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Policy Preferences for Conservation of Transportation Energy in Case of Fuel Shortage

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The attitude and behavior of travelers during the oil embargo of the winter of 1973-1974 were analyzed. Immediately after the embargo period, questionnaires containing forced-choice pairs of combinations from a set of 10 possible transportation-related energy-conservation policy actions were mailed to 2323 households in regions of Iowa that did not contain a city of 50 000 or more population. Tabular analysis of the data indicated that respondents overwhelmingly favored policies of uniform speed regulation and voluntary participation and were strongly opposed to increased prices as a conservation policy. Analysis of the data by means of paired-comparison scales indicated that the aggregate sample was more concerned about the degree of constraint and its effect on life-styles than about the type of conservation policy (pricing versus rationing). Young adults favored severe rationing or severe price increases less than other groups. Persons earning high incomes favored voluntary participation more than speed-limit regulation, and low- and middle-income groups felt the opposite. Regions with few high-speed highways favored the 88.5-km/h (55-mph) speed limit significantly more than did other areas. Public acceptance of any future transportation-related energy policy appears to be strongly related to the perceived distribution of available transportation options.

The oil embargo imposed by the Middle Eastern petroleum-exporting nations from November 1973 through March 1974 created a situation in which transportation-related energy conservation policies could be evaluated. The embargo affected manufacturing processes that depended on relatively cheap fuels, agricultural fertilizer production, homes heated by oil, and those portions of the power industry that used oil-fired furnaces to generate electricity. But the impacts on automobile transportation were the most dramatic and pervasive. The general public, legislative and executive governmental processes, and the market economy were subjected to three conditions:

1. Gasoline shortage—Available gasoline supplies were significantly short of demand in some areas, which produced long lines at service stations;
2. Price rise—The pump price for gasoline approximately doubled in most areas during the embargo period; and
3. Conservation debate—A highly publicized debate developed about the various social and economic aspects of conservation policies.

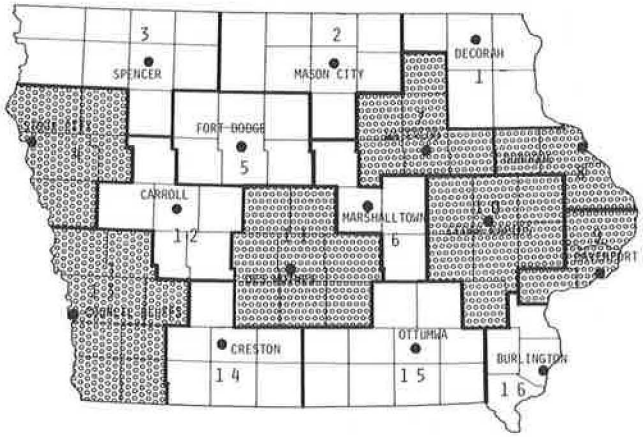
Several research activities resulted that were designed to examine fuel consumption levels and public perception of the long- and short-term impact of policy alternatives (1, 2, 3). The research reported here is one such study.

CONTEXT OF THE RESEARCH

The original research dealt with 59 Iowa counties in nine multicounty planning regions that do not contain cities of 50 000 or more population as regional centers (Figure 1). A random sample of 2323 households was selected from cities ranging in size from 32 366 (Burlington, 1970 census) to 599 (Titonka, 1970 census) to individual rural residences to represent the approximately 1 200 000 persons residing in the 59 counties.

A questionnaire designed to determine individual preferences for policy alternatives and other data to be correlated with the preferences was initially mailed to all sample households. The first mailing was followed up with a postcard—a combination reminder-thank you—7 d later. A second mailing to all nonresponding households about a month later and subsequent telephone contacts brought the total returns to 1837 questionnaires (83.7 percent of the original sample). A total of 1398 questionnaires were completed and analyzed. Deceased persons and untraceable bad addresses accounted for 127 questionnaires, and 3.8 percent of the households refused to participate in the survey. The response rate is attributed to the systematic approach to both the design of the questionnaire and to distribution procedures as well as extensive media efforts to keep the public in-

Figure 1. Nine multicounty Iowa study regions (unshaded areas).



formed of the survey content and the results. These details of the survey are reported elsewhere (4, 5, 6).

