Seasonal Trafficability Classification

Needs Assessment

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Summary

- The aim of the study was to examine: (1) the current status of R&D work on the seasonal trafficability classification of private roads; (2) the needs of the forest sector for a trafficability assessment tool; and (3) requirements for further development measures.
- Seasonal trafficability refers to the ability of a fully loaded vehicle combination to travel on a specific section of a gravel road without causing damage to the road. Trafficability varies according to seasonal conditions.
- A seasonal trafficability classification system suitable for operational use by companies would consist of a commercial classification tool, analytical models for assessing seasonal trafficability under different conditions, and the public and private geospatial datasets required by these models.
- A commercial seasonal trafficability classification tool is not yet available. Factors affecting trafficability and their impacts are currently being modelled in several research projects in Finland and abroad. Testing of the models is expected to commence during 2027. Only part of the data required for the classification system is currently available in a comprehensive, open and up-to-date form. Ongoing research is exploring various data sources and data collection methods to improve data availability.
- Forest companies have identified several challenges in the planning of timber harvesting and transport, as well as a number of benefits that a seasonal trafficability classification tool could bring to these planning processes. Climate change, in particular, is increasing the variability of operating conditions and reducing their predictability.
- Key next steps include cooperation between forest companies, other companies and ongoing R&D projects, the identification of critical input data and their availability, and a more detailed assessment of the costs associated with the seasonal trafficability classification system and the data required to support

Contents

1. Background and Objectives of the Study

- Seasonal variation causes annual additional costs of €70 million for timber supply, of which road thaw damage accounts for a significant proportion of both harvesting and transport operations (Venäläinen et al. 2017).
- By better understanding and anticipating road conditions, harvesting and transport operations can be precisely targeted to different areas according to their seasonal trafficability.
  - This reduces seasonal fluctuations in the use of harvesting and transport personnel and equipment, decreases road damage, reduces seasonal timber storage, improves transport road safety, and increases the efficiency of timber procurement staff.
- The ultimate objective is a commercial application (web service or mobile application) presenting the seasonal trafficability classification of private roads.
- The objective of Metsäteho's study was to map out:
  - the current status of R&D work on seasonal trafficability classification
  - the needs of the forestry sector for such a tool
  - the requirements for next steps.

Conduct of the Study

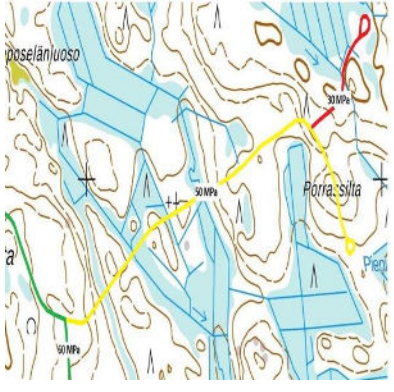
- The study was carried out by
  - mapping the results of research projects on the seasonal trafficability classification of private roads, both completed and ongoing, predominantly in Finland
  - interviewing representatives of research projects in the subject area, public-sector actors producing private road data, and state gravel road development
  - interviewing representatives of the forestry companies that participated in the study's steering group.
- The interviewed actors were
  - Metsä Group, Metsähallitus Metsätalous, Stora Enso, UPM-Kymmene
  - Geological Survey of Finland (GTK), Finnish Meteorological Institute (FMI), University of Eastern Finland (UEF), Natural Resources Institute Finland (Luke), Finnish Geospatial Research Institute of the National Land Survey of Finland (FGI), National Land Survey of Finland (MML), University of Oulu (UO), Finnish Forest Centre (abbreviated SMK in the report), Finnish Environment Institute (SYKE)
  - Finnish Transport Infrastructure Agency (state gravel roads).
- Metsäteho thanks the individuals who took part in the interviews.
- Based on the results of the study, a description has been prepared of the seasonal trafficability classification tool's
  - content and user groups
  - benefits relative to the current state
  - cost types of implementation and maintenance
  - further action needs.

Description of the Seasonal Trafficability Classification

- According to the YTPA report (Venäläinen et al. 2026 (eds.)):
  - Seasonal trafficability refers to the capacity to drive a fully laden vehicle combination (76 tonnes) over a specific gravel road section without causing road damage. Where necessary, seasonal trafficability may be further specified to cover, e.g. the capacity to drive a low-loader carrying a forestry machine, or an empty or partially laden vehicle combination.
  - **The static seasonal trafficability class** describes which class each road belongs to (the class changes only if the road's bearing capacity permanently deteriorates or improves through maintenance works).
  - **Dynamic seasonal trafficability** describes the prevailing road conditions at a selected point in time (i.e. whether it is, for example, the thaw season, during which only thaw-resistant roads are passable).
- Seasonal trafficability varies according to the time of year (see the following slide). The trafficability of private roads is also affected by other factors independent of seasonal variation (e.g. bridge weight restrictions, steep gradients).

