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**THE EFFECTS OF FOREST COVER AND ROAD DENSITY ON WETLAND
INSECT SPECIES RICHNESS IN EASTERN ONTARIO.**

by

Erik A. Klingbeil, B.Sc.H.

A thesis submitted to the Faculty of Graduate Studies and Research
in partial fulfillment of the requirements for the degree of

Master of Science

Department of Biology

Carleton University

Ottawa, Ontario, Canada

18 January 2002

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**The undersigned recommend to the Faculty of Graduate Studies
and Research acceptance of the thesis**

**The Effects of Forest Cover and Road Density on Wetland Insect Species
Richness in Eastern Ontario.**

Submitted by Erik A. Klingbeil, B.Sc.(Hons.)

**A thesis submitted to
the Faculty of Graduate Studies and Research
in partial fulfilment of the requirements for
the degree of Master of Science**

Thesis Supervisor

Chair, Department of Biology

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Jan. 18, 2002

Abstract

In this study, the anthropogenic effects of surrounding forest cover and road density on wetland insect species richness were investigated. Multiple regression analyses were used to determine the relationships between species richness and wetland area, forest cover, and road density. There was no significant relationship between species richness of all aquatic insects and wetland area in this study. Species richness of all aquatic insects increased with increasing road density at a distance of 100 meters from the wetland boundaries, while no significant effect was produced for forest cover. However, when the same analysis was performed on dragonfly species richness and wetland area a significant positive effect was determined. Dragonfly species richness was positively affected by both gravel road density (1750 meters) and forest cover (100 meters). The increase in species richness with the presence of these anthropogenic effects is initially counterintuitive, however possible explanations are made.

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TABLE OF CONTENTS

LIST OF TABLES.....	vi
LIST OF FIGURES.....	vii
LIST OF APPENDICES.....	viii
INTRODUCTION.....	1
MATERIALS AND METHODS.....	6
Wetland Location.....	6
Aquatic Insect Sampling.....	6
Forest Cover and Road Density.....	8
Statistical Analyses.....	10
RESULTS.....	13
Species-area Relationships.....	13
Effects of Paved Roads and Forest Cover.....	13
DISCUSSION.....	15
Effects of Forest Cover and Road Density on Aquatic Insect Species....	15
LITERATURE CITED.....	21

LIST OF TABLES

Table 1. Effect of paved road density on aquatic insect species richness.....	31
Table 2. Effect of forest cover on aquatic insect species richness.....	33
Table 3. Effect of wetland area and gravel road density on dragonfly species richness.....	34
Table 4. Effect of wetland area and forest cover on dragonfly species richness.....	36

LIST OF FIGURES

Figure 1. Location of study sites in eastern Ontario.....	26
Figure 2. Example of a digitized wetland and the corresponding 13 buffers (100 to 3000 meters).....	27
Figure 3. Species-area relationship for aquatic insects in 29 eastern Ontario wetlands	28
Figure 4. Relationship of insect species richness and insect abundance.....	29
Figure 5. Species-area relationship for dragonfly species in 29 eastern Ontario wetlands	30
Figure 6. Plot of the relationship between aquatic insect species richness and paved road density for 0-100 meters.....	32
Figure 7. Partial plot of the relationship between dragonfly species richness and gravel road density for 0-1750 meters.....	35
Figure 8. Partial plot of the relationship between dragonfly species richness and forest cover for 0-100 meters.....	37

LIST OF APPENDICES

Appendix 1. Universal Transverse Mercator (UTM) coordinates of the wetland sites.....	38
Appendix 2. Taxonomic keys used in this study to identify aquatic insect species.....	39
Appendix 3. Legend to Appendix 4.....	40
Appendix 4. Forest cover, road density, and insect data for 29 wetlands in eastern Ontario	43

Introduction

The effect of forest removal and the presence of roads on ecosystems has received much attention in terrestrial ecological studies. Agriculture, residential development and road construction resulting in forest removal, have been shown not only to reduce the amount of habitat for organisms, but also to fragment the habitat making movement between forest patches difficult if not impossible for many organisms (Mader 1984; Trombulak and Frissell 2000). When forested areas are cleared, sedentary species (i.e. plants) and slow moving species (i.e. many invertebrates) will be killed during the clearing process or shortly after due to exposure to unfavorable conditions and predators (Trombulak and Frissell 2000). The removal of forest also leads to edge effects in the remaining forest. Edge effects tend to favor the increase in populations of generalist species while decreasing the populations of interior-inhabiting species (Lidicker 1999). Invasive species tend to be generalists, which may lead to edge habitat providing favorable conditions for their establishment and spread (Lidicker 1999). Habitat fragmentation through forest removal can also create and isolate subpopulations, reduce the exchange of genes between populations, alter species interactions, and change or even inhibit some ecological processes (Davies and Margules 1998). The effects of habitat destruction are quite obvious, whereas the effects of roads are not as obvious.

The presence of roads affects organisms in many different ways. Road noise produced by passing cars has been shown to reduce population densities

of nesting birds along the sides of roads (Reijnen *et al.* 1995). Male willow warblers were shown to have difficulty in attracting and keeping a mate due to the distortion of the song by road noise (Reijnen and Foppen 1994). Dust and sand blown by the wind or by passing cars can damage plants by destroying cells, blocking stomata, facilitating the effects of gaseous pollutants from car exhausts, and affecting photosynthesis, respiration, and transpiration (Spellerberg 1998; Trombulak and Frissell 2000). Plants and animals that live along the sides of roads have been shown to have increased concentrations of heavy metals in their tissues (Spellerberg 1998; Wade *et al.* 1980). The gases emitted in car exhaust have been shown to cause damage to plants and trees, resulting in stunted growth, and in some cases increased growth from the addition of nitrogen to the soil (Spellerberg 1998). The most obvious effect of roads on animal species is fatal collisions with automobiles. Amphibians have been shown to suffer high mortality when crossing roads to access overwintering and breeding sites (Vos and Chardon 1998; Fahrig *et al.* 1995). There have been many studies on the road-kill mortality of large mammals and bird species (Trombulak and Frissell 2000). In some cases animals, such as many amphibian and reptile species, are even attracted to roads to absorb the warmth from the pavement surface (Rosen and Lowe 1994).

The presence of roads also affects species in less obvious ways. Road salt run-off has been shown to reduce species richness and abundance of plants that are not tolerant of elevated salt concentrations (Richburg *et al.* 2001). In

aquatic systems this may increase the possibility of invasion by native or introduced brackish-water species into freshwater habitats (Richburg *et al.* 2001). The presence of roads can also act as barriers between habitats or populations, and reduce the amount of genetic exchange between subpopulations, increasing the risk of patch extinctions (Baur and Baur 1990; Mader 1984; Spellerberg 1998; Trombulak and Frissell 2000; Vos and Chardon 1998). The construction and presence of roads can also cause debris flows in streams and rivers, alter the natural flow rates and pathways of water, as well as cause sedimentation in aquatic habitats (Gunn and Sein 2000; Jones *et al.* 2000; Trombulak and Frissell 2000). Road networks are also believed to be a factor in the spread of invasive species (Lonsdale and Lane 1994; Spellerberg 1998; Trombulak and Frissell 2000).

The effect of road mortality on insects has received very little attention in the past simply due to the logistical nightmare of trying to determine how many insects have been hit by passing automobiles (Riffell 1999). For many aquatic insect species roads probably have little direct effect (e.g. road-kill) due to the sedentary nature of the adults since they feed and breed in the wetland itself (Riffell 1999). However, for some groups of insects such as dragonflies and many fly taxa, the adults will travel between the wetlands and foraging or breeding grounds on a daily basis (Riffell 1999). The road mortality potential for these species may be much greater than for other taxa because there is a higher frequency of road crossings, especially when roads border or cross a wetland

(Riffell 1999). In some cases insects are even attracted to roads and this could result in extreme road mortality. Many species of swarming insects such as mayflies and caddisflies are attracted to lights along roads and bridges (Merritt and Cummins 1996) where the probability of being struck by passing cars is very high. A recent study by Kriska (1998) has shown that mayflies are attracted to road surfaces by the polarized light reflected from the asphalt surface that imitates the light reflected from a water surface. The higher temperature above a paved road at night also helps to prolong mating flights, which may increase the likelihood of being struck by an automobile (Kriska 1998). The attraction of insects to roads would probably also occur at a relatively close distance since the attractive cues would have to be within sight of the wetland.

There have been many studies on the effects of human activities on rivers, streams, and lakes, but apart from studies on pollution, few have looked at wetlands. However, a study by Findlay and Houlihan (1997) investigated the effects of road density and forest cover (within buffer zones) on wetland plants and animals. Their data showed a strong positive relationship between wetland area and species richness for all studied taxa (Findlay and Houlihan 1997). This result is consistent with the idea that a larger area will support more species, which is a common idea in conservation studies and management (Wilson 1992). This also supports the common idea in wetland evaluations that the inherent value of a wetland increases with its area (Findlay and Houlihan 1997; OMNR 1994; Environmental Laboratories 1987). The species richness of all the taxa

except mammals showed a significant negative relationship with road density within 2 kilometers of the wetland boundaries (Findlay and Houlihan 1997). The species richness of herptiles and mammals also showed a significant positive relationship with forest cover within 2 kilometers of the wetland (Findlay and Houlihan 1997). These results suggest that road construction and the destruction of forest habitats within 2 kilometers of a wetland may have a detrimental effect on the diversity and abundance of wetland species (Findlay and Houlihan 1997).

The purpose of this study is to determine whether the forest cover and road density surrounding the wetlands affects the species richness of aquatic insects. If there is an effect of forest cover or road density on aquatic insect species richness, the distance at which the effect is greatest will be identified. This was accomplished by performing a study that is complementary to that of Findlay and Houlihan (1997), by sampling the insect fauna in 29 wetlands, and relating species richness to forest cover and road density in increasingly large buffer zones around the wetland.

Materials and Methods

Wetland Location

The twenty-eight wetlands used in this study were a subset of sites selected from the research of Jeff Houlahan (Houlahan, pers. comm.). One additional wetland belonging to the Canadian Museum of Nature was also included in the study. The sites were in the vicinity of Ottawa, Canada, between 44° 54' and 45° 40' North, and between 74° 50' and 76° 30' West (Figure 1, Appendix 1). The sites used in this study were selected to represent a range of wetland types, surrounding forest cover and road density, and ranged in size from approximately 2 to 230 ha (Houlahan pers. comm.). The types of wetlands used in the study included swamps, bogs, and marshes as well as wetlands comprised of combinations of these types.

