PLANNING A TRANSPORTATION SYSTEM FOR THE NATIONAL FORESTS

By Bruce B. Burnett
Senior Highway Engineer, U. S Forest Service

SYNOPSIS

The national forests cover an area over one-tenth that of the continental United States. Their timber, minerals, grazing lands, game, recreation facilities and water, making up a large share of this country's resources, are administered by the Forest Service for the most productive use for the permanent good of the whole people. Transportation facilities are essential for orderly resource development, for their protection from fire, and for their proper utilization.

In earlier days forest roads were built largely for fire protection but now the planning of forest transportation systems is coordinated with land use and long-term resource management including the protection factors This planning requires a detailed inventory of the timber, minerals, recreation sites, grazing land, fish and game, water and hydro power, existing roads and trails, agriculture, population, and the like. These are all located on maps and their values, annual production, and such related data are tabulated Decisions on land use are made on the principle of multiple resource utilization. Population change and other trends are studied and all these data are converted into terms of traffic, not only for the present but for the reasonably predictable future. Forest transportation systems are then planned with standard and location of each road determined by the character, volume, origin, and destination of the traffic.

The planning includes an economic analysis of each project and if necessary the system is adjusted to make it economically sound. Resource traffic has a value depending on the products hauled. The amounts that can be economically provided for roads to haul timber can be definitely determined. The loss of weight and selling price of sheep driven on foot to market can be compared with the smaller loss in weight, better condition, and better price obtained by transporting in trucks. Travel for recreation or through traffic across the forests has values measured by cost of vehicle operation All these credits on an annual basis are weighed against the yearly expense for the road which is the depreciation and interest on original cost plus annual maintenance. The fact that vehicle operation, repair, and depreciation costs are greater on low-standard roads than on high-standard roads forms the basis for determining savings to traffic when improvement of an existing road is planned

The planning recognizes that changing conditions necessitate flexibility and accordingly provision is made for review from time to time and adjustment to meet unforeseen situations

Scattered throughout the United States there are more than one hundred and seventy-five million acres of national forests—mostly in the eleven western states.

The value of these forests is incalculable. Their resources are essential to the strength and prosperity of the nation. The timber, water, minerals, grazing, wild game, recreation facilities, and numerous other elements are all indispensable in our way of life; a heritage not fully appreciated.

Obviously these resources should be used; judiciously used; and they must be perpetuated for use by future generations. This is a task, or should we say a privilege, which has fallen to the U. S. Forest Service, a bureau of the Department of Agriculture.

In approaching its responsibilities, the Forest Service is largely guided by the policy expressed by the Secretary of Agriculture in a letter to the Forester in the early days of the Service as follows: "In the administration of the forest reserves it must be clearly borne in mind that all land is to be devoted to its most productive use for the permanent good of the whole people, and not for the temporary benefit of individuals or companys, ... You will see to it that water, wood, and forage of the forests are conserved and wisely used for the benefit of the home builder, first of all, upon whom depends the best permanent use of lands and resources alike."

To carry out this policy successfully and to discharge the increasing responsibilities of forest land management which have since developed, a well designed and constructed transportation system is of paramount importance. Transportation facilities are essential for orderly development, protection, and utilization of the resources and for proper coordination of land use.

Protection of the resources, principally from destruction by fire, is perhaps the first requirement. Recognizing this the Forest Service first directed its efforts toward developing a system of roads and trails for that purpose. Money was hard to get. So the Service laid out and started to construct a system of low type roads believed to be the minimum necessary for protection of the forests.

In some regions this system of roads, together with other facilities for detection and suppression of fires, proved very effective. But in other regions, notably on the Pacific Coast, where there has been steady and rapid increase in population and forest use, these low type single purpose roads often made attractive resources and recreation areas accessible, and soon became overburdened with traffic for numerous other purposes for which they were not designed and were highly unsuited. This necessitated unexpected and excessive expenditures for betterment and maintenance. In many cases, and in a surprisingly short time, a new road had to be constructed and the old one abandoned.

Had the monetary loss in such cases been the only ill effect it might have been borne for a time because of the urgent need for protection roads and the necessity for stretching available funds to the limit. But other unfavorable conditions developed. Erosion, for example, could not be controlled due to continual disturbances of the soil resulting from construction of new routes or constant betterment of the old; landscape disfiguration was increased; roadside natural scenic values could not be restored and right-of-way problems increased. Rights-of-way were acquired and a roadside timber screen preserved only to find that soon the road had to be relocated and in order to attain the higher standard necessary the new route must be constructed through a cut-over or burned-over area devoid of scenic attraction.

It has been said that we must expect roads to become obsolete and be replaced or abandoned just as equipment in a manufacturing plant becomes obsolete. That may or may not be true. But certainly it is not good business to construct roads and abandon them if it can be avoided This applies particularly to the national forests where construction of roads so violently disturbs the balance of nature Here, of all places, road construction should be held to an absolute minimum necessary to adequately serve requirements. That can be done only by long range planning.

So in 1937 the Forest Service started preparation of an All-Purpose Transportation Plan for the national forests; a master plan designed to serve all present and future needs as far as can be foreseen.

The plan has three essential parts. First, a complete inventory is taken of all forest resources. Second, each resource is thoroughly studied to determine if, when, and to what extent it will be used. Third, the present, and expected future use of each resource is converted into terms of traffic, to which is added scenic and non-forest traffic. The traffic is traced from source to destination which provides a complete pattern as the basis for location and design of the road system Finally the plan is correlated with County, State, and National road plans

In beginning the planning, a national forest region is divided into planning units of about one or two million acres. The unit usually extends a short distance outside the boundary of the national forests and is bordered by fixed high type Federal or State highways which are known to be on final location. Since there is relatively little permanent population within the national forests, practically all the traffic within the planning unit flows to or from these bordering highways. Each resource is shown in its proper proportion and position on a base map of the unit usually on a scale of ½ in. to the mile. This provides a suitable visual presentation of the resource from which studies are made to determine present and probable future use in terms of traffic.

Ordinarily planning one unit involves the use of from 30 to 35 maps, graphs, and charts, with supporting memoranda Resources as follows are usually shown on separate maps, but they may be combined or otherwise changed to accommodate varying conditions

1. Timber
2. Mining and Minerals
3. Recreation
4. Stock Range
5. Fish and Game
6. Water and Hydro Power
7. Agriculture
8. Population
9. Traffic
10. Existing Roads
11. Composite of 1 to 10

The composite map will show all resources and their present and expected future use in terms of traffic.