Seasonal Trafficability Classifications

- The table presents the classifications set out in the YTPA report.
- Forest companies use classifications based on the Forest Data Standard, either in their original form or with some modifications.
  - In some cases, the classifications are applied only to short road sections, while in others they are used more broadly through generalisation.
- Additional classifications may also have been applied in research projects.



Picture: Solonen et al. 2024

Road data standard (Long-distance seasonal trafficability of storage site)	papiNet standard: RoadAvailability	Additions by Metsäteho
1 = Always	AllYear – Road is available all year for all kind of traffic	Road passable year-round (including during the thaw season) (bearing capacity measured in spring at least 60 MN/m²)
2 = Good summer road	NotInWinter – Road is not available in winter season. Only available in spring, summer and autumn season.*	Road passable year-round except during the thaw season (summer bearing capacity 50–60 MN/m²)
3 = Summer	NotinHeavyRain – Road is not available for trucks in heavy rain periods.	Road passable only during dry summer conditions and in winter (see next class) (bearing capacity 30–50 MN/m²) *(the threshold value of 30 requires further verification)*
4 = Winter	NotInSevereThawing – Road is not available for trucks in severe soil frost thawing.	Road passable only when the road substructure is frozen (bearing capacity below 30 MN/m², *threshold value requires further verification)*
5 = Winter road**	InWinter – Road is available for trucks only in winter season. In the Nordic region it is common with ice-roads over lakes etc in the winter season.	
	NotAvailable – Road is temporarily not available for transporting***.	

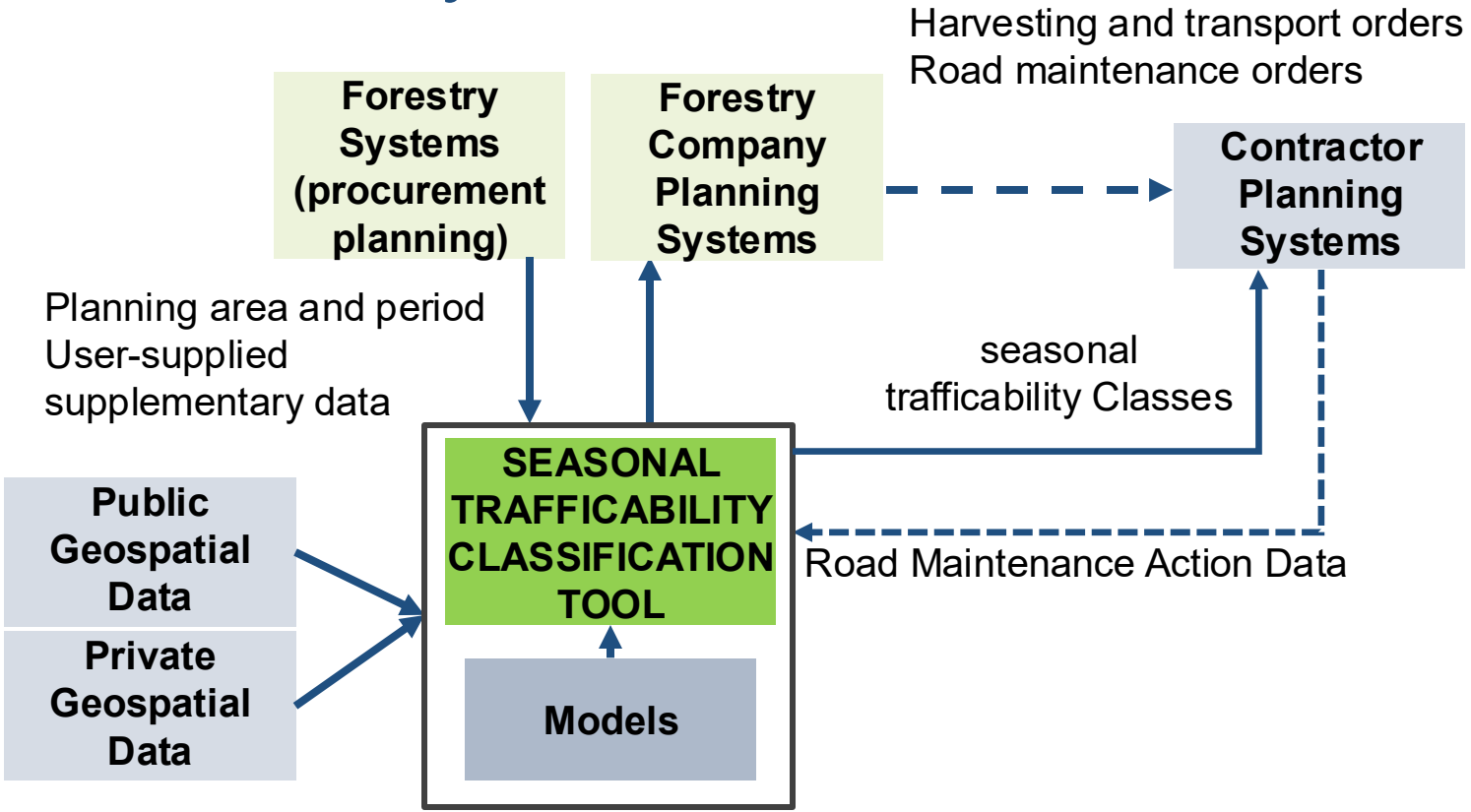
*For example, locations where winter maintenance operations are not feasible
**Winter roads are treated in the YTPA report as a separate road category
***For example, roads that receive no winter maintenance
****Based on the document Strandström 2017c