Aquatic Insect Sampling

The use of aquatic sweep nets was determined to be the most appropriate method to collect aquatic insects for this study. Since many sites were used in this study, the use of submerged traps was not possible because they must be emptied every 24 or 48 hours. Otherwise, large predators (insects, fish or amphibians) would devour smaller insects, thus skewing the results and possibly eliminating small herbivorous insects from the species lists. Previous studies have shown that standardized aquatic sweep net sampling results in the collection of larger numbers of individuals and taxa when compared to other collecting techniques (Furse *et al.* 1981; Mackey *et al.* 1984; Murkin *et al.* 1983;

Turner and Trexler, 1997). Many other techniques tend to be selective for certain groups of aquatic macroinvertebrates. Activity traps (i.e. funnel or minnow style traps) tend to be susceptible to predation by fish and large predatory invertebrates as well as selective against ambush predators such as dragonfly nymphs and other relatively sedentary species (Murkin *et al.* 1983). Stovepipe samplers tend to select for sedentary and benthic creatures, and thus do not collect many free-swimming species (Murkin *et al.* 1983).

Insect specimens were collected using standardized aquatic sweep net samples. The nets were constructed using strong materials (1/4 inch steel hoop, 30 centimeters in diameter, and fiberglass window screen bags with canvas skirts to protect from damage) in order to resist damage from underwater obstructions. The pore size of the window screen bags was approximately 1 millimeter. The nets were mounted upon 1.8 meter long handles that allowed a long reach in order to sample areas of the marsh that were not disturbed by our movements through the wetlands. The sweeps were standardized by making a 2 meter long sweep at eight locations throughout the area of each wetland. Two of the eight sweeps were made at a greater depth in order to sample the benthic insects. The distribution of sample locations in each wetland was chosen in order to cover the largest amount of the area as possible. The sweeps were made through the submerged vegetation along a border of open water. Vegetation borders typically have higher richness and abundance than dense

vegetation or the open water column (McLaughlin and Harris 1990; Painter 1999). The eight samples were pooled for each of the individual wetlands.

The specimens were collected once from each site during the peak of species richness and abundance of the aquatic insects as determined from a previous study (Klingbeil, unpublished data). In the previous study, insect specimens were collected on a weekly basis from the beginning of May to the end of August. Species richness and abundance for each week were plotted and peaks in species richness and abundance were determined. Specimens were collected once from each wetland to represent a collection protocol used for a survey or monitoring type of study using indicator species. All of the samples were taken within a 10 day period from June 18th to the 27th. The live specimens were then returned to the laboratory and sorted, then stored in preservative (70% acetic alcohol) for later identification. The specimens were identified to the species level (if possible) using taxonomic keys (see Appendix 2). In some cases only nymphs were collected (e.g. Odonata, Ephemeroptera and Trichoptera) and they were identified to the species level (if possible). Specimens that could not be identified to the species level were separated into operational taxonomic units.

Forest Cover and Road Density

The forest cover and road density data used in this study were calculated from a different source than those used in the paper by Findlay and Houlihan

(Houlahan, pers. comm.). The data used in the Findlay and Houlahan study were compiled from Government of Canada 1:50,000 topographic maps produced from aerial photographs between 1976 and 1989 (Findlay and Houlahan 1997). The data used in this study were calculated using geo-referenced aerial photographs (1999) providing more detail and accuracy than the topographic maps made from information ten years ago. The wetland boundaries were digitized and buffers were created from 100 to 3000 meters from the wetland boundary (Figure 2; Houlahan pers. comm.). The buffers were delineated areas on the air photos within which forest cover and road density could be calculated. The buffers were determined at specified distances from the wetland border. The forested areas and roads (road type determined from topographic maps) were then digitized and the total forested area and road length were calculated within each buffer. The estimates of the proportion of forest cover were made by dividing the total amount of forested land in a distance interval by the total area of the distance interval, not including the area of the wetland or any relatively large areas of open water (e.g. lakes or rivers) (Houlahan, pers. comm.). The estimates of road density were calculated by taking the total length of roads within a distance interval and dividing by the total area within the interval, including the wetland area (Findlay and Houlahan 1997). The area of the wetland was included in this calculation since in several cases roads passed along or through the boundaries of the wetlands (Findlay and Houlahan 1997). The estimates of road density were broken into two categories: paved roads and gravel/dirt roads (Findlay and Houlahan 1997). The forest cover

and road density data for 28 of the wetlands were acquired from Jeff Houlahan. The data for the Museum of Nature wetland were compiled by the author.

Statistical Analyses

In order to determine the species-area relationship of the insect fauna, simple linear regressions were performed using the log-transformed species richness of aquatic insects and the log-transformed area of the wetland. The analysis was also run using a measure of corrected species richness in order to remove bias due to unequal abundance in the wetlands. This was accomplished by using the residuals of the regression of log-transformed species richness on log-transformed total abundance of aquatic insects as the dependent variable in the species-area regression.

Before fitting final regression models, a preliminary series of 64 backwards stepwise multiple regressions were performed in order to determine which of the variables had the greatest effect on species richness and which should be included in the final analysis. The stepwise regressions included the species richness of aquatic insects as the dependent variable and forest cover, paved roads, and gravel road density (for each distance interval) as the independent variables. A subset of four distance classes (0-250, 0-500, 0-1000, and 0-2000 meters) was used in order to reduce the number of iterations that needed to be performed. The preliminary analysis was also run with the corrected species richness as the dependent variable.

The preliminary analysis of the insect data led to three important findings. Gravel road density did not have a significant influence on the insect data once the effect of forest cover or paved road density were taken into account. Therefore, gravel road density was excluded as a variable in the final models. The second finding is that, for the insect data, at every distance the forest cover and paved road densities were significantly negatively correlated. The third point was that paved road density was the only variable included in the final stepwise models. This indicates that forest cover may have very little effect on insect species richness. However, since forest cover and paved road density were highly significantly negatively correlated, the approach of Findlay and Houlihan was also applied, by forming separate models for paved road density and forest cover in the final analysis.

The analysis was also repeated with the species richness of dragonflies in order to determine if the effects of forest cover and road density would differ for highly mobile (adults) insect species when compared to all the wetland insect species. The preliminary series of 64 stepwise backward regressions for dragonflies indicated that gravel roads and wetland area were the most important variables for the final analysis. Since the wetland area was also included in the final models, partial regression plots were used to demonstrate the relationship between species richness and gravel road density. The partial regression plots are comprised of the residuals of the relationships between log-transformed dragonfly species richness and log-transformed wetland area, and the residuals

of the relationship of log-transformed wetland area and gravel road density. As in the analysis for all of the wetland insect species, forest cover was also fitted in a separate final model due to the highly significant negative relationship with roads.

Results

Species-area Relationships

The species richness in the 29 wetlands ranged from 9 to 31 species (Appendix 1). Wetland area was not a significant predictor of species richness (Figure 3; $F = 0.888$; $df = 1, 27$; $p = 0.354$). There was a highly significant positive relationship between log-transformed species richness and log-transformed abundance (Figure 4; $F = 18.383$; $df = 1, 27$; $p < 0.001$). The species-area relationship using the corrected richness (residuals from the regression of species richness on abundance) was even less significant ($F = 0.212$; $df = 1, 27$; $p = 0.649$). Wetland area had a significant positive effect on species richness of dragonflies (Figure 5; $F = 6.275$; $df = 1, 27$; $p = 0.019$).

Effects of Paved Roads and Forest Cover

Paved road density had a significant positive effect on aquatic insect species for the first two distance classes (Table 1). The distance class that produced the model of best fit (highest R^2) was the 0-100 meter distance class (Figure 6). The model using the corrected richness produced a comparable model with slightly higher R-squared values (0-100m $R^2 = 0.216$; 0-200m $R^2 = 0.21$). Since the corrected model was only marginally better, the original uncorrected model was used for comparison to the results of Findlay and Houlihan. Since the model has a significant positive relationship, the final model predicts that an increase of 2 m/ha of paved road in the within 100 meters of the wetland will result in a 2.4% increase in insect species.

The effect of forest cover on aquatic insect species was not significant at any distance from 100 to 3000 meters (Table 2). The model of best fit (R^2) for forest cover was for the 200 meter distance (Table 2). However, the results were not significant ($p > 0.5$) with very low R^2 values ($R^2 < 0.021$).

The analysis using dragonfly species richness as the dependent variable revealed a significant effect of both gravel road density and forest cover. The effect of wetland area and gravel road density on dragonfly species richness was significant and positive at all distance classes (Table 3). The distance class that produced the best model fit (highest $R^2 = 0.503$) was the 1750 meter distance class (Figure 7). The final model predicts that for a 2 m/ha increase in gravel roads within 1750 meters from the wetland there will be a 2.75% increase in dragonfly species. The effect of wetland area and forest cover on dragonfly species richness produced a significant negative relationship at the three smallest distance classes and marginally significant (all $p < 0.066$) at the remaining distance classes (Table 4). The distance class that produced the best model fit (highest $R^2 = 0.220$) was for the 0-100 meter distance class (Figure 8). The model for forest cover predicts a 7.19% increase in dragonfly species if the forest cover is decreased by 20% (e.g. 50% to 30%) within 100 meters from the wetland.

Discussion

Effects of Forest Cover and Road Density on Aquatic Insect Species

This study reveals three interesting results pertaining to wetland insect species richness: 1) Insect species richness did not significantly increase with increases in wetland size; 2) Species richness of aquatic insects significantly increased with increasing paved road density up to 200 meters from the wetland; 3) Forest cover did not significantly influence insect species richness at any distance. The fact that the relationship between species richness and wetland area was not statistically significant was somewhat unexpected. Species-area relationships are common and widespread ecological relationships that appear to apply to most organisms (Wilson 1992). Other factors not measured (i.e. pollution, pH, and nutrient levels) in this study may have been more important determinants of species richness and may have obscured the species–area relationship.

The findings of this study regarding the effects of forest cover and road density were unexpected and opposite to the predictions. Findlay and Houlihan (1997) demonstrated a significant decrease in species richness of plants, birds, and amphibians, and a marginal decrease in that of mammals with increasing paved road density. However, for insects there was an increase in species richness with increasing road density. The lack of forest and presence of roads near a wetland would indicate the presence of agricultural or residential areas. Nutrient run-off into the wetland from these areas would increase the productivity

of the wetland (Mitsch and Gosselink 2000). The increase in the productivity would likely allow the wetland to support a higher abundance and possibly a higher species richness of aquatic insects. Thus the increase in insect species richness with decreasing forest cover may be due to the nutrient run-off from the surrounding cleared lands. However, if there is too much nutrient run-off the productivity of algae may become so great as to cause the wetland to become eutrophic and lacking in oxygen (Mitsch and Gosselink 2000). Eutrophic conditions would eventually lead to a reduction in the number of insect and other wetland species due to the lack of oxygen (Mitsch and Gosselink 2000).

