CHAPTER V

CONSUMER WELFARE MEASURE

The calculation of consumer surplus is different with discrete choice travel cost models than with conventional travel cost analysis. With discrete choice models, we estimate the conditional utility functions and then compute directly the Hicksian compensating variation (CV) or equivalent variation (EV). In the conventional travel cost analysis, we generally calculate Marshallian measures of consumer surplus from the estimated demand functions. [1]

The standard consumer surplus measure employed for discrete choice models is based on the assumption that total trips do not change with policy changes. This measure will result in an under- or over-estimate of "true" consumer surplus, depending upon whether total trips increase or decrease. We develop a consumer surplus measure that incorporates the change in trips predicted by the participation model. Additional complexity is added to the measure with a NMNL model when the choice occasion income (budget) is not observed and the marginal utility of income is not

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[1] Feenberg and Mills (1980, pp. 114-115) calculate the welfare measure C^*, defined as

$$V(p + C^*, q, y, s) = V(p, q', y, s)$$

where V is the indirect utility function. That is, C^* is the amount by which the price would have to be raised in order to offset the effect of the change in the quality. Hanemann (1983, pp. 134-35) argues that CV is more appropriate than C^* since it is a natural generalization to the discrete choice context of the conventional Hicksian compensating variation.

constrained to be constant across alternatives due to the computational complexity of such a procedure. We propose a simplifying procedure that makes the calculation tractable under those circumstances.

Welfare Measure for Individual Choice Occasions

Procedures to calculate the choice occasion welfare changes in the NMNL context have been developed by many researchers.[2] As defined previously by (III.4), let

$$\tilde{V}(\mathbf{P}, \mathbf{Q}, y) = \max_m \{\tilde{u}_m\}$$

be the maximum random utility an individual can receive on a choice occasion when facing trip cost P, site quality Q, and choice occasion budget *y*. The expected compensating variation $\mathcal{C}$ and equivalent variation $\mathcal{E}$ corresponding to a site quality change from $\mathbf{Q}^0$ to $\mathbf{Q}^1$ in the random utility model are defined as

$$E[\tilde{V}(\mathbf{P}, \mathbf{Q}^1, y^1 - \mathcal{C})] = E[\tilde{V}(\mathbf{P}, \mathbf{Q}^0, y^0)] \quad \text{(V.25)}$$

$$E[\tilde{V}(\mathbf{P}, \mathbf{Q}^1, y^1)] = E[\tilde{V}(\mathbf{P}, \mathbf{Q}^0, y^0 + \mathcal{E})]. \quad \text{(V.26)}$$

$\mathcal{C}$ is the expected maximum amount of money individuals require to compensate them for the change in site conditions, and $\mathcal{E}$ is the expected minimum amount of money people require to compensate them for foregoing the quality change. Note that both will be positive for quality improvement $(\mathbf{Q}^1 \succ \mathbf{Q}^0)$, and negative for quality deterioration $(\mathbf{Q}^1 \prec \mathbf{Q}^0)$. $\mathcal{C} \neq \mathcal{E}$ for utility functions that yield different values of the marginal utility of income at y^0 and y^1.

It has been shown that for the MNL model

$$E[\tilde{V}(P, Q, y)] = E[\max_m \{\tilde{u}_m\}]$$

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[2] See Small and Rosen (1981) and Hanemann (1982, 1985). Hanemann (1983) also has the calculation for marginal exogenous variable changes. For applications see Carson and Hanemann (1987) and Jones 1988, 1990).

$$= \ln \sum_m e^{u_m(P,Q,y)} + \text{constant}$$
$$= I(P,Q,y) + \text{constant},$$

where $I(P,Q,y)$ is the inclusive value of choices with parameters P,Q and individual choice occasion income y. Therefore, we can rewrite equations (V.25) and (V.26), defining the compensating variation, $\mathcal{C}$, and equivalent variation, $\mathcal{E}$:

$$\ln \sum_m e^{u_m(P,Q^1,y^1-\mathcal{C})} = \ln \sum_m e^{u_m(P,Q^0,y^0)}$$
$$\ln \sum_m e^{u_m(P,Q^1,y^1)} = \ln \sum_m e^{u_m(P,Q^0,y^0+\mathcal{E})}.$$

In general. closed-form solutions for the consumer surplus measures $\mathcal{C}$ and $\mathcal{E}$ are not available, and numerical techniques have to be employed.