FORMAT OF SURVEY QUESTIONNAIRE

A trade-off strategy was used to estimate a preference for one fuel conservation policy over another by the forced-choice method of paired comparisons (7). It is difficult for persons or households to relate an existing value system to an unknown and untried transportation alternative. Questions that require direct valuation—such as, If a bus came to your door and was fare-free, would you ride it?—have in the past overestimated the willingness of people to ride a bus. People are prone to answer yes without comparing the trip advantages at the origin with a potentially more efficient means of reaching the destination. A forced-choice paired comparison always provides reference data for scaled ranking of preferences to avoid such respondent bias.

Several factors were considered significant in establishing the format of the questionnaire items:

1. If n alternatives are presented, (n/2) (n - 1) paired choices must be presented for a complete scale of n factors. Thus, the total number of unique alternatives had to be minimized to ensure a reasonable rate of cooperation on a mailed survey questionnaire.
2. Each alternative policy should be presented at several levels of conservation constraint. Some of the alternatives had to be presented at a severe enough level to involve sacrifice by all households and yet for all alternatives there had to be at least a remote possibility of implementation.
3. The range of alternatives should include price variations, constraints on fuel availability, tax incentives, intercity travel-speed constraints, and various incentives to individual participation. Such diverse alternatives would cover the public debate and experimentation encountered during the embargo period, which households were asked to use as a reference.

Transportation-related energy conservation policy alternatives were then formulated in the form of constraints and incentives, as follows (1 L = 0.26 gal, 1 km = 0.62 mile, and 1 km/L = 2.35 miles/gal):

Constraint	Policy
Gasoline price	
$0.26/L	D-1
$0.40/L	D-2
$0.80/L	D-3
Fuel supply	
75.7 L/week/household	E-3
37.8 L/week/household	E-4
18.9 L/week/household	E-5
Travel speed	
Rigidly enforced 88.5-km/h limit	F-3
72-km/h limit at present enforcement level	F-4
48-km/h limit at present enforcement level	F-5

Incentive	Policy
Individual participation	
Subsidies to bus systems to encourage increased ridership	G-1
Special incentives to car pooling	G-2
Voluntary reduction in household travel	G-3
Tax	
Automobiles with <8.5-km/L efficiency	H-1
Automobiles with <10.6-km/L efficiency	H-2

These alternatives would have generated 91 separate pairs from which survey respondents would have had to make choices. Consultation with other researchers involved in this kind of research (the mail survey) led the staff to believe that people simply could not or would not complete such a long list of paired choices, especially when it was combined with other survey items. The length of the paired-choice list was therefore reduced by using only two gasoline-price constraints [$0.26 and $0.80/L ($1 and $3/gal)], two fuel-supply constraints [37.8 and 18.9 L/week (10 and 5 gal/week)], one tax incentive to automobile efficiency [<8.5 km/L (<20 miles/gal)], two intercity travel-speed constraints [rigid 88.5-km/h (55-mph) speed limit and 72-km/h (45-mph) speed limit], and all three incentives to individual participation.

Further reduction in the required number of pairs was achieved by assuming that most respondents would not be able to perceive a significant difference between the incentives to voluntary behavior and the other, more drastic alternatives. Thus, no pairs comparing voluntary travel reduction, bus subsidies, and car-pool incentives were presented. A further assumption was that all respondents sought to minimize personal costs and maximize personal options. Therefore, it was assumed that all persons preferred 37.7 L (10 gal) to 18.9 L (5 gal) of gasoline per week as a ration limit, preferred to pay $0.26/L ($1/gal) for gasoline rather than $0.80/L ($3/gal), and preferred a speed limit of 88.5 km/h (55 mph) rather than 72 km/h (45 mph). This reduced the set of paired choices to 39, and these were arranged in random order before the questionnaires were printed.

