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Impacts with Yielding Fixed Objects by Vehicle Weight

Impacts with Yielding Fixed Objects by Vehicle Weight

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Summary

This report describes the frequency of impacts with trees and poles in vehicle-to-object crashes (excluding those that were primarily rollover) and the resulting damage to the impacted tree or pole. Previous research has shown that injury rates are lower in heavier vehicles in both multiple-vehicle and single-vehicle crashes. Part of the explanation for the lower injury rates among occupants of heavy vehicles seems to be that when a heavy vehicle collides with another vehicle, the other vehicle tends to be lighter. That is, what might appear to be an advantage of the absolute weight is largely the advantage of the relative weight in vehicle-to-vehicle impacts.

The explanation for the lower injury rates for occupants of heavy vehicles in single-vehicle crashes is more elusive. It has been suggested that part of the explanation may be that heavier vehicles are more likely to damage the object contacted, which would mean a lower crash severity for the vehicle and its occupants. This paper addresses this suggestion by exploring how many the vehicle-to-object crashes involved tree and poles, how often these vehicles were damaged by the vehicle impact, and how these crashes varied by vehicle weight.

It appears that about half of vehicle-to-object crashes involved trees and poles, and about a third of these trees or poles were damaged by the impact. Damage to the tree or pole appears more likely for heavier vehicles than for lighter vehicles in front impacts, but not in side impacts.

Data

There were 7,452 vehicle-to-object crashes of towed light vehicles investigated by the National Accident Sampling System (NASS) during the six years from 1988 to 1993. For this analysis, impact type was defined by the most severe damage to the vehicle and the associated object contacted in that collision (regardless of whether there was a less-severe vehicle-to-vehicle impact). Vehicles classified as "primary rollovers" (those that rolled over and also had primary damage caused by either overturn, ground contact, or an impact with a ditch, culvert, or curb) or with an unknown contact were not included here. Of the investigated vehicles involved in vehicle-to-object crashes:

- 3,852 contacted a tree or pole,
- 3,597 contacted another identified object, and
- 3 were reported as involved in a noncollision event.

These vehicles included 2,475 with primary damage to the front and 1,386 with primarily side damage.

Method

Light passenger vehicles were classified as passenger cars, utility vehicles, passenger vans, or pickup trucks using the NASS body type variable. Passenger cars were divided into six classes based on the vehicle curb weight

reported by the NASS investigators. The weight classes were defined in the standard 500-pound categories used by the agency, as follows:

Minicompact	= up to 1,949 pounds
Subcompact	= 1,950 through 2,449 pounds
Compact	= 2,450 through 2,949 pounds
Intermediate	= 2,950 through 3,449 pounds
Fullsize	= 3,450 through 3,949 pounds
Largest	= 3,950 pounds and over.

Utility vehicles were divided into the three subcategories defined by the 1992 and 1993 NASS body type: compact utility vehicles, large utility vehicles, and utility station wagons. Utility vehicles in cases investigated between 1988 and 1991 were reclassified into the later scheme using the reported vehicle make, model, and model year. Passenger vans were classified as either minivans or large vans, as defined by the NASS body type. Pickup trucks were classified as either compact pickup trucks or large pickup trucks, as defined by the NASS body type. Pickup trucks with slide-in campers and convertible pickups were reclassified as compact or large pickup trucks based on the reported vehicle make and model.

The NASS data are stored as Statistical Analysis System (SAS) files, and SAS was used to create the tables included here. The tables show the number of investigated cases, the national estimates produced by statistically weighting the data (using the national inflation factors), and relevant percentages for damage received from impacts with trees and poles. No adjustments have been made for missing data, so the results are underestimates of the number of occurrences nationwide during these six years. However, the results should be useful in describing the relative frequency of impacts and damage involving trees and poles.

NASS is a statistical sample, and estimates derived from NASS contain both sampling and nonsampling errors. Some idea of the reliability of the estimates is suggested by the number of investigated cases on which each estimate is based, with estimates based on only a few cases being particularly susceptible to sampling error.

