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Access to study areas may be an important factor in long-term field-oriented research, particularly in regions without well-developed road and communications systems. In a wildland hydrometeorology research project in subarctic Alaska, access to and within a 40-square-mile research watershed has been developed both in accordance with a general plan prepared at project inception and in response to developing research requirements. Foot trails, trails for "off-road" low-ground-pressure tracked vehicles, helicopter transport, long-term data recorders, and radio telemetry of data have all been incorporated in an access and communications system. Cost estimates indicate that incorporation of gravel roads into the system would be economically advantageous, given adequate funding for initial road construction.

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PREFACE

This report was prepared by Dr. Charles W. Slaughter, Hydrologist, of the Alaskan Projects Office, U.S. Army Cold Regions Research and Engineering Laboratory. The research described in this report was funded under Corps of Engineers Civil Works Project 31003.

Technical reviewers of this manuscript were P.V. Sellmann, R.K. Haugen and K.L. Carey of USA CRREL, and several helpful suggestions were provided by A.E. Helmers, Institute of Northern Forestry.

Many persons, from many agencies, have contributed to development of the current access trail system in the Caribou-Poker Creeks Research Watershed. These include personnel from the U.S. Bureau of Land Management, the Institute of Northern Forestry (U.S. Forest Service), the University of Alaska, Division of Lands (State of Alaska), National Weather Service (NOAA), Arctic Environmental Research Laboratory (EPA) and CRREL.

The planning and development of this access network, and plans for future improvements, have involved input from all the above agencies and from other participants in the Inter-Agency Technical Committee for Alaska. Individuals from many of the same agencies have contributed time and labor to trail improvement.

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SITE ACCESS FOR A SUBARCTIC RESEARCH EFFORT

by

Charles W. Slaughter

INTRODUCTION

Transportation and communication are often given only cursory attention when field-oriented research projects are proposed and planned. However, in disciplines requiring extensive field observation or experimentation extending over a number of years, site access can prove to be a critical element in success of research endeavors.

This report briefly describes the site access modes developed or envisioned for a continuing interagency hydrometeorology research project, initiated in 1969 at the Caribou-Poker Creeks Research Watershed in virgin forested upland terrain of the central Alaska Yukon-Tanana Uplands. The existing system of access modes, while conforming to a broad outline developed when the project was originally planned, has necessarily been implemented in phases responsive to immediate project needs. Access development has had minimal funding, and has been accomplished largely by contributed labor from the 12 agencies which are cooperating in the watershed. Consequently, most routes are merely cleared paths for travel by foot or off-road vehicles. The existence of ice-rich permafrost at shallow depth throughout much of the research area has restricted other low cost options available for ground access.

ACCESS WITHIN THE CARIBOU-POKER CREEKS RESEARCH WATERSHED

The Caribou-Poker Creeks Research Watershed is located 30 miles north of Fairbanks, Alaska, in the subarctic taiga. The close proximity of this area to the existing road system was one of the factors considered in selecting it as a site for sustained hydrometeorological and environmental research. The watershed is situated between the Steese and Elliott Highways (Fig. 1); thus getting into the area for instrument installation or servicing and research activities did not originally appear to be a major problem. In fact, however, access has proven to be one of the primary obstacles to the development of a truly comprehensive research program. Access to the research sites was initially accomplished by four-wheel-drive vehicle travel on an existing trail to the southeast edge of the basin, and then by foot to study sites.

Trail access

A trail was built early in the operation to give vehicular access to the Caribou Creek basin, the locale for initial baseline data acquisition. Also, a route suitable for low-ground-pressure tracked