However, the positive effect of paved road density on insect species richness may not be due to the roads themselves. The ditches on the sides of the roads may in fact be affecting insect species richness. Any ditch that holds water for a relatively long period of time, or permanently, could act as habitat for many aquatic insect species. Ditches can support many of the groups of aquatic insect species that were found in the wetlands used in this study (Klingbeil, unpublished data). The area of ditch habitat could increase the area of "wetland" habitat for aquatic insect species. Assuming a ditch has 1 meter in width of water, 10 kilometers of road would be equivalent to 1 hectare of habitat. However, since there is usually a ditch on each side of the road, this estimate would become 5 kilometers of road for each hectare of ditch habitat. The increased wetland area, through the presence of ditch habitat may increase the insect species richness and abundance. The ditches may also act as corridors,

linking other wetlands, allowing dispersal of the insect species. Therefore, the positive effect of paved roads may in fact be due to the presence of roadside ditches, rather than the actual paved roads themselves.

Since a large portion of aquatic insects are relatively sedentary (Riffell 1999), there would likely be little effect of road mortality on wetland insect species richness. The sedentary insect species would experience less of an effect of roads because they would leave the wetland only a few times, for a short duration while mating or dispersing. Therefore, the presence of roads would probably have little effect on the sedentary species. The effects of roads on sedentary wetland insects would also be likely to occur at a much smaller scale than other highly mobile taxa; this is a better representation of the movements of the majority of wetland insects (i.e. short and infrequent movements). This may explain why the positive effect of paved road density on species richness was greatest at 100 meters, since the majority of species would likely not be venturing very far from the wetland on a regular basis, if at all. However, for other insect taxa such as dragonflies, the adults fly larger distances from the wetland and with greater frequency than other insect taxa while traveling to foraging or breeding grounds (Riffell 1999). The travels of these highly mobile species may occur once a day, or even many times a day during foraging flights (Riffell 1999). Therefore, the small distance at which the effects of paved roads are observed may be due to the larger proportion of sedentary species masking

the effects of paved roads at a larger distance on the highly mobile species, which are in the minority.

The analysis on the effects of gravel road density on dragonfly species helps to support this idea that the effects are being masked by species that do not or infrequently venture from the wetlands. Dragonfly species richness was shown to increase with increasing gravel road density. The scale at which roads have a positive effect on dragonflies is greater than the scale at which roads have an effect on all species. This may be due to the shoulders of the gravel roads providing open foraging habitat and corridors for the adults. The amount of ditch habitat may also affect dragonfly species richness by providing more habitat for the nymphs and adults. Instead of melting the snow and ice using road salt, gravel roads tend to be plowed and sanded for traction in the winter. Road salt run-off has been shown to affect many species (Richburg *et al.* 2001). The lack of road salt run-off along gravel roads may be a factor in the increase in dragonfly species with increases in gravel road density. Again, these points indicate that the effects of gravel roads on dragonfly species richness is being masked by the combined effect of all of the wetland insect species.

The non-significant effects of forest cover on insect species richness in the preliminary model does not necessarily indicate no effect at all. Due to the highly negative correlation of paved road density and forest cover it is very difficult to determine which of the variables has the greatest effect on species

richness (Findlay and Houlihan 1997). However, since the effect of forest cover was not significant at any distance in this study, the amount of forest cover probably does not have an effect on insect species richness. It is likely that the majority of aquatic insect species that do not travel into the forested habitat around the wetland, due to their sedentary nature (see discussion of paved roads), are little affected by forest cover. Therefore the effects of forest cover on a smaller number of species, such as dragonflies, that do travel between the wetland and the surrounding habitat may again be masked in the analysis on the entire assemblage by the dominance of more sedentary species.

Since the effect of gravel roads on dragonfly species richness occurs at such a large distance (1750 meters), it is somewhat surprising that forest cover has the greatest effect at the smallest scale (100 meters). Dragonfly species tend to hunt and patrol open areas while foraging for food and searching for mates (Corbet 1980). For many species mating occurs in the wetland or close to the wetland boundaries (Corbet 1980). Wetlands with little surrounding forest cover would provide the largest amounts of nearby foraging and breeding grounds, and therefore would have the largest effect on dragonfly species richness.

The research on the ecological effects of roads and forest cover needs to be continued to gain a better grasp of the ways and extent of human impacts on the environment. While the results of this study suggest that the effects of

decreasing forest cover and increasing road density are beneficial for insect species richness, there may be other confounding issues contributing to these findings. Although species richness of aquatic insects increased in the presence of increased anthropogenic effects, there may be a threshold to this increase. Once this threshold has been achieved, the insect species richness may decline as it did for the taxa studied by Findlay and Houlihan (1997). Aquatic insect species may take a longer time to fully exhibit the effects of road density and forest cover than other organisms. Thus, as human development continues to encroach upon pristine and natural areas, aquatic insects may eventually show the same declining trend as other taxa.

The effects of forest removal and habitat fragmentation on organisms and ecosystems has received a great deal of research, but we are still learning about the wide reach and effect of our actions of clearing and fragmenting the landscape. With the worldwide population increasing along with our increasing dependence on automobiles, studies investigating the effects of forest removal and roads on the environment will become even more important in the near future.

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Figure 1. Location of study sites in eastern Ontario (Horizons Technology, Inc., 1996).

Figure 2. Example of a digitized wetland and the corresponding 13 buffers (100 to 3000 meters)(National Capital Commission Air Photo, 1999).

Figure 3. Species-area relationship for aquatic insects in 29 eastern Ontario wetlands ($p = 0.354$).

Figure 4. Relationship of insect species richness and insect abundance ($p < 0.001$).

Figure 5. Species-area relationship for dragonfly species in 29 eastern Ontario wetlands ($p = 0.019$).

Table 1. Effect of paved road density on aquatic insect species richness.*

Distance(m)	n	alpha	beta	R²	RMS	p Total
0-100	29	17.863	0.217	0.139	30.576	0.047
0-200	29	17.748	0.183	0.135	30.72	0.05
0-300	29	18.069	0.123	0.092	32.247	0.11
0-400	29	18.344	0.0912	0.059	33.412	0.205
0-500	29	18.501	0.0789	0.048	33.816	0.256
0-750	29	18.791	0.0548	0.028	34.507	0.385
0-1000	29	19.067	0.0370	0.013	35.056	0.563
0-1250	29	19.075	0.0359	0.011	35.115	0.59
0-1500	29	19.195	0.0283	0.006	35.28	0.684
0-1750	29	19.324	0.0205	0.003	35.396	0.778
0-2000	29	19.439	0.0134	0.001	35.456	0.854
0-2500	29	19.387	0.0176	0.001	35.45	0.844
0-3000	29	19.604	0.00326	0	35.499	0.965

*The final regression models are of the form $S = \alpha + \beta(\text{Pave})$, where α and β are the fitted regression coefficients, S is the insect species richness, and Pave is the density of paved roads. RMS stands for the residual mean square.

Figure 6. Plot of the relationship between aquatic insect species richness and paved road density for 0-100 meters ($p = 0.047$).

Table 2. Effect of forest cover on aquatic insect species richness.*

Distance(m)	n	alpha	beta	R²	RMS	p Total
0-100	29	21.336	-2.537	0.012	35.091	0.579
0-200	29	21.872	-3.456	0.021	34.74	0.448
0-300	29	21.471	-2.957	0.017	34.914	0.506
0-400	29	20.918	-2.125	0.009	35.197	0.632
0-500	29	20.703	-1.79	0.006	35.286	0.687
0-750	29	20.714	-1.868	0.006	35.285	0.687
0-1000	29	21.349	-3.063	0.015	34.987	0.534
0-1250	29	21.327	-3.046	0.013	35.033	0.553
0-1500	29	21.016	-2.541	0.009	35.195	0.632
0-1750	29	20.653	-1.9	0.005	35.336	0.725
0-2000	29	20.532	-1.696	0.004	35.371	0.755
0-2500	29	20.544	-1.766	0.004	35.362	0.747
0-3000	29	21.288	-3.331	0.014	35.021	0.548

*The final regression models are of the form $S = \alpha + \beta(\text{For})$, where α and β are the fitted regression coefficients, S is the insect species richness, and For is the proportion of forest cover. RMS stands for the residual mean square.

Table 3. Effect of wetland area and gravel road density on dragonfly species richness.*

Distance(m)	n	alpha	beta1	beta2	R ²	RMS	p1	p2	p Total
0-100	27	0.179	0.187	0.0113	0.303	0.02577	0.0040	0.0490	0.0090
0-200	27	0.195	0.177	0.0092	0.252	0.02765	0.0080	0.1490	0.0230
0-300	27	0.137	0.204	0.0097	0.286	0.02642	0.0040	0.0720	0.0130
0-400	27	0.110	0.209	0.0129	0.305	0.02569	0.0030	0.0470	0.0090
0-500	27	0.108	0.205	0.0146	0.305	0.02569	0.0030	0.0470	0.0090
0-750	27	0.102	0.198	0.0181	0.325	0.02496	0.0030	0.0300	0.0060
0-1000	27	0.064	0.212	0.0211	0.349	0.02409	0.0020	0.0180	0.0040
0-1250	27	-0.012	0.234	0.0290	0.441	0.02066	0.0034	0.0020	0.0010
0-1500	27	-0.053	0.244	0.0337	0.476	0.01938	0.0002	0.0010	0.0002
0-1750	27	-0.096	0.253	0.0391	0.503	0.01837	0.0001	0.0004	0.0001
0-2000	27	-0.088	0.245	0.0392	0.462	0.01989	0.0002	0.0012	0.0003
0-2500	27	-0.057	0.227	0.0388	0.407	0.02193	0.0010	0.0050	0.0010
0-3000	27	-0.067	0.210	0.0470	0.430	0.02109	0.0010	0.0030	0.0010

*The final regression models are of the form $\log S = \alpha + \beta_1(\log A) + \beta_2(\text{Grav})$, where α , β_1 and β_2 are the fitted regression coefficients, S is the insect species richness, A is the area of the wetland, and Grav is the gravel road density. RMS stands for the residual mean square, p_1 and p_2 are the probability values for wetland area and gravel road density respectively.

Figure 7. Partial regression plot of the relationship between dragonfly species richness and gravel road density for 0-1750 meters (for explanation of partial plot see Materials and Methods).

Table 4. Effect of wetland area and forest cover on dragonfly species richness.*

Distance(m)	n	alpha	beta1	beta2	R²	RMS	p1	p2	p Total
0-100	27	0.343	0.167	-0.136	0.220	0.0288	0.013	0.314	0.039
0-200	27	0.339	0.163	-0.125	0.216	0.0290	0.014	0.351	0.042
0-300	27	0.326	0.162	-0.107	0.210	0.0292	0.015	0.414	0.047
0-400	27	0.304	0.159	-0.067	0.197	0.0297	0.018	0.613	0.058
0-500	27	0.292	0.157	-0.043	0.192	0.0299	0.020	0.747	0.063
0-750	27	0.288	0.156	-0.034	0.191	0.0299	0.021	0.805	0.064
0-1000	27	0.286	0.155	-0.029	0.190	0.0300	0.021	0.841	0.065
0-1250	27	0.275	0.153	-0.003	0.189	0.0300	0.023	0.986	0.066
0-1500	27	0.258	0.151	0.037	0.190	0.0299	0.025	0.813	0.064
0-1750	27	0.244	0.149	0.069	0.195	0.0298	0.026	0.662	0.060
0-2000	27	0.237	0.148	0.086	0.198	0.0297	0.026	0.587	0.057
0-2500	27	0.234	0.149	0.091	0.199	0.0296	0.024	0.570	0.056
0-3000	27	0.247	0.151	0.060	0.193	0.0298	0.022	0.710	0.062

*The final regression models are of the form $\log S = \alpha + \beta_1(\log A) + \beta_2(\text{For})$, where α , β_1 and β_2 are the fitted regression coefficients, S is the insect species richness, A is the area of the wetland, and For is the proportion of forest cover. RMS stands for the residual mean square, p_1 and p_2 are the probability values for wetland area and forest cover respectively.