SURVEY FINDINGS

Compatibility With Socioeconomic Census Data

The table below compares the age, education, and household income of the sample respondents with 1970 U.S. Census data for the survey population (8):

Characteristic	Percentage of Population (1970 Census)	Percentage of Sample
Age		
14 to 18	13.3	0.2
19 to 24	7.8	7.4
25 to 64	58.5	69.6
65 and over	20.4	20.0
No response		2.8
Total	100	100

Characteristic	Percentage of Population (1970 Census)	Percentage of Sample
Education		
No school	0.5	0.1
Some grade school	7.8	1.6
Completed grade school	21.8	11.4
Some high school	14.2	11.9
Completed high school	38.2	35.1
Some college	10.6	19.6
Completed college	6.9	13.7
Trade school		0.4
No response		6.2
Total	100	100
Income		
< $3000	12.4	6.7
$3000 to $4999	12.8	7.8
$5000 to $6999	15.4	8.7
$7000 to $9999	23.6	16.1
$10 000 to $24 999	32.7	45.3
$25 000 and over	3.1	6.5
No response		8.9
Total	100	100

If persons 18 years old and younger are deleted from the total 1970 population distribution, it conforms closely to the indicated age profile of the respondents. It was assumed that in almost all households an adult would complete the questionnaire.

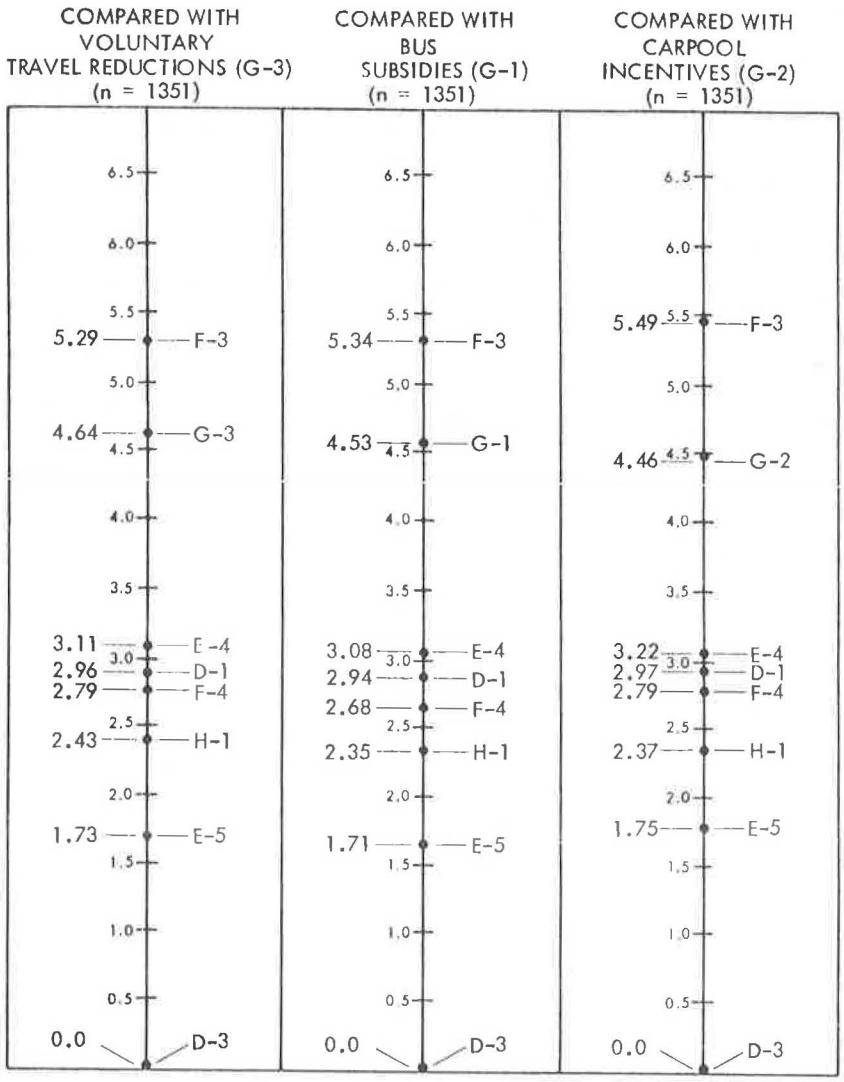
Respondents to mailed-questionnaire surveys tend to be better educated but, because a substantial proportion of the respondents to this survey had not completed high school or had only completed grade school, the education bias was considered minimal. Furthermore, because of a strong correlation between education and income, income was taken to be a better variable than education in explaining variation in preferences. Income levels tended to be higher in 1974 than the 1970 Census indicated they were for 1969. This is partly accounted for by the inflation that occurred between 1969 and 1974 and partly by the higher education levels within the sample.