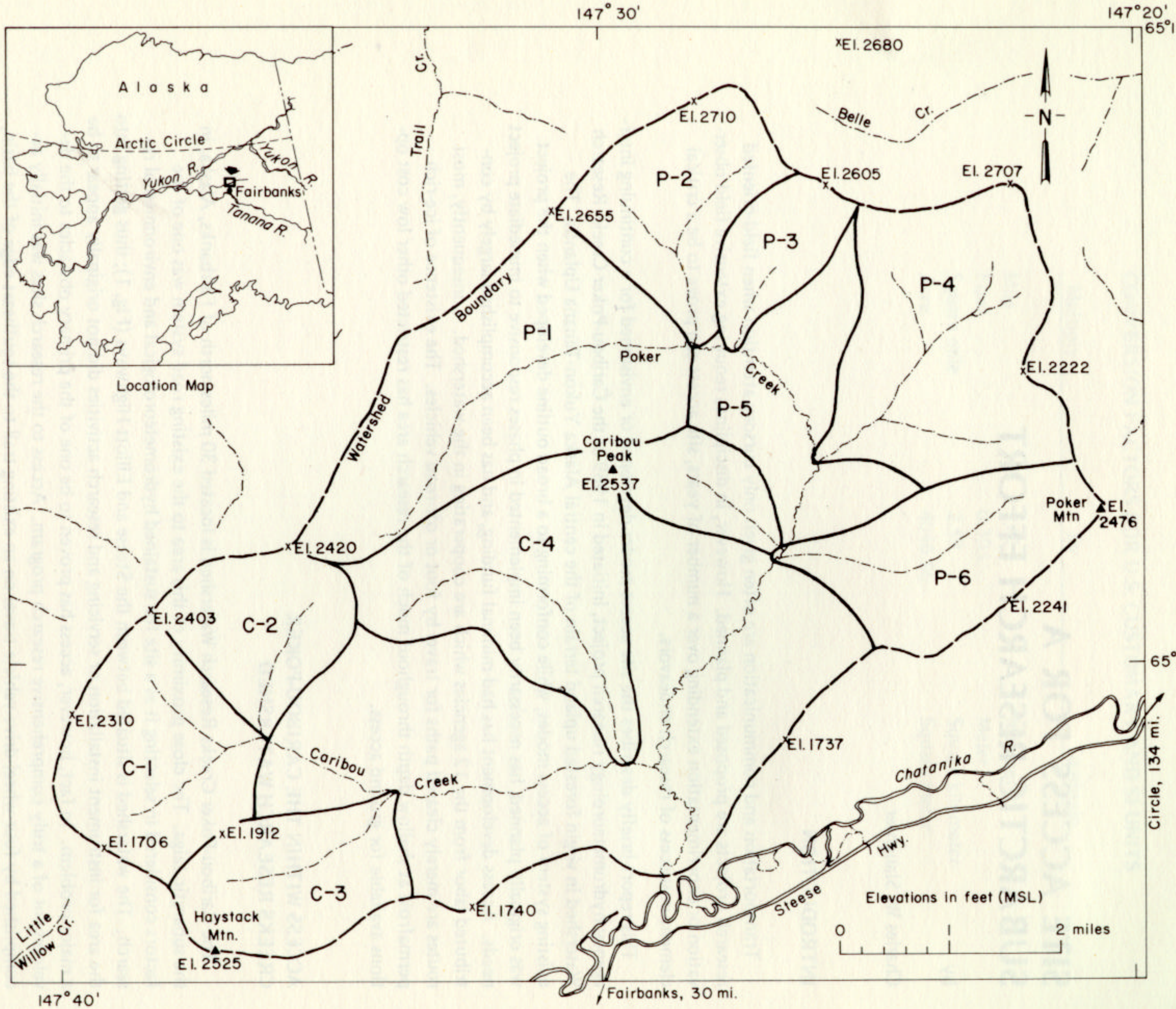

Figure 1. Caribou-Poker Creeks Research Watershed.

Figure 2. Low-ground-pressure tracked vehicle (Volvo BV-202A) used for off-road trail travel to field instrumentation sites.

vehicles (Fig. 2) was cleared from the end of the existing vehicle trail to the valley floor in Caribou Creek. This trail was later extended west to within walking distance of instrument sites in the northwest sector of the watershed, and has since been extended east to a hydrometeorological installation at the confluence of Caribou and Poker Creeks, and to the headwaters of Poker Creek and to Caribou Peak (Fig. 3). Access to study sites on the slopes remains confined to travel by foot or small all-terrain vehicles (ATV's), or by snowmobiles in the winter (Fig. 4 and 5).