Figure 8. Partial regression plot of the relationship between dragonfly species richness and forest cover for 0-100 meters (for explanation of partial plot see Materials and Methods).

Appendix 1

Universal Transverse Mercator (UTM) coordinates of the wetland sites.

Wetland	Nearest City/Town	Easting	Northing
AL62093	Alfred	506244	5043799
Ashton Station	Ashton	417688	5002429
Asphalt Plant	Gloucester	456582	5017372
Corkery Creek	Corkery	414339	5015777
Cranberry Creek	Kars	449157	4994559
East of Fish Ponds	White Lake	391054	5022896
Findlay Creek	Gloucester	454744	5018542
Glen Cairn	Nepean	431957	5017230
Grove Creek	Almonte	404365	5005107
Junkyard	Gloucester	453167	5012128
Kilmaurs	Kilmaurs	408529	5033708
Limoges Marsh	Limoges	480544	5021490
Lower Poole	Stittsville	425191	5013151
Lowney Lake	White Lake	384282	5015236
Merrickville Marsh	Merrickville	433194	4973838
Mud Lake	Ottawa	437690	5024782
Mud Pond	Kanata	426439	5027174
Museum Marsh	Manotick Station	452254	5005400
Nopoming	Arnprior	399189	5031804
Ok Kee Lee	Carleton Place	409408	4998628
Panmure	Panmure	409449	5020186
Petro Can.	Stittsville	424932	5013963
Reid Lake	Middleville	388380	5000989
Stanley Creek	Clayton	393580	5007242
Stony Swamp	Nepean	435472	5015858
Trailer Park	Gloucester	452986	5012826
West Queensway	Stittsville	423357	5013497
West Burnt Lands	Almonte	405399	5012231
Wolf Creek	Limoges	482378	5022256

Appendix 2

Taxonomic keys used in this study to identify aquatic insect species.

Taxa:	Taxonomic keys:
Orders	Borror et al. 1992
Genus (all orders)	Merritt and Cummins 1996
Odonata (nymphs)	Merritt and Cummins 1996
Hemiptera (all species)	Needham and Westfall 1955
Hemiptera: Gerridae	Blatchley 1926
	Andersen 1993
	Cheng and Fernando 1970
	Drake and Harris 1934
Coleoptera (all species)	Downie and Arnett 1996
Coleoptera: Dytiscidae	Larson et al. 2000
Coleoptera: Gyrinidae: Gyrinus	Oygur and Wolfe 1991
Coleoptera: Hydrophilidae	Smetana 1988

Appendix 3

Legend to Appendix 4.

Code:	Insect Species:
Numspecies	Total Number of Species in each wetland
LogSpecies	Log base 10 of "Numspecies"
TotAbundance	Total abundance for each wetland
LogAbundance	Log base 10 of "TotAbundance"
Area	Wetland Area
LogArea	Log base 10 of "Area"
For"xxxx"	Percent Forest Cover within a "xxxx" meter buffer (Using total area of buffer minus wetland area)
Tfor"xxxx"	Percent Forest Cover within a "xxxx" meter buffer (Using total area of buffer minus wetland area and area of lakes or rivers)
Four"xxxx"	Density of Four-lane highways (meters per hectare)
Hwy"xxxx"	Density of Two-lane highways (meters per hectare)
Hard"xxxx"	Density of other paved roads (meters per hectare)
Pave"xxxx"	Density of all hard surface (paved) roads (Sum of four-lane, two-lane, and other paved roads)
Grav"xxxx"	Density of gravel roads (meters per hectare)
Ephem1	Ephemeroptera: Unknown Nymphs 1
Ephem2	Ephemeroptera: Unknown Nymphs 2
Ephem3	Ephemeroptera: Unknown Nymphs 3
Odon1	Odonata: Anisoptera: Libellulidae sp.
Odon2	Odonata: Anisoptera: Aeschnidae: <i>Aeshna</i> sp.
Odon3	Odonata: Anisoptera: Aeschnidae: <i>Aeshna canadensis</i>
Odon4	Odonata: Anisoptera: Aeschnidae: <i>Aeshna ermita</i> Scudder
Odon5	Odonata: Anisoptera: Aeschnidae: <i>Aeshna verticalis</i>
Odon6	Odonata: Anisoptera: Aeschnidae: <i>Boyeria grafiana</i> Williamson
Odon7	Odonata: Anisoptera: Aeschnidae: <i>Boyeria vinosa</i> Say
Odon8	Odonata: Anisoptera: Gomphidae sp.
Odon9	Odonata: Anisoptera: Libellulidae: <i>Leucorrhinia intacta</i> Hagen
Odon10	Odonata: Anisoptera: Libellulidae: <i>Myathyria</i> sp.
Odon11	Odonata: Anisoptera: Libellulidae sp.2
Odon12	Odonata: Anisoptera: <i>Tetragoneuria canis</i> McLachlin
Odon13	Odonata: Zygoptera: Coenagrionidae sp.
Odon14	Odonata: Zygoptera: Lestidae sp.
Odon15	Odonata: Zygoptera: Calopteryx sp.
Pleco	Plecoptera: Unknown Nymphs
Hemi1	Hemiptera: Nepidae: <i>Ranatra fusca</i>
Hemi2	Hemiptera: Belostomatidae sp.
Hemi3	Hemiptera: Pleidae: <i>Neoplea striola</i> Fieber
Hemi4	Hemiptera: Hydrometridae: <i>Hydrometra martini</i>
Hemi5	Hemiptera: Notonectidae: <i>Notonecta insulata</i>
Hemi6	Hemiptera: Notonectidae: <i>Notonecta irrorata</i>
Hemi7	Hemiptera: Notonectidae: <i>Notonecta undulata</i>
Hemi8	Hemiptera: Mesovelidae: <i>Mesovelia mulsanti</i>
Hemi9	Hemiptera: Saldidae: <i>Saldula</i> sp.
Hemi10	Hemiptera: Gerridae: <i>Limnoporous</i> sp.1
Hemi11	Hemiptera: Gerridae: <i>Gerris buenoi</i>

Hemi12	Hemiptera: Gerridae: <i>Gerris comatus</i>
Hemi13	Hemiptera: Gerridae: <i>Gerris marginatus</i>
Hemi14	Hemiptera: Corixidae sp.
Coleo1	Coleoptera: Haliplidae: <i>Halipus</i> sp.1
Coleo2	Coleoptera: Haliplidae: <i>Halipus borealis</i>
Coleo3	Coleoptera: Haliplidae: <i>Halipus connexus</i>
Coleo4	Coleoptera: Haliplidae: <i>Peltodytes muticus</i>
Coleo5	Coleoptera: Curculionidae sp.
Coleo6	Coleoptera: Elmidae sp.
Coleo7	Coleoptera: Heteroceridae sp.
Coleo8	Coleoptera: Hydrophilidae: <i>Berosus peregrinus</i>
Coleo9	Coleoptera: Hydrophilidae: <i>Berosos striatus</i>
Coleo10	Coleoptera: Hydrophilidae: <i>Helophorus sempervarians</i>
Coleo11	Coleoptera: Hydrophilidae: <i>Hydrochus squamifer</i>
Coleo12	Coleoptera: Hydrophilidae: <i>Tropisternus mixtus</i>
Coleo13	Coleoptera: Hydrophilidae: <i>Tropisternus natator</i>
Coleo14	Coleoptera: Hydrophilidae sp.1
Coleo15	Coleoptera: Hydrophilidae sp.2
Coleo16	Coleoptera: Hydrophilidae sp.3
Coleo17	Coleoptera: Hydrophilidae sp.4
Coleo18	Coleoptera: Hydrophilidae sp.5
Coleo19	Coleoptera: Hydrophilidae sp.6
Coleo20	Coleoptera: Gyrinidae: <i>Gyrinus</i> sp.1
Coleo21	Coleoptera: Gyrinidae: <i>Gyrinus ventralis</i>
Coleo22	Coleoptera: Gyrinidae: <i>Gyrinus impressicollis</i>
Coleo23	Coleoptera: Gyrinidae: <i>Gyrinus americanus</i>
Coleo24	Coleoptera: Scirtidae Nymphs
Coleo25	Coleoptera: Chrysomelidae sp.1
Coleo26	Coleoptera: Chrysomelidae sp.2
Coleo27	Coleoptera: Chrysomelidae sp.3
Coleo28	Coleoptera: Chrysomelidae sp.4
Coleo29	Coleoptera: Chrysomelidae: <i>Donacia</i> sp.
Dytisc1	Coleoptera: Dytiscidae sp.1
Dytisc2	Coleoptera: Dytiscidae sp.2
Dytisc3	Coleoptera: Dytiscidae sp.3
Dytisc4	Coleoptera: Dytiscidae sp.4
Dytisc5	Coleoptera: Dytiscidae sp.5
Dytisc6	Coleoptera: Dytiscidae sp.6
Dytisc7	Coleoptera: Dytiscidae sp.7
Dytisc8	Coleoptera: Dytiscidae sp.8
Dytisc9	Coleoptera: Dytiscidae: <i>Stictotarsus</i> sp.
Dytisc10	Coleoptera: Dytiscidae: <i>Laccobius</i> sp.
Dytisc11	Coleoptera: Dytiscidae: <i>Laccophilus maculosus</i>
Dytisc12	Coleoptera: Dytiscidae: <i>Hygrotus</i> sp.
Dytisc13	Coleoptera: Dytiscidae: <i>Agabetes</i> sp.
Dytisc14	Coleoptera: Dytiscidae: <i>Acilius semisulcatus</i>
Dytisc15	Coleoptera: Dytiscidae: <i>Colymbetes</i> sp.
Dytisc16	Coleoptera: Dytiscidae: <i>Hydaticus</i> sp.
Dytisc17	Coleoptera: Dytiscidae: Medium Dytiscidae
Dip1	Diptera: Chironomidae sp.
Dip2	Diptera: Culicidae sp.
Dip3	Diptera: Stratiomyidae sp.