Figure 1 is a composite map showing the resources of the Tahoe National Forest in California. Figure 2 shows the timber resource alone.

Figure 3 shows the range resources, and Figure 4 shows only the mining development.

Traffic for the utilization of each resource is traced to logical connections with the fixed highways bordering the planning unit, taking into consideration topography and service to communities and other resources en route. This resource traffic, plus non-forest through travel, provides a complete traffic pattern for the unit and determines the proper location and standard for the planned transportation system. Existing roads are then correlated with the planned system to the fullest practical extent and purely protection roads are added in a few cases as found necessary. In California the planned system represents a reduction of around 20 per cent in mileage from the existing and previously proposed system.

The probable future use of forest resources and recreation facilities is determined from exhaustive studies of trends of population, automobile registration and use, gasoline consumption, demand for forest products, and a number of other related factors. It is known that the population of the nation and of different states and areas of the nation eventually will reach a peak, that the use of automobiles, of forest resources, of roads, must reach a peak. According to economists and statistical experts the population peak will be reached before the end of the current century; and it is surprising to note the consistency of the numerous estimates These data provide a dependable basis for predicting future travel in the forests.

When the entire system of roads has been laid out, each project is subjected to an economic analysis to check the justification for its cost and standard.

In making this analysis, it is recognized that every transportation facility has two standards: (a) a service standard and (b) a construction standard.