Helicopter access

An alternative approach is the utilization of rotary wing aircraft for travel. A helicopter landing area was cleared early in the operation at a valley location (now known as the "main site") near Caribou Creek. Helicopter landing without clearing is possible at a number of ridge and valley locations (Fig. 6), depending on the helicopter model utilized. While expensive, helicopter transport has been the only feasible method for moving some items, such as a 10- × 55-ft field lab trailer which was moved from the Steese Highway to a Caribou Creek site (Fig. 7) by a Sikorsky Sky Crane in 1971. Similarly, a Chinook (CH-54A) helicopter was utilized in 1972 to transport a 10- × 20-ft EPA* lab trailer and associated equipment (including diesel generator and fuel) to a site at the junction of Caribou and Poker Creeks (Fig. 8). In both cases, overland transport was simply not feasible due to the lack of roads and due to strictures against the environmental disturbance which would have resulted from utilizing crawler tractors to move these trailers.

Smaller loads have also been transported by helicopter. Recently UH1B "Huey" helicopters were used for installation of large storage rain gages at isolated points. The large gages, fully assembled,

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* Arctic Environmental Research Laboratory, Environmental Protection Agency.

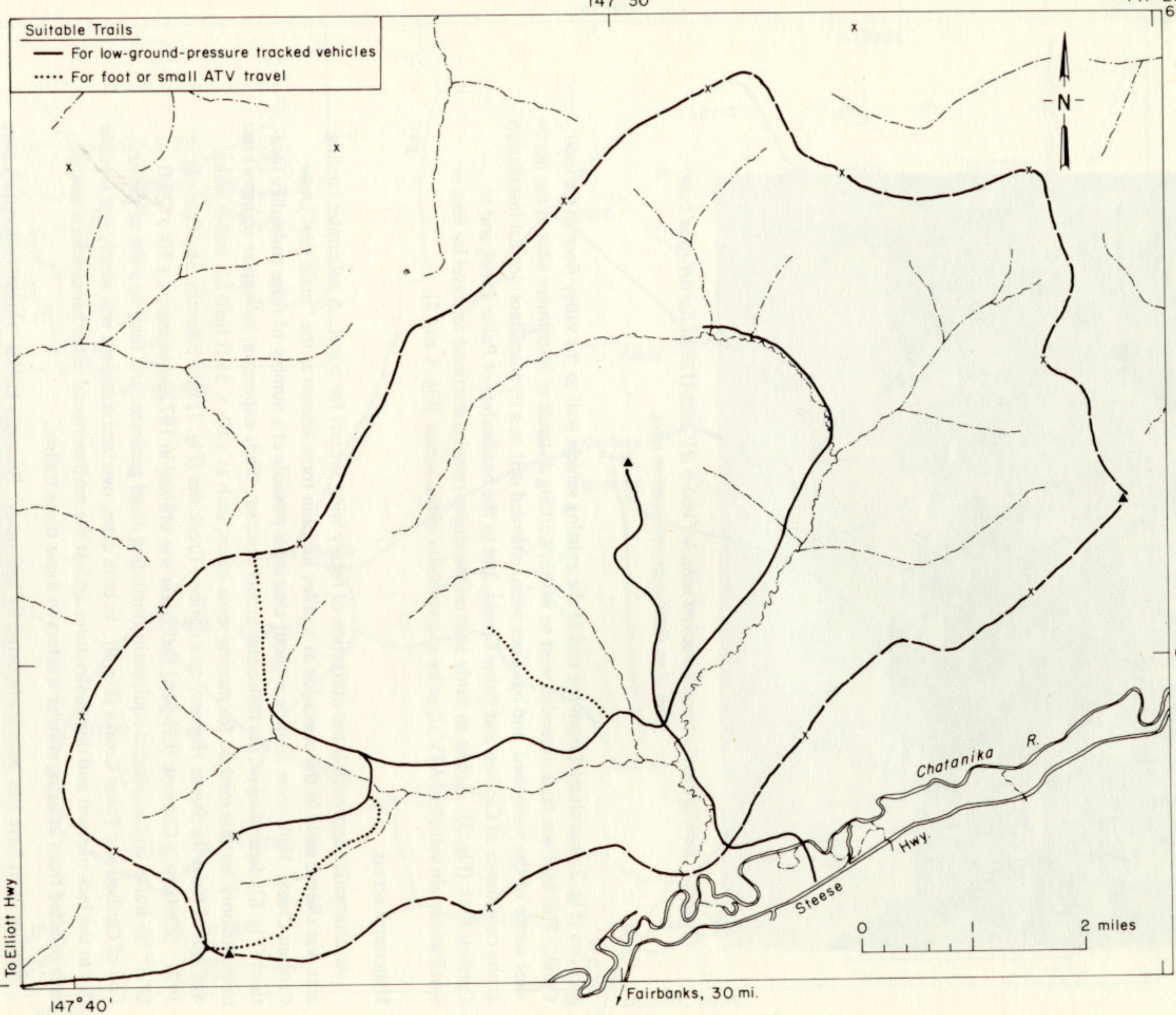

Figure 3. Existing access trails.

Figure 4. Small all-terrain vehicle (Cushman "Trackster") used for summer access to study sites.

Figure 5. Snow machine ("Skidoo") used for winter access to study sites.

Figure 6. Helicopter approaching instrument site at Caribou Peak (elev 2537 ft MSL).