Dip4	Diptera: Tipulidae sp.
Dip5	Diptera: Chaoboridae sp.
Trich1	Trichoptera: Leafy Cases (Cylindrical)
Trich2	Trichoptera: Sticks and Stones
Trich3	Trichoptera: Small Sticks (triangular case)
Trich4	Trichoptera: Sandy Cases
Trich5	Trichoptera: Grass tube (long pieces, conical)
Trich6	Trichoptera: Grass spirals (short pieces, conical)
Trich7	Trichoptera: Wood (long pieces, cylindrical)
Trich8	Trichoptera: Wood (small pieces, cylindrical)
Trich9	Trichoptera: Mixed (vegetation, sticks, and shells)
Trich10	Trichoptera: Needles (like a porcupine)
Trich11	Trichoptera: Layered leaf (stacks of leaf pieces)
Lepid	Lepidoptera Unknown Larvae
Hymen	Hymenoptera Unknown Larvae

Appendix 4

Forest cover, road density, and insect data for 29 wetlands in eastern Ontario (see Appendix 2 for legend).

Wetland	NumSpecies	LogSpecies	TotAbundance	LogAbundance	Area	LogArea	For100	Tfor100
AL62093	13	1.113943352	112	2.049218023	2.13	0.328379603	0.884393064	0.884393064
AshtonStation	20	1.301029996	133	2.123851641	152.59	2.183526073	0.238834336	0.238834336
AsphaltPlant	9	0.954242509	12	1.079181246	5.5	0.740362689	0.460531102	0.460531102
CorkeryCreek	24	1.380211242	82	1.913813852	212.86	2.328094058	0.795821772	0.795821772
CranberryCreek	25	1.397940009	511	2.7084209	230.34	2.362369363	0.499440237	0.526886203
EastofFishPonds	16	1.204119983	107	2.029383778	20.23	1.305995883	0.792509816	0.792509816
FindlayCreek	25	1.397940009	132	2.120573931	36.73	1.565020928	0.557668199	0.557668199
GlenCairn	19	1.278753601	108	2.033423755	42.4	1.627365857	0.474528302	0.474528302
GroveCreek	22	1.342422681	152	2.181843588	11.32	1.053846427	0.41500994	0.41500994
Junkyard	12	1.079181246	52	1.716003344	17.92	1.2533338005	0.974241355	0.974241355
Kilmaurs	19	1.278753601	510	2.707570176	83.09	1.919548759	0.598902774	0.659285355
Limoges	16	1.204119983	92	1.963787827	18.25	1.261262869	0.893301562	0.893301562
LowerPoole	19	1.278753601	60	1.77815125	19.57	1.291590826	0.385614702	0.385614702
LowneyLake	22	1.342422681	106	2.025305865	26.93	1.430236353	0.619508058	0.865813182
Merrickville	9	0.954242509	24	1.380211242	81.85	1.913018684	0.159094664	0.304361568
MudLake	18	1.255272505	124	2.093421685	18.38	1.264345507	0.476974602	0.495218777
MudPond	24	1.380211242	77	1.886490725	156.67	2.194985843	0.849550257	0.988824263
MuseumMarsh	19	1.278753601	115	2.06069784	9.95	0.997823081	0.301670731	0.301670731
Nopoming	28	1.447158031	350	2.544068044	27.48	1.439016728	0.656436364	0.70925664
OkKeeLee	26	1.414973348	150	2.176091259	4.26	0.629409599	0.14770318	0.215242019
Panmure	30	1.477121255	175	2.243038049	94.84	1.976991545	0.83493298	0.83493298
PetroCan	31	1.491361694	217	2.336459734	10.05	1.002166062	0.387455741	0.387455741
ReidLake	25	1.397940009	142	2.152288344	19.85	1.297760511	0.885245902	0.895589898
StanleyCreek	15	1.176091259	75	1.875061263	34.34	1.535800291	0.716351949	0.729541735
StonySwamp	20	1.301029996	53	1.72427587	228.33	2.358562977	0.896570867	0.896570867
TrailerPark	20	1.301029996	42	1.62324929	21.21	1.326540669	0.874625375	0.874625375
W.Queensway	16	1.204119983	38	1.579783597	34.05	1.53217116	0.799735333	0.799735333
WestBurnt	17	1.230448921	225	2.352182518	71.94	1.856970433	0.885709587	0.895056086
WolfCreek	11	1.041392685	112	2.049218023	80.46	1.905580028	0.962278622	0.965442462

Four100	hwy100	hard100	Pave100	grav100	For200	Tfor200	four200	hwy200
0	0	0	0	0	0.952718676	0.952718676	0	0
3.101496159	0	8.107561666	11.20905782	2.19975738	0.222186904	0.222186904	4.933352864	0
0	0	10.66989997	10.66989997	0.545619885	0.530838531	0.530838531	0	0
0	1.784858951	0.307560441	2.092419391	0.86974059	0.739338072	0.739338072	0	1.977243377
0	1.666710275	4.531777388	6.198487663	0.497134933	0.449071392	0.475328235	0	2.143989003
0	0	0	0	2.905886764	0.73502595	0.73502595	0	0.753933566
0	0	15.69925523	15.69925523	1.217638019	0.547272147	0.547272147	0	0
0	0	4.823113208	4.823113208	0	0.560581583	0.560581583	0	4.027513802
0	0	20.54707379	20.54707379	17.36641221	0.436713055	0.437873754	0	0
0	0	0	0	0	0.874144115	0.874144115	0	5.387332829
0	0	0	0	0	0.540722548	0.591626214	0	0
0	0	0	0	0	0.870779823	0.870779823	0	1.01300917
0	8.253471543	15.07920986	23.3326814	0	0.442463533	0.442463533	0	14.021043
0	0	7.696786213	7.696786213	2.771308803	0.617471557	0.825814003	0	0
0	0	0	0	3.020087091	0.134782263	0.244794679	0	0
0	0	8.393285372	8.393285372	8.503966058	0.323031329	0.359962258	0	2.767817122
0	0	4.619646087	4.619646087	0.446397912	0.84521545	0.985012048	0	0
0	0	0	0	8.958967635	0.313222032	0.313222032	0	0
0	0	0	0	12.97932038	0.632476817	0.691456431	0	0
0	17.43617599	0	17.43617599	15.58935361	0.119857946	0.162064826	0	27.98948752
0	0	5.433472415	5.433472415	5.299026426	0.768810732	0.768810732	0	0
13.98390342	0	29.47686117	43.46076459	1.408450704	0.336551414	0.336551414	16.19344202	0.76937168
0	0	6.039837224	6.039837224	2.034696937	0.898029135	0.902825637	0	0
0	0	9.843081312	9.843081312	19.98335711	0.749031109	0.771912781	0	0
0	2.315675676	0	2.315675676	0	0.878110398	0.878110398	0	4.638702229
0	7.72244898	2.693877551	10.41632653	0	0.826684251	0.826684251	0	7.6114082
17.88638368	0	7.620607129	25.5069908	0	0.697605133	0.697605133	18.29871414	0
0	0	2.717503616	2.717503616	4.701384584	0.877515422	0.882320229	0	0
0	0	0.906735751	0.906735751	0.089333572	0.971351271	0.974348489	0	0

hard200	Pave200	grav200	For300	tfor300	four300	hwy300	hard300	pave300
0	0	0	0.951861602	0.951861602	3.399023685	0	0	3.399023685
6.951808994	11.88516186	3.448073825	0.228189567	0.228189567	5.348900973	0	6.208015354	11.55691633
10.13919646	10.13919646	9.237583043	0.503162182	0.503162182	0	0	14.35367952	14.35367952
1.530487592	3.507730969	1.963282259	0.707448804	0.707448804	0	1.872403163	1.982308002	3.854711165
5.574753241	7.718742244	1.403234121	0.417223925	0.442826162	0	3.030165502	5.64733291	8.677498412
3.441870629	4.195804196	6.66520979	0.686925611	0.686925611	0	2.471048167	7.243490448	9.714538615
12.62618538	12.62618538	2.653716733	0.564409122	0.564409122	0	0	12.57785372	12.57785372
7.466739071	11.49425287	0	0.463430243	0.463430243	0	5.323494532	8.090657531	13.41415206
17.75932143	17.75932143	15.42675384	0.440540186	0.449919657	0	0	13.80294554	13.80294554
2.245773404	7.633106233	0	0.754	0.754	0	6.241519674	7.411804613	13.65332429
0	0	0	0.515999583	0.572312139	0	0	0.734625596	0.734625596
0	1.01300917	0	0.847508334	0.847508334	0	3.519668737	1.234841763	4.7545105
12.22552608	26.24656908	0	0.468890727	0.468890727	0	13.06278236	10.28976476	23.35254713
10.9094483	10.9094483	9.546586293	0.661926917	0.839877952	0	0	11.24553203	11.24553203
0	0	4.564735371	0.122639584	0.209576138	0	2.613485007	0.921559451	3.535044458
16.22590766	18.99372479	9.211116091	0.218775584	0.264984575	0	6.08682098	28.99228431	35.07910529
5.064734269	5.064734269	0.640314847	0.846183453	0.988045589	0	0	5.876880713	5.876880713
0	0	8.863128039	0.264857035	0.264857035	0	0	0	0
0	0	17.6	0.56297989	0.634457893	0	0	0	0
0	27.98948752	7.542706965	0.111111111	0.138865546	0	43.10588235	0	43.10588235
5.903732209	5.903732209	5.302058518	0.733773986	0.733773986	0	0	5.731626623	5.731626623
36.08719546	53.05000916	2.674482506	0.283894932	0.283894932	18.40103008	6.56677982	39.34215147	64.30996137
6.675191816	6.675191816	3.299232737	0.882266681	0.887846527	0	0	7.839056538	7.839056538
7.510977583	7.510977583	17.16354672	0.699504678	0.749134311	0	0	6.010016694	6.010016694
0	4.638702229	0.658654273	0.858921562	0.858921562	0.680024001	5.435485958	0.158829135	6.274339094
7.005347594	14.61675579	0	0.81424209	0.81424209	0	9.907492005	5.40201005	15.30950206
9.957138147	28.25585229	0.832509067	0.632509363	0.632509363	22.09489705	0	9.125634139	31.22053118
2.452848627	2.452848627	5.195608977	0.882137152	0.886056014	0	0	2.353888184	2.353888184
1.159072742	1.159072742	0.408244833	0.974795535	0.978899248	0	0	1.743095806	1.743095806