Frequency of Tree and Pole Impacts

Table 1 shows that a substantial fraction of vehicle-to-object crashes involved impacts with trees and poles. An estimated:

- 44 percent of front damage and
- 55 percent of side damage

in vehicle-to-object crashes was attributed to contacts with trees and poles. The percentage of car-to-object frontal crashes that involved impacts with trees and poles was:

- 37 percent for minicompact cars,
- 48 percent for subcompact cars,
- 44 percent for compact cars,
- 42 percent for intermediate cars,
- 43 percent for fullsize cars, and
- 46 percent for the largest cars.

Figure 1 suggests that cars of all weights were about as likely to have a tree or pole as the object contacted in frontal vehicle-to-object towaway crashes.

The percentage of car-to-object side crashes that involved impacts with trees and poles was:

60 percent for minicompact cars,
43 percent for subcompact cars,
53 percent for compact cars,
60 percent for intermediate cars,
67 percent for fullsize cars, and
58 percent for the largest cars.

The results seems to suggest that trees and poles accounted for a larger fraction of side-impact vehicle-to-object crashes for heavier cars. The fraction of side-impact vehicle-to-object crashes that involved trees and poles was 48 percent for the three lightest classes combined and 62 percent for the three heaviest classes combined. Minicompact and the largest cars do not seem to fit the pattern, but these classes have the smallest number of investigated cases.

A greater fraction of large utility vehicles, large vans, and large pickup trucks involved in front-impact vehicle-to-object crashes had a tree or pole as the object contacted than was the case for compact utility vehicles, minivans, and compact pickup trucks, respectively. That is, the larger version of each of these three vehicle had a larger fraction of vehicle-to-object crashes into trees and poles (rather than into other objects). This was also the case for utility vehicles and pickup trucks involved in side impacts, but not for passenger vans in side impacts. However, some of these comparisons are based on small numbers of investigated cases.

Damage to Impacted Trees and Poles

Most vehicle-to-object crashes involved damage to the front or side of the vehicle, so consideration of the effect of the impact on the tree or pole was limited to these two vehicle damage areas. Table 2 shows the outcome for trees and poles impacted by the front or side of a light vehicle. An estimated 35 percent of the trees and poles contacted by either the front or the side of the vehicle were damaged. This damage included cracked, sheared, and tilted trees and poles, uprooted trees, poles separated from the base, and poles reported to have been "replaced."

The likelihood of damage to the tree or pole when it was impacted by the front of a light vehicle seemed to vary by vehicle size. For passenger cars with front damage from tree or pole contact:

32 percent of minicompact cars,
32 percent of subcompact cars,
28 percent of compact cars,
44 percent of intermediate cars,
41 percent of fullsize cars, and
56 percent of the largest cars

caused some sort of damage to the tree or pole. Figure 2 seems to show a pattern of increasing tree or pole damage with increasing car weight, which suggests that heavier vehicles could offer more protection to their occupants in tree and pole frontal impacts. The larger versions of utility vehicles and passenger vans also had higher rates of damage to the impacted tree or pole in frontal impacts, but this was not the case for pickup trucks.

A different effect is suggested by the data for side impacts. For passenger cars with side damage from tree or pole contact:

39 percent of minicompact cars,
33 percent of subcompact cars,
30 percent of compact cars,
37 percent of intermediate cars,
23 percent of fullsize cars, and
27 percent of the largest cars

caused some sort of damage to the tree or pole. There does not appear to be a consistent pattern of either increasing or decreasing damage to trees and poles associated with differences in car weight. There were very few investigated cases of utility vehicles or passenger vans impacting a tree or pole. There were more pickup trucks, and compact pickup trucks had a higher rate of tree or pole damage than did large pickup trucks (based on a small number of investigated cases).

Delta V for Tree and Pole Impacts

The NASS investigators do not attempt to estimate either pre-crash or at-crash speeds, but they do attempt to estimate delta V (the change in the vehicle velocity during the impact). It would be useful to compare the fraction of damaged trees and poles to the delta V. However, Table 3 shows that damage to the tree or pole virtually precludes estimation of delta V; damage to the tree or pole usually violates an assumption needed to use the estimation method.