Figure 7. Stream-gaging site in Caribou Creek valley; 10- × 55-ft lab trailer in upper right of photo was transported to its site by helicopter.

Figure 8. Lab trailer (with generator shed at right side) at confluence of Caribou and Poker Creeks.

were "slung" below the helicopter for transport to the field locations. Later, personnel, recorders, and tools were flown-in to complete the installation.

Helicopters have also been used for field sampling and site servicing. As mentioned above, most valley locations are accessible by helicopter. For example, the EPA has accomplished an extensive water sampling program of all tributaries in the Research Watershed by utilizing helicopters to reach 12 sampling points in two days; it is estimated that a full week would have been required, with personnel living in the field, to accomplish the same work without helicopters.

In 1972 a plan was devised for servicing all climate-measuring sites by helicopter, involving landing personnel at ridge locations and subsequently meeting them in the valley below (Fig. 9). While this was successful for the few times it was tried, available funds did not permit the use of helicopters for this purpose on a regular basis.

Road access

Experience with all the foregoing means of transportation – foot, tracked vehicle, helicopter – has clearly pointed out the need for at least minimal road development for access to this research area. Most investigators have neither the funds nor the time available for purchase and maintenance of reliable tracked vehicles or for charter of rotary wing aircraft. Foot travel is often impractical simply because of the time required, as well as due to load limitations. Thus we have too often seen