Overall, the sample group was sufficiently compatible with 1970 U.S. Census information to be considered representative of the approximately 1 200 000 persons residing in the survey regions.

Aggregate Sample Preferences

The percentage rankings of the paired choices made on each pair of alternatives are given below, in descending order of preference. The table indicates average preference for each of the 10 policy alternatives over the other 9 possible choices (n = 1398):

Figure 2. Preference scale for nonvoluntary versus voluntary measures.



Policy	Percentage of Sample Preferring Policy	Policy	Percentage of Sample Preferring Policy
F-3	85.2	E-4	40.7
G-3	75.3	H-1	40.3
G-1	73.9	E-5	22.7
G-2	67.9	D-1	17.4
F-4	55.1	D-3	3.9

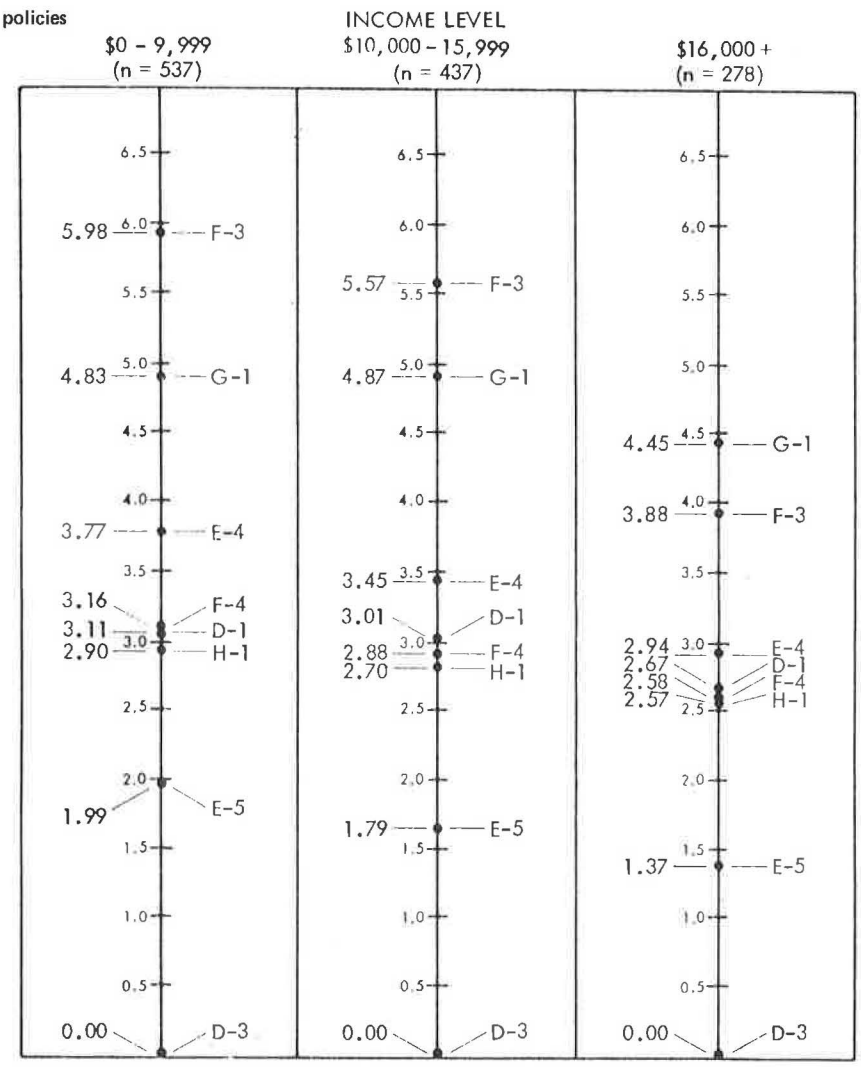
Note that no direct comparison is made among policies G-1, G-2, and G-3.