Figure 1 (above) and Figure 2 (below)

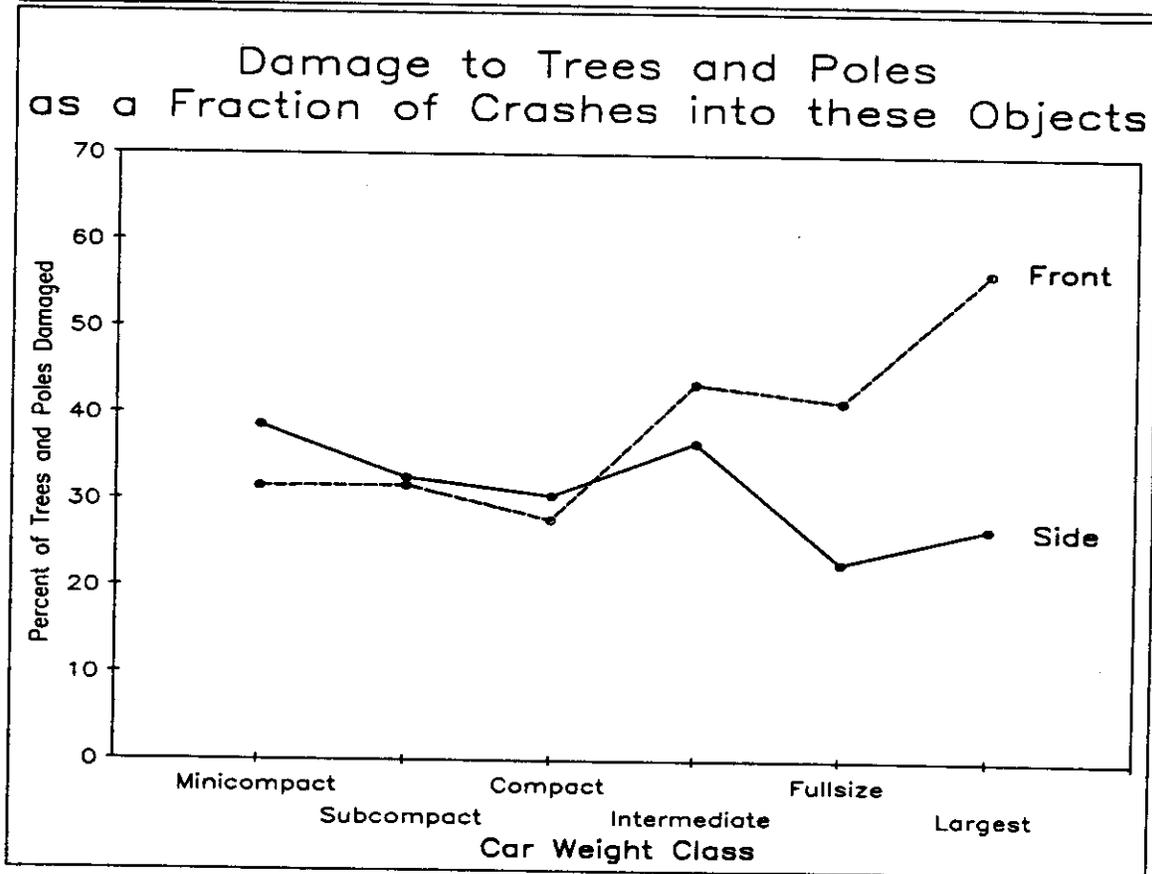
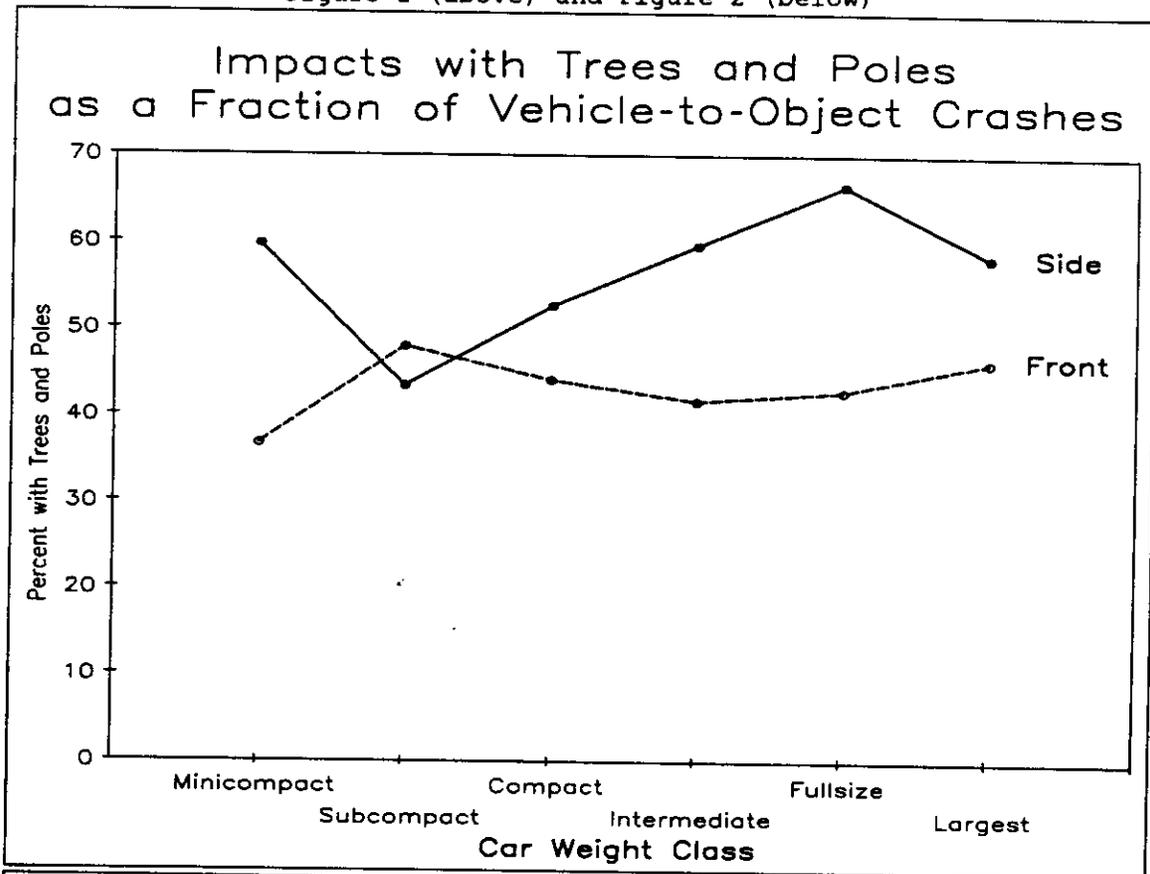