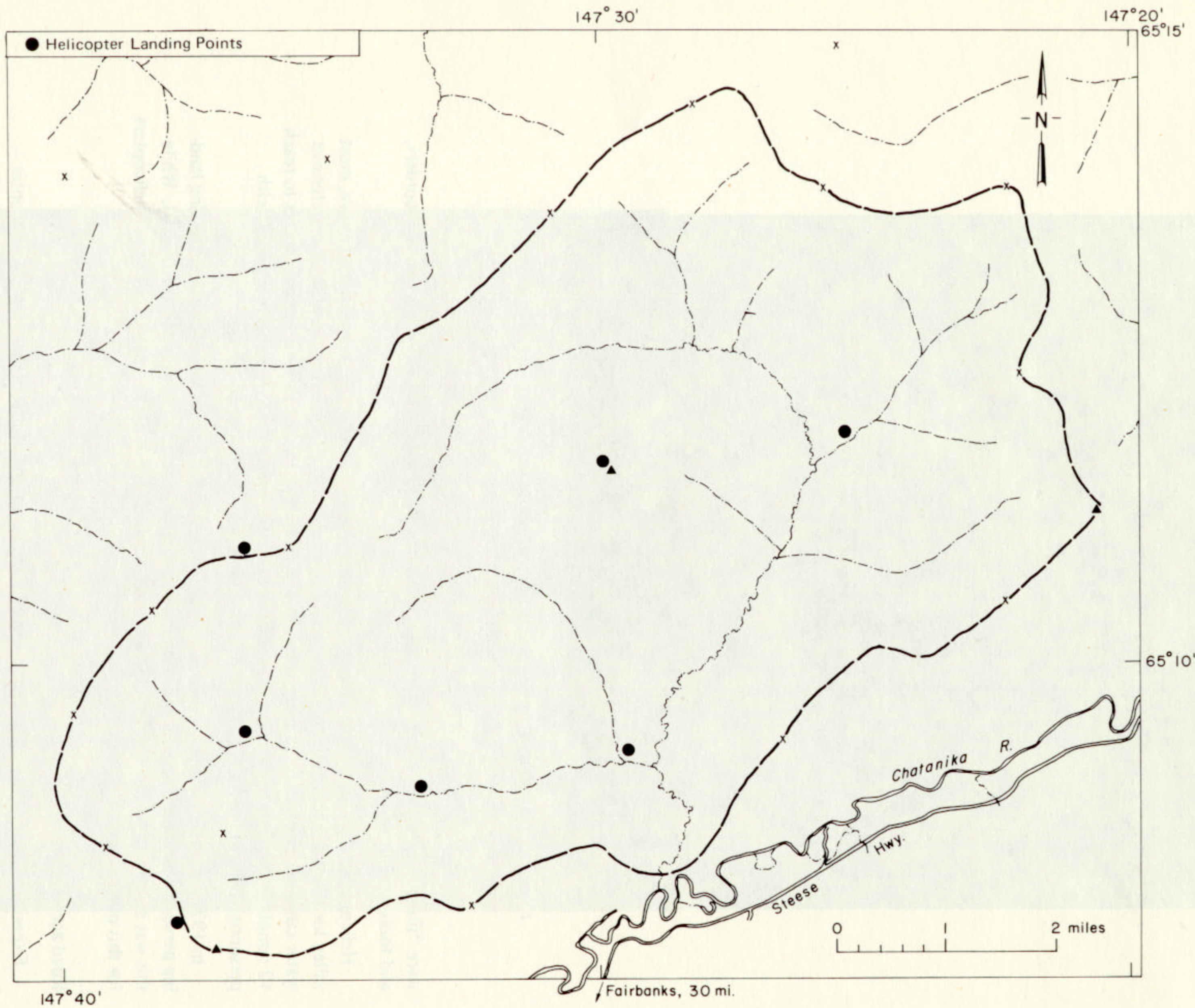

Figure 9. Helicopter landing points utilized during this program.

opportunities for accomplishing needed research and data acquisition passed up because of access restrictions.

In recognition of this, a minimal road network was outlined and was tentatively surveyed in 1971. It was determined that slightly less than 10 miles of gravel road, suitable for conventional wheeled vehicles, would allow ready access to a majority of existing or planned study sites, and would greatly facilitate reaching remote sites by small ATV's which could be carried on trailers behind a pickup or van. However, at this time none of the road network proposed in 1971 has been constructed.

ALTERNATIVE APPROACHES

Complementary approaches to the transportation problem for this and similar areas involve lowering the access requirement. For some purposes, such as collection of environmental data on a recurring basis, three possibilities are seen: long-term in-situ recorders, real-time telemetry systems, and remote sensing (airborne or satellite-based).

Long-term recorders

In the case of Caribou-Poker Creeks, each of these alternatives is being utilized in some degree. The least expensive approach would seem to be the use of long-term in-situ recorders for obtaining data. The U.S. Geological Survey utilizes such recorders for its stream-gaging operations throughout the United States, and two such stations are operative in this watershed. Water-level recorders utilized are either paper-tape digital or pen-trace analog recorders, with clocks driven by batteries, springs or weights. Unattended operations up to 4½ months are attainable. (However, more frequent servicing is required for stage-discharge calibration and checking for instrument malfunction.) In the Caribou-Poker Creeks Research Watershed these recorders are operated by the USGS only during the open-water season.

