The method of using the harvester for logging in cutting areas with soft terrain

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Abstract. Article materials relate to the forest industry and can be used in logging operations on cutting sites with soft terrain. The result of the research is a developed technological scheme for the movement of the harvester and forwarder in the cutting area. It allows you to reduce the number of skidding trails for moving the forwarder on logging sites with soft terrain, which are able to provide a one-time movement of a harvester, but require additional costs for strengthening of skidding trails for multiple movements of a forwarder. The forwarder works only on skidding trails that are located at distances from each other equal to ten distances of movement of harvester manipulator. This helps to reduce the cost of transport operations on cutting areas with soft terrain. The proposed technology can be used for clear cutting in cutting areas with soft terrain.

1. Introduction
Currently, in forests on cutting areas with soft terrain, a large potential stock of wood is concentrated. In these forest areas, various cutting techniques and various forestry equipment can be used, in particular a set of machines consisting of a harvester and forwarder [1-4].

Among the various options for reducing the cost of transport operations when working on cutting areas with soft terrain include options for the strengthening of skidding trail. However, studies of different options for increasing the bearing power of soils [5] show significant costs for strengthening skidding trails.

The marked options do not exclude the possibility of simultaneously increasing of the width of the forest swathes. This is especially true on soils that are able to provide a single movement of harvester, but requiring significant additional costs for strengthening the skidding trails for multiple movements of forwarder.

2. Methods and Materials
Currently, in the forest industry, there are various options for work technology that can increase the width of forest swathes [6-8]. Among them are variants of technological schemes for the operation of the harvester and forwarder in cutting areas with wide forest swathes with one or two intermediate trails between the skidding trails for moving the harvester along them [9]. The main part of damage to soils, undergrowth and reserved trees is carried out as a result of movement of the forwarder. On the cutting areas with one intermediate trail in a forest swathes, the forwarder works only on skidding trails, which are located at distances from each other equal to 3-3.5 distance of extension of the...
harvester manipulator. On the cutting areas with two intermediate trails in the forest swathes, the forwarder works only on skidding trails, which are located at distances from each other equal to 4-5 distance of extension of the harvester manipulator. The harvester performs felling, limbing, cutting into lengths when moving along the intermediate trail, as well as along the skidding trails. In both cases, the harvester stacks the bundles of logs so that the logs can be reached by the manipulator of the forwarder when it moving along the skidding trails. This ensures the availability of logs harvested by the harvester moving along the intermediate trail for the forwarder moving along the skidding trails. Using these methods allows to reduce the total length of skidding trails on the cutting area and increase the width of the forest swathes. However, when using these methods, the width of the forest swathes does not exceed 4-5 effective distances of movement of the manipulator of the harvester and can be further increased when developing new technological schemes. An additional increase in the width of forest swathes can increase the efficiency of work on cutting areas with soft terrain.

The closest in technical essence is the method of logging with obtaining logs by harvesters and forwarders using intermediate trail in forest swathes when performing voluntary-selective cutting, even gradual cutting, two-pass cutting system [10].

Similarly to the methods described earlier, this method, in order to reduce the degree of impact of forestry machines on the forest environment and reduce the area of the technological network of skidding trails in the cutting area, involves placing additional intermediate trails on the forest swathes between skidding trails for the movement of the harvester. The width of forest swathes can be up to 40-50 meters. The harvester, moving along intermediate trails, felling trees and laid trees in the direction of the nearest skidding trail, perpendicular to it. The harvester moves along the intermediate trail only once. Further, the harvester moves to the skidding trail and moves along it. The harvester performs felling, limbing, cutting into lengths, and also it additionally limbing and cuts to length of the trees which lying on the ground. The harvester pulls the trees lying on the ground, grabbing them by the top, into the processing zone. The harvester moves the harvester head to the basis of tree and cuts into lengths. These trees were harvested earlier at a time when the harvester was moving along the intermediate trail. Sawed logs are stacked on the right and left near the skidding trail. Felling residues are stacked on the skidding trail. The forwarder begins skidding on the skidding trail after the harvester moves to another swathes. The machines operate at a safe distance from each other.