Venäläinen et al. 2026

2. Seasonal Trafficability Classification

- The seasonal trafficability classification to be utilised in companies' operational activities consists of three components (see also the diagram on the following slide).
  1. The seasonal trafficability classification's commercial **tool**, in which the analysis of up-to-date seasonal trafficability is performed using various source data and analytical models. seasonal trafficability analyses are transmitted from the tool to other systems that utilise it.
  2. The **models** that analyse the seasonal trafficability of roads in different situations, currently being developed in various R&D projects. The commercial tool may utilise one or more models being developed in R&D projects, or the tool provider may develop its own models.
  3. Public and private **geospatial data** required by the models to produce a reliable seasonal trafficability analysis.
- The above components, service usage and synergies with other tools are described in sub-sections a–e.
  - The descriptions presented in this report are based on interviews with forestry companies and on data from research studies on seasonal trafficability.
  - A more detailed description of the tool's operating model should be prepared as the ongoing development work progresses.

Seasonal Trafficability Classification



a) Tool

- The seasonal trafficability classification tool consists of two separately published components.
  - **The static component** contains only fixed or slowly changing factors (e.g. soil type).
    - The static component is of particular value to forestry companies for identifying potential risk locations (scheduling of harvesting and transport in quarterly or annual planning).
  - **The dynamic component** contains factors that may change very rapidly (e.g. rainfall on a given day).
    - The dynamic component can be utilised by forestry companies as well as harvesting and transport contractors for near-term transport planning (from a timeframe of a couple of weeks down to the hourly level).
  - Any supplementary **user-supplied data** on road characteristics and maintenance actions (e.g. gravelling) refines the output of the underlying model.
- Seasonal trafficability can be presented:
  - **By road segment** – segment-level definition is used to identify precise problem or risk locations on the road network (locations that may require minor works such as gravelling, or significant works such as full reconstruction).
  - **By inter-junction section** – inter-junction-level definition is used for transport and route planning.

Connections to Background Systems and System Roles

- **Source data systems**
  - Permanent road data systems (National Topographic Database – NTD, Digitraffic Road Network, GTK soil data)
  - Finnish Forest Centre systems: Metka, condition data
  - Finnish Meteorological Institute weather data and forecasts
  - SYKE datasets
  - Supplementary analyses (e.g. ditch depth) (carried out by the service provider and/or another party)
- **Other forest sector information systems**
  - Company-specific harvesting and transport planning information systems and forest management systems
  - Shared information systems (e.g. LogForce, WoodForce, Pinja Forestry Operations, LeafPoint) (potentially displaying the analysis directly in these)
  - Road maintenance planning information systems
  - Terrain trafficability classification tool
- **The service's data management will be defined later**
  - E.g. data transfer methods, data interfaces, descriptions of other systems
  - Data security matters (openness of data sharing in the current security situation)

b) Models

- Factors influencing seasonal trafficability and their effects are being modelled in ongoing research projects.
- Models related to seasonal trafficability being developed in research projects are described on the following slide.
  - These models have often been developed in previous projects too, and collaboration on model development takes place between projects.
  - Future model maintenance and development will be influenced by available research funding (plus any potential commercial agreements).
  - In addition, the actors in these projects and other organisations have separate models supporting the seasonal trafficability models (e.g. frost and soil moisture models).
    - The Finnish Forest Centre's Private Roads map service shows the need for basic improvement of private roads, whose background variables share several factors with seasonal trafficability.