Climatic data such as air temperature, precipitation, wind, barometric pressure and solar radiation can similarly be measured by on-site unattended recording, provided that appropriate sensors and recorders are available. The lack of 110-V line power sharply restricts the field of potential commercially available equipment, however, and our experience with battery-powered "package weather stations," supposedly designed for year-round use, has been less than satisfactory. One such unit, offering 90-day unattended recording of air temperature, wind speed, and wind direction proved satisfactory only during the first year after purchase, and then the winter record was poor. Only during summer months have these units proven worthwhile in this central Alaska setting.

It is also possible to obtain (sometimes only by special order) battery or spring driven clocks, which will operate for 30 days or longer, for such instruments as thermographs, hygrothermographs and weighing rain gages. For these clocks, a loss in time resolution must be balanced against a longer interval between required on-site servicing visits. It has been our experience that reliance on off-the-shelf equipment, even with long-term recorders, must still be accompanied by frequent site visits to check operation, adjust pen inking, etc. Failure to do so results in a loss of records which may seriously impair use of the data which are obtained. Thus, the use of a 90-day unattended recorder in a site difficult to visit regularly may increase the probability of obtaining reliable records, but occasional access is still highly desirable to assure good reliability.

Telemetry systems

Real-time telemetry of data from field sites to a central point, such as an office or laboratory, is an attractive option. With a properly working telemetry system, operation of sensors can be monitored from the office, and presumably site visits need only be made to correct difficulties as they arise. Offsetting these advantages, however, are the high cost for the telemetry system itself (radio or ground line) and the need for maintenance and servicing. Since some sensors have an output not readily adapted to electrical transmission, new sensors or sensor/transmitter interfaces may have to be designed. In central Alaska one real-time telemetry system is in operation for the Tanana River flood-warning network; another has been proposed for snow survey data acquisition at selected points in the state. In the Caribou-Poker Creeks Research Watershed a data telemetry network has been designed (and is currently being installed) to provide real-time information in Fairbanks from a microclimatology site (Slaughter et al. 1974). Designed to operate from battery power, the apparatus of this telemetry system will be amenable to handling input from a large number of sensors (and sites) other than the basic microclimatology station. It is hoped that this installation will provide the basis for an expanded program of data telemetry from a number of study sites in the Research Watershed.

Remote sensing

Remote sensing provides another means of obtaining information. Aerial photography is probably the best-known form of remote sensing and has widespread utility. Such photography has been utilized in the Caribou-Poker Creeks project for soils, vegetation, and geological investigations. Satellite-based imagery offers many exciting possibilities, but application is currently quite limited for areas as small as the 40-square mile area of the Research Watershed. On an ERTS-1 image this 25,000-acre watershed is less than one inch in longest dimension (scale 1:1,000,000); nevertheless, image interpretation supplemented with ground observations has provided useful information on seasonal snow cover (K. Crowder 1974, personal communication). It is anticipated that remote imagery of greatly improved resolution and, of course, larger scale will be available in the future.

It must be remembered, however, that evaluation of remotely acquired imagery often requires ground truth data to a greater or lesser extent, depending on the subject and locale. For site-specific research, satellite imagery interpretation will still require access to the study area for the foreseeable future. Similarly, real-time data telemetry requires site access for equipment installation and maintenance. Further, these modes of information gathering are often providing baseline or background information for research which must be conducted in the field. In the case of sustained research, such as in the Caribou-Poker Creeks Research Watershed, remote sensing and real-time telemetry must be viewed only as valuable complements to a ground access system.

RELATIVE COSTS

Although firm dollar figures are lacking, it is still possible to provide estimates of comparative costs of communication modes based on our experience in the Research Watershed. Table I gives estimates of first-year and subsequent year costs for data telemetry and for access by gravel road, helicopter, tracked-vehicle trail, and foot travel – in each case based on the exclusive use of that mode, and on one field technician's time at $16,000 per year. These estimates indicate that exclusive use of helicopter travel would be extremely expensive and cannot be realistically considered for this project. Of the remaining modes, the highest first-year cost would, as might be expected, be for gravel road construction – $93,200 – but road availability would lessen subsequent year costs to the lowest of the options, about $4700/year (assuming only one day per week required for field technician work).