The service standard represents the ser-

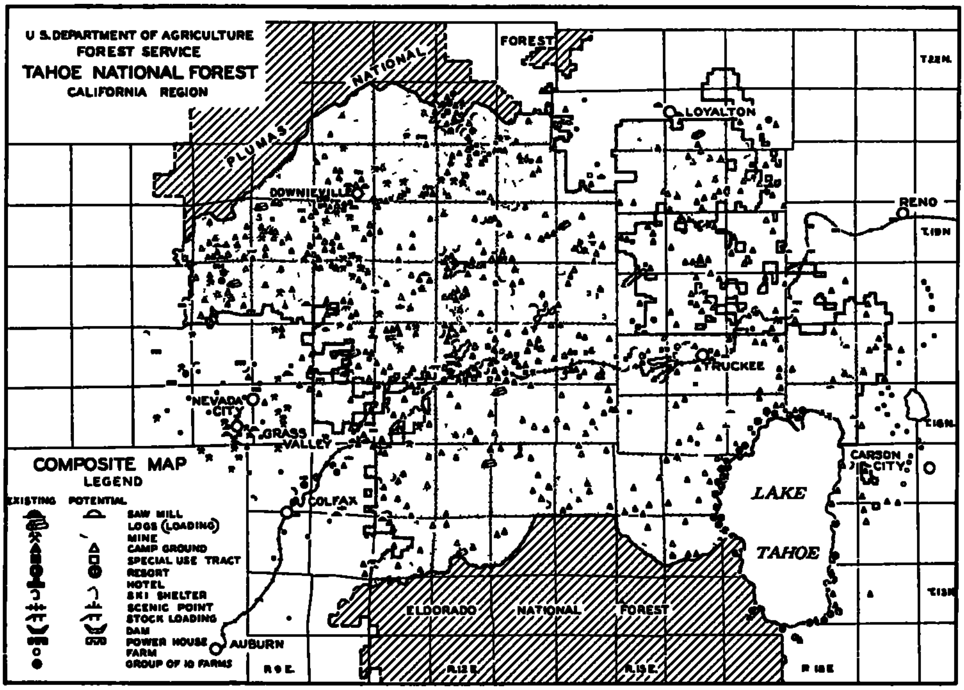

Figure 1. Resources of the Tahoe National Forest

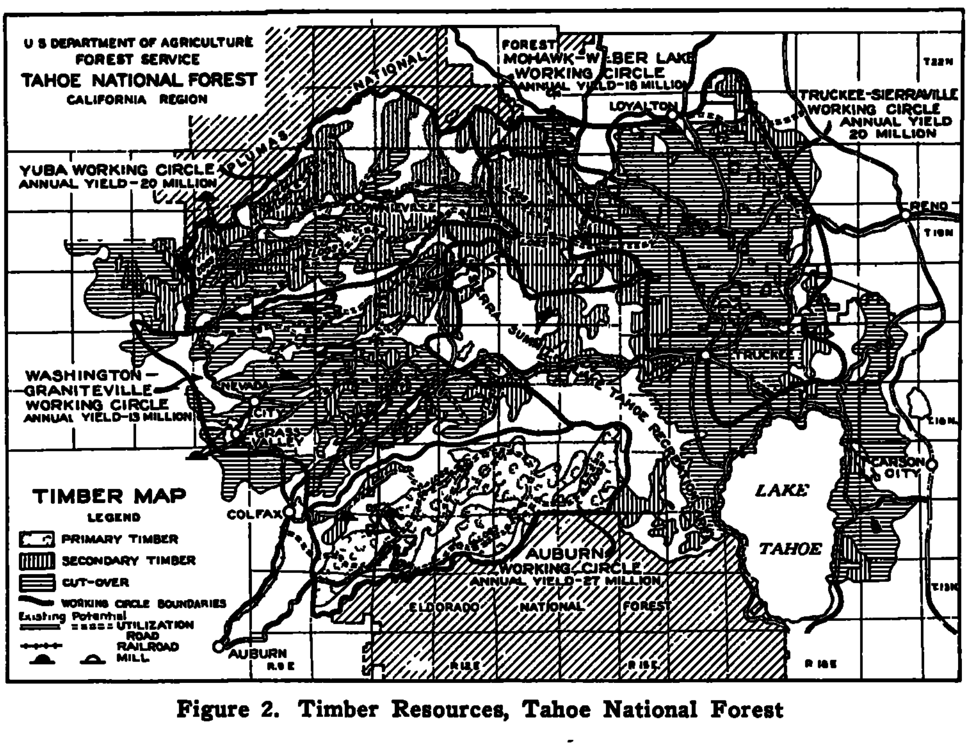

Figure 2. Timber Resources, Tahoe National Forest

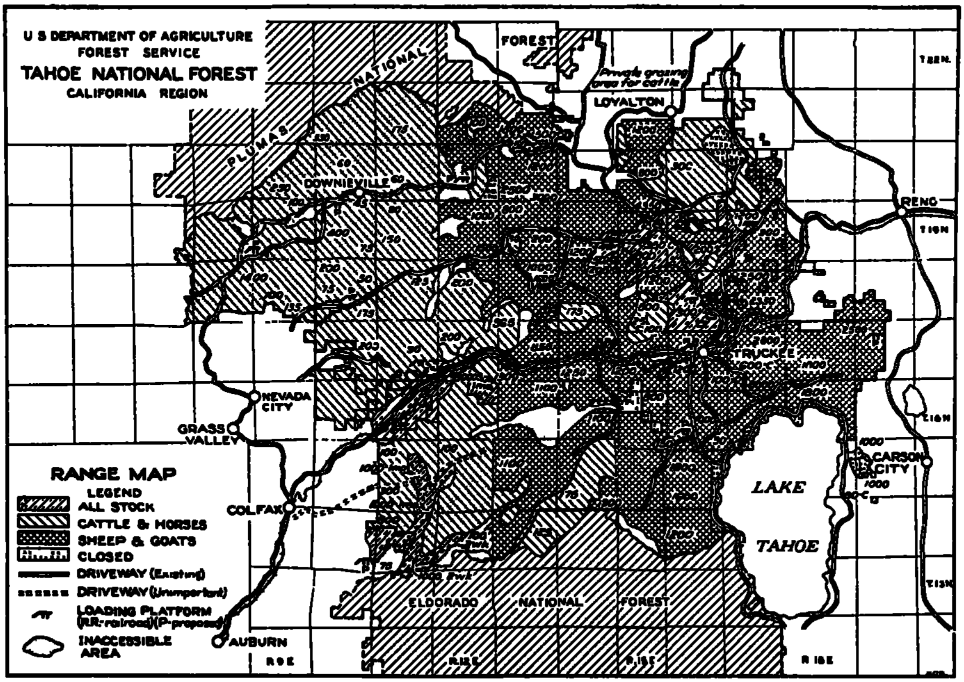

Figure 3. Range Resources, Tahoe National Forest

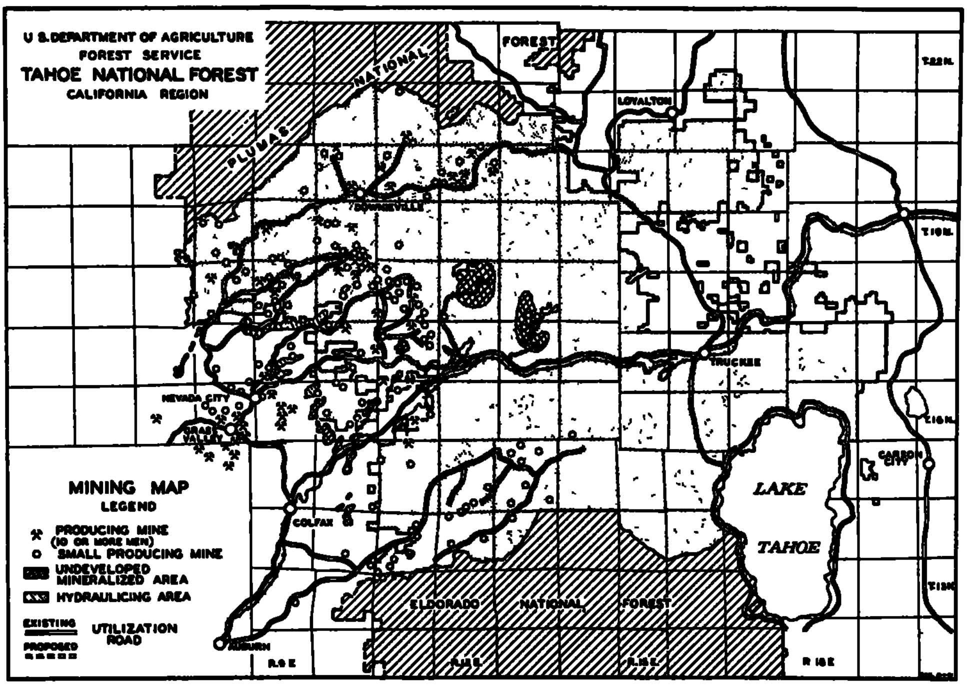

Figure 4. Mining Development, Tahoe National Forest

vice required from the road to permit free flow of traffic at required speed with safety and comfort under normal peak conditions. Peak condition as used for planning purposes is either the average daily traffic for 15 consecutive days or the average daily week-end traffic, during the season of highest use. The factors which determine the service standard are the volume, type, and travel time requirements of traffic.

The construction standard represents the essential physical characteristics of the road, such as width, curvature, gradient, and type of surface which are required to accommodate the volume of traffic as indicated by the service standard. Any one of these elements may be the controlling factor in determining the limiting capacity or density of traffic. Therefore all elements of the construction standard should be related to, and in conformity with each other. No single element should be designed to a higher or lower standard than any other if the most efficient and economic service to traffic is to be attained.

Assuming that the volume, type, and travel time requirements of traffic to be served by a proposed road are known, then there are two criteria which should be employed to select the proper construction standard. They are (a) the practical carrying capacity, or the maximum number of vehicles which may use the road at the same time without slowing the travel time below the requirements of the service standard; and (b) the economic capacity, or the maximum and minimum number of vehicles which can travel a given construction standard at a lower cost than upon any other standard constructed on the same route. The road standards—service and construction—shown in Table 1 were worked up in accordance with these principles and are used in the All-Purpose Transportation Plan.

Obviously the cost of construction for any of the standards set up in the table will vary widely due to topography and numerous other conditions. Therefore construction costs are not shown but, since the cost of highway transportation is a combination of vehicle costs, plus highway costs, the construction costs must be considered when selecting the standard to be constructed.

The ideal standard is one which will produce the minimum sum of vehicle costs and highway costs for each unit of traffic. It is apparent that this minimum cannot be attained when vehicle costs are excessive on account of a heavy volume of traffic being forced to travel a low standard road; or, conversely, when large expenditures are made for construction of a high standard road which is utilized by only a small amount of traffic, thus resulting in a disproportionate share of the road costs to each unit of traffic, as compared with the saving in time or vehicle costs.