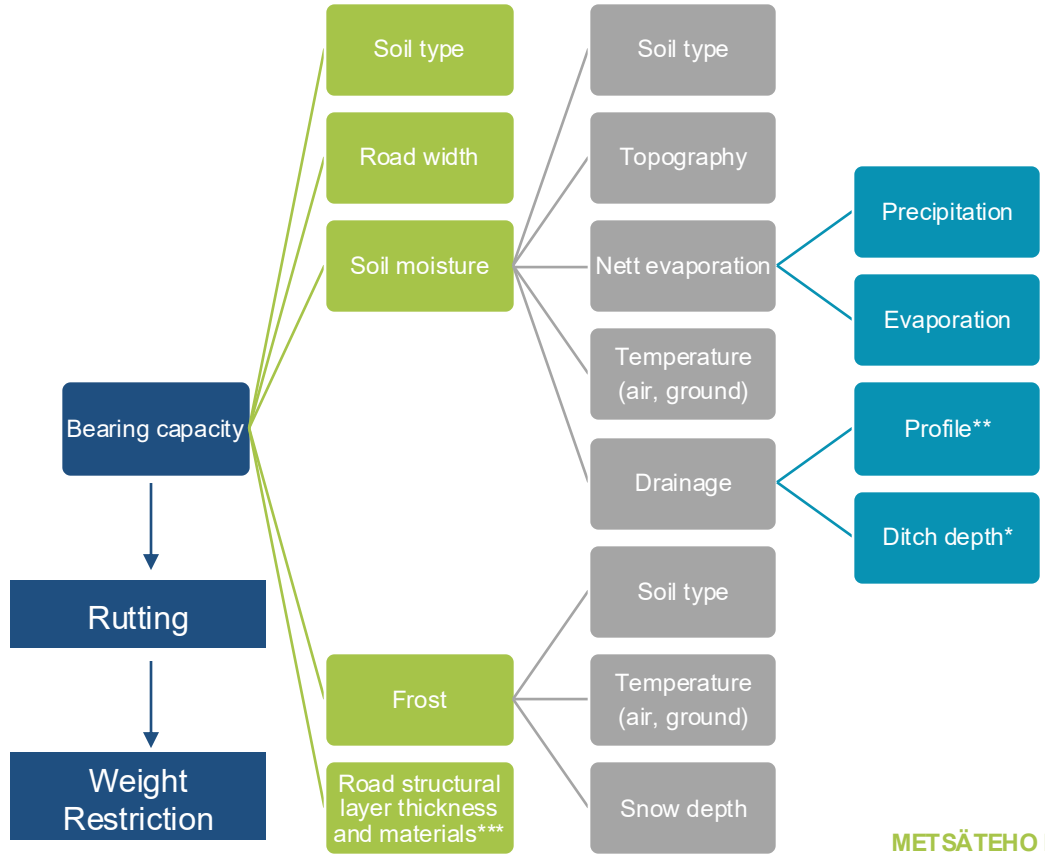
Key Models

Model type	Model	Timetable	Link
Seasonal trafficability model 1	Models developed in the Northern Traffic Lights (NTL) project (Luke et al.)	Project ends in 2028	Link
Seasonal trafficability model 2	Models developed in the OptiforValue project (Luke et al.)	Project ends in 2028	Link
Seasonal trafficability model 3	Models developed in the ModyFroad project (Aalto, FGI, UEF)	Project ends in 2028	Link
Seasonal trafficability model 4	Models developed in the SoilSeason project (UEF, Luke)	Project ends in 2029	Link
Gravel road weather model	Finnish Meteorological Institute model Currently under development, including in the NTL project A more limited RoadSurf model library		Link
Soil water and ice content model	GTK, UO et al. in various projects Based on the HydroBlocks model Application to gravel roads under development		

c) Data

- Background data is required for determining the seasonal trafficability classification of private roads, part of which is already comprehensively, openly and currently available (key datasets in the next slide).
  - Some open background data is only available in limited form or is not updated on a regular basis.
  - Some data is not openly available at all, in which case its availability must be secured through commercial agreements.
- Research projects are studying and modelling the significance of different source datasets in determining a reliable seasonal trafficability classification.
  - Potential source datasets, their possible public sources, and the data collection methods used to acquire them are described in the separate annex document *KUKL tietolajit* accompanying this report.
  - The significance of the various factors in determining trafficability will be further refined during the model testing phases of the research projects in 2027.
  - Identifying the most critical factors is important in order to limit data collection requirements and to keep the costs of data collection and processing at a reasonable level.

Factors Determining Seasonal Trafficability



- The magnitude of the effect of each factor depends partly on the time of year.
- The effect of some factors is bidirectional (e.g. rutting can be used to identify roads of poor quality).

*depending on soil type
**cross-fall, road edge berms
***separately entered data

Methods for Long-term Data Collection

- The following slide compiles examples of road data collection methods that would be suitable for calibrating and developing the seasonal trafficability classification and its models.
- The methods must be:
  - relatively straightforward and cost-effective to procure and use, so as to achieve regionally comprehensive data collection
  - sufficiently reliable relative to their cost, so that the resulting data can be genuinely utilised
  - based on automatic data transfer and standardised interfaces and data formats, so that data utilisation is computationally efficient.
- The number of methods deployed at any one time cannot be too large, owing to varying interface and post-processing requirements, amongst other factors.
- Identifying and testing suitable methods, as well as establishing an operational model for the practical organisation of data collection and cost-sharing, will require a separate study.

