the future.

Imagine that we would have an unlimited amount of resources to spend on developing a dataset. Discuss with your group what the ideal dataset would look like. If time is limited, choose only one of the applications. Note the main points of the discussion below:

Management application			
Timber	Wildlife	Wildland fuels	Biomass

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