MEDZINÁRODNÁ VEDECKÁ KONFERENCIA
30 ROKOV VŠLD — 175 ROKOV LESNÍCKEHO VYSOKÉHO ŠKOLSTVA V ČSSR
МЕЖДУНАРОДНАЯ НАУЧНАЯ КОНФЕРЕНЦИЯ
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TRANSPORTATION STRATEGIES UNDER INTERACTIVE COMPUTER GRAPHICS

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The construction of all-weather logging roads associated with timber harvesting operations represents a large component of the total cost of the harvest, when such roads need to be built. The level of expenditure for, and the relative permanence of, a road network necessitates the making of a sound economic decision in regard to road placement. Two general types of road networks are possible: roads whose spatial placement is largely in response to topographic features, and roads which are roughly parallel and equally spaced. When the area to be harvested is sufficiently flat and free of significant impediments to construction, the latter situation is probable, and is the topic of this paper.

The transportation of logs from stump to road in this instance is usually accomplished with some type of ground based forwarding equipment such as a skidder or feller-forwarder. Two general costs are directly involved with the spacing of parallel roads: the cost of road construction, and the cost of transporting (skidding) the logs to roadside. With both costs, only those costs which are affected by the road spacing should influence the spacing decision. Fixed per unit volume costs such as felling and bunching can (and should) be excluded from consideration in this regard.

The total variable cost of timber extraction (per unit volume) can then be expressed as the sum of the road construction cost and the variable skidding (forwarding) cost. As will be shown later, in the event that logs are skidded not to the nearest road, but rather to the nearest landing (located along the roads), then a landing construction cost enters the total cost equation.

In the case of skidding to the nearest road, the spacing is optimized when the total extraction cost (C) is minimized. An equation for the minimum can be determined by differentiating C with respect to S (road spacing), setting $dC/dS = 0$, and solving for S. In the event that the line representing the skidding cost

passes through the origin, the minimum occurs at the point of intersection of the two component cost curves (Figure 1). The resultant equation is used to determine the optimal spacing, S, and is in the form developed by Lussier (1961), although it was originally proposed by Matthews (1942):

$$S = \sqrt{\frac{8.712\ RL}{TFCV}}$$

Where S = optimal road spacing (100 feet),

L = average skidder load (cords),

T = variable skidding time per 100 feet (minutes per 100 feet),

F = sinuosity factor (ratio: actual over straightline distance),

C = skidder cost including labor ($ per minute), and

V = volume to be removed per acre (cords).

In the case of skidding to the nearest landing (Figure 2) there also exists an optimum landing spacing (W), as the total extraction cost for any fixed S varies depending on W. In this instance, the partial derivatives dC/dS and dC/dW need to be solved simultaneously to determine the S and W values associated with the minimum total cost.

Bryer (1981) incorporated interactive computer graphics techniques into the methods of Corcoran (1973) and Lussier to produce what is a component of a larger scale road planning data base computer system, used in conjunction with timber salvage operations necessitated by spruce budworm infestation in the State of Maine (Phillips et al. 1980). In addition to the standard numeric output (Figure 4) Bryer's program (CORD) allows the user to produce a grid showing the roads and landings associated with the optimum solution, drawn to any map scale (Figure 5). Such output can be used as an overlay to a map or aerial photograph in the initial stages of actual road layout. Graphics hardware necessary to utilize CORD consists of a graphics terminal (a Tektronix, for example) and an optional flatbed or drum plotter.

Figure 6 is a flowchart in which the general workings of CORD are illustrated. The manner in which the user effects input, controls program flow, and produces output is accomplished through interaction with the computer by means of a thumbwheel cursor (or similar positioning device) and crosshairs, which appear on the screen when needed. During the pause in program execution which accompanies the appearance of the crosshairs, the user positions the crosshairs to the desired screen location and causes a resumption in program execution. The position of the crosshairs is noted by CORD and program flow is altered accordingly, thus interaction is achieved.

The first substantive action taken by the user is to input the values associated with the eight input variables: average skidder load, road construction cost, skidder unit cost, volume to be removed per acre, sinuosity factor, skidding time loaded, skidding time empty, and landing construction cost (if landings are used). For each of the variables, a scale is plotted on the screen with sufficiently unrealistic upper and lower limits. The user then places the crosshairs along the scale at a point corresponding to the desired values. Figure 3 shows the content of the screen following the entire input process. Note that the values chosen have been plotted at the right of the respective scales.

Following the input process, the algorithm (either Corcoran's or Lussier's) which calculates the solution is then employed, after which the numeric solution is plotted on the screen (Figure 4). The user can then produce grids (Figure 5) drawn to scale in either English or metric units.

Improvements to the program dealing with the attendant assumptions (constant timber density, flatland conditions, lack of impediments, etc.) would increase the usefulness of CORD's output in terms of the entire road planning process. However, the current state of the system represents a viable starting point in the spatial placement of all-weather logging roads, with an aim at cost minimization.