However, with a linear-in-income conditional utility u_m that has a constant marginal utility of income η (the coefficient on y): the above equations become

$$\ln \sum_m e^{u_m(P,Q^1,y^0)+\eta(y^1-y^0-\mathcal{C})} = \ln \sum_m e^{u_m(P,Q^0,y^0)}$$
$$\ln \sum_m e^{u_m(P,Q^1,y^0)+\eta(y^1-y^0)} = \ln \sum_m e^{u_m(P,Q^0,y^0)-\eta\mathcal{E}}.$$

which simplify: respectively, to:

$$\ln \sum_m e^{u_m(P,Q^1,y^0)} + \eta\,(y^1-y^0) - \eta\,\mathcal{C} = \ln \sum_m e^{u_m(P,Q^0,y^0)}$$
$$\ln \sum_m e^{u_m(P,Q^1,y^0)} - \eta\,(y^1-y^0) = \ln \sum_m e^{u_m(P,Q^0,y^0)} - \eta\,\mathcal{E}.$$

Therefore,

$$\mathcal{C} = \mathcal{E} = \frac{I(P,Q^1,y^0) - I(P,Q^0,y^0)}{\eta} + (y^1 - y^0). \qquad \text{(V.27)}$$

This formula presents the consumer surplus per choice occasion. The equality of $\mathcal{C}$ and $\mathcal{E}$ is the result of the linear-in-income indirect utility assumption. When the choice occasion income y is assumed fixed, i.e., $y^1 = y^0$, the second term on the right hand side of equation (V.27) drops out.

The use of this formula is not limited to site quality changes only. As mentioned in Bockstael et al. (1991), the value of adding or deleting sites can also be computed a s

$$\mathcal{C} = \frac{I^1(P^1, Q^1, y^0) - I^0(P^0, Q^0, y^0)}{\eta}$$

where $I^0(P^0, Q^0, y^0)$ is the inclusive value before the change, and $I^1(P^1, Q^1, y^0)$ after. However, the site change has to be small so that the choice occasion income *y* will stay the same.

The above derivation assumes that the marginal utility of income is constant across alternatives (as well as across quality changes.) When that assumption does not apply. the derivation is more complicated. As Hanemann (1982) has shown:

$$\mathcal{C} = \mathcal{E} \approx \frac{\sum_m e^{u_m(P,Q^0,y)} - \sum_m e^{u_m(P,Q^1,y)}}{\sum_m \eta_m e^{u_m(P,Q^1,y)}}$$

Using the approximation that $z \approx \ln(1+z)$, this formula can be re-written to show more clearly its similarity to the constant MCI version:

$$\mathcal{C} = \mathcal{E} \approx \frac{\ln(\sum_m e^{u_m(P,Q^0,y)}) - \ln(\sum_m e^{u_m(P,Q^1,y)})}{\sum_m \eta_m \pi^1_m} = \frac{I^1 - I^0}{\bar{\eta}}$$

where

$$\pi^1_m = \frac{e^{u_m(P,Q^1,y)}}{\sum_l e^{u_l(P,Q^1,y)}}$$

is the probability of choosing product line m after the quality change, and we define $\bar{\eta}$ to be the weighted MUI

$$\bar{\eta} = \sum_m \pi_m \eta_m.$$

Remember that in our framework, we model the trip-duration choice within the macro-level participation model, external to the NMNL analysis. Consequently, we calculate separate compensating or equivalent variations for each of the three trip-duration groups. For simplicity, we have suppressed the subscript *d* for the trip-duration groups in the formula above - but we will incorporate it explicitly in the calculations below.