grav300	For400	tfor400	four400	hwy400	hard400	pave400	grav400	For500
0	0.919199228	0.919642857	8.512639624	0	0	8.512639624	0	0.919801397
4.763972033	0.227377649	0.227377649	4.890738814	0	5.674892225	10.56563104	5.528095734	0.237084175
14.1411074	0.408260288	0.408260288	0	0	15.67941764	15.67941764	12.66771339	0.343194941
2.710092481	0.689990791	0.689990791	0	1.794908078	3.546276845	5.341184922	2.954142221	0.675700668
1.639889867	0.389822784	0.413064879	0	3.305332073	5.560481001	8.865801731	1.801880549	0.379796792
7.051707605	0.667069706	0.670270927	0	2.197802198	7.428355958	9.626158156	10.80586081	0.686086917
3.736978449	0.561657464	0.561657464	0	0	13.79542396	13.79542396	4.639131898	0.567322296
0	0.427787701	0.427787701	0	6.984334204	11.89495883	18.87929303	0	0.404850214
14.71629181	0.483759929	0.49949877	0	0	11.3946397	11.3946397	12.12485957	0.489613295
0	0.649692531	0.649692531	0	6.203504457	13.79034737	19.99385183	0	0.60842665
2.24024439	0.494703671	0.557123311	0	0	3.08531517	3.08531517	2.210805819	0.488296375
0.879917184	0.83402439	0.83402439	0	4.757201646	1.788751715	6.545953361	1.042524005	0.814452945
2.967751986	0.476983413	0.476983413	0	12.36365713	11.14156816	23.50522529	5.659299869	0.470020179
10.62230776	0.675932307	0.833719008	0	0	11.4088369	11.4088369	13.07139634	0.696281975
6.101731524	0.112724733	0.182902822	0	4.089418946	2.636784988	6.726203934	6.30793579	0.127405273
10.32655288	0.170615196	0.218809504	0	6.503548964	37.64787351	44.15142247	9.758208783	0.144564514
0.96748986	0.83770741	0.977562634	0	0	5.893232717	5.893232717	1.116078506	0.831518581
8.92873765	0.293667273	0.293667273	0	0	0	0	9.123732125	0.299942613
16.71674517	0.510050002	0.604442177	0	0	0	0	13.98002853	0.470574695
27.63921569	0.085395227	0.102550618	0	56.86192469	0	56.86192469	20.58577406	0.074360362
5.660893969	0.714644315	0.714644315	0	0	5.714595729	5.714595729	5.412590195	0.690314984
5.852744937	0.266245327	0.266245327	18.02434839	6.552822943	36.55527412	61.13244546	7.337200752	0.284142811
4.908081859	0.874639145	0.878443027	0	0	6.899816931	6.899816931	6.224354523	0.878508655
16.64997218	0.692234943	0.744008132	0	0	4.78234994	4.78234994	14.04097943	0.693381652
0.96944598	0.83015282	0.83015282	0.893400813	6.508350053	0.599926132	8.001676998	1.47635732	0.807119664
0	0.782359879	0.784467465	0	10.44298737	4.273948505	14.71693587	0.379817688	0.742974775
2.196359296	0.611968487	0.611968487	22.76974974	0	8.022974883	30.79272462	2.379541414	0.597309085
4.895599571	0.866422794	0.870974373	0	0	2.298558763	2.298558763	4.868570089	0.853311149
0.532730992	0.97654856	0.980046048	0	0	1.724108731	1.724108731	0.909475824	0.974423989

tfor500	four500	hwy500	hard500	pave500	grav500	For750	tfor750	four750
0.921041544	8.143187831	0	0	8.143187831	0	0.842458195	0.86184439	6.611987382
0.237084175	4.403621205	0	4.462730214	8.866351419	5.226480836	0.264830453	0.264830453	3.610578018
0.343194941	0	0	15.51641313	15.51641313	10.3175874	0.327899994	0.327899994	0
0.675700668	0	1.749616554	4.644520164	6.394136718	2.958275549	0.641864655	0.641864655	0
0.403455043	0	3.580348827	5.251460503	8.83180933	1.888070443	0.343531987	0.369748724	0
0.694803711	0	2.113142006	6.686791829	8.799933835	12.64576958	0.72538687	0.734774118	0
0.567322296	0	0	14.77556733	14.77556733	5.341730814	0.560403587	0.560403587	0
0.404850214	0	7.249703205	15.80134547	23.05104867	0	0.421045544	0.421045544	0
0.512511709	0	0	9.691840019	9.691840019	10.2819336	0.487089685	0.513093171	0
0.60842665	0	7.2040845	15.77591456	22.9799906	0.309147969	0.560492061	0.560492061	0
0.548031341	0	0	3.563595198	3.563595198	2.356076508	0.480271358	0.524940155	0
0.814452945	0	4.854822939	2.448667262	7.303490201	1.028780343	0.765777766	0.765777766	0
0.470020179	0	11.59808528	11.46194721	23.0600325	5.858328576	0.446420765	0.446420765	0
0.842413992	0	0	10.46181808	10.46181808	13.58466665	0.701815783	0.868883697	0
0.196753502	0	4.091701854	4.495593905	8.587295759	6.198366073	0.16851741	0.229297139	0
0.195080976	0	10.49774169	36.11478626	46.61252794	9.051507824	0.104219969	0.153556181	0
0.973987674	0	0	5.860471968	5.860471968	1.052398972	0.780910979	0.921416964	0
0.299942613	0	0	0	0	7.974830995	0.278806476	0.278806476	0
0.582412712	0	0	0	0	12.87069563	0.391639439	0.527888404	0
0.087090349	0	65.93579286	0	65.93579286	15.99940133	0.059663498	0.068191117	0
0.690314984	0	0	5.967307721	5.967307721	5.217675844	0.646345479	0.646345479	1.517124025
0.284142811	16.21148036	6.229607251	32.90030211	55.34138973	10.22356495	0.356015711	0.356015711	12.52455959
0.88132514	0	0	5.852601156	5.852601156	6.16088632	0.86064967	0.871514243	0
0.74474536	0	0	4.124928328	4.124928328	12.80312995	0.690078341	0.772945145	0
0.807119664	0.979846148	6.436875631	1.027707195	8.444428974	1.989279126	0.735290698	0.735290698	1.101086599
0.749600277	0	10.13903743	3.376623377	13.51566081	1.521772345	0.659894352	0.674431942	0
0.597309085	21.38655311	0	7.124039121	28.51059223	2.425204807	0.535956712	0.535956712	18.53042275
0.85741843	0	0	2.224987073	2.224987073	5.039749224	0.822746868	0.827048083	0
0.978020502	0	0	1.702472639	1.702472639	1.776553961	0.965257624	0.969342142	0

hwy750	hard750	pave750	grav750	For1000	tfor1000	four1000	hwy1000	hard1000
0	1.177707676	7.789695058	2.759200841	0.818474758	0.830388418	5.387256772	0.310314129	2.693628386
0	5.774756313	9.385334331	4.569061792	0.319979998	0.319979998	3.105146576	0	6.741746249
0	13.3933952	13.3933952	5.824394359	0.362083186	0.362083186	0	0	10.49114081
1.643790635	6.016286859	7.660077494	3.485913181	0.641157459	0.641157459	0.582254804	1.534075482	7.539646625
4.296512899	5.129287281	9.425800179	3.277588949	0.314581777	0.339758744	1.065667376	5.040830497	5.286444734
1.905925473	7.870494808	9.776420281	13.96701283	0.693070472	0.706233944	0	1.696953935	6.758557914
0	14.11347958	14.11347958	6.115219688	0.554626383	0.554626383	0	0	12.68199832
6.135028645	25.58679204	31.72182069	0.39884938	0.428398823	0.428398823	0	7.982330312	30.03357893
0	7.049841354	7.049841354	7.439846642	0.498794662	0.533066501	0	0	5.76987729
5.88075217	18.24366615	24.12441832	0.55786867	0.530744396	0.530744396	0	6.898583853	15.24188796
0	4.163112097	4.163112097	3.280544741	0.437902686	0.469612466	0	0	4.530271861
4.450993344	5.144555663	9.595549007	1.211828667	0.720155188	0.720155188	0	3.890187312	7.311248857
9.679176284	18.60103224	28.28020852	7.015587312	0.442249213	0.442249213	0	9.135590308	18.10448531
0	9.270123974	9.270123974	11.58547232	0.681331312	0.887742339	0	0	7.894897573
4.69458202	11.85201861	16.54660063	6.255440492	0.248211958	0.311633736	0	4.609252791	13.45061821
12.04527553	42.13658508	54.18186061	6.753405875	0.078458273	0.116858238	0	11.5020521	52.61204034
0	7.027060431	7.027060431	1.251055707	0.717320233	0.840979684	0	0	8.939095215
0	0	0	6.072194177	0.286269487	0.286269487	0	0	0
0	0.31477179	0.31477179	11.09045942	0.348291083	0.491988963	0	0	1.458981857
78.08894278	0	78.08894278	12.59435992	0.063925832	0.071256594	1.789574826	74.86428057	0
0	6.410874089	7.927998114	4.288950622	0.631119082	0.631119082	1.69274212	0	6.764863008
5.234939558	30.38063206	48.14013121	9.34430051	0.339646247	0.339646247	7.940462367	3.318906365	19.26105774
0	4.147555655	4.147555655	7.895178432	0.848961599	0.86797731	0	1.721170396	5.057311312
0	3.275210084	3.275210084	14.18487395	0.688541493	0.791059856	0	0	3.199538805
6.184392493	2.48929865	9.77477741	2.243661508	0.656947638	0.656947638	1.137381523	5.979064681	4.739610457
8.397457344	2.053826995	10.45128434	0.925616148	0.564108956	0.578072688	0	7.158996617	3.811833791
0	9.499575912	28.02999866	2.857015312	0.562685442	0.562685442	16.71026218	0	10.02494069
0	2.147735146	2.147735146	5.686604423	0.779825904	0.78796254	0	0	2.662573308
0	1.698244543	1.698244543	2.62984753	0.936413138	0.939881623	0	0	2.699094621