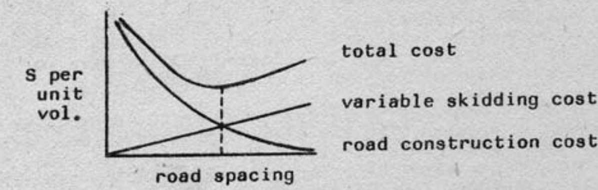

Figure 1. The relationship between component total costs.

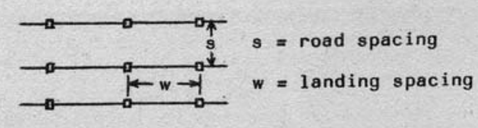

Figure 2. Road and landing configuration.

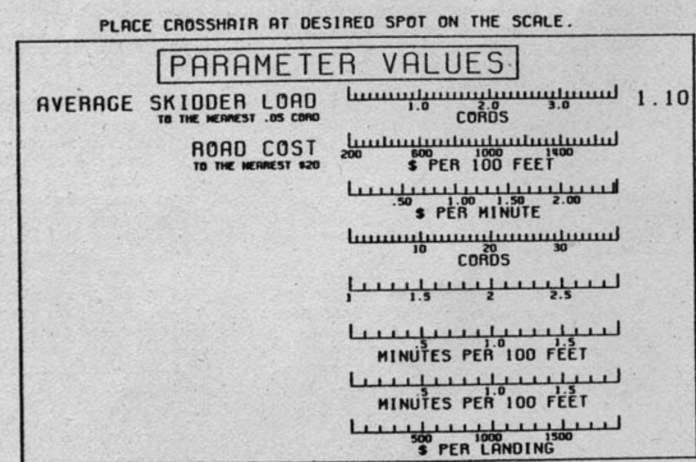

Figure 3. Terminal screen following the input process

PARAMETER VALUES	
AVERAGE SKIDDER LOAD	1.10 CORDS
ROAD COST	$ 620 PER 100 FEET
SKIDDER UNIT COST	$0.70 PER MINUTE
VOLUME PER ACRE	17.5 CORDS
SINUOSITY FACTOR	1.05
SKIDDING TIME LOADED	0.60 MIN. PER 100 FT.
SKIDDING TIME EMPTY	0.50 MIN. PER 100 FT.
LANDING COST	$ 900 PER LANDING

SOLUTION VARIABLES		
OPTIMAL ROAD SPACING		3193 FEET
OPTIMAL LANDING SPACING		936 FEET
AVERAGE SKIDDING DISTANCE		861 FEET
ROAD COST COMPONENT	$	4.83 PER CORD
LANDING COST COMPONENT	$	.75 PER CORD
SKIDDING COST COMPONENT	$	6.33 PER CORD
TOTAL MINIMIZED COST	$	11.91 PER CORD

PRESS ANY KEY TO CONTINUE. CALCOMP? YES NO

Figure 4. Numeric output associated with Figure 4 grid.

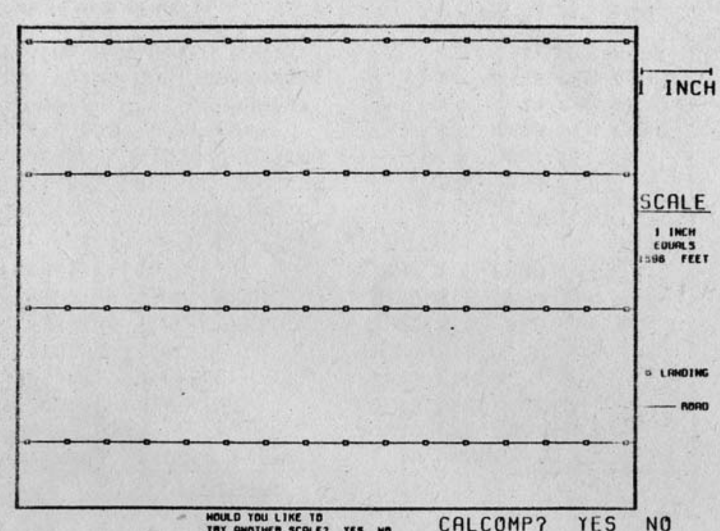

Figure 5. Grid showing roads and landings, drawn to scale.