The respondents have in effect said that they most prefer the current major conservation effort: the 88.5-km/h (55-mph) speed limit. The next most preferred alternatives were those policies that involve incentives to individual behavior, which leave the individual free to participate or not depending on what best suits each person's needs, desires, and opportunities for participation—i.e., voluntary travel reduction, bus subsidies, and car-pool incentives. These are essentially "soft" policies in that none requires a radical restructuring of most life-style patterns. The remaining order and percentages of the preferences seem to indicate that the respondents emphatically preferred strong regulatory measures over greatly increased prices. (Data collected on energy-related policy alternatives have in the past most often been presented and analyzed in this form.)

An analysis of the preferences by use of a paired-comparison attitude scale reveals a somewhat different pattern for the "hard" policies. Figure 2 shows the separate scales constructed for each of the voluntary-behavior policies. The 88.5-km/h (55-mph) speed limit was still clearly the most preferred of the alternatives presented and voluntary travel restriction was the next most preferred alternative in each scale. (Note that the higher the scale value is, the more an alternative is preferred with respect to choices lower in value on the scale.)

D-3 was the least preferred alternative, which is consistent with the raw average preferences. However, E-4, D-1, and F-4 were all about equally preferred, F-4 being the least preferred of the three. This is a reversal of the average preferences given in the table above. Such a finding is particularly important because tabular analysis of the preferences would ordinarily have shown a strong tendency among respondents to indicate a potential willingness to adopt strict governmental conservation measures rather than market price constraints on consumption if large reductions in consumption were required. The relatively high ranking of policy D-1, with respect to all the alternatives presented to the respondents except F-3 and the voluntary-behavior alternatives, suggests that overall the survey respondents were no more strongly opposed to pricing than to other options as a means of curtailing energy consumption.

Figure 3. Preference scale by income level for policies including bus subsidies (G-1).