Restriction of access only to foot travel would offer lower first-year costs than the use of existing off-road vehicles on the existing trail network, but would have greater subsequent year costs than any of the other options. Data telemetry and the use of off-road vehicles are estimated to have intermediate first-year costs but they would have higher subsequent-year costs than the gravel road option.

Table I. Estimated comparative costs for different data acquisition modes.

Mode	Estimated costs* First year			Subsequent years	
Foot travel	Technician, 3 days/week†	$ 9,600		Technician, 3 days/week	$ 9,600
Offroad vehicles (existing trail network)	a) New vehicle purchase to	$17,000		Vehicle maintenance	2,000
	or			Technician, 2 days/week	6,400
	b) Maintenance of existing available vehicles		$3,500		$8,400
	Technician, 2 days/week	6,400	6,400		
		$23,400	$9,900		
Data telemetry (base, 3 remote sites, radio repeater)	Hardware	$25,000		Technician, 1½ days/week	$4,800
	Installation, first-year maintenance	8,600			
	Technician, 2 days/week	6,400			
		$40,000			
Gravel road, 10 miles	Construction	$90,000		Maintenance	$1,500
	Technician, 1 day/week	3,200		Technician, 1 day/week	3,200
		$93,200			$4,700
Helicopter access	UH1B, 2 hours/week at $650/hour	$67,600		UH-1, 2 hours/week at $650/hour	$67,600
	Technician, 4 hours/week	1,600		Technician, 4 hours/week	1,600
		$69,200			$69,200

* These costs are based on research conducted in the Caribou-Poker Creeks Watershed during 1971-1974.
† Technician salary estimated at $16,000 per year.

The high initial cost of data telemetry, here estimated at $40,000 for hardware and installation, is partially offset in subsequent years by reduced field time, but 1½ days per week is still required for telemetry system maintenance and field sensor checking (further, not all field sites can be equipped for unattended data telemetry).

As indicated elsewhere, exclusive use of any one mode is not a real question – but the estimates in Table I indicate the advisability of constructing gravel road access to valley sites as rapidly as is feasible. Decreased operation costs would offset the initial investment in a matter of 7 to 10 years, even ignoring both reduced off-road vehicle costs and the positive effects associated with increasing the utility of the research area to investigators now lacking regular access to tracked vehicles.

A DESIRABLE SYSTEM

In view of the variety of access alternatives described above, it is possible to outline a transportation/communication system to take advantage of available resources and provide a maximum of flexibility for long-term research, with greater efficiency than achieved without such a system (Fig. 10).

This system basically consists of formally identifying and combining the components discussed above – surface roads, surface trails, rotary wing aircraft, long-term recorders, and data telemetry. In brief, an all-weather road network would allow easy access to heavy-use sites which are in the lower reaches of the research basin, in valley locations. This road network would be designed to avoid troublesome permafrost-underlain terrain to the maximum extent possible. Branching from this road system would be two classes of trails: one type for larger tracked vehicles (such as those utilized now on the existing access trails) and the other type for foot travel, small ATV's or