The economic balance between road costs and vehicle costs for different volumes of traffic and for different standard roads may be determined by comparing the sum of the road cost and vehicle cost for each project.

Table 2 shows the variation in the transportation cost per vehicle mile for different standard roads constructed on the same location with a traffic volume of 200,000 vehicles per year.

The different road standards are as shown in Table 1.

The vehicle operation costs per mile are for a combination of vehicles, composed of 80 per cent recreation, 10 per cent commercial, and 10 per cent trucks. They are taken from Table 3 which in its entirety includes various combinations of these three classifications.

The operating costs include fuel, lubrication, tires, depreciation from use and from age, repairs, licenses, insurance, and interest on investment. The operator's time for commercial vehicles is also included. No time cost is included for vehicles used for recreation.

It is evident, that due to changing eco-

TABLE 1

SERVICE AND CONSTRUCTION STANDARDS OF FOREST ROADS

All-Purpose Transportation Planning—Region Five

November, 1940

Class	Capacity No vehicles per day	Speed Av vehicle speed m p h	Width: Lanes No	Width: Lanes Width	Width: Roadbed ft	Alignment: Min radius	Gradient: Ruling grade %	Gradient: Max grade %	Surface or pavement	Vehicle costs[b]: Av. time cost, vm	Vehicle costs[b]: Av oper cost, vm	Remarks
				ft.		ft	Group 1[a]			$	$	
AA	5,000–20,000	Cars —60 Trucks—45	3 or 4 div	11–12	40–100	1,000	5	6	Hard surf — cement or bit conc or equal	0 02 0 025	0 045 0 09	Arterial F. H Part of Federal or State Hwy. System.
A	1,000– 7,000	Cars —50 Trucks—40	2	11–12	28–50	500	5	6	Hard surf — cement or bit. conc. or equal	0 02 0 03	0 045 0 09	Forest Hgwy.—Usually part of the Federal or State System.
B	400– 2,000	Cars —40 Trucks—30	2	11	28–48	300	6	7	Hard surf.—cement or bit. conc. or equal	0 03 0 035	0 05 0 10	Forest Hgwy — Medium service.
							Group 2[c]					
C	150– 500	Cars —30 Trucks—20	2	10–11	26–48	150	6	8	Road or plant mixed bit surf Good gravel or d g	0 03 0 04	0 06 0 12	Low service—Forest Highway.
D	30– 200	Cars —20 Trucks—15	1	10	14–19	100	6	8	Crushed grav. or equivalent	0 04 0 055	0 075 0 15	High service—Truck trail.
E	20– 50	Cars —15 Trucks—10	1		12	50	8	10	Natural soil	0 055 0 085	0 09 0 17	Medium or Low service—T.T

[a]Essentially through routes for commercial and tourist traffic [b]Subject to revision.
[c]Essentially for local traffic and utilization of National Forest resources.

nomic conditions accurate transportation costs cannot be established for an extended period of time, but the relative costs resulting from different standards will remain consistent.

As a rule the economic capacity will indicate a road of higher standard than is required for the carrying capacity. Exceptions may occur when the total annual traffic is restricted to only a part of the year as in the case of a road being closed during the winter months due to snow. In that case the economic capacity derived from the total annual traffic may indicate a road standard with a lower carrying capacity, than is desirable to serve the seasonal 15-day average peak traffic.

Space does not permit a detailed description here of the All-Purpose Transportation Planning procedure, but there follows a brief example of the planning for a small unit which will serve to explain the salient features.

Figure 5 is a typical national forest area about 25 miles long and 15 miles wide. High type highways U. S. 99 and State route 39 border the unit south, west, and north. The city of Bridgeport with a population of about 10,000 and Middleton, a town of about 2,000 population lie in the farming region on the south, and the small city of Colma, population 5,000, is located in a fertile valley in the mountains north of the planning unit. These communities have grown in the past 40 years from settlements of two or three families

In the early days the growth of Bridge-

TABLE 2

EXAMPLE OF COST OF TRANSPORTATION FOR DIFFERENT STANDARD HIGHWAYS

Annual Number of Vehicles = 200,000

	Road Standards				
	A	B	C	D	E
	$	$	$	$	$
Av. vehicle operating cost per mile	0 054	0 061	0 073	0 092	0 112
Av annual road cost per mile	4,300	2,150	1,300	400	250
Annual vehicle cost	10,800	12,200	14,600	18,400	22,400
Annual transportation cost	15,100	14,350	15,900	18,800	22,650
Av cost per vehicle mile	0 0755	0 0717	0 0795	0 094	0 1132

TABLE 3

AVERAGE COST OF VEHICLE OPERATION PER MILE FOR DIFFERENT TYPES OF TRAFFIC

Per cent of Vehicle Types

Road Standard												
	Recreation %	100	90	90	80	80	80	70	70	70	70	60
	Commercial %	0	10	0	20	10	0	30	20	10	0	40
	Trucks %	0	0	10	0	10	20	0	10	20	30	0
		$	$	$	$	$	$	$	$	$	$	$
A and AA		045	047	052	049	054	059	051	056	061	067	053
B		050	053	058	056	061	067	059	064	070	075	062
C		060	063	070	066	073	080	069	076	083	090	072
D		075	079	088	083	092	101	087	096	105	114	091
E		090	095	106	101	112	123	106	117	128	139	112

port was suddenly stimulated by discovery of gold on the mountain ten miles to the north. A community of several hundred people developed near the site of the mine and a low type dirt road was constructed by the mining company from Bridgeport to the property. Later, as automobiles were improved and were acquired by the mine employees, there was a general exodus of residents from the mining community to Bridgeport where home life offered more attractions. This increased the traffic on the mining road as the employees daily traveled back and forth to their work.

To obtain timber for the mine the road was extended into the region a few miles beyond and, incidentally, made accessible an attractive recreation area. Traffic over the old road, already more than its economic capacity, was thereby further increased.

As the town of Bridgeport continued to grow, an increased water supply was needed and was provided by development of a reservoir about 12 miles up the canyon. For use in building the dam, a low type road was constructed from the dam site to a connection with the old mining road.