Welfare Measure for Multiple Choice Occasions

Since there are multiple choice occasions in a season, most researchers derive the total consumer surplus by first calculating the choice occasion compensating variation C, then multiplying C by the total number of trips N over a season. This yields the seasonal consumer surplus

$$\mathcal{W} = \mathcal{C} \cdot N.$$

Whether N is taken as the number of trips N^0 before a site quality improvement or the predicted number of trips N^1 after an improvement. the calculation is not accurate. In tile former case, the welfare gain associated with the new trips is not included, whereas in the latter case, the formula gives an over-estimate of the true loss.[3] For a quality improvement, we do know that the annual utility gain W is bounded by

$$\mathcal{C} \cdot N^0 \leq \mathcal{W} \leq \mathcal{C} \cdot N^1.$$

The surplus $C \cdot N^0$ is the lower bound on the actual benefits because the increase in total value associated with the increase in trips is not included. The surplus measure $C \cdot N^1$ is the upper bound because the increase in value is calculated based on the (greater) number of trips that would only be taken under improved site conditions.[4] When there are only marginal changes in site quality and hence the change in total trips N is small, these bounds are tight.

In this section, we propose a procedure to compute the seasonal consumer surplus more precisely for a proposed improvement in site conditions. First, for each trip type d (= day, weekend, or vacation) and each month n (= April - October) during a season, we denote the "true" pre- and post-policy inclusive values by I^0_{nd} and I^1_{nd} (corresponding to the site qualities Q^0_n and Q^1_n), respectively. As discussed above,

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[3] See Parsons (1990, p. 14) or Bockstael et al. (1988, p. 18) for a discussion.

[4] See Parsons and Kealy (1990)

we cannot calculate I^0_{nd} or I^1_{nd} because we do not know choice occasion income The pseudo-inclusive values that we can calculate from the MNL parameter estimates are denoted by $\bar{I}^0_{nd}$ and $\bar{I}^1_{nd}$, respectively; as defined in (III.15). The expected number of trips N^0_{nd} and N^1_{nd} can then be estimated with the competing risks duration model proposed in chapter IV. Let y_d be the choice occasion income for a type-d trip. The expected seasonal compensating variation for an individual in the sample will consist of two components: one associated with the trips already taken before the policy, and the other associated with new trips that would only be taken after the policy.

Eased on the derivations above, the expected welfare gain for the N^0_{nd} trips of duration d in month n that occurred before the improvement is

$$\mathcal{W}^0_d = \frac{I^1_{nd} - I^0_{nd}}{\tilde{\eta}_d} \cdot N^0_{nd}$$

If we replace the MUI estimates that vary across product lines η_{md} with the weighted MUI for trip duration d, $\tilde{\eta}_d$, in the formulas for the inclusive value indices I^1_{nd} and I^0_{nd}, then this simplifies to:

$$\mathcal{W}^0_d = \frac{\bar{I}^1_{nd} - \bar{I}^0_{nd}}{\tilde{\eta}_d} \cdot N^0_{nd}$$

For the $(N^1_{nd} - N^0_{nd})$ new trips that would only occur after the site improvement, we assume that the expected no-trip utility u_0 is simply $[\alpha + \tilde{\eta}_d y_d]$ for the linear conditional utility function (III.14) since no travel cost is incurred and no site attributes are enjoyed. The associated compensating variation is thus

$$\begin{aligned} \mathcal{W}^1 &= \frac{I^1_{nd} - E[u_0]}{\tilde{\eta}_d} \cdot (N^1_{nd} - N^0_{nd}) \\ &= \frac{I^1_{nd} - [\alpha + \tilde{\eta}_d y_d]}{\tilde{\eta}_d} \cdot (N^1_{nd} - N^0_{nd}) \end{aligned}$$