Table 1: Vehicle-to-Object Crashes Excluding Primary Rollover, by the Type of Object Contacted
1988-1993 NASS Data

Vehicle Type	DAMAGE=Front				DAMAGE=Side				
	NASS Investigated Cases		National Six-Year Weighted Estimates		NASS Investigated Cases		National Six-Year Weighted Estimates		
	Non-collision	Collision with: Tree/Pole Other	Non-collision	Collision with: Tree/Pole Other	Non-collision	Collision with: Tree/Pole Other	Non-collision	Collision with: Tree/Pole Other	
All Vehicles	1	2,475	2,481	4,957	99	791,656	990,077	1,781,831	44.43
Car Minicompact	0	84	100	184	0	23,877	41,176	65,053	36.70
Car Subcompact	0	546	585	1,131	0	171,481	185,908	357,389	47.98
Car Compact	1	557	515	1,073	99	179,302	227,740	407,141	44.04
Car Intermediate	0	412	437	849	0	126,230	176,991	303,221	41.63
Car Fullsize	0	218	202	420	0	58,893	78,845	137,738	42.76
Car Largest	0	107	122	229	0	45,836	53,520	99,356	46.13
Car Unknown	0	2	2	4	0	797	67	865	92.23
Utility Compact	0	82	62	144	0	21,768	32,799	54,568	39.89
Utility Large	0	19	14	33	0	8,079	8,501	16,581	48.73
Utility Stationwagon	0	4	3	7	0	964	3,844	4,808	20.05
Van Minivan	0	49	36	85	0	12,012	17,439	29,451	40.79
Van Large	0	64	68	132	0	18,590	18,839	37,429	49.67
Van Unknown	0	1	2	3	0	15	1,062	1,077	1.39
Pickup Compact	0	141	164	305	0	39,283	64,237	103,520	37.95
Pickup Large	0	174	156	330	0	78,917	77,424	156,341	50.48
Pickup Unknown	0	0	1	1	0	0	178	178	0.00
Light Truck Other	0	15	12	27	0	5,610	1,508	7,117	78.82