pave1000	grav1000	For1250	tfor1250	four1250	hwy1250	hard1250	pave1250	grav1250
8.391199288	4.441053033	0.820852919	0.828800221	4.504581219	0.965632344	2.527334037	7.9975476	4.892877823
9.846892825	4.284079937	0.337624457	0.35698558	2.740073094	0	6.4625441	9.202617194	3.897921826
10.49114081	5.781784271	0.364853396	0.371618984	0	0	9.454649204	9.454649204	4.559534808
9.655976911	3.897285828	0.662667	0.69412955	0.799020297	1.450683584	7.654935657	9.904639537	3.718054245
11.39294261	3.493690354	0.286287714	0.321912159	1.719649687	5.127947955	5.783530206	12.63112785	3.498566199
8.455511849	13.118843	0.656981678	0.674044463	0	1.47738412	5.931708911	7.409093031	12.04546515
12.68199832	5.096663305	0.520596989	0.531346306	0	0	10.68409315	10.68409315	4.294383071
38.01590924	0.658538176	0.43349924	0.454657323	0	7.056766304	34.34613715	41.40290345	2.441056696
5.76987729	6.683896453	0.498492284	0.529244676	0	0	7.270586183	7.270586183	6.036287509
22.14047181	0.496455167	0.469353441	0.488096519	0	6.460706114	14.80362538	21.26433149	0.892439545
4.530271861	2.975202955	0.405540617	0.430316991	0	0	4.556492524	4.556492524	3.146882225
11.20143617	1.243098601	0.686279608	0.694317783	0	3.464183659	9.410568121	12.87475178	1.387610791
27.24007561	6.691871456	0.465973381	0.488313396	1.917378848	8.304968533	18.39875603	28.62110341	6.643485075
7.894897573	10.05582498	0.673032224	0.897971841	0	0	7.308777245	7.308777245	8.75456912
18.059871	5.689245077	0.283589713	0.34092683	0	4.323223178	13.54119511	17.86441829	4.914149906
64.11409244	6.915255636	0.065426362	0.097368608	0	10.3646091	59.13069025	69.49529936	6.508226126
8.939095215	1.659773268	0.670477255	0.787589264	0	1.118385635	8.679210878	9.797596513	2.265859716
0	8.085904653	0.29111541	0.29111541	0	2.392443028	0	2.392443028	12.1267377
1.458981857	9.571424079	0.305339244	0.446977669	1.363000477	0	2.400100037	3.763100513	9.223699327
76.65385539	14.44391064	0.105036724	0.114892551	3.229527105	64.34361649	0	67.57314359	14.03089819
8.457605129	3.524383729	0.603142701	0.633484432	2.222341128	0	6.473802177	8.696143305	4.010677701
30.52042648	5.924205637	0.368022146	0.378338482	6.973657341	3.118527378	19.62571837	29.71790309	6.01826191
6.778481708	8.322041967	0.831486617	0.860395183	0	2.241932147	5.650082747	7.892014894	8.744052544
3.199538805	14.23794768	0.686838025	0.800789306	0	0	3.043697904	3.043697904	12.05586428
11.85605666	2.248724091	0.596306069	0.634526997	1.139799263	5.810940886	7.190742523	14.14148267	3.167522506
10.97083041	2.473989915	0.474108809	0.496641739	0	6.273917611	6.155736475	12.42965409	2.336422301
26.73520287	3.027860575	0.578820022	0.603072953	13.18949343	0.176580951	8.723098996	22.08917338	2.936761947
2.662573308	6.396008165	0.741637726	0.766761691	1.727110303	0	2.999717895	4.726828198	6.779926653
2.699094621	2.963962365	0.898585509	0.906721319	0	0	4.720689311	4.720689311	2.793662073

For1500	tfor1500	four1500	hwy1500	hard1500	pave1500	grav1500	For1750	tfor1750
0.772835671	0.780211368	3.861823327	1.078285477	2.211461052	7.151569857	4.955965944	0.698090856	0.706210228
0.339649848	0.362141784	2.457888784	0	6.226243975	8.684132759	4.39709374	0.332038391	0.354945323
0.358616094	0.364990804	0	0.942742688	8.746724496	9.689467185	3.990843649	0.339740308	0.345671218
0.675742565	0.715740145	0.864610397	1.376641984	7.717448359	9.95870074	3.367325716	0.675245896	0.725535466
0.263195085	0.304092988	1.97901889	5.13813186	5.930710072	13.04786082	4.191368625	0.2572844	0.298348112
0.636977094	0.660369174	0	1.107107877	5.464705471	6.571813348	9.408667973	0.637695394	0.66247045
0.488182805	0.498246082	0	0.709394122	9.157128816	9.866522938	4.016993754	0.475494741	0.485382713
0.439442579	0.45890207	0	6.297197999	34.46593776	40.76313576	2.765703156	0.420607494	0.442226151
0.495787532	0.534120491	0	0	8.893459657	8.893459657	6.657572496	0.499687515	0.537852837
0.414727679	0.431743782	0	5.913345083	16.78055401	22.69389909	1.831308495	0.383551308	0.400383009
0.393272003	0.414512721	0	0	4.419720853	4.419720853	3.06230475	0.390855272	0.409866456
0.679504128	0.685703624	0	3.293696249	9.3619884	12.65568465	1.627302315	0.67854121	0.683916104
0.466687213	0.494757478	3.735566296	7.210660993	19.42989737	30.37612466	5.390111251	0.456798514	0.486607005
0.67062703	0.893628175	0	0	6.811467069	6.811467069	7.789747009	0.669543219	0.895417085
0.318829833	0.373976413	0	4.093796913	12.64054018	16.73433709	5.447416594	0.344960414	0.39660041
0.055795784	0.082611859	0	9.3402369	62.33992456	71.68016146	5.952523966	0.046486856	0.068428321
0.641779792	0.764015249	0	1.282871332	7.974285078	9.25715641	2.608145694	0.61068627	0.73840917
0.306037827	0.306037827	0	2.718685159	0	2.718685159	12.02001792	0.335813301	0.335813301
0.283161814	0.415955011	1.655923133	0	2.234857699	3.890780832	8.143395767	0.268660413	0.395059031
0.126711643	0.138766037	3.259175951	54.80382854	0	58.06300449	15.54376223	0.152510013	0.169539379
0.580060317	0.607005992	2.114339825	1.1726671	6.106286108	9.393293033	3.89486169	0.562042541	0.58375
0.390355045	0.425774993	8.225353316	3.422601562	17.72082937	29.36878425	7.583348467	0.411957345	0.451549479
0.815349157	0.861651517	0	2.27331762	5.387464525	7.660782144	8.349607966	0.801976759	0.870448529
0.684237479	0.803012679	0	0	3.513083707	3.513083707	10.34006393	0.694936217	0.821455088
0.546374264	0.57818681	1.163073818	5.603644486	9.312353778	16.07907208	3.734821993	0.492290724	0.516597022
0.395674868	0.412095704	0	5.627964648	9.470292248	15.0982569	2.38181058	0.346089407	0.358768487
0.542310653	0.559695769	11.40607018	1.057214999	11.76076539	24.22405057	3.011903331	0.51207697	0.532729513
0.705471394	0.731618302	1.781879127	0	3.243612131	5.025491259	7.159631481	0.667103828	0.694293766
0.870820322	0.878671481	0	0	6.499046765	6.499046765	3.391275093	0.85479149	0.8617034

four1750	hwy1750	hard1750	pave1750	grav1750	For2000	tfor2000	four2000	hwy2000
3.380075154	1.091558977	3.086793145	7.558427275	4.958298964	0.633508228	0.641607784	3.035537125	1.059190476
2.232054858	0	6.054899658	8.286954516	4.462012708	0.317525543	0.34071682	2.046348744	0
0	1.883032625	8.125308947	10.00834157	4.006271626	0.337427688	0.342572713	0	2.335598267
0.891958231	1.307983525	7.416898947	9.616840704	3.145705926	0.661078281	0.71495621	0.900952137	1.244792629
2.235085876	6.090741922	6.199572184	14.52539998	3.361854368	0.267209201	0.307672446	2.137846328	5.646482705
0	0.86355668	5.056513168	5.920069849	7.853863836	0.624710185	0.648848249	0	0.692779985
0	1.771122273	8.049703876	9.820826149	3.802134093	0.463596873	0.475799372	0	1.915179836
0	5.419574374	35.91470879	41.33428317	3.217440019	0.402710018	0.423319227	0	5.482327074
0	1.473871173	9.013508449	10.48737962	6.964428294	0.498966761	0.536367118	0	1.770406621
0	5.374664175	16.74964957	22.12431375	2.447144025	0.371338629	0.388183915	0	4.90794331
0	0.869070486	5.107420244	5.97649073	3.203294638	0.377246015	0.393289954	0	1.668840306
0	3.674893653	9.674907809	13.34980146	1.898317561	0.698680579	0.704351792	0	3.318276876
5.07720604	6.38464719	20.49845303	31.96030626	5.713817243	0.455731599	0.486008719	5.014851852	5.725802314
0	0	6.556064458	6.556064458	8.062240339	0.678185785	0.903370315	0	0
0	3.791115944	11.58980799	15.38092394	5.594780451	0.374589939	0.423086386	0	3.496912386
0	8.841486829	64.56877352	73.41026035	5.822325474	0.039513872	0.058178445	3.154742724	8.298686703
0	1.524999015	7.295634073	8.820633088	2.635494026	0.580107376	0.711834327	0	1.622218822
0	2.647262613	0	2.647262613	11.65919093	0.339030636	0.339030636	0	2.463489487
1.716134202	0.33228111	3.213353791	5.261769104	7.385436314	0.255826293	0.370935614	1.702932444	1.020051247
3.070730305	45.68319547	0	48.75392578	14.77153094	0.181424677	0.204694336	3.042500951	38.90237577
1.99552347	1.930503452	5.77180732	9.697834242	4.295655875	0.555708113	0.574041929	1.87184263	1.918489822
7.421431894	4.143238369	14.43074337	25.99541363	7.072149636	0.422633318	0.457941038	6.755077735	4.375060353
0	2.201243826	5.084657502	7.285901327	8.999880974	0.805637822	0.878773215	0	2.073026951
0	0	3.337683069	3.337683069	8.641615568	0.703684573	0.837130922	0	0
1.110745974	5.359842261	11.79667194	18.26726018	4.074627312	0.446873604	0.465609982	1.690685584	5.904319302
0	5.225812363	11.72700929	16.95282165	2.504381092	0.306920895	0.317236408	0	5.725577294
9.890485743	1.316144309	12.17482816	23.38145822	3.805044891	0.506300888	0.53245625	8.917011722	1.309532015
1.781264801	0.615308581	3.645723935	6.042297317	7.890282325	0.631816884	0.656816015	1.705316329	1.093044452
0	0	6.913975341	6.913975341	3.660252531	0.84121511	0.849129061	0	0