Data Collection Methods and Measurable Factors

Remote Sensing Satellites, radars, aerial photography, laser scanning, drone imaging and measurement	**Air temperature, net evaporation**
Measurements above the road surface Mobile radar and laser scanners, falling weight deflectometer measurements, vehicle sensors, road condition imaging	**Traffic, road maintenance actions** **Snow**
Measurements at the road surface Temperature sensors, manual measurements, test loadings	**Rutting, road edge berms, frost heave, condition of ditches** **Road width, longitudinal and cross-gradients** **Drainage**
Measurements below the road surface Temperature, moisture, frost and earth pressure sensors; soil samples	**Road structure temperature, moisture, frost** **Road surface material** **Road structure layer thicknesses and materials** **Soil type**

Methods and measurable factors are described in greater detail in the separate KUKL Tietolajit document.

Supplementary Private Data Sources

- A wide variety of measurement methods have been utilised in the seasonal trafficability classification and other R&D projects relating to gravel road condition, to refine the permanent characteristics of private roads and to monitor road conditions and bearing capacity variation (see the *KUKL tietolajit* document for further detail).
  - The use of these methods has often been limited to restricted areas, and a high level of reliability and accuracy has been required of them. At their most expensive, measuring equipment has cost several tens of thousands of euros.
- The development and maintenance of a commercial seasonal trafficability classification tool and the models utilised within it will likely require data collection supplementing public data sources.
  a) Data collection can partly be combined with separate R&D projects (paid geospatial datasets and data collection equipment).
  b) In part, long-term data collection jointly implemented by the tool provider, its users and their partners will likely be required (further detail on the following slide).
  c) One option is also for users to enter supplementary data about their own roads into the tool (e.g. road structure data, maintenance actions, traffic volumes), which would be taken into account in the tool's analysis output.

Private Data Collection Methods

	Strengths	Weaknesses
Road sensors (temperature, moisture, frost, earth pressure)	Cost-effective Depending on sensor type, data requires little further interpretation	Localised Requires road owner consent
Road weather stations	Multiple datasets from the same location, data requires little further interpretation	Localised Requires road owner consent Installation requires precision
Vehicle FMS data	Wide regional coverage Data is generated regardless Growing prevalence of sensors (automation) Also used in emissions calculations	Data requires further analysis
Separate vehicle sensors	Wide regional coverage Depending on sensor type, data requires little further interpretation	Sensor performance must be monitored Risk of breakage
Road condition imaging + machine vision analysis	Wide regional coverage Versatility of data	Data requires further analysis Camera installation requires precision

In addition, separate agreements may be made for the utilisation of more expensive methods or their measurement results (e.g. falling weight deflectometer measurements).

d) Service Usage 1

- Potential applications of the seasonal trafficability classification include:
  A. Long-term transport planning for forestry companies* (annual/quarterly)
  B. Medium-term transport planning for forestry companies and harvesting and transport contractors* (monthly/weekly)
  C. Near-term transport planning for harvesting and transport contractors* (weekly/daily/hourly)
  D. Identification of road maintenance requirements
  E. Needs of other sectors and the public sector (customisations to be agreed with the selected provider)
  F. Other sector and public sector use cases (Any customisation requirements to be agreed with the selected service provider.)

**In addition to planning actual timber transport and the transport of forest machinery on low-loader trailers, the tool could also support, over different planning horizons, the planning of timber procurement and roadside storage locations. In this way, the decisions made would also be linked to harvesting planning.*

Service Usage 2

- The seasonal trafficability classification does **not** include the following, but they may be considered for the same tool if required:
  - **bridge weight restrictions and other restrictions that completely prevent driving**
    - Digitraffic Road Network data (i.e. the former Digiroad)
    - The Finnish Forest Centre has also mapped bridge conditions, but does not address weight restriction needs (Private Roads and Bridges Condition Map)
    - Road user observations, for example of flooding or landslides
  - contact details for use by forestry companies and contractors (GDPR challenge)
    - Road maintenance associations/road manager (was previously in the Finnish Forest Centre's map service); private road register
    - Economic Development Centres (driving permits during the spring thaw season)
  - private roads' ownership data and property boundaries
    - Road use permits, storage location placement, road condition estimate
    - E.g. data sharing at least among the service's users
  - boundaries of road maintenance associations' operating areas
    - Access rights units in the Finnish Forest Centre's map service Finnish Forest Centre's Road Maintenance Association Map
  - prohibited timber storage locations along public roads (see also Metsäteho's report on roadside storage location planning (Riekki and Malinen 2026))
  - bridge condition
  - localised road repair requirements.