Vehicle Type	DAMAGE=Front				DAMAGE=Side				
	NASS Investigated Cases		National Six-Year Weighted Estimates		NASS Investigated Cases		National Six-Year Weighted Estimates		
	Non-collision	Collision with: Tree/Pole Other	Non-collision	Collision with: Tree/Pole Other	Non-collision	Collision with: Tree/Pole Other	Non-collision	Collision with: Tree/Pole Other	
All Vehicles	2	932	452	1,386	1,979	316,228	252,832	571,039	55.38
Car Minicompact	0	31	15	46	0	5,704	3,846	9,550	59.73
Car Subcompact	0	182	128	310	0	58,973	76,856	135,828	43.42
Car Compact	0	239	109	348	0	64,036	57,577	121,613	52.66
Car Intermediate	1	207	81	289	1,804	71,191	46,346	119,341	59.65
Car Fullsize	0	96	41	137	0	47,645	23,963	71,608	66.54
Car Largest	0	40	12	52	0	15,605	11,170	26,775	58.28
Car Unknown	0	0	1	1	0	0	8	8	0.00
Utility Compact	0	21	7	28	0	4,210	2,234	6,444	65.34
Utility Large	0	6	2	8	0	2,501	51	2,553	97.99
Utility Stationwagon	0	3	3	6	0	118	1,091	1,209	9.77
Van Minivan	0	14	6	20	0	5,159	893	6,051	85.25
Van Large	1	9	9	19	175	1,129	1,332	2,636	42.84
Van Unknown	0	1	0	1	0	356	0	356	100.00
Pickup Compact	0	51	19	70	0	28,016	21,631	49,647	56.43
Pickup Large	0	28	17	45	0	11,293	3,989	15,282	73.90
Light Truck Other	0	4	2	6	0	291	1,846	2,136	13.62

Table 1 (continued): Vehicle-to-Object Crashes Excluding Primary Rollovers, by the Type of Object Contacted
1988-1993 NASS Data

Vehicle Type	NASS Investigated Cases				National Six-Year Weighted Estimates				Tree/Pole as Percent of Total
	Non-collision		Collision with:		Non-collision		Collision with:		
	Tree/Pole	Other	Tree/Pole	Other	Tree/Pole	Other	Tree/Pole	Other	
All Vehicles	0	53	67	120	0	14,606	37,606	52,213	27.97
Car Minicompact	0	2	3	5	0	263	366	628	41.80
Car Subcompact	0	14	28	42	0	1,710	22,609	24,319	7.03
Car Compact	0	9	16	25	0	3,004	8,530	11,534	26.05
Car Intermediate	0	16	7	23	0	7,147	956	8,103	88.20
Car Fullsize	0	7	7	14	0	1,848	2,662	4,510	40.98
Car Largest	0	1	2	3	0	148	1,155	1,303	11.35
Car Unknown	0	1	0	1	0	10	0	10	100.00
Utility Stationwagon	0	1	0	1	0	292	0	292	100.00
Van Minivan	0	1	0	1	0	145	0	145	100.00
Pickup Compact	0	1	2	3	0	39	522	561	6.97
Pickup Large	0	0	2	2	0	0	807	807	0.00