Then more mountain recreation facilities were desired by the people of Bridgeport and an area was made accessible by constructing a few miles of road to a connection with the road to the dam.

From Colma a road was constructed to a recreation area in the forest about eight miles southwesterly and soon there developed a demand to continue the road to the dam where connection could be made with the road to Bridgeport. Eventually this link was constructed and traffic began to flow in increasing volume across the forest between Colma and Bridgeport.

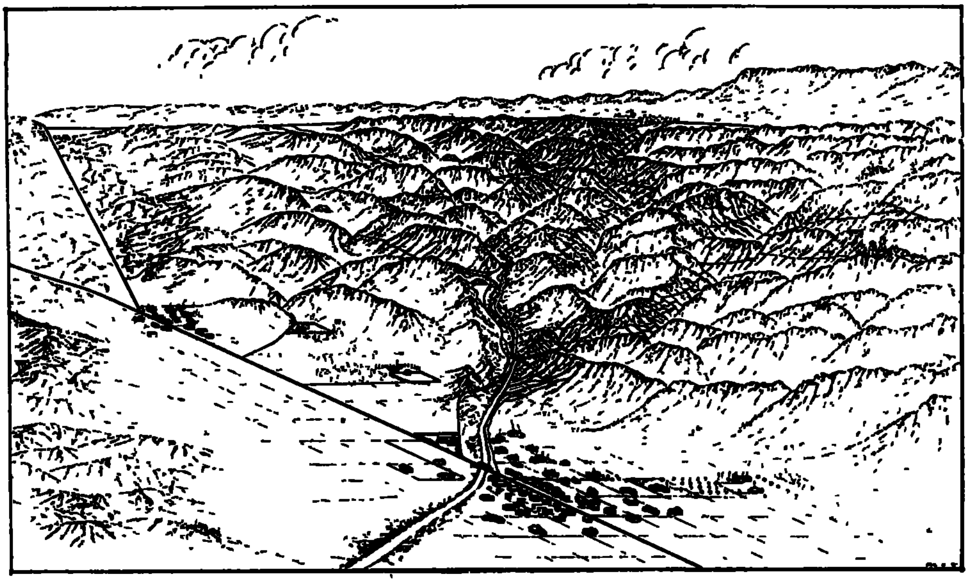

Figure 5. Example of Transportation Planning for Typical Area of National Forest—California Region

Needless to say, this system of roads, each constructed for a single purpose, was wholly inadequate to serve the multiple use which naturally developed.

Residents of the communities bordering the forest areas, Chambers of Commerce, and other interested agencies began urging reconstruction of the system of forest roads, particularly the through route between Bridgeport and Colma.

Traffic studies were made and it was found that:

(a) 200 cars daily were traveling between Bridgeport and Colma by way of U. S. 99 and State route 39. These highways were congested with traffic and immediate expenditure of five or six hundred thousand dollars was necessary to improve the standard of the routes. Fifty cars daily were using the old route across the forest which was hardly more than a trail; difficult, slow, expensive and dangerous to travel.

(b) The distance between Colma and Bridgeport via State route 39 and U. S. 99 was 34 miles, while the direct route across the forest would be 20 miles.

(c) The traffic was mostly commercial and figuring vehicle operating costs at 7 cents per mile, the annual volume of traffic at 73,000 cars and a difference of 14 miles in distance traveled between the two populous centers, the annual saving in cost of vehicle operations if a high type direct road were constructed between Bridgeport and Colma would amount to $71,540. This sum amortized over a period of 30 years at 2½ per cent compound interest, has a present worth of $1,497,332, sufficient to pay the cost of constructing the highway across the forest.

But this saving to traffic, relief of congestion, elimination of the necessity of expending five or six hundred thousand dollars for betterment of the existing highways are only a fraction of the benefits which would accrue and are of secondary importance in considering the necessity for the forest highway. Of far greater importance is the stabilization of the communities adjacent to the forest and the welfare of their people who are in large part dependent on the forest resources. The water from the forest is essential for farming, for manufacturing, and for domestic use. The timber, the minerals, and the recreation facilities, all are essential to the life of these communities.

So a highway across the forest must be more than a route merely to serve through traffic. It must be an integral part of the forest transportation system, since in practically all cases of this kind the larger proportion of traffic over the highway is due to the influence of the forest resources. In the case of the Tahoe forest 75 per cent of the traffic is due to the forest influences. It is therefore essential that plans for development and utilization of the forest resources should be carefully studied as a prerequisite to location and design of the trans-forest highway. Such a study was made of the area shown in Figure 5 and the principal resources are shown in Figure 6.

The resources consist of campgrounds, resorts, summer home sites, dams, reservoirs, power plants, grazing, fish and game, timber, and other features attracting or in any way affecting traffic. Each resource is shown in detail on separate maps. For instance, grazing lands and large bodies of timber cannot be clearly shown in their entirety on the composite map (Fig. 6). These resources are shown by a small symbol with the amount of traffic they will develop at the point of loading for transportation to market.

Large bodies of timber in the national forests are in general divided into units of several thousand acres known as "working circles." The allowable annual cut on these units may equal, but must not exceed, the annual growth. This permits a constant annual yield provided the timber stand is not depleted by losses such as from insect infestation or fire. Knowing the amount of lumber which will be produced from a certain area it is not difficult to compute the approximate number of trucks and passenger carrying vehicles which will be used in the operations, or to determine the locations and standards of roads necessary to transport the product to market.

There are two loading points for timber shown in Figure 6. They are in T. 6 S., R 5 E, and it will be noted they are designated T 5/16 and T 6/16 respectively. Interpreted, T 6/16 means: annual traffic due to timber utilization 6 cars and trucks daily, and 16 cars and trucks daily for 15 consecutive days of highest use The peak volume of traffic for 15 consecutive days determines the service standard required for the road. Of course, traffic using the road for purposes other than timber must also be considered in locating and designing the route.

The use of recreation resources, present and potential, is computed and converted into terms of traffic as shown by Table 4.

The triangular symbol, for example, designated R-8, 36/133 is a recreation site generating an average of 36 cars daily throughout the year and an average of 133 cars daily for the 15 consecutive days of highest use. There are 40 acres of attractive area developed by the Forest Service for picnicking and used principally by residents of Colma.