User Groups and Access Rights

- Potential user groups of the seasonal trafficability classification tool include
  1. **Service developers (= subscribers in the service's first stage)**
  2. **Service subscribers** (pay for use of the tool)
     - Forest sector consignors
     - Harvesting and transport companies
       - Sufficient added value must be ensured for experienced contractors
     - Other forest sector processes (movements of forest management machinery, seedling transports)
     - Road maintenance contractors
     - Other owners of private roads
     - Road associations and road maintenance associations
     - Actors from other sectors and the public sector – e.g. the energy, communications network, mining, defence, and rescue sectors (customisations to be agreed with the service provider)
     - Recreational users.
- A reliable seasonal trafficability classification requires a wide range of background data and model development, so a broad user group is needed to secure a reasonable cost level and sufficient development effort.

e) Synergies with Other Tools

- **Harvest availability classification of forest land**
  - Developed in various projects in collaboration with, among others, the Finnish Meteorological Institute (Harvester Seasons)
  - The interviews revealed differing views on whether harvest and seasonal trafficability classifications should be in the same tool.
    - In practice, however, harvesting and transport are planned in parallel. Both harvest availability and seasonal trafficability must be sufficient in an area for operations to be planned there. The connection between the two processes therefore needs to be taken into account regardless (particularly for sawlog timber).
    - The background data identified in defining the seasonal trafficability classification may also be usable for determining harvest availability.
    - Recommendations for further actions: for now, only the seasonal trafficability classification tool will be advanced, but the connection to harvest availability will be kept in mind and developments in its tools will be monitored.
- **Transport emissions reporting**
  - The CountEmissionsEU Regulation on emissions reporting has entered into force.
  - The road network and condition data produced by the seasonal trafficability classification can help explain differences in emissions reported from transport routes.
  - => Recommendations for further actions: Developing this synergy is not a priority at this stage.

3. Status of R&D Projects

- Ongoing research projects related to the seasonal trafficability classification that have Finnish partners are presented in the slide showing the models, slide 13.
  - The status of the models being developed in the projects will become clearer in connection with testing starting in 2027.
- Key background factors for seasonal trafficability identified in the projects are presented in the data section of this report (Section 2c) and in more detail in a separate annexed table (*KUKL Tietolajit*).
- The following slide compiles further R&D work needs based on research reports and interviews.
  - The seasonal trafficability classification's roadmap work also forms part of the Northern Traffic Lights research project

Development and Further Research Needs

	Short-term	Long-term
Models	R&D funding required for further model development New pilot areas outside the current project areas	R&D funding required for model maintenance
Open public data		Coverage and resolution of soil type data (Soil Pilot project recommendations) Higher frequency of 20-point laser scanning data
Data to be derived from public information	Longitudinal gradient data	
Private sector data	Comparison of lower-cost sensors and weather stations with more expensive alternatives Testing and cost-effectiveness of built-in and separate vehicle sensors, interfaces (vehicle manufacturer interviews) Data model specification (YTPA working group)	Private measurement network required for model calibration and development (particularly during periods of low bearing capacity)
Road owner's own data	Data model specification (YTPA working group); bearing capacity, road structures, gravelling and ploughing	
General	Standardisation of data collection method interfaces, data models and terminology Utilisation of artificial intelligence tools in combining observations, analysis and model development	

4. Preliminary Cost–Benefit Analysis

- This study has examined the benefits of the seasonal trafficability classification tool primarily from the perspective of forestry companies. To some extent, benefits have also been presented for other actors in the timber supply chain.
  - Current challenges, the additional challenges brought by climate change, and the benefits achievable with the tool have been mapped on the basis of previous studies and forestry company interviews.
  - The cost effects of the benefits have not been assessed.
- The costs of the seasonal trafficability classification tool have at this stage been examined only roughly, by cost category.
- The analysis needs to be supplemented in later stages.

Current challenges

- According to forestry company interviews conducted by Niinistö (2019) on seasonal trafficability classification, the following situations in particular create **challenges** for the planning and execution of harvesting and transport operations. The responses have been supplemented on the basis of the forestry company interviews carried out for this study.
  - current company-specific seasonal trafficability classifications, which are often based on **subjective assessment**
  - **imposition of thaw restriction periods**
    - difficulties in assessing the effects of thaw conditions, unnecessary thaw restrictions, large year-to-year variation
  - **spring thaw conditions**
    - As an annual phenomenon, partly foreseeable, but the precise timing varies considerably
  - **rapid deterioration** of seasonal trafficability during harvesting of a felling site
  - **abnormal rainfall** periods (difficult to predict)
  - increasing prevalence of **autumn thaw conditions** especially in southern Finland (less predictable than spring thaw conditions, alternating with frost periods, including even winter thaw conditions)
  - **limited human resources** in timber procurement and the increasing transfer of harvesting planning to contracting companies => assessment of seasonal trafficability must be based on new data sources
  - **exploitability of the felling potential of peatlands** on roads with low bearing capacity.