hard2000	pave2000	grav2000	For2500	tfor2500	four2500	hwy2500	hard2500	pave2500
5.117517326	9.212244927	5.783436945	0.56914647	0.575139612	2.5030645	0.943210847	7.438078395	10.88435374
6.337000587	8.383349331	4.87466993	0.328240321	0.356061929	2.001748049	0	6.915364009	8.917112058
7.503691495	9.839289762	3.840993058	0.342011433	0.348921804	0	3.200059428	7.744688578	10.94474801
7.158564733	9.304309499	3.971582804	0.63860398	0.693013964	1.022018514	1.129145322	7.581378629	9.732542464
6.308831405	14.09316044	4.051623767	0.267364946	0.30507378	2.038243962	6.347323687	7.767400158	16.15296781
5.085858752	5.778638737	8.918584671	0.579726682	0.604419759	0	0.474697783	5.881228065	6.355925848
7.882226807	9.797406643	3.59974916	0.432956094	0.444879069	0	3.03213345	7.700438982	10.73257243
41.73264633	47.2149734	3.752790024	0.366165591	0.381531493	2.54321448	5.659831746	35.22755377	43.4306
8.536922592	10.30732921	6.510569064	0.49069246	0.531680351	0	1.846000404	7.805305854	9.651306258
15.99375808	20.90170139	3.716621444	0.362758253	0.377869481	0	5.012828572	13.68565453	18.69848311
5.169543879	6.838384185	3.473247074	0.349161836	0.361096366	0	2.544712446	5.345665417	7.890377863
8.698362681	12.01663956	1.933158399	0.726446494	0.734611838	0	2.708863013	6.971452454	9.680315466
22.1010382	32.84169237	5.911664263	0.469386157	0.502960591	4.518867155	4.863602268	21.22277972	30.60524915
6.32486297	6.32486297	8.544787387	0.664493539	0.895026284	0	0	5.172748751	5.172748751
10.98206323	14.47897562	5.404166176	0.401361831	0.446881657	0	3.023871435	9.752608327	12.77647976
63.09564042	74.54906985	5.766404426	0.022190889	0.028578005	3.481751364	5.212769313	50.56859405	59.26311473
6.700243527	8.322462349	2.681394149	0.546644381	0.701158871	0	1.58548869	6.239753537	7.825242227
0	2.463489487	10.99740922	0.303816059	0.30078439	0	4.392630665	0.059460285	4.45209095
3.309065766	6.032049457	6.780412413	0.262802102	0.380969235	1.474996221	1.024860424	3.958692808	6.458549452
0	41.94487672	14.61977384	0.247508017	0.288111799	2.633954625	3.230777648	25.7974358	31.66216808
5.537120909	9.327453361	4.228683722	0.521421113	0.535781597	1.640182399	1.736348653	5.258224649	8.634755701
13.37753887	24.50767696	6.636624071	0.418919095	0.45116495	5.790258665	4.371200888	14.26211597	24.42357552
4.750365846	6.823392797	8.375645044	0.802605977	0.850359379	0	1.844004077	4.562856661	6.406860739
3.198392603	3.198392603	7.33580047	0.701604917	0.841094223	0	0.874643865	2.601523068	3.476166933
13.20283867	20.79784356	4.516018169	0.350088352	0.360297443	2.613491542	6.552427773	16.65184066	25.81775998
12.57144724	18.29702453	2.596130068	0.287731025	0.295062167	0	5.370756847	12.48841027	17.85916711
10.5801704	20.80671413	4.187851572	0.533739583	0.570687778	6.583844573	2.384852185	10.65487463	19.62357139
4.045168966	6.843529747	8.01623912	0.539305941	0.56265925	1.383206161	1.708310091	6.006345584	9.097861836
6.769444549	6.769444549	3.892352374	0.820126765	0.861248964	0	0.05668187	6.308164826	6.364846695

grav2500	For3000	tfor3000	four3000	hwy3000	hard3000	Pave3000	grav3000	ephem1	ephem2
6.012033424	0.541450392	0.54650806	2.093926227	0.833344339	8.623661168	11.55093173	4.667256567	0	0
5.013136149	0.305069745	0.329489295	1.544311641	0.753804046	7.300651389	9.598767077	5.340958199	4	0
4.060534526	0.358222666	0.36706736	0	3.496092533	7.165520496	10.66161303	3.659336517	1	0
4.249483239	0.620292653	0.673349187	0.990811446	1.025231343	7.278179343	9.294222132	3.955880207	7	1
3.673221587	0.264485981	0.299102928	1.934262779	6.22699087	8.347058768	16.50831242	3.798140059	5	0
10.43210247	0.593289494	0.617255702	0	0.345686294	5.49630285	5.841989143	9.409438929	6	0
3.97190518	0.399020042	0.40979109	0	3.722090133	7.014609036	10.73669917	4.145465623	2	1
3.781718839	0.334755939	0.347278547	2.757707763	6.204427065	29.83048876	38.79262359	4.736123535	0	0
6.440796007	0.458891491	0.493984108	0	2.474253434	7.419685168	9.893938602	7.289299454	20	0
4.470826366	0.387892235	0.406426259	0	4.966345851	11.69174287	16.65808872	3.967014931	1	0
3.420505953	0.335819281	0.346696414	0	3.168930514	5.100503889	8.269434403	3.032004236	11	0
1.929097446	0.724458816	0.73829328	1.402039842	2.270517828	7.15742744	10.82998511	1.832485741	0	0
5.66267261	0.447343954	0.479376198	4.042431435	3.962090225	18.97631203	26.98083369	5.007371658	3	0
9.52264566	0.652015755	0.890907922	0	0	4.504611931	4.504611931	9.59422018	19	3
5.068026114	0.439549936	0.495989098	0	2.714466481	8.790657925	11.50512441	4.444464074	4	0
4.150894294	0.025903708	0.036999638	5.53311269	6.405545281	71.9487167	83.88737467	5.5525812	0	0
3.230823046	0.495172941	0.63233517	0	1.573394953	6.501833205	8.075228157	3.776283116	7	0
10.36427675	0.263033813	0.260734195	0	4.896523484	1.051876087	5.948399571	8.712333793	1	0
6.071229363	0.233484295	0.334394025	1.424535071	1.390665318	3.748846869	6.564047257	5.303513096	1	0
11.74542238	0.283537049	0.334782011	2.268095181	2.62888446	21.41867383	26.31565347	9.710302682	1	0
4.33697629	0.506535829	0.519053725	1.458711014	1.555060401	6.234834326	9.24860574	4.439181086	1	0
5.688804488	0.405306231	0.431294441	4.774932909	3.970452163	14.95528784	23.70067291	5.017476015	1	0
8.935493968	0.782201501	0.830236298	0	1.643295863	5.108065825	6.751361687	7.993973809	35	0
6.139935905	0.687322733	0.835976173	0	1.170305586	2.059528848	3.229834433	5.828017325	0	0
5.326831677	0.301562803	0.308800333	2.695793632	6.075495501	18.92728315	27.69857228	5.503743596	1	0
3.716250528	0.296796093	0.305206986	0	4.918359365	11.93087816	16.84923753	4.241037265	0	0
4.075782947	0.563366147	0.605784935	5.721709563	2.318463233	9.841372526	17.88154532	3.898054982	2	0
7.472089777	0.483329807	0.504135964	1.10195392	2.082971103	9.679382411	12.86430743	7.122903409	1	0
3.853048957	0.782575922	0.832528344	0	0.587741681	7.113913191	7.701654871	4.54504282	0	0

pleco	hemi1	hemi2	hemi3	hemi4	hemi5	hemi6	hemi7	hemi8	hemi9	hemi10	hemi11	hemi12	hemi13	hemi14	coleo1	coleo2
0	3	7	0	0	12	0	0	0	0	4	0	0	0	47	0	6
0	0	1	0	0	2	0	0	6	0	0	3	0	0	28	0	9
0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
0	0	3	8	0	3	0	0	1	1	0	3	0	0	10	0	3
0	9	6	298	0	19	0	0	0	0	0	18	2	0	91	0	5
0	0	6	0	0	3	0	0	0	0	0	1	0	0	51	0	0
1	0	0	0	2	0	0	0	3	0	1	0	10	0	2	0	16
0	0	0	16	0	3	0	0	0	0	0	0	0	0	11	2	0
0	2	22	21	0	0	0	0	2	0	0	7	0	0	11	0	4
0	0	0	0	0	0	0	0	0	0	8	0	0	0	4	0	18
0	0	1	273	0	0	0	0	0	0	0	8	0	1	3	0	169
0	2	29	0	0	2	0	0	1	0	0	1	0	0	21	0	17
0	1	10	0	2	0	0	0	0	0	0	2	0	0	6	1	9
0	0	5	1	0	1	0	0	5	0	1	7	0	0	2	2	0
0	0	0	1	0	0	0	0	0	0	0	4	0	0	0	0	0
0	0	1	1	0	1	3	0	2	0	0	0	0	0	0	0	10
0	0	0	0	0	1	1	0	0	0	0	5	0	0	0	0	0
0	0	3	11	0	2	0	0	1	0	1	2	0	0	18	0	0
0	0	11	121	2	0	0	0	0	0	0	4	0	0	6	0	0
0	0	3	1	0	6	0	0	0	0	0	1	0	0	3	0	17
0	0	54	1	5	2	0	0	0	0	1	7	0	0	31	0	10
0	0	37	65	3	1	0	0	0	0	0	0	0	0	51	0	9
0	1	14	12	0	5	0	0	1	0	0	0	0	4	2	0	2
0	0	0	1	0	1	0	0	11	0	3	5	11	0	2	1	30
0	0	2	2	0	4	0	0	0	0	0	0	0	0	6	0	1
0	0	3	0	0	0	0	0	0	0	0	7	0	0	0	2	7
0	0	4	0	1	2	0	0	0	0	0	3	0	0	1	0	5
0	6	7	1	0	0	0	0	1	0	0	14	0	0	2	0	0
0	0	4	0	0	0	0	1	0	0	1	2	0	0	52	0	9

coleo3	coleo4	coleo5	coleo6	coleo7	coleo8	coleo9	coleo10	coleo11	coleo12	coleo13	coleo14	coleo15	coleo16	coleo17
0	7	1	0	0	0	9	0	0	0	0	0	0	0	0
2	12	0	0	0	0	4	28	0	0	0	0	0	0	0
0	0	0	0	0	0	0	3	0	0	0	1	0	0	0
0	3	8	0	0	0	4	2	0	0	0	0	3	0	0
0	7	0	0	0	0	0	2	0	0	0	0	0	0	0
0	3	1	0	0	0	2	3	0	0	0	0	1	0	0
1	25	2	2	0	0	0	43	2	0	0	0	0	0	0
0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
0	4	0	0	0	0	5	16	0	0	0	0	0	0	0
0	2	1	0	0	0	0	2	0	0	0	0	0	0	0
0	0	0	0	0	0	1	2	0	2	0	0	0	1	0
4	31	0	0	0	0	1	1	0	0	1	0	0	0	0
0	4	0	0	0	0	2	1	0	0	0	0	0	0	0
0	7	0	0	0	0	0	1	0	0	0	0	1	0	0
6	1	0	0	0	0	0	0	0	0	0	1	0	0	1
0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
0	3	1	0	0	0	0	1	0	0	0	0	0	1	0
0	22	0	0	0	0	0	0	0	0	0	0	0	0	0
0	15	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	13	0	0	0	1	4	0	2	0	0	0	0	1
0	1	2	0	0	0	1	1	0	0	0	0	0	0	0
0	0	1	0	0	0	2	1	1	0	0	0	0	1	0
0	0	2	0	0	0	1	10	0	0	0	0	1	0	0
0	10	0	0	0	0	0	0	0	1	0	0	0	0	0
0	22	0	0	0	0	0	0	0	0	0	0	0	0	0
2	9	1	0	0	0	4	0	1	0	0	0	0	0	0
0	4	0	0	0	0	2	0	0	2	0	0	1	0	0
0	10	0	0	0	0	0	1	0	0	1	0	0	0	0
1	17	0	0	0	0	0	0	3	0	0	0	0	0	0
0	4	0	0	0	0	1	5	0	0	0	0	0	0	0