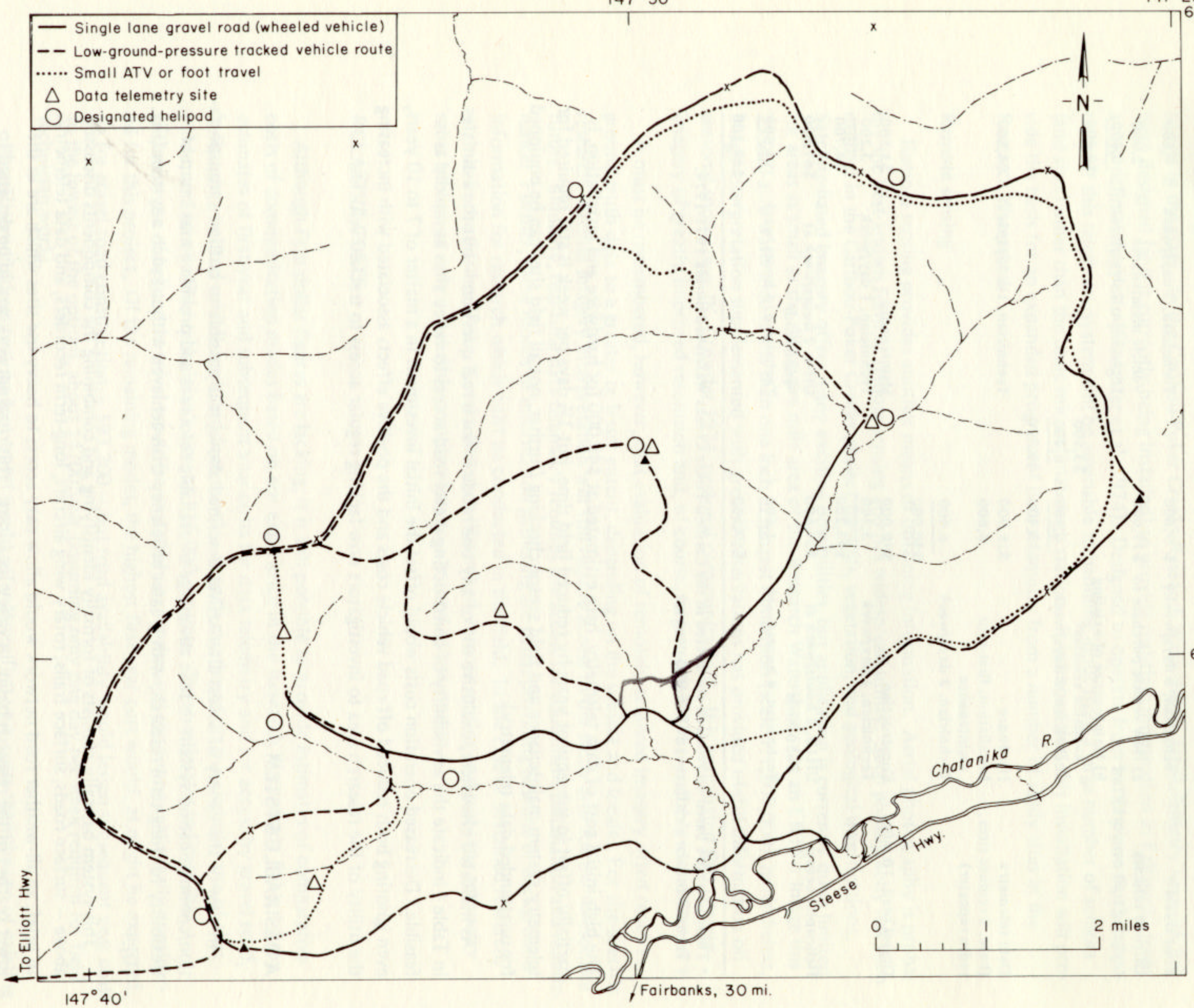

Figure 10. Projected access system.

snowmobiles. The first type of trail would extend to sites where heavy equipment and/or frequent visits justify the use of larger trail vehicles but where actual road construction is not required; the other trails would extend to lightly visited sites or to points where the use of large vehicles would not be acceptable from an environmental degradation viewpoint.

A formal system of helipads would be similarly designated for use when helicopter travel is feasible. In the case of the Research Watershed, this would simply entail identification and marking of points where helicopters have operated in the past.

Long-term in-situ recorders would have to be used where monitoring of environmental parameters is required. Linking some or all these recorders to the radio telemetry system would allow reliable monitoring of sensor operation and more ready use of the information required. Both long-term recorders and data telemetry will be dependent on the acquisition or development of appropriate sensors, storage modes, translators, and power supplies for remote sites.

All the foregoing proposals would set the stage for intensive field research into the processes and functioning relationships significant to the hydrometeorological regimen of this upland taiga setting, into biological and ecological research in the subarctic environment, and into experimental landscape management and environmental impact research.

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