Further Challenges (Väätäinen et al. 2025)

- Growing **maintenance backlog** on private roads (Solonen et al. 2023)
  - Currently compounded by Finland's difficult economic situation
- **Roads built too lightly** for transport needs (Kaakkurivaara et al. 2015), particularly in northern Finland
- Road **drainage deficiencies** are common (Greis et al. 2019)
- Roads in poor condition
  - reduce transport speeds or increase the need to use alternative routes, causing **transport costs** to rise
  - increase the risk of **transport equipment breakdowns**
- Rapid and significant **drops in bearing capacity** (Väätäinen et al. 2025)
  - Road bearing capacity can drop to as little as 10–15% of maximum capacity.
  - In one research location, road bearing capacity dropped 45% on a mild day compared with capacity recorded during the preceding frost night.

Challenges Mentioned in Forestry Company Interviews

- **Road associations/road maintenance associations'** (subjective) **views** on road trafficability (need for data-based discussion)
  - Agreeing on driving permits is urgent, e.g. as insect damage seasons approach
- Identifying road maintenance **action needs** required in advance (proactivity needs to be increased)
- When assessing seasonal trafficability, it is necessary to look separately at **turning areas, junctions** with the public road network, and the locations of **roadside storage areas**
- Practical **identification** of roads belonging to different seasonal trafficability classes
- **Very localised rain showers** (information on these is difficult to access)
- **Large differences in road** condition even within a small area, e.g. according to their owner type
  - The weakest link can determine the trafficability of even an extensive area
  - Need to identify points that are of a lower standard than the rest of the road connection

Challenges Posed by Climate Change (Väätäinen et al. 2025 and forestry company interviews)

- **General rise in temperatures:**
  - Forecast: temperature rise of 3–4 °C in winter and 2 °C in summer for the period 2040–2069 compared with the period 1981–2010 (Ruosteenoja and Jylhä 2021)
- Increasing prevalence of **extreme weather events** (precipitation, drought and temperatures) often highly localised phenomena
  - => Average-based assumptions are not sufficient.
- **Rapid changes** becoming more common and predictability declining
- Winter load-bearing **frost periods shortening** especially in southern Finland and their predictability declining
  - At the same time, pressure to increase winter felling is growing
- Greater **variation in precipitation** than previously
- Very rapidly appearing **floods** following heavy downpours
- Increasing prevalence of **winter precipitation**
  - => The need for timber **storage** and use of terminals increases => additional costs and quality impacts
  - => The risk of needing to **suspend** transport operations increases
  - => Increasingly up-to-date condition information is required for decision-making

Benefits of the Seasonal Trafficability Classification 1

- In Niinistö's (2019) interviews, forestry companies identified the following potential **benefits** of the seasonal trafficability classification. They are presented below in the order of importance identified in the interviews conducted for this study:
  - The risk of the need for **road damage** compensation and repair is reduced.
  - Road network development and **problem prevention become** easier (problem locations more readily identified).
  - The **reliability** and planning of timber supply operations improve.
  - Transport of pulpwood and energy wood, which is more flexible in terms of **transport scheduling, can be timed** more readily according to seasonal trafficability.
  - Prevention of **dangerous transport situations** (particularly for drivers unfamiliar with the area).
  - The need to **construct new roads** decreases as the existing road network can be utilised more efficiently.
  - Timber reaches industry from the forest more quickly.
    - Improved quality of sawlog timber, better yield of fibre and pine oil, reduced requirement for chemical pulping agents for pulpwood.
  - Bucked timber **stocks can be reduced** as felling can be planned more effectively.
    - => Quality impacts of storage are reduced.

Benefits of the Seasonal Trafficability Classification 2

- The following benefits were also identified in the forest company interviews conducted for this study (presented here in the order in which they arise within the process):
  - **The number of field visits** could be reduced.
    - On the other hand, as forest resource data become increasingly digitalised, the number of field visits decreases, reducing the experience and expertise of company personnel regarding road conditions.
  - Real-time data also for **harvesting operation planning.**
  - More precise **planning of storage locations** according to road network bearing capacity.
    - Extended short-haul transport or alternative routing from the felling site where necessary.
  - **By identifying localised road repair needs** in a timely manner, transport can be enabled across even very large areas (bottleneck locations).
  - Effective targeting of **road repair expenditure.**
  - Predicting load-bearing capacity, particularly **prior to thaw periods and insect damage seasons**, in order to reduce the risk of timber deterioration.
  - Support for determining the **timing of temporary weight restrictions** (forestry companies on their own roads and road maintenance associations on their own).
  - It must be ensured that the classification tool provides sufficient added value, particularly for **contractors** very familiar with their area (=> willingness to pay).
  - The seasonal trafficability classification would generate data and documentation for **post-hoc discussions** with road maintenance associations and municipalities (e.g. removal of unnecessary thaw restrictions, repair requirements).
  - Data as an aid for estimating **transport arrival times** at reception points (particularly where reception time windows are in use).
    - E.g. exploitation of night frosts.