The area has been developed for an ultimate capacity of 200 people It will be used to capacity for 60 days of each year, to 50 per cent capacity for 60 days and 10 per cent capacity for 100 days. This is equivalent to full capacity use for 100 days of each year, a total of 20,000 visitors annually.

Since it is a picnic area, the length of stay per visitor will ordinarily be one day. Each automobile used for recreational travel in the forests transports an average of a little more than 3 persons, and in this case makes the round trip, in and out of the recreational site in one day, so the number of visitor days per

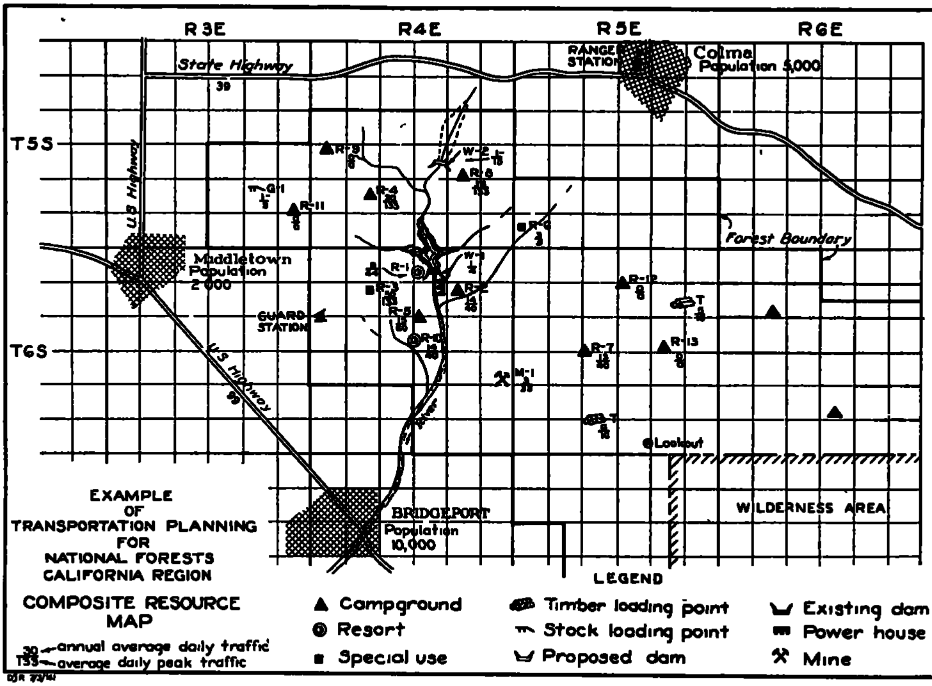

Figure 6. Resources of Area Shown in Figure 5

TABLE 4
TRANSPORTATION PLANNING
Estimate of Recreational Traffic

Inventorial data						Seasonal use				Estimated ultimate use				
					A				B	A × B = C	D	E	A − E = F	C ÷ E = G
Inv No	Name	Area (Ac)	Type	Ownership and status	Ultimate capacity (people)	Est No days at 100% cap	Est No days at 50% cap	Est No days at 10% cap	Total equiv days at 100%	Annual No of visitor days	Period of visit per person	Est. vis days per unit of traffic	Daily peak traffic 15 days	Annual volume traffic
R-1.	Blue Lake Resort	20	R. s.	Priv Exist.	400	30	60	150	75	30,000	6	9.0	44	3,300
R-2	West Fork	30	C g.	Govt Res	300	60	120	100	130	39,000	5	7 5	40	5,200
R-3	Mill Valley	160	S. h	Govt. Res.	2,000	60	120	150	135	270,000	10	15 0	133	18,000
R-4	Deer Creek	40	P. g	Govt Exist	200	30	80	120	82	16,400	1	1 5	133	10,930
R-5	Cedar Crest	100	C g	Govt. Pot	450	60	60	10	91	41,060	5	7 5	60	5,475
R-6	Manzanita Springs	10	S. h.	Govt. Exist	80	180	90		225	18,000	10	15 0	5	1,200
R-7	Bear Valley	360	C g	Govt Pot	300	60	120		120	36,000	5	7 5	40	4,800
R-8	Happy Creek	40	P g.	Govt. Pot.	200	60	60	100	100	20,000	1	1 5	133	13,300
R-9	Iron Mountain	10	H c	Govt	50	0	0	0	0	0	0	0	0	0
R-10	Pine Cove	100	R. s	Priv Pot.	360	60	120	100	130	46,800	6	9 0	40	5,200

C g — Campground, H. c — Hunter's camp; P. g — Picnic grounds, S. h.— Summer home site; R. s — Resort site unit of traffic will be 1.5. The 15-day high average traffic will be 133 cars daily, and the total annual volume of traffic will be 13,300 cars.

R-10 is a privately owned potential resort site expected to be developed soon for a capacity of 360 people. Here the length of stay will be 6 days compared to 1 day for the picnic ground The 15 days of highest traffic will be 40 cars.

extent and the traffic must be considered in designing the road intended for other use. Two recreation sites north of the Wilderness Area are accessible by trail only They are favorite objectives for pack trips as are also numerous recreation sites in the Wilderness Area which are not shown. Roads are not permitted to be constructed in designated Wilderness Areas.