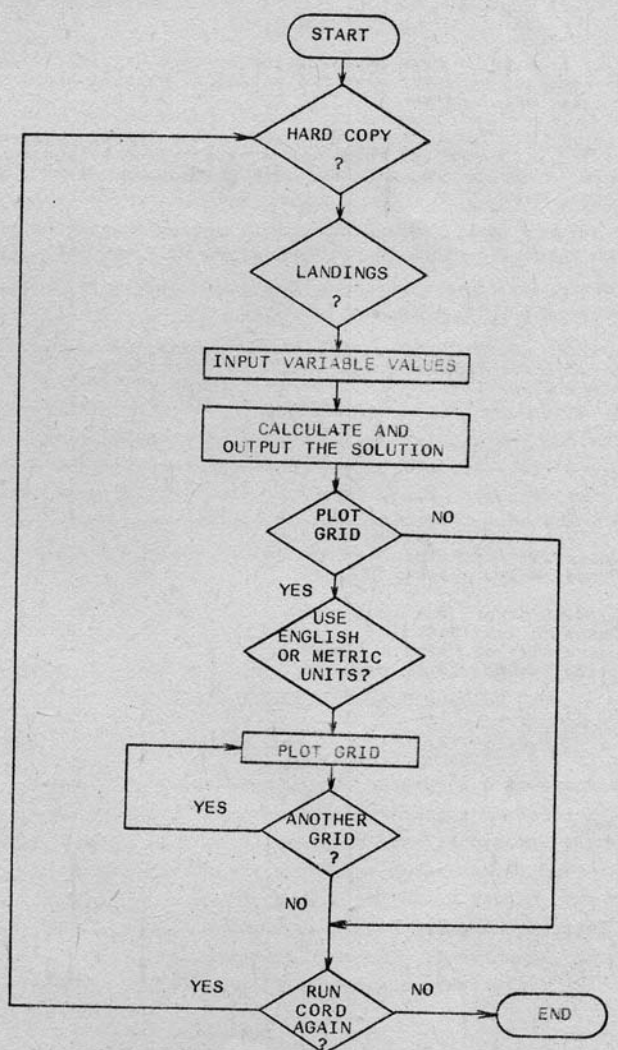

Figure 6. Flowchart of CORD /Cost Optimisation of Road Density/.

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DOPRAVNÉ STRATÉGIE PRI VYUŽITÍ INTERAKTÍVNEJ POČÍTAČOVEJ GRAFIKY

Konštrukcia dopravných ciest spojená s ťažbou dreva predstavuje veľký podiel celkových nákladov na ťažbu dreva. Existuje také rozmiestnenie lesnej dopravnej siete, pri ktorom sa premenlivé náklady na ťažbu dreva zminimalizujú. V prípade, že sa nedopravujú kmene k najbližšej ceste, ale k najbližšiemu skladu /sklady sú rozmiestnené v rovnomerných rozostupoch pozdĺž ciest, ktoré sú optimálne rozmiestnené/ potom v tomto prípade existuje taktiež rovnomerné rozmiestnenie.

Uvedený je matematický prehľad metód použitých pre stanovenie optimálneho rozmiestnenia. Po stručnej diskusii o povahe počítačovej iterakčnej grafiky sa udáva spôsob akým sa tieto techniky začlenia do existujúcich postupov pre optimálne rozmiestnenie lesnej dopravnej siete. Zlepšenie systému by zvýšilo použiteľnosť výstupu, avšak systém predstavuje v súčasnom stave dobrý začiatok v priestorovom rozmiestnení lesnej dopravnej siete s cieľom minimalizácie nákladov.

ТРАНСПОРТНАЯ СТРАТЕГИЯ ПРИ ИСПОЛЬЗОВАНИИ СИСТЕМЫ ИНТЕРАКТИВНОГО ГРАФИЧЕСКОГО ИЗОБРАЖЕНИЯ С ПОМОЩЬЮ ЭВМ

Конструкция лесовозных дорог, связанная с лесозаготовками, составляет существенную долю от общих затрат на заготовку древесины. Существует такое размещение сети лесовозных дорог,когда перемещенные затраты на заготовку минимизируются. В случае, если хлысты не транспортируются к ближайшей дороге, а к ближайшему складу /склады расположены в равномерных интервалах вдоль дорог, которые в свою очередь размещены оптимально/, то в этом случае существует также и равномерное размещение.

Приведены математические методы, используемые для определения оптимального размещения. Наряду с краткими рассуждениями о характере графического изображения с помощью ЭВМ намечаются пути использования такого рода техники для определения оптимального размещения сети лесовозных дорог. Усовершенствование системы позволит улучшить использование выхода, однако и в настоящее время она представляет собой хорошее начало для территориального размещения сети лесовозных дорог с целью минимизирования затрат.

VERKEHRSSTRATEGIEN MIT DER AUSNÜTZUNG DER INTERAKTIVEN RECHNERGRAPHIK

Die Konstruktion der Verkehrswege stellt in der Verbindung mit der Holznützung einen großen Anteil an die gesamten Holznützungskosten dar. Es gibt solche Verteilung des Waldwegenetzes, bei der die verändelichen Holznützungskosten minimalisiert werden. Falls die Stämme nicht zum nächsten Weg, sondern zum nächsten Holzlager /die Lager sind in gleichen Abständen entlang Der Wege verteilt, die auch optimal angeordnet sind /transportiert werden, so entsteht in diesem Falle auch eine gleichmäßige Verteilung.

Es wird eine mathematische Übersicht der zur Ermittlung der optimalen Verteilung verwendeten Methoden angeführt. Nach kurzer Behandlung des Charakters der interaktiven Rechnergraphik wird die Methode der Eingliederund dieser Technik in die vorhandenen Verfanren für die optimale Verteilung des Waldwegenetzes angegeben. Die Verbesserung des Systems könnte die Verwendbarkeit des Austrittes erhöhen. Das System stellt im heutigen Zustand einen guten Beginn für die räumliche Verteilung des Waldwegenetzes hinsichtlich der Kostenherabsetzung dar.