Benefits of the Seasonal Trafficability Classification 3

- The forestry company interviews conducted for this study also highlighted these general benefits, which are not linked to specific process stages:
  - **fact-based** decision-making instead of subjective assessments
  - a fact-based approach also supports the **automation** of planning and processes
  - a more **uniform** operating model nationally and regardless of staff skill level
  - the ability to **respond** to rapid, localised changes in conditions that practical experience alone cannot prepare for.
  - The decision-making support provided by the tool reduces **work-related pressures**.
  - **erroneous situational** assessments are reduced.

Benefits of the Seasonal Trafficability Classification 4

- Other sources have also identified the following aspects that could be influenced by a seasonal trafficability classification system.
  - Poor road condition reduces **driver job satisfaction** and exacerbates the driver shortage.
    - A trafficability classification system could reduce traffic on roads in poor condition.
  - **New remote sensing data** and its increasingly sophisticated analysis, including by artificial intelligence, enhances the utility of the classification tool.
  - Opportunity to exploit **night frosts** during otherwise low bearing capacity periods.
    - Exploitation opportunity limited if a weight restriction has already been imposed on the road.
  - The seasonal trafficability classification confirms trafficability even where no temporary **weight restriction** sign has been erected on a private road. Conversely, it provides grounds for removing unnecessary weight restrictions.

Costs Arising in the Current Situation

- The forestry company interviews highlighted the following costs related to seasonal trafficability:
  - Private road **repairs**, gravelling and grading (before or after transport operations)
  - Contractors' and own staff's **field visits** before harvesting and transport
    - However, these visits also serve other needs (e.g. assessing the suitability of turning areas)
  - Timber **storage** in case of spring thaw damage
  - **Numerous driving permit negotiations**, if roads' bearing capacity deteriorates rapidly, unexpectedly early, or just before the insect damage season.

Costs of the Seasonal Trafficability Tool

- The costs of the seasonal trafficability classification have at this stage been identified only at the cost-type level.

1. **Costs of preparatory measures**
   - Companies' collaboration with R&D actors developing the models
   - Collaboration related to securing data availability
2. **Specification costs**
   - Carrying out the tool's content and technical specification to a level sufficient to request a proposal for the tool's implementation
3. **Implementation costs**
   - Incl. testing, approval, deployment and integration of the service with users' other systems
   - Service purchased from the provider, cost determined by tendered offers
   - Number of interfaces required (incl. data producers)
4. **Maintenance costs**
   - Service purchased from the provider, cost determined by tendered offers
   - Cost of the data required, relative to the number of the service's subscribers
5. **Development costs**
   - Separately agreed development work, which may be carried out by the service provider, the service's subscribers, or other partners
   - If needed, supplementary research collaboration with universities under separate project funding

5. Conclusions and Next Steps

- In Finland, forestry companies use seasonal trafficability classifications for private roads that are currently based on the subjective assessments of their own staff.
  - These assessments are also fairly static and make little use of geospatial data.
- Forestry companies need a more dynamic and reliable seasonal trafficability classification of private roads than currently exists.
  - This need is increased by the extreme weather events becoming more common due to climate change, rapid fluctuations, and significant regional differences.
  - Users of the classification tool would be the forestry companies themselves, as well as the harvesting, transport and road maintenance contractors they use. The tool could also be utilised by consignors in other sectors, road managers and other contractors serving road maintenance associations.
- Variation in seasonal trafficability and the factors explaining that variation have been studied, and are currently being studied, in Finland, other Nordic countries and Canada, among others.
  - Ready-made seasonal trafficability models do not yet exist, so collaboration between R&D projects and companies is needed to compare and test the models under development, and to develop reliable models.

Conclusions and Next Steps 2

- The aim is for seasonal trafficability to be classified using a commercial tool that could be integrated into companies' various systems (particularly for transport and road maintenance planning, but a connection to harvest planning and harvest availability tools is also essential).
- A reliable and useful seasonal trafficability tool requires
  - functioning models for describing the effects of the various factors influencing seasonal trafficability
  - static and dynamic data needed by the models, which must be sufficiently comprehensive, up to date and reliable
  - technical interfaces and visualisations for utilising the tool's results.
- As a whole, the tool should meet the needs of different user groups, creating sufficient added value, and do so cost-effectively.

Conclusions and Next Steps 3

- This study has identified several benefits potentially achievable with the seasonal trafficability classification tool.
  - The costs of developing and maintaining the tool have so far been described only at a very rough level. A more precise assessment of costs is indeed one key further action need.
  - Cost estimates can be refined on the basis of future testing of the models developed in R&D projects. This will also clarify the input data critical to the tool and its current availability.
  - At the same time, the timeline for the feasibility of the seasonal trafficability classification tool will also become clearer. The tool's deployment can also be carried out in stages (initially only the static classification, even though the actual benefits are achieved only once the dynamic tool is in place).

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