Policy Preference by Income Level

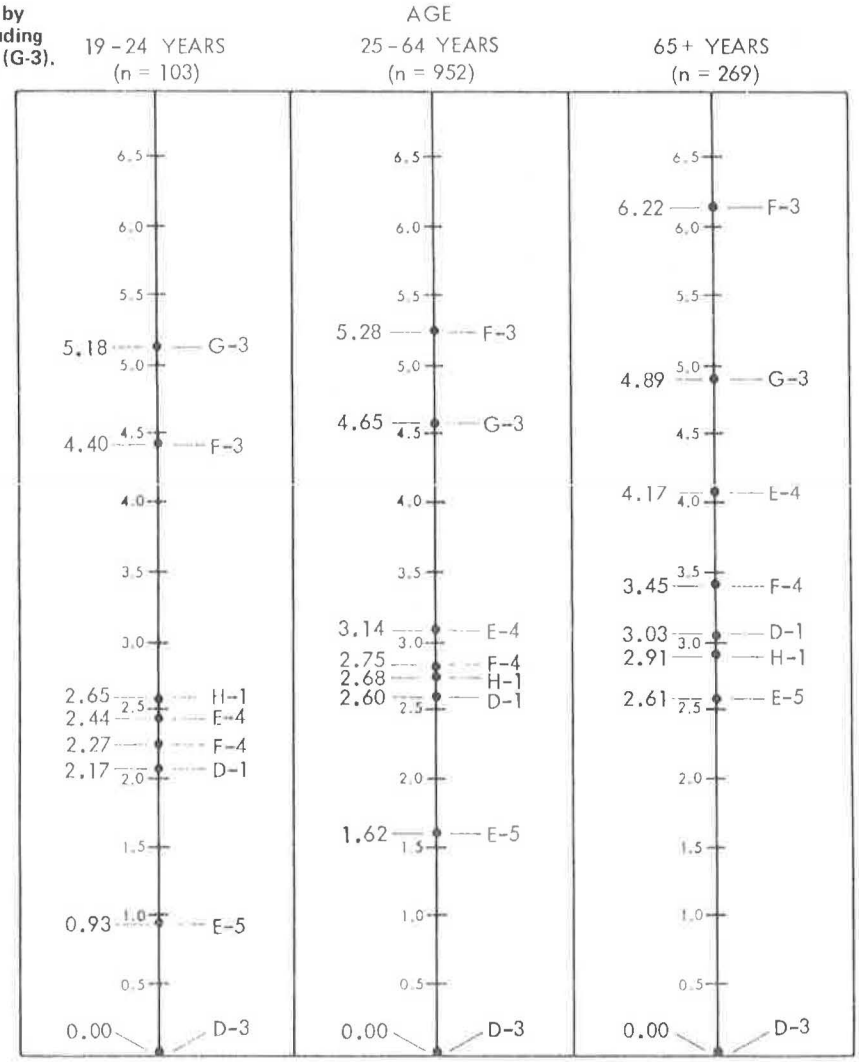
The respondents were subdivided into subsamples by income levels of <$10 000/year (household budgets with little economic flexibility), $10 000 to $16 000/year (households with the potential to have more than one automobile), and $16 000 or more/year (households with sufficient income to purchase alternative transportation in a crisis) to test the possible effect of income bias on the scaling of price-related policies. Figure 3 shows that, in contrast to the total sample pattern, E-4 is now preferred to D-1 by the low- and middle-income groups. These two groups represent about 80 percent of the total population. If one assumes nationwide average annual travel of about 16 000 km/year/automobile (10 000 miles/year/automobile) and current nationwide average automobile efficiencies, 37.7 L/week (10 gal/week) represents a driving allowance of about 10 800 km/year (6700 miles/year). A vehicle that averages more than 8 km/L (19 miles/gal) of gasoline could be driven approximately 16 000 km/year on 37.7 L/week. A gasoline price of $0.26/L ($1/gal) would have represented a doubled price at the time of the survey. The fact that a policy that would on the average tend to curtail travel by one-third is perceived by the vast majority of respondents as being more restrictive (but not greatly more so) than a doubling of fuel prices is interesting.

The high-income scale for all three policies that involve voluntary, individual participation showed an interesting and important shift in the ranking of alternatives. (Although Figure 3 shows only one of the three sets of scales, all three scales were similar.) First, the scales closed up significantly with respect to the zero-value alternative (D-3); extremely high-priced fuel was indicated as acceptable to such persons under certain conditions. Second, the nationwide 88.5-km/h (55-mph) speed limit was perceived as less desirable than the voluntary-behavior policies. Apparently persons with substantial incomes do not value the savings in energy and the greater safety associated with the lowered speed limit as much as they value their travel time for intercity trips. This implies that public acceptance of an energy policy is related to variations in income-related options within the population.

Policy Preference by Age Level

The total sample was factored by age to seek a measure of the age-related effect of life-style on policy preferences. The age groups chosen were those aged 19 to 24, to represent young households without an established community position or occupation; 25 to 64, to represent those in the primary employment years; and 65 and older, to represent the group withdrawing from active participation in the regular travel demands associated with employment. Figure 4 shows preference scales by

Figure 4. Preference scale by age group for policies including voluntary travel reduction (G-3).