----- DAMAGE=Back -----

Vehicle Type	NASS Investigated Cases				National Six-Year Weighted Estimates				Tree/Pole as Percent of Total
	Non-collision		Collision with:		Non-collision		Collision with:		
	Tree/Pole	Other	Tree/Pole	Other	Tree/Pole	Other	Tree/Pole	Other	
All Vehicles	0	94	136	230	0	34,081	80,344	114,425	29.78
Car Minicompact	0	4	3	7	0	557	1,051	1,608	34.61
Car Subcompact	0	21	29	50	0	4,383	17,197	21,580	20.31
Car Compact	0	24	37	61	0	4,656	23,635	28,291	16.46
Car Intermediate	0	9	25	34	0	1,454	12,780	14,234	10.21
Car Fullsize	0	4	11	15	0	1,365	5,842	7,206	18.94
Car Largest	0	5	6	11	0	16,887	4,569	21,456	78.71
Utility Compact	0	5	3	8	0	1,889	1,330	3,219	58.69
Van Minivan	0	2	5	7	0	125	9,327	9,452	1.32
Pickup Compact	0	8	5	13	0	1,123	1,620	2,743	40.95
Pickup Large	0	11	11	22	0	1,603	2,970	4,573	35.06
Light Truck Other	0	1	1	2	0	38	24	62	61.52

----- DAMAGE=Other -----

Table 1 (continued): Vehicle-to-Object Crashes Excluding Primary Rollovers, by the Type of Object Contacted
1988-1993 NASS Data

Vehicle Type	NASS Investigated Cases				National Six-Year Weighted Estimates				Tree/Pole as Percent of Total
	Collision with:		Total Cases	Non-collision	Collision with:		Total Estimate		
	Tree/Pole	Other			Tree/Pole	Other			
All Vehicles	0	298	461	759	0	133,753	279,736	413,488	32.35
Car Minicompact	0	5	13	18	0	2,168	5,049	7,217	30.04
Car Subcompact	0	56	89	145	0	25,443	63,337	88,780	28.66
Car Compact	0	70	86	156	0	29,624	32,495	62,119	47.69
Car Intermediate	0	45	84	129	0	28,983	51,465	80,448	36.03
Car Fullsize	0	26	43	69	0	11,046	13,958	25,004	44.18
Car Largest	0	11	22	33	0	4,748	5,391	10,139	46.83
Car Unknown	0	1	1	2	0	5	909	914	0.56
Utility Compact	0	9	11	20	0	4,026	5,516	9,542	42.19
Utility Large	0	4	4	8	0	725	1,026	1,751	41.40
Utility Stationwagon	0	1	3	4	0	107	1,159	1,266	8.48
Utility Unknown	0	1	1	2	0	1,775	173	1,948	91.12
Van Minivan	0	9	12	21	0	3,863	7,444	11,308	34.17
Van Large	0	10	16	26	0	4,117	5,932	10,049	40.97
Van Unknown	0	0	1	1	0	0	164	164	0.00
Pickup Compact	0	21	28	49	0	3,501	43,281	46,782	7.48
Pickup Large	0	27	47	74	0	13,460	42,437	55,897	24.08
Light Truck Other	0	2	0	2	0	160	0	160	100.00

Table 2: Vehicle-to-Object Crashes into Trees and Poles
by the Vehicle Size and Condition of the Tree and Pole
1988-1993 NASS Data