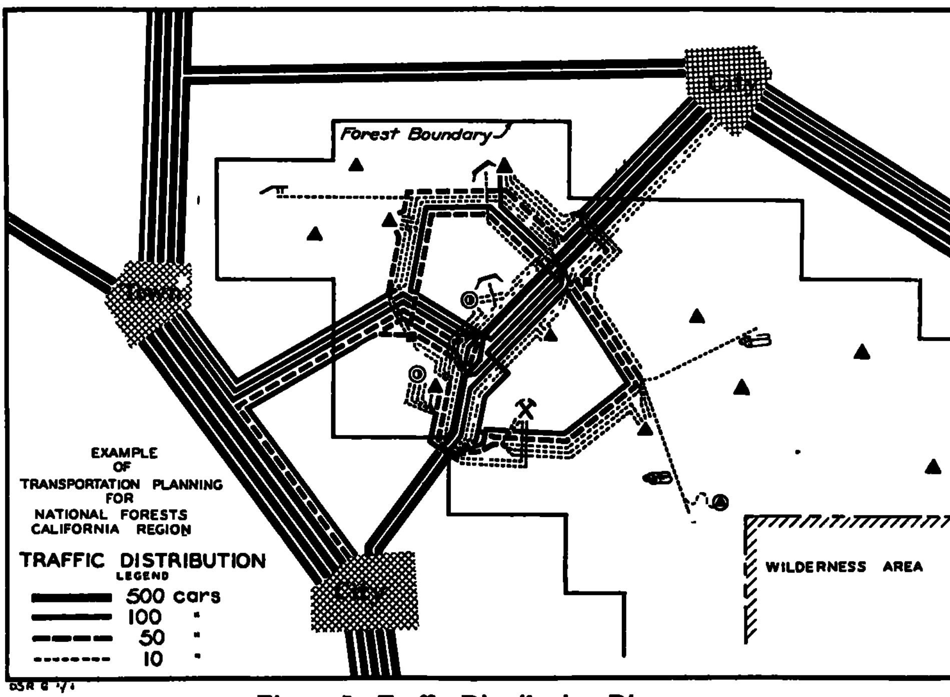

Figure 7. Traffic Distribution Diagram

The present and expected use of all resources is converted into terms of traffic and traced in 10-car units from source to destination as shown in Figure 7.

Studies of recreation trends, population, forest use, automobile registration, gasoline consumption, and other statistical material indicate that there will be no need to develop and make accessible some recreation areas. They will never be used. However, they are shown to complete the resource inventory and in case a road, planned for other purposes, makes them accessible they may then be used to some

A study of the traffic distribution diagram—Figure 7, and the Typical Forest Area—Figure 5, will show that topography influences considerably the design of the traffic pattern. Traffic is taken from source to destination by the most direct route practicable with due consideration for cost of road construction, length of route, cost of transportation, scenic and safety values, erosion control, and many other conditions. Complete integration of the system is always an aim.

With the traffic distribution diagram—

TABLE 5

TRANSPORTATION PLANNING

Summary of Derivation of Service and Economic Road Standards*

Route and section	Daily Peak Traffic					Average Annual Traffic									Indicated standard (economic)
	Total by vehicle types			Total vehicles	Indicated standard (service)	Percentage of vehicle types			Total vehicles	Average cost of transportation per vehicle mile by standard					
	Rec cars	Commercial				Rec cars	Commercial								
		Cars	Trucks				Cars	Trucks		A	B	C	D	E	
										$	$	$	$	$	
1-A	607	213	64	884	B	50	40	10	146,350	*078*	082	091			A
1-B	444	411	112	967	B	30	60	10	196,250	*079*	086	095			A
1-C	667	413	139	1,219	A	30	60	10	205,350	*076*	085	094			A
2-A	190	204	54	448	C	20	70	10	93,670	.095	*094*	100	119		B
2-B	266	202	51	519	B	20	70	10	89,150	100	*098*	103	119		B
3-A	223	3	4	230	C	100	0	0	19,420		115	089	*084*	084	D
3-B	350	12	13	375	C	90	10	0	24,050		098	*085*	086		C
4-A	170	2	34	206	C	70	0	30	16,850		132	*117*	122		C
4-B		2	12	14	E		10	90	1,550			479	323	*320*	E
5-A	170	11	43	224	C	50	10	40	24,550		135	*125*	138	165	C
5-B		3	12	15	E		10	90	1,550			439	309	*283*	E
6-A	7	7	4	18	E	30	50	20	620			762	341	*215*	E

* For complete derivation, see pages 67 and 68.

TABLE 6
TRANSPORTATION PLANNING
Annual Road Cost

Route	Section	Length mi	Initial cost per mile—dollars					Annual Maintenance cost per mile—dollars					Annual cost per mile—dollars				
			Class					Class					Class				
			A	B	C	D	E	A	B	C	D	E	A	B	C	D	E
1	A	3 3	42,000	25,000	15,000			500	500	500			2,640	1,775	1,265		
	B	4 2	45,000	27,000	16,000			600	600	600			2,895	1,977	1,416		
	C	2 5	40,000	25,000	15,000			500	500	500			2,540	1,775	1,265		
2	A	5 6	44,000	20,000	12,000	4,000		500	400	200	80		2,744	1,420	812	284	
	B	2 4	50,000	25,000	15,000	4,500		500	400	300	80		3,050	1,675	1,065	310	
3	A	4 0		17,000	5,000	2,000			400	300	80	60		1,267	525	182	
	B	5 0		14,000	4,500	1,500			400	300	100	60		1,114	530	177	
4	A	5 0		12,000	4,000	1,000			350	250	90	80		962	454	141	
	B	4 0		12,000	5,000	1,000	750			250	90	80			505	141	118
5	A	6 0		15,000	4,500	1,200	400		400	300	100	70		1,165	530	161	90
	B	4 0		12,000	4,000	1,600	400			240	80	40			444	162	60
6	A	4 0			4,200	1,600	300			200	100	25			414	182	40

TABLE 7

TRANSPORTATION PLANNING

Derivation of Road Service Standards

Route and section	Daily peak traffic												
	Recreation cars		Resource utilization and development		Administration and protection		Through traffic (commercial)		Totals			Total vehicles	Indicated standard (service)
									Rec cars	Commercial			
	Resource	Through traffic	Cars	Trucks	Cars	Trucks	Cars	Trucks		Cars	Trucks		
1-A	207	400	7	12	6	2	200	50	607	213	64	884	B
1-B	44	400	5	10	6	2	400	100	444	411	112	967	B
1-C	267	400	1	35	12	4	400	100	667	413	139	1219	A
2-A	140	50	1	3	3	1	200	50	190	204	54	448	C
2-B	66	200			2	1	200	50	266	202	51	519	B
3-A	73	150	1	3	2	1			223	3	4	230	C
3-B	200	150	6	12	6	1			350	12	13	375	C
4-A	20	150		33	2	1			170	2	34	206	C
4-B				11	2	1				2	12	14	E
5-A	20	150	5	41	6	2			170	11	43	224	C
5-B				11	3	1				3	12	15	E
6-A	7		1	3	6	1			7	7	4	18	E

TABLE 8

TRANSPORTATION PLANNING

Derivation of Economic Road Standards

Annual traffic

Route and Section	Recreation cars		Resource, utilization and development		Administration and Protection		Through traffic (commercial)		Totals			Total vehicles	Per cent		
									Rec. Cars	Commercial			Rec Cars	Commercial	
	Resource	Through Traffic	Cars	Trucks	Cars	Trucks	Cars	Trucks		Cars	Trucks			Cars	Trucks
1-A	23,850	50,000	1,200	900	300	100	60,000	10,000	73,850	61,500	11,000	146,350	50	40	10
1-B	4,250	50,000	600	600	300	100	120,000	20,000	54,250	120,500	20,800	196,250	30	60	10
1-C	30,150	30,000	100	4,300	600	200	120,000	20,000	60,150	120,700	24,500	205,350	30	60	10
2-A	18,200	5,000	20	50	300	100	60,000	10,000	23,200	60,320	10,150	93,670	20	70	10
2-B	9,000	10,000			100	50	60,000	10,000	19,000	60,100	10,050	89,150	20	70	10
3-A	9,200	10,000	20	50	100	50			19,200	120	100	19,420	100		
3-B	23,300	10,000	700	700	300	50			22,300	1,000	750	24,050	90	10	
4-A	2,400	10,000		4,200	200	50			12,400	200	4,250	16,850	70		30
4-B				1,400	100	50				100	1,450	1,550		10	90
5-A	2,400	10,000	1,500	10,400	200	50			12,400	1,700	10,450	24,550	50	10	40
5-B				1,400	100	50				100	1,450	1,550		10	90
6-A	200		20	50	300	50			200	320	100	620	30	50	20

Economic Capacity

Route and section	Average cost of vehicle operation per mile—dollars					Average annual cost of road per vehicle mile—dollars					Average cost of transportation per vehicle mile—dollars					Indicated standard (economic)
	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	
1-A	060	070	082			018	012	009			*078*	082	091			A
1-B	064	076	088			015	010	007			*079*	086	095			A
1-C	.064	076	088			.012	009	006			*.076*	085	094			A
2-A	066	079	.091	.116		029	015	009	003		095	*094*	100	119		B
2-B		079	091	116		034	.019	012	003		100	*098*	103	.119		B
3-A		.050	060	.075			.065	029	009			115	.089	*084*	084	D
3-B		053	.063	.079			045	022	007			098	*085*	086		C
4-A		075	.090	114			.057	027	008			132	*117*	122		C
4-B			.153	146	.244			326	091	.076			479	323	*320*	E
5-A		087	103	.131	.161		046	021	007	004		.135	*125*	138	165	C
5-B			.153	196	.244			286	.104	039			.439	309	*283*	E
6-A			095	121	.150			670	251	065			762	341	*215*	E

Figure 7—as a guide for location and standards, the ultimate road and trail system is laid out as shown in Figure 8. Low type roads purely for administration and protection of the forests, not for public travel, are added if necessary.

Field reconnaissance is made to check the location of each route as plotted on topographic maps and to estimate cost of construction. An economic analysis is for the economic standard, then studies should be made to see if the cost of the route cannot be decreased without reduction of standard, or if the service standard might be reduced without too seriously affecting the free flow and safety of traffic. If the choice of standard does not become apparent from these studies, then as a general practice, the higher standard should be adopted pro-

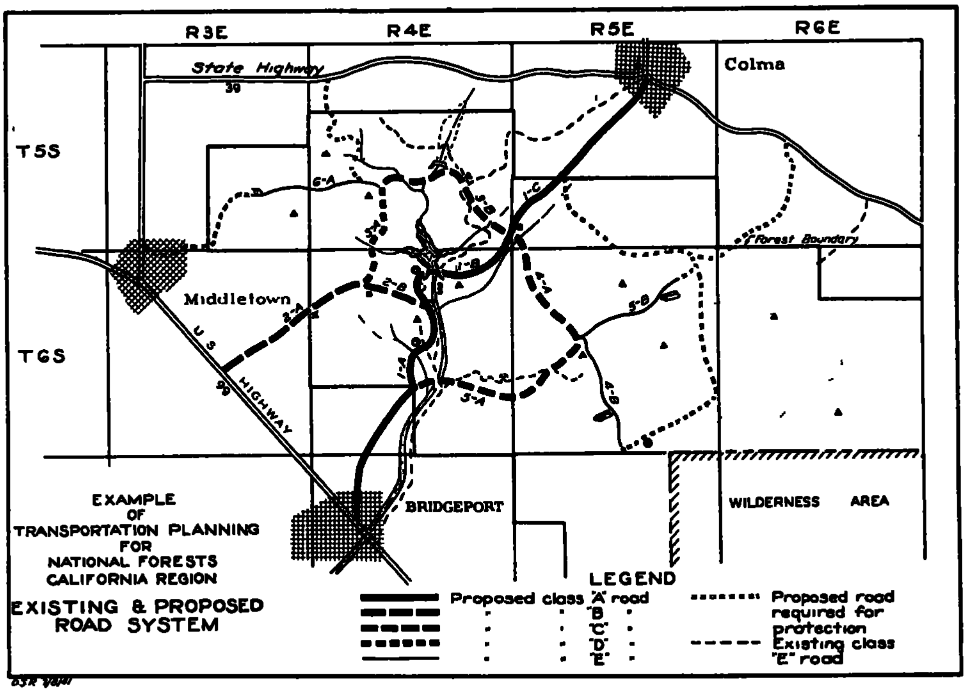

Figure 8. Road and Trail System

then made to check the standard and cost of the route as indicated by the traffic distribution diagram.

A comparison of the service standard and the economic standard is shown in Tables 5 and 6. It will be noted that economic standard and the service standard correspond in the majority of cases.

When the economic capacity indicates a higher standard than is required by the service standard, obviously the higher standard should be adopted. When the service requirement shows that a higher standard is necessary than is indicated vided the cost is not unreasonably out of proportion with the standard indicated by the economic analysis.

The plan is not to be frozen; that is, it is not to be strictly adhered to regardless of changing conditions. It is assumed to be sufficiently flexible to permit revision to conform to unforeseen requirements without monetary loss or without losing any of the advantages it is designed to attain. Corrections will be made as found necessary, and a thorough review of the entire plan will be made at intervals of perhaps five years.