Again if we substitute $\tilde{\eta}_d$ for η_{md} in I^1_{nd}, the choice occasion income cancels out in the before-policy and after-policy terms and this simplifies to:

$$\mathcal{W}^1 = \frac{\bar{I}^1_{nd}}{\tilde{\eta}_d} \cdot (N^1_{nd} - N^0_{nd}).$$

Therefore, the total seasonal CV for an individual *i* is the sum

$$\mathcal{W}^{*} = \mathcal{W}^{0} + \mathcal{W}^{1} = \sum_{n}\sum_{d}\left[\frac{\bar{I}^{1}_{nd} \cdot N^{1}_{nd} - \bar{I}^{0}_{nd} \cdot N^{0}_{nd}}{\bar{\eta}_{d}}\right] \qquad \text{(V.28)}$$

CHAPTER VI

DATA SOURCES AND DESCRIPTIVE STATISTICS

This chapter describes the data used in this study to estimate the models discussed in previous chapters. Three categories of information have been collected from federal and state sources: angler data: species- and month-specific catch rate data, and other site quality data. Since the units of the site analysis are the 83 Michigan counties: all site quality data and distance measures are defined on a county basis.[1] We describe each category of data in turn.

Angler Survey Data

The primary dataset for estimating the model is a detailed mail surrey of 1% of the anglers Licensed to fish in Michigan during the 1983 and 1984 license-years. This survey was sponsored by the Michigan Department of Natural Resources (MDNR) and had a response rate of 59%. The full sample size is 10,948 licensees, of whom 9,628 fished during 1983 or 1984 prior to their return of their survey.[2] The survey provides detailed information on the angler's most recent fishing trip, including species sought:

[1] See map VI.1 for the geographic locations of the 83 Michigan counties. They are numbered alphabetically from 1 to 83.

[2] The earliest survey returns would be from the surveys sent out in November or December 1983 or January 1984, which represent more than 60% of the total. The remaining surveys were sent out in May 1984 and September 1984.

location, trip length, trip expenditures, etc., as well as demographic background and extensive fishing experience and preference information

Sample Definition

The model embodies three nested levels of choice: trip duration; fishing product line; and fishing site. Below, we first explain how we define the anglers' fishing product lines and trip durations. We then explain our sample selection procedures and present descriptive statistics for key analysis variables.

Definition of Product Lines

Kikuchi (1986) performed a factor analysis of the MDNR 1983-84 angler survey which identified eleven distinct market segments of fishing experiences. We refer to the segments as *product lines* (PLs). Key distinctions among the product lines include targeted species (coldwater or warmwater) and destination type (Great Lakes: inland lakes, or inland streams). [3] Other distinctions include a category for ice fishing anglers, a category for anglers targeting "anything biting." and a minor category of smelt anglers. The analysis also examined the role of fishing mode (boat, shore) and method (casting, snagging, fly. ice, etc.), but did not find significant differences along these dimensions. [4]

Because ice fishing is quite limited, we restrict our study to open water angling that occurs between April and October. The anadromous run product lines are further restricted to April, May, September, and October. We combined the anadromous-inland-lake and anadromous-inland-stream product lines due to small sample sizes,

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[3] Coldwater species consist of mainly salmon and trout, and hence are also called "salmonid."

[4] When estimating the MNL model for product lines in which both modes are well represented, we also examined predictions separately by mode choice to reevaluate the modeling decision. We observed no mode-related pattern to the prediction errors.

particularly for the lake category. Inland lake coldwater and in!and stream coldwater are also combined for the same reason. The six product lines employed in our MNL analysis are, therefore, Great Lakes coldwater *(GLcd)*. Great Lakes warmwater *(GLww)*, anadromous run *(Anad)*. inland lake/stream coldwater *(LScd)*, inland lake warmwater *(ILww)*, and inland stream warmwater *(ISww)*.