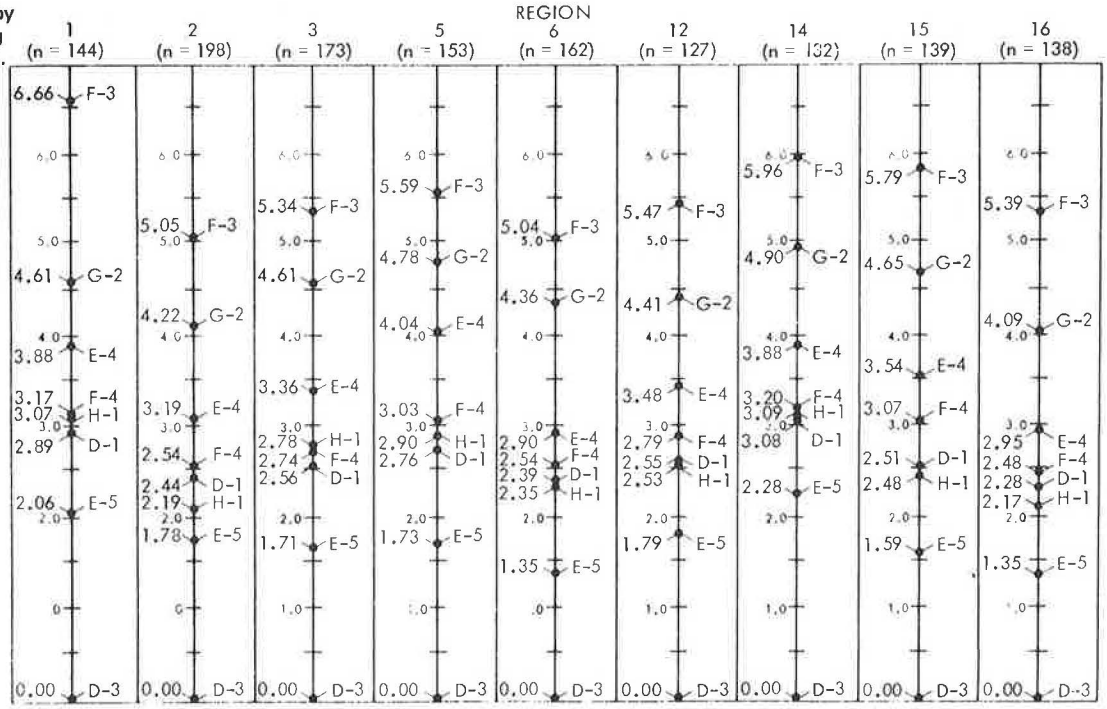


Figure 5. Preference scale by region for policies including car-pooling incentives (G-2).

age group for policy sets containing the car-pooling incentive. (A similar pattern existed for the other scale groups containing voluntary measures.) The 19-to-24 age group ranked the restrictive or hard policy alternatives lower than did the other age groups. Preferences of younger persons tended to be very similar to those of the high-income group; both groups showed no preference for any policy that represents a constraint on household mobility. Younger persons also considered an 18.9-L/week (5-gal/week) ration limit almost as restrictive as a gasoline price of $0.80/L ($3/gal).

The elderly indicated a preference pattern significantly different from that of the total sample. They strongly favored those policies that could be considered to have little or no effect on the life-style of retired persons, such as the 88.5-km/h speed limit and the policies involving voluntary participation. The indication that elderly persons do not favor policies that will constrain their life-style is significant for obtaining public support for conservation policies in states in which a large proportion of the population is over 65 (e.g., Iowa, Nebraska, and Florida).

Policy Preference by Region

The total sample was divided into subsamples by planning regions in which respondents resided. Preference scales by region for policy sets containing the car-pool incentive are shown in Figure 5. Region 1 consistently showed an unusually high preference for the 88.5-km/h (55-mph) speed limit. Region 1 is in the northwest part of Iowa where a large proportion of the highways are in sharp curves and high-speed vehicle operation is thus not safe or prudent. Residents in these regions thus indicated a preference for a policy from which they incur little or no penalty. Representatives of some western states have contended that the nationwide imposition of an 88.5-km/h speed limit is more of a penalty on their areas than it is on the eastern part of the nation. The variations in topography and highway networks found in this sample indicate that these representatives may be expressing the views of their constituents. The preference scales do indicate that any highly restrictive and rigidly enforced energy policy should consider regional variations if widespread public support is needed to ensure policy effectiveness.

IMPLICATIONS AND CONCLUSIONS

The preferences indicated in the total sample illustrated that, immediately after the fuel shortage associated with the 1973-1974 oil embargo, people desired the energy conservation policy that least affected their personal life-style or, as an option, allowed them to decide the conditions under which to participate. Thus, they were most disposed to accept the already existing 88.5-km/h speed limit or to be in favor of actions such as voluntary reduction of travel, car-pool incentives, and bus subsidies. Further stratification of the total sample indicated that young people were not at all in favor of severe ration limits, that high-income groups preferred policies that encouraged individual participation to the existing 88.5-km/h speed limit, that the elderly were strongly in favor of the 88.5-km/h speed limit over anything else, and that areas without high-speed highways preferred the 88.5-km/h speed limit. In other words, people preferred those policies that would least affect their life-style, and after that they preferred those policies that were comparatively less severe in nature. These findings suggest that, in making future policy choices between the hard options of rationing and pricing, the issue is not which of the two is a more acceptable philosophy to the public but whether the resulting distribution of supply is perceived as acceptable to the household life-style, regardless of the form the conservation policy takes.

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findings and conclusions are solely our responsibility. The manuscript was typed by Nante Brewer.

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L_{eq} Traffic Noise Prediction Method

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The development, accuracy, reliability, and application of the L_{eq} highway noise prediction method developed in Ontario are outlined. This empirical method for predicting energy-equivalent sound levels is based on 182 sound measurements taken near rural and urban freeways, highways, and residential streets. The method is in the form of a nomograph and can be used to predict traffic noise on both highways and residential streets. The standard error of estimate for the L_{eq} method was about 2.24 dBA. Comparisons of measured and calculated L_{eq} levels indicated that this method is more accurate than the Revised Design Guide method of the National Cooperative Highway Research Program. The paper also outlines a simple method for direct prediction from annual average daily traffic volumes of day-night A-weighted equivalent sound levels (L_{dn}) caused by traffic noise.

The original 1974 Ontario highway noise prediction method predicts L_{10} and L_{50} sound levels (sound levels exceeded 10 and 50 percent of the time) for all typical highway situations (1). The accuracy of the L_{10} predictions provided by the method has been shown to be equal to or better than the accuracy of the predictions of some more complicated methods (2, 3). However, the original Ontario method does not enable the prediction of energy-equivalent sound level (L_{eq}), which is now coming into common use. For this reason, the method has been expanded to include a simple, reliable prediction of L_{eq}.

Some of the characteristic differences between the L_{eq} and L_{10} measures and the reasons for the growing use of L_{eq} are as follows:

1. A recent experimental study by Pearsons and others (4) concluded that L_{eq} correlates with annoyance and speech interference caused by traffic noise as well as or better than L_{10}. Although other studies (5, 6) have not reached exactly the same conclusion, they have not established a practical difference between L_{eq} and L_{10} in regard to the correlation with annoyance caused by traffic noise. This may be explained by a very high correlation between the L_{eq} and L_{10} levels themselves (2).
2. The adoption of a universal noise measure for the measurement and evaluation of all transportation noise sources is one of the basic requirements for transportation noise control (and noise-pollution control in general) and for consistent and integrated analyses of transportation systems. For example, a transportation planner should be able to compare directly the noise environment near an expressway with the noise environment near a railroad. This requirement cannot be met by using L_{10}.
3. Units of measurement for transportation noise should be understandable to planners, who in turn should be able to explain the results of noise studies to the public. L_{eq} does not appear to be more difficult to grasp than L_{10}. Both units generally use the A-weighting.
4. Because L_{eq} for any given period does not depend on the sequence in which noise events occur, a theoretical prediction of traffic noise that uses L_{eq} is less complicated than a prediction that uses L_{10}. This also applies to the prediction of noise from other sources, such as railway, construction, and industrial noise.
5. L_{eq} is potentially easier to measure than L_{10}; savings in instrumentation costs can be expected to result from the adoption of L_{eq} as a universal noise measurement. A relatively cheap instrument for direct L_{eq} measurement is becoming available.
6. The adoption of a widely recognized measurement unit makes the studies, research, and experience of other countries fully accessible. The trend in both the United States (7) and Europe (8) is definitely toward the use of L_{eq}.
7. Units of sound measurement should enable easy manipulation of measured or calculated quantities. L_{eq} levels emitted by different sources can be added, but adding L_{10} or similar statistical measures is rather complicated. (Direct addition of the L_{10} levels from two sources may not yield the L_{10} of the sources operating together.) These considerations are important in, for example, noise analyses of joint rail and highway corridors.