Vehicle Type	NASS Investigated Cases			National Six-Year Weighted Estimates			Damage as Percent of Known		
	Damage to Tree or Pole?		Total Cases	Damage to Tree or Pole?		Total Estimate			
	No	Yes		No	Yes				
All Vehicles	1,683	763	29	2,475	509,471	274,037	8,148	791,656	34.98
Car Minicompact	55	28	1	84	16,187	7,444	245	23,877	31.50
Car Subcompact	407	134	5	546	116,671	53,960	850	171,481	31.62
Car Compact	381	170	6	557	127,800	48,857	2,645	179,302	27.66
Car Intermediate	264	143	5	412	71,027	54,928	275	126,230	43.61
Car Fullsize	142	76	0	218	34,487	24,405	0	58,893	41.44
Car Largest	76	31	0	107	19,984	25,852	0	45,836	56.40
Car Unknown	1	1	0	2	675	122	0	797	15.34
Utility Compact	55	27	0	82	14,903	6,865	0	21,768	31.54
Utility Large	11	7	1	19	4,079	3,263	737	8,079	44.45
Utility Stationwagon	1	3	0	4	66	898	0	964	93.16
Van Minivan	35	12	2	49	9,748	2,157	107	12,012	18.12
Van Large	41	20	3	64	13,583	4,954	53	18,590	26.73
Van Unknown	1	0	0	1	15	0	0	15	0.00
Pickup Compact	94	43	4	141	21,705	14,476	3,101	39,283	40.01
Pickup Large	108	64	2	174	53,870	24,913	135	78,917	31.62
Light Truck Other	11	4	0	15	4,670	940	0	5,610	16.76

Vehicle Type	NASS Investigated Cases			National Six-Year Weighted Estimates			Damage as Percent of Known		
	Damage to Tree or Pole?		Total Cases	Damage to Tree or Pole?		Total Estimate			
	No	Yes		No	Yes				
All Vehicles	626	291	15	932	200,967	108,538	6,722	316,228	35.07
Car Minicompact	23	7	1	31	3,490	2,194	20	5,704	38.60
Car Subcompact	134	47	1	182	39,787	19,176	10	58,973	32.52
Car Compact	171	64	4	239	44,176	19,356	504	64,036	30.47
Car Intermediate	130	73	4	207	44,592	25,788	812	71,191	36.64
Car Fullsize	61	32	3	96	32,998	9,739	4,908	47,645	22.79
Car Largest	24	16	0	40	11,412	4,193	0	15,605	26.87
Utility Compact	13	8	0	21	2,288	1,923	0	4,210	45.66
Utility Large	2	4	0	6	1,549	953	0	2,501	38.09
Utility Stationwagon	3	0	0	3	118	0	0	118	0.00
Van Minivan	7	6	1	14	1,994	2,870	294	5,159	59.00
Van Large	4	4	1	9	273	683	174	1,129	71.48
Van Unknown	1	0	0	1	356	0	0	356	0.00
Pickup Compact	33	18	0	51	10,488	17,528	0	28,016	62.56
Pickup Large	17	11	0	28	7,199	4,094	0	11,293	36.26
Light Truck Other	3	1	0	4	249	42	0	291	14.29

Table 3: Vehicle-to-Object Crashes into Trees and Poles
by the Vehicle Delta V and Condition of the Tree and Pole
1988-1993 NASS Data

Delta V (mph)	NASS Investigated Cases			National Four-Year Weighted Estimates			Damage as Percent of Known
	Damage to Tree or Pole?		Total Cases	Damage to Tree or Pole?		Total Estimate	
	No	Yes		No	Yes		
Unknown	436	729	1,184	144,126	267,036	6,953	418,115
00-09	44	0	44	53,933	0	0	53,933
10-19	536	17	559	216,675	5,677	981	223,333
20-29	472	10	485	76,601	952	205	77,758
30-39	143	4	148	13,665	121	10	13,796
40-49	40	2	42	3,952	236	0	4,188
50 +	12	1	13	518	13	0	531

----- DAMAGE=Front -----

Delta V (mph)	NASS Investigated Cases			National Four-Year Weighted Estimates			Damage as Percent of Known
	Damage to Tree or Pole?		Total Cases	Damage to Tree or Pole?		Total Estimate	
	No	Yes		No	Yes		
All	626	291	932	200,967	108,538	6,722	316,228
Unknown	302	282	595	105,354	107,289	6,438	219,080
00-09	81	2	83	39,359	552	0	39,912
10-19	147	4	153	46,864	661	166	47,691
20-29	69	0	71	7,760	0	119	7,879
30-39	22	3	25	1,275	36	0	1,311
40-49	4	0	4	208	0	0	208
50 +	1	0	1	147	0	0	147

----- DAMAGE=Side -----