The disadvantages of this method include the fact that this method, like the previous methods described, does not make it possible to make apiary widths of more than 4 effective distances of movement of the manipulator of the harvester. Consequently, it is possible to create a new method that allows even more to reduce the damage to the soil cover on the cutting area with soft terrain by the forwarder.

The result of this study, proposed on the basis of the search for equivalent technological solutions, is the reduction in the number of skidders trails for the movement of the forwarder on logging sites with soft terrain, which are able to provide a one-time movement of a harvester, but require additional costs for strengthening of skidding trails for multiple movements of a forwarder.

3. Results and discussions

The technical result of the technological scheme of work in the cutting area with soft terrain proposed in this article is achieved by the fact that the forest swath is divided into five parts. On the forest swath on each side of the skidding trail, there are two additional trails for the movement of the harvester. The width of the swath reaches ten effective distances of movement of the manipulator of the harvester.

The development scheme of one swath in the cutting area is presented in figure 1.

The method provides for the separation of the cutting area into forest swathes, the placement of the skidding trail 1 in the middle of the forest swathes for the movement of the forwarder 2 and harvester 3 in the process of work on the cutting area.
Figure 1. The method of using the harvester for logging in cutting areas with soft terrain.

When the harvester moves along the intermediate trails 4 of the forest swath, which are farthest away from the skidding trail, the harvester performs felling trees 5, limbing and lays sticks 6 in the direction of the skidding trail of this forest swath perpendicular to it. The bases of trees are directed towards the skidding trail.

When the harvester moves along intermediate trails 7, adjacent to the skidding trail, the harvester performs felling, limbing, cutting into lengths, and the harvester also cuts to length of the sticks which lying on the ground. These sticks were harvested earlier at a time when the harvester moves along the intermediate trails of the forest swath, which are farthest away from the skidding trail. The resulting logs are stacked in the direction of the skidding trail of the forest swath perpendicular to it. The harvester stacks the bundles of logs so that the logs can be reached by the manipulator of the forwarder when it moving along the skidding trails.

When the harvester moves along the skidding trail, the harvester performs felling, limbing, cutting into lengths. Bundles of logs 8 are stacked near the skidding trail. The machines operate at a safe distance from each other.

The forwarder begins work at the forest swath after the harvester moves to another forest swath. The forwarder collects logs and skidding them, moving only along the skidding trail. The forwarder does not move along the intermediate trails.
Skidding trails in cutting sites with soft terrain, intended for the movement of the forwarder are strengthened to ensure the movement of the forwarder with logs along them. The bearing power of soil can be enhanced by adding additional elements or materials to the soil of skidding trails and logging tracks. As a result, the pressure caused by the wheels of the forest machines is distributed over a much larger surface. When the area under the contact surface increases, the pressure of the forest machine on the ground decreases. Traditionally, skidding was reinforced with logging residues and low-quality woods. Sometimes, for example, in the summer, this is not enough if work is carried out on peatlands. Serious soil damage can occur even after several passes of harvester or forwarder. To strengthen the skidding of the cutting areas with soft terrain, any currently known technical means can be used. This can be steel landing mats, mats made of wood boards, rubber mats, portable bridges, mats made of vulcanized rubber, etc.

4. Conclusion
Thus, according to the proposed method of cutting operations on cutting areas, the forwarder works only on skidding trails that are located at distances from each other equal to ten distances of movement of harvester manipulator. It allows you to reduce the number of skidding trails for moving the forwarder on logging sites with soft terrain, which are able to provide a one-time movement of a harvester, but require additional costs for strengthening of skidding trails for multiple movements of a forwarder. The proposed technology can be used for clear cutting in cutting areas with soft terrain.

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