Definition of Trip-Duration Groups

The trip-duration categories were chosen on the basis of whether trip destination types were different across the trip duration categories. Based on a χ^2 test, one-, two-, three-, and four-day[5] trips have significantly different destinations from one another. Four- and five-day trips are only different at the 10% level. Destinations of trips of five days are not significantly different from those of trips of greater length. The results suggest that the effect of residential location, which dominates the site choice for day trips, is not completely attenuated until five-day trips. Due to sample size considerations, trips of two to four days are grouped together to form one category; which we label "weekend" for convenience. [6] The three resulting duration groups are hence one-day trips, weekend trips (2-4 days), and vacation trips (at least 5 days and up to the maximum of 16 days).[7] labeled as *Day, Wkn,* and *Vac*, respectively

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[5] The number of days in a trip is calculated from the date/time people left their homes and the date/time people returned to their homes. If the combined hours in the first trip day and the last trip day are greater than 12, both days count. Otherwise, the first and last days together count as only one trip-day. For example: a trip from 10pm the first day to 7am the second day is considered a l-day trip, even though it invo!ves two calendar days.

[6] Note that the categorization is strictly based on trip length, not on which days of the week are involved, so that "weekend" trips do not necessarily occur over the weekend.

[7] We truncate vacation trips at 16 days because it is two weeks plus the extra weekend days. We delete people from our MNL analysis for whom the most recent trip was of more than 16 days, on the grounds that the longer trips have many other purposes than fishing.

Travel Distance and Cost

For the estimation of the model. we need to calculate the distance between an individual's residence and every county in his cr her choice set. To characterize travel distance between origin (home) and destination, we used the county-to-county distance matrix developed by the Michigan State Department of Transportation, based on highway distance measures The distances are measured between the geographical centers of the 83 Michigan counties.

The travel distance is calculated slightly differently for in-state and out-of-state anglers. For an in-state angler, the distance between the home county and any other county can be obtained from the distance matrix. [8] For an angler from other states, the point where he or she entered the state of Michigan (the entry point) is first assigned according to his or her origin and destination. For the chosen site. the travel distance outside Michigan is then calculated as the difference between the self-reported total travel distance and the entry-destination distance.[9] The distance between his or her home and any other potential fishing site is then computed as the sum of the out-of-Michigan distance and the distance between the entry point and the county in question.

To calculate the travel time from the travel distance, we use the sample average speed of 40.5 miles per hour. To calculate the distance-cost variable for a site, the two-way distance is multiplied by the vehicle operating cost per mile, $.23,[10] and then multiplied by the share of the total fishing party size represented by the respondent's family

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[8] For people who fished in their home counties, 10 is used as the one-way driving distance.

[9] If the self-reported total travel distance is less than, the calculated entry-destination distance, we use the self-reported driving time (in hours) instead for the calculation.

[10] This is the 1983/1984 estimate provided by the American Automobile Association (AAA).

Sample Selection

To select individuals for the MNL analysis, we defined samples (from the 1% MDNR sample of licensed anglers) that include all individuals whose choices met the definitions of the six product lines and three duration groups, and who indicated fishing as a purpose of the trip.

Of necessity: we deleted individuals if (1) there was an inconsistency between the self-reported travel time/distance data and the values in the Michigan State Department of Transportation distance matrix: because we could not be sure these individuals were properly assigned to the product line or site,[11] or (2) there was incomplete or inconsistent information on trip duration, trip location, or species sought. The resulting sample, called N^* and consisting of 18 PL-duration subsamples (6 PLs by 3 durations). provides the basis for extrapolation of the analysis to the population of licensed anglers.

However, estimation of the MNL model was restricted to a subset of the anglers in each PL-duration group because all individuals with any missing data on the MNL esplanatory variables had to be deleted. The sample used for MNL estimation is called N_{MNL}. To create the analysis sample N_{PART} for estimating the parameters of

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[11] We performed three types of data checking to make sure that information in the returned survey questionnaires is internally consