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Anu Lähteenmäki-Uutela [1], Salla Rantala [1], Brent Swallow [2], Heidi Lehtiniemi [1], Tuomas Pohjola [3] and Riikka Paloniemi [1]

Increasing access to forest data for enhancing forest benefits to all

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Highlights

- Environmental protection, everyone's forest use, bioeconomy, and tourism may benefit from increased access to forest data.
- Environmental rights, everyone's rights and indigenous rights need to be strong and clear for non-landowners to benefit from forest data.
- Transparent forest data forms the basis for trade in forest ecosystem services.

Abstract

In this discussion paper, we discuss what benefits Finnish citizens and companies can derive from forest data, and how the benefits of that data depend on rights to forests. Environmental protection, everyone's forest use, bioeconomy, and tourism may benefit from increased access to forest data. Access to forest data is a democratic right by itself. Forest data allow actors to derive more value from their existing forest rights and may spark demands for clarification or reformulation of forest rights. Transparency of forest data also allows voluntary trade in forest ecosystem services. Increased access to forest data may also contribute to forest-related conflicts, given that various, at times contradictory interests are directed at forests. At best, increased access to forest data and information may support the renewal of forest governance to become more democratic, legitimate, and effective.

Keywords access to data; environmental rights; everyone's rights; Finland; indigenous rights; institutions; property rights
Addresses [1]Finnish Environment Institute (Syke), Societal Change, Latokartanonkaari 11, FI-00790 Helsinki, Finland ; [2]University of Alberta, Faculty of Agricultural, Life and Environmental Sciences, 5-67 General Services Building, 9007 - 116 St NW, Edmonton, AB, T6G 2H1, Canada; [3]University of Turku, Development Projects, Pohjoisranta 11 A, FI-28100 Pori, Finland
E-mail anu.lahteenmaki-uutela@syke.fi
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1 Introduction

Data are seen as a solution to many societal problems (OECD 2019). Access to environmental data is seen as enhancing democracy and enabling innovations (Davies et al. 2013; Huijboom and van den Broek 2011; European Commission 2020a; Eskelinen et al. 2017), helping in reaching the UN Sustainable Development Goals (UNECE 2020) and sustainability transitions more broadly (Yarime 2018), and can even be considered a fundamental right (Kravchenko 2010; Aarhus Convention; Escazú Agreement). The Aarhus Convention on access to environmental information, right to participate in environmental matters and access to efficient legal remedies is binding for Finland.

Access to forest data and information is an important part of access to environmental data and information (Rantala et al. 2020), considering the importance of forests for both local species and societies and for earth systems. Governments use forest data for planning, licensing, and monitoring, and data are shared between government branches to enhance the knowledge base and to cut costs (Kim et al. 2014). Forest data are shared between researchers (Fady et al. 2014) and between governments and researchers (Liang and Gamarra 2020). Individual citizens, non-governmental organizations and private sector organizations are also increasingly asking for and gaining access to forest data (Rantala et al. 2020). Making forests "smart", i.e., digital and connected (Gretzel et al. 2015; Gabrys 2020), is expected to contribute to more democratic and just forest governance (Meyers et al. 2009; Meyers 2014) and to enhance the recognition of forest ecosystem services and the different values of forests (Daily et al. 2009). Forest data are needed for reporting, measuring, and possibly redirecting various environmental policy efforts, as well as private sectors environmental action (Vihervaara et al. 2017). Lack of data or functioning measuring tools is a key barrier standing in the way of biodiversity action for companies (Lehtiniemi and Närhi 2022).

In this discussion paper, we discuss how Finnish citizens and companies can benefit from forest data, and how the benefits of data are conditioned by institutions that shape rights to forests and markets in forests and forests ecosystem services (Nguyen et al. 2020; Rantala et al. 2022).

By "forest data", we refer to data on what exists and happens in the forests, including their natural resources and ecosystem services. Such data could include, e.g., habitat types, species index, amount of carbon dioxide bound on a site, volume of timber and its growth per year, volume of non-timber forest products, availability and accessibility for recreation and tourism, geospatial locations of everything above, utilization and utilization plans of everything above, and economic values of everything above. Information on forest land ownership is also relevant. Both the state and other public institutions as well as private citizens own significant amounts of forest in Finland.

National Forest Inventory in Finland has been conducted since 1921, and data products can be accessed on Natural Resource Institute's (Luke) website. Further, the Metsään.fi service by the Finnish Forest Centre (Metsäkeskus) shares information regarding e.g., forest habitats, tree stands and forest use on private forest land. In 2018, the Forest Information Act (419/2011) was renewed increasing access to data on private forests, the largest category of forest ownership (Rantala et al. 2020). At the EU level, the Commission is expected to propose a new regulation in 2023 on harmonizing forest data to improve decision making concerning European forests (European Commission 2022). Finland as the most forested EU country needs a vision on how forest data can support enhanced value provision from forest ecosystem services and enhanced realization of fundamental and human rights now and in the future.

Our discussion on the benefits of forest data is informed by insights from two workshops organized in Helsinki and in Kuusamo, Finland, in 2018, additional interviews with potential forest data users in Kuusamo in 2019 (described in more detail in Supplementary file 1, available at https://doi.org/10.14214/sf.23034), and reviews of relevant literature and legal provisions in force in the summer of 2023.

2 Rights and markets condition how actors benefit from forest data

The values of forest data are connected to the values of forests through the actors that have a stake in the forest resources, and the institutions that govern access to data and resources (Rantala et al. 2022). Institutions, or rules of the game – formal rules such as laws but also social norms and shared strategies (Crawford and Ostrom 1995) – condition human action in relation to resources and hence the opportunities to benefit from data and forests. Thus, it is logical that forest data institutions are designed or negotiated to enable the capture of benefits of forests through data, and data are never "neutral" but always connected to the diverse interests that spurred their production (Rantala et al. 2022). Forests have private value for individuals and firms, and public value that includes economic, sociocultural, and ecological value (Benington 2011; Rantala et al. 2020).

In relation to both forest data and forest resources, property rights are a particularly relevant category of institutions. Because questions of access and ownership condition who gets to benefit from forests, many discussions on the benefits of forests data revolve around who has rights to forests and the law concerning forest use. If property owners have all the rights to forests with no duties towards others or the society, increased access to forest data will not automatically lead to more even sharing of forest benefits in the society through private and public value creation. Whether non-owners can use forest data to derive more value from forest ecosystem services depends on their access rights, gathering rights, and environmental rights that are either based on law and/or resolved in well-functioning forest ecosystem service markets. For data on suitable gathering, hiking, camping, swimming, and climbing places to be beneficial, the rules on these activities must be clear. Under environmental rights and in environmental service markets, biodiverse environments, carbon sequestration, and clean water are major elements and functions of forests.

The use of private and public forests in Finland is regulated by the Forest Act (1093/1996, modified by Act 1085/2013), constrained by international agreements, European Union law, and the Constitution (731/1999). In the general Western model, landowners have rights concerning their property (Nichiforel et al. 2020). Landowners decide on harvesting forests, while the Forest Act mandates forest renewal thereafter. Neighbors, recreational users, or tourism companies have no say. Forests with nature values can be voluntarily protected under the Forest Biodiversity Programme for Southern Finland (METSO) (Ministry of Environment 2023a), and forest owners can voluntarily enter carbon sequestration programs.

In addition to the rights of landowners, the rights of others are relevant for defining benefits of forests enabled by data (cf., Rantala et al. 2022). Finnish citizens have a right to a healthy environment, and they share the responsibility to protect the environment (Finnish Constitution, Section 20.1). The EU has an ambitious biodiversity strategy (EU Commission 2020) the national implementation of which Finland needs to consider (Lehtiniemi and Närhi 2022), particularly under the Nature Protection Act (9/2023), and the national climate neutrality goal by 2035 is enshrined in the Climate Act (423/2022). Everyone's rights (formerly known as everyman's rights) to roam private lands are based on tradition, not on written law. On indigenous rights, Finland has signed the (non-binding) UN Declaration on the Rights of Indigenous Peoples. According to the Finnish Constitution, the Sámi have a right to uphold their culture (17.3 §). The Sámi community in Finland has urged the Finnish government to ratify the International Convention on Indigenous and Tribal Peoples (ILO 169), a binding international convention that includes traditional land and water use. For the Sámi, this means reindeer herding. A UN report on the rights of Sámi (United Nations Human Rights Council 2016) concludes that current Finnish legislation does not adequately safeguard the rights of the Sámi, referring to the Mining Act (621/2011, and the implementation of the Metsähallitus Act (234/2016) that governs the use of state-owned forests. The climate goals and the move away from fossil fuels may mean more mines and more wind energy, both of which may threaten nature protection, tourism, and the Sámi way of life.

All societal interests in Finnish forests are increasingly hard to fulfill and settle. Increased access to forest data may highlight the tensions between forest owners, indigenous peoples as traditional users and governors, other users, non-users, future generations, and nature itself. Increased access to data may empower non-landowners to demand the realization of their environmental rights, everyone's rights, and indigenous rights. They may particularly start to demand conservation and the protection of carbon sinks and storages. In this way, renewed forest data institutions enabling increased access to data function as impetus for renewal in forest governance (Rantala et al. 2022).

3 Benefits of forest data

3.1 Forest ecosystem services and forest rights

Forests provide several types of ecosystem services that enable the appropriation of public and private benefits (Masiero et al. 2019; IUCN 2019). Barrio and Loureiro (2010) list biodiversity/habitat preservation, carbon storage, watershed services, goods, recreational opportunities, and scenic landscapes. Ecosystem services can be categorized into "regulating", "supporting", "provisioning" and "cultural" services (Millennium Ecosystem Assessment 2003; United Nations 2014). "Regulating services" of forests refer to their role in erosion control, flood prevention, climate regulation, carbon sequestration and water purification, and "supporting services" relate to nutrient cycling, soil formation, and biodiversity (United Nations 2014). All the ways in which forest ecosystems mediate or moderate the environment can be grouped as ecological functions (Forest Europe 2014). "Provisioning services" are physical forest products, including wood, fiber, food such as berries and mushrooms, and medicinal plants (European Environment Agency 2016), here named products. "Cultural services" are non-material outputs, referring to forests as sources of physical and mental wellbeing and recreation (Paracchini et al. 2014), also including their spiritual values (Clark 2011; Ritter and Dauksta 2013). Here, we call these experiences. As implied in the concept, all ecosystem services rely on ecosystems: if the nature is degraded, its capacity to produce not only ecological functions but also safe and healthy products and experiences is diminished. Further, climate change and biodiversity loss are increasingly a part of business. Forest data are valuable for risk assessment as well as for corporate responsibility work.

Among the public benefits of forest data, ecological functions are vital and life-sustaining for everyone. Products and experiences constitute private benefits for individual persons and for business sectors and public economic benefits through the bioeconomy and the tourism industry. Enhanced protection against forest threats and disturbances can create both private and public benefits (Table 1). Finally, we identify a category of public benefits of forest data related to political values (Benington 2011): enhanced democracy in forest governance through increased access to forest data and information, including increased civic participation, equity and legitimacy of decision making, and realization of forest-related rights (Table 2).

3.2 Enhanced ecological functions

The Finnish boreal forests cover 23 million hectares, 75% of the land area (Lier et al. 2019). Vast majority are heath forest, while there are some herb-rich forests in the southern parts of the country. However, 79% of the total amount of forested habitats in Southern Finland and 56% of the total amount of forested habitats in Northern Finland are endangered. Larger conservation areas are concentrated in the Northern parts (Ministry of Environment 2023b).

Table 1. Potential benefits of forest data including potential conflicts.

Category of benefit	Type of data	Users of data	Examples of benefits	Potential conflicts
Enhanced ecological functions	Biodiversity data: data on species, ecosystems, biodiversity	Forest owners, citizens, environmental non-governmental NGOs (non-governmental organizations)	More efficient conservation of forest species and biotopes, designation of critical habitat	-Limitations for forest owners OR new income opportunities for forest owners through ecological compensation markets -Enhanced opportunity to harm endangered species (criminal activity)
	Carbon flow and carbon stock data	Forest owners, citizens, environmental NGOs	More efficient carbon sequestration and storage	Limitations for forest owners OR new income opportunities for forest owners through carbon markets
Enhanced benefits from bioeconomy products	Timber data + forest management plans	Forest owners, forest service companies, forest industry, tourism industry	More efficient and sustainable forestry, new business opportunities, growth and jobs	Possible negative impacts for non-owners: weaker recreation possibilities, weaker destination quality for tourism OR possibility to negotiate
	Data on non-wood forest resources, e.g., berries, mushrooms	Berry pickers, mushroom collectors, non-wood forest product companies, tourism companies	More efficient gathering, enhanced food supplies, new income opportunities, new business opportunities, growth and jobs	Possible nuisance for forest owners and for protective former collectors OR possibility to negotiate
Enhanced benefits from experiences	Data on touristic sites: nature types, landscapes, routes, sports, history etc.	Recreational users, tourists, hunters, destination marketers	Enhanced recreational experiences, "nowness" (real-time, data-driven, customer-centric co-creation), wellbeing, new business opportunities, growth and jobs	-Possible overcrowding: disturbance to wildlife, wearing of terrain -Possible nuisance for forest owners OR new income opportunities through landscape compensation
Enhanced protection against forest threats and disturbances	Data on forest pests, pathogens, fires and storms	Forest owners, all forest users, insurance companies, forest protection companies	Enhanced forest protection, i.e., more effective threat management, new business opportunities, growth and jobs	Species connected to wildfires may need support
Enhanced democracy	All forest data	Citizens, NGOs, companies, business researchers, educators	Participation, transparency, enhanced monitoring, knowledge, legitimacy, realization of rights, governance mechanisms	

Table 2. Benefits of forest data and relevant forest-related and other rights.

<table>
<tr><td>Enhanced ecological functions</td><td>Enhanced product innovation</td><td>Enhanced experience innovation</td><td rowspan="2">Enhanced democracy</td></tr>
<tr><td colspan="3">Protection against threats and disturbances = enhanced ecological functions, products, and experiences</td></tr>
<tr><td>Right to a healthy environment of everyone</td><td colspan="2">Property rights of forest owners
Everyone's rights of visitors</td><td>Participatory rights of everyone</td></tr>
<tr><td colspan="4">Indigenous rights
(in Finland: the rights of the Sámi to their traditional culture, livelihoods, and participation)</td></tr>
</table>

Data on species, habitats and biodiversity is needed for nature protection, i.e., conservation (König et al. 2019; Underwood et al. 2018; Turner 2014), and increased access to data is presumed to lead to enhanced and more effective nature protection. Biodiversity data allows the identification of valuable nature sites and actions to protect them. The Finnish Museum of Natural History (Luomus) has the Finnish Biodiversity Info Facility (FinBIF, Laji.fi) which contains species-level nature data open to everyone (Schulman et al. 2021). In the Metsään.fi service, the Finnish Museum of Natural History and the Finnish Forest Centre share their data on the nests of predatory birds to forest owners, expecting the nesting trees to be saved (Luomus 2019). Misuse is a threat, and it is monitored.

Designation of critical habitat may cause controversy, as it often means significant limits to the way that land can be used by private landowners. In the interviews, it was noted how open data can potentially heighten forest-related conflicts: if valuable nature sites are identifiable through open forest and biodiversity data, demands for more nature to be protected may enter public discussion and create pressure for stricter case-by-case judgments and stricter new laws.

Forest carbon data are a focus of major global attention (Cook-Patton et al. 2021). Finnish Natural Resource Institute (Luke) provides forest carbon sink data at the Metsainfo.luke.fi site. Access to carbon flow and carbon stock data may evoke demands for legally protecting specific forests that are important carbon sinks and storages. Carbon data can also be used as the basis for mandatory or voluntary carbon markets where landowners and communities managing forests can earn income from carbon sequestration and storage. The payers would be public or private actors that need or want to compensate/offset their carbon emissions. In Finland and broader in the EU, the sinks and emissions of the land use, land use change and forestry (LULUCF) sector are calculated and regulated, but official EU or Finland carbon sink markets do not yet exist. In Finland, the forest management associations have launched the Hiilipalvelu service where forest owners can voluntarily sequester more carbon through extra fertilization and receive a compensation (Metsänhoitoyhdistys 2023; Green Carbon Finland Oy 2022).

In addition to those related to biodiversity and carbon, ecological functions provided by forests also include watershed services (water quantity and quality), soil stabilization and erosion control, and air quality (García-Nieto et al. 2013).

3.3 Enhanced product innovation

Increased access to timber data is expected to make Finnish forestry more efficient (Venäläinen et al. 2015; Holopainen et al. 2014). In 2018, the gross value of forest industry production in Finland was over 23.4 billion euro. Pulp, paper, paperboard, packaging materials and sawnwood are the most important products. Side streams are used also for biodiesel and bio-oils, and wood fibers have potential for the medicines, functional foods, plastics, cosmetics, and textiles industries. (Ministry of Agriculture and Forestry 2021.) In addition to timber sellers, efficient forest management will benefit the timber buyers in the form of good-quality raw material. In Finland, timber data are collected by the Forest Centre and published at the Metsään.fi website. The data are collected using laser scanning, aerial photography, sample plot measurements, and site visits. For forest owners, the site suggests logging or forestry actions for each forest stand. The site offers advice on calculating how much carbon one's forest can sequester but does not provide these numbers directly. Forestry service providers can see stand-specific data if the forest owner has consented to it in Metsään.fi, and several companies are offering forest management services based on the data. UPM and Stora Enso, two large forest industry companies, offer mobile apps where one can see the value of one's forest as well as recommended actions. MetsäForest, the part of Metsä Group specializing in timber trade and forest services, offers forest owners a possibility to visit their forests in virtual reality.

Reaching the best possible income from loggings is a clear benefit for forest-owners, however loggings in general are a potential cause of conflicts between them and other forest users. Logging plans and open data about them may bring conflicting forest values to the surface. In Finland, negative opinions on clear-cuts have increased (Kangas and Niemeläinen 1996; Valkeapää and Karppinen 2013; Pöntinen 2021). Three recent citizens' initiatives at the Finnish national level have called for legislation to limit clear-cuts in Finnish forests. A citizens' initiative can be submitted to the parliament if signed by 50 000 citizens (Finnish Constitution, Section 53.3). One of the three forestry-related initiatives proceeded to the parliament (VN/1699/2018). The parliament did not prohibit clear-cuts in state-owned forests as suggested by citizens, but economic targets for state forestry were modified, and discussion on forestry methods was promoted.

Non-wood forest products are a growing business area in Finland, and their valorization is a major research focus (Sacchelli et al. 2021). Based on everyone's rights. wild berries and mushrooms can be gathered without any permit regardless of who owns the forest. Gathering forest products is also very common: 70% of Finns pick berries or mushrooms (Finnish Food Authority 2021). The Natural Resource Institute (Luke) and the Finnish Environment Institute (Syke) offer some open databases. Important berries include bilberry (*Vaccinium myrtillus* L.), lingonberry (*Vaccinium vitis-idaea* L.), crowberry (*Empetrum nigrum* L.), cloudberry (*Rubus chamaemorus* L.), raspberry (*Rubus idaeus* L.), cranberry (*Vaccinium oxycoccos* L.), and sea buckthorn (*Hippophae rhamnoides* L.). The annual crop of forest berries is estimated at over 500 million kg, of which under 10% is currently gathered (Arktiset Aromit 2023; Himelrick 2001). The revenue from gathered berries is approximately 15–20 million euros per year (Kantar TNS Agro 2020). The value of household use is higher, though: the average Finn consumes eight kilograms of wild berries per person per year (Arktiset Aromit 2023; Himelrick 2001). According to Finnish Food Authority (2023), 3–16 million kilograms of mushrooms are picked each year. Better berry or mushroom data are presumed to prompt more people to look for extra revenue or for new household uses. A service by the company Innofactor, Mustikkaan.fi, predicts when and where bilberries will ripen, based on temperature data from the Finnish Meteorological Institute and the historical bilberry ripening data from the Finnish Museum of Natural History. The "competing" Marjahavainnot.fi web page by the Natural Resource Institute (Luke) and 4H, in turn, presents citizen observations on different berries on maps. According to the Finnish Natural Resource Institute, their berry crop forecasts are interesting for both domestic pickers and for companies. At our Kuusamo workshop and interviews, identification of sites for the commercial harvest of wild foods, including herbs and spruce sprouts, was considered an interesting new opportunity. New high-value products, e.g., medicine and cosmetics, could be developed. Potential disbenefits with opening or sharing non-wood forest product data were also discussed. Increasingly useful and valuable data may lead into a need to clarify everyone's rights to avoid conflicts between landowners and users, such as berry pickers venturing too close to private homes or businesses creating value from non-wood forest products on private land based on everyone's rights.

3.4 Enhanced experience innovation

Increased access to forest data can contribute to enhanced forest experiences. Nature is an important source for physical and mental wellbeing (Hartig et al. 1991; Bell et al. 2007; Joye et al. 2014; Puhakka et al. 201), and exposure to biodiverse environments is beneficial through its impacts on our microbiota and the immune system (Ruokolainen et al. 2017). In Finland, nature tourism relies on forests, marshland, fells in Lapland, lakes and rivers, and the Baltic Sea. Everyone's rights in Finland allow one to walk, ski, cycle, and put up a tent in all forests. In the waters, one can swim, boat, and fish with a rod and line. In the winter, one can walk, ski and skate on ice. (Ministry of

Environment 2023c.) Forests offers opportunities for hiking, biking, and scenic landscapes (Barrio and Loureiro 2010), and forest data can give ideas to new sites for relaxation, recreation, learning, immunity boost, identification of sites for nature photography and for identification of potential sites for building free-time residences. In addition to nature as such, forests have cultural and industrial heritage that may interest tourists and locals alike. Historical data and narratives could be used to create new services. Forests can provide emotionally extraordinary and transformative "peak" experiences (Kirillova et al. 2017). Service providers could use data to help deepen attachment to places (Birbaum et al. 2021) and to make experiences even more meaningful (Buhalis and Sinatra 2019; Pohjola et al. 2020). In developing "smart" tourism (Caragliu et al. 2011; Gretzel et al. 2015; Buhalis and Amaranggana 2015), forests could be seen as spaces where tourists and other public and private actors create value together (Suntikul and Jachna 2016; Mariani et al. 2018), blending the physical space with real-time interaction with others (Buhalis 2019; Garcia et al. 2019; Gretzel et al. 2016; Ciasullo et al. 2018). Big data including visitor behavior and IoT (Internet of Things) sensor data can be used to enhance the overall, long-term sustainability of nature tourism operations and stakeholder networks (Koo et al. 2019; Pohjola et al. 2020), for example through helping to manage tourism flows in sensitive areas (Gretzel et al. 2015; Boes et al. 2016; Caruso et al. 2017). The Finnish Metsähallitus offers the Nationalparks.fi (Luontoon.fi) service where one can search destinations and activities on maps. In the Eräluvat.fi portal, one can buy permits for the methods of fishing that are not covered by everyone's right, for hunting, and for snowmobile use. This portal covers activities in state-owned forests governed by Metsähallitus. In our workshops, the development of "one-stop shops", i.e., places for finding all relevant data and services for recreation, stirred great interest.

However, it was acknowledged in the interviews that as with the berry-pickers, recreational use or tourism may lead to conflicts with landowners. Particularly business activities, such as guided hiking, nature photography or horseback tours were mentioned as prone to cause controversy and needed to be delicately navigated with the landowners. Information about sacred sites should always be treated as sensitive and accompanied with advice on how to respect religious and cultural rights, which may not be compatible with opening such data and information. For example, a sacred site for the Sámi indigenous people, the Ukonsaari (in Sámi: Äijih) island in the Lake Inari was recently closed from tourists after decades of controversy (Kaleva 2020).

Virtual nature tourism and digital twins of nature destinations may present as alternatives for the tourism growth paradigm (Fuchs et al. 2020). Virtual green care or virtual nature therapy may offer possibilities (White et al. 2018). Finnish company OiOi provides a Virtual Nature Experience which is described as "an immersive and interactive space that imitates nature as it is". Landscape videos bring the four seasons of Finnish year cycle and different times of day into built environments, including soundscape. Another Finnish company, Halipuu, has released Forest in your Pocket, a mobile app that enables people to virtually visit a Laplandic forest, with a personal live guide. Virtual nature tourism does not seem to conflict with landowners' rights to real property. The question of whether landowners should receive some compensation has not been addressed. Photography and filming in private forests is allowed under everyone's right, yet landowners may feel discomfort about commercial activities, and any long-term operations would go beyond everyone's rights. In the future, virtual forests might have a role in fulfilling citizens' environmental rights and their right to health.

3.5 Enhanced protection against threats and disturbances

Data on forest threats and disturbances is important for all forest ecosystem services as disturbances such as pests, wildfires and storms can compromise the productive capacity of forests (Francini et al. 2022 about disturbance data and carbon sinks). Climate change is increasing the conditions suitable for insects and fungi as well as the occurrence of forest fires and storms. Pest species pose a major threat to the health of global forests, and fungal pathogens carried with pests can amplify the negative effects of pests and cause significant damage in their own right (Linnakoski and Forbes 2019). Fuel load and moisture content of trees will impact the damage caused by forest fires, and data on vulnerable forest types, locations, and vegetation structures may help in fire risk mitigation. While forest fires may be detrimental for human activities, they benefit multiple species, especially through nutrient dynamics (Knelman et al. 2017). In Finland, data on threats to forests is available in the Metsainfo.luke.fi service, and as Valonen et al. (2019) anticipated, the Metsään.fi service by Finnish Forest Centre has also been developed to allow the forestry sector to identify and share information regarding the threats. Data on soil microbes (Raison and Khanna 2011) or tree microbes (Steidinger et al. 2019) may be important for developing forest health solutions.

3.6 Enhanced democracy of forest governance

The democracy benefits of increased access to forest data are based on data enabling and empowering citizens more effectively and equitably to participate in public decision-making. Transparency and openness are important for citizen empowerment. The more citizens know about nature, natural resources, and ecosystem services, including their value for different stakeholders and for society, the better equipped they are to decide on policies for the benefit of themselves, others, and future generations. Data may spark citizens to demand the realization of their existing rights or to demand new rights, or it may spark the creation of market-based governance systems. If one needs more rights than granted by the law, one can either try to change the laws, or one can try to buy such rights on the markets.

Forest data can be powerful if citizens and indigenous peoples have substantive legal rights to benefit from the forest ecosystem services. If property owners have all the rights to forests with no duties towards others or the society, forest data will not enhance equity and justice in relation to forests, contrary to the expectations.

- When non-owners have strong and clear rights concerning the natural resources/ecosystem services of forests, increased access to data may strengthen these rights in practice.
- When non-owners have weak or unclear rights concerning the natural resources/ecosystem services of forests, increased access to data can spark demands for stronger and clearer rights.

The benefits of environmental data for environmental goals such as biodiversity protection and climate change mitigation thus depend on the foundations in environmental law and ecosystem service governance. Data on suitable hiking/camping/swimming/climbing/gathering places is not beneficial for recreational users and tourists if these activities are not allowed either by law or through contract. For forest owners, voluntarily engaging in ecosystem service trade may seem easier to accept than any legal restrictions to loggings. However, for non-owners, it may seem unjust if everyone else pays for biodiversity and carbon removal except the property owners. If citizens can legally demand ecosystem services such as clean water, biodiversity, and carbon sequestration, they can use data as a basis for their claims towards the State, and the State has a duty to respect, protect, and fulfill their rights.

4 Conclusions and discussion

In this discussion paper, we have explored the benefits of increased access to forest data and how the benefits of those data depend on rights to forests. Suppl. file 2 summarizes main forest info databases, and Suppl. file 3 summarizes the main laws that are relevant for benefiting from forests. Data may empower non-landowners to uphold their rights and support renewal of laws in the democratic governance sphere. At the same time this may highlight the tensions between forest owners, indigenous peoples as traditional users and governors, other users, non-users, future generations, and nature itself.

Democracy is essentially about negotiations over who has rights and benefits and who has duties and responsibilities. Environmental rights, everyone's rights and indigenous rights in Finland need to exist in practice, not merely on paper. Forests are essential for both carbon regulation and biodiversity conservation, and enhanced understanding and transparent discussion on these vital functions is welcome. The physical and mental health impacts of forest experiences, the cultural and economic values of innovative non-wood forest products, and the impacts of nature-based tourism on employment and livelihoods also need to be fully recognized in Finland.

In the free markets sphere, increased access to data can facilitate the development of services for rights-holders and enable the creation of trading systems for ecosystem services. Biodiversity and carbon data services are developed for offset traders, forestry and forest health information services for landowners, berry info services for pickers and bioproduct companies, and recreational and destination info services for recreational users and tourism companies.

For the vision of enhanced micro-level and macro-level benefits of forest data to realize, forest data needs to be accessible and usable for citizens, businesses, NGOs, and public organizations. There can be impediments related to quality, compatibility, comparability, and metadata (Zuiderwijk et al. 2012). User interfaces must encompass the perspectives of users and practitioners (Ofoeda et al. 2019). Continuous development of data services will be needed.

We suggest at least these building blocks should be combined in forest data platforms (Fig. 1):

- science-based, accessible, and usable forest data and information
- democratic participation possibilities (citizen-government interaction at State level and city level, e.g., hearings and petitions), and
- markets for negotiating and contracting over forest rights and licenses (between private parties, citizen to citizen, businesses included).

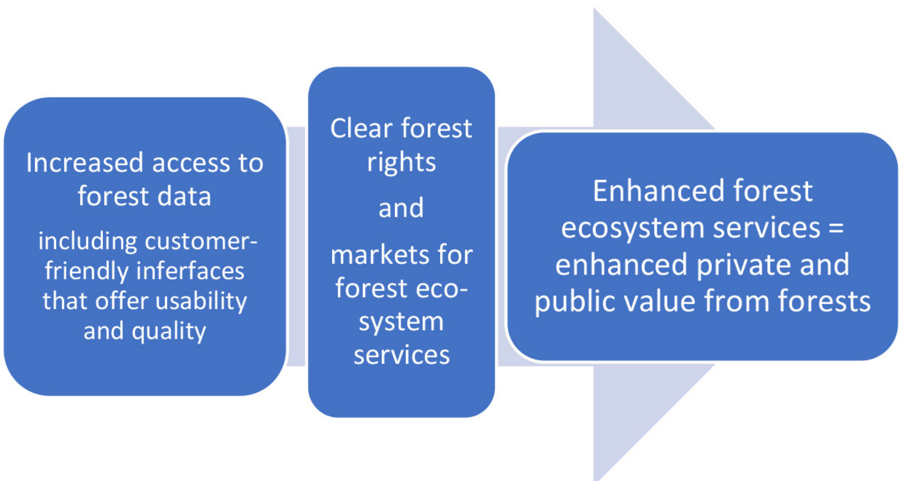

Fig. 1. Data, rights, and markets for enhanced forest ecosystem services.

Ideally through such a data-enabled, democratic, and transparent process, citizens are empowered, forest governance is increasingly just, and businesses utilize their competences and networks to the fullest. Data should aid in fitting the competing interests together through enhanced public participation and deliberation involving increasingly multiple voices in forest governance – acknowledging unavoidable trade-offs between the competing interests but seeking satisfactory compromises.

Declaration of interests

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Author contributions

Lähteenmäki-Uutela wrote the original manuscript and the revised manuscript. Everyone else provided additions. Rantala, Swallow and Paloniemi organized the workshops in the GoDiCo project. They participated particularly in planning the article structure and in writing the introduction and the conclusions. Pohjola wrote the parts about experiences and forest tourism. Lehtiniemi wrote the parts about the accessibility of forest data. Paloniemi secured funding for the GoDiCo project and led the GoDiCo project.

Supplementary files

S1.pdf; Empirical materials,
S2.pdf; Main forest databases in Finland and their content,
S3.pdf; Main laws applicable in Finland and their goals,
available at https://doi.org/10.14214/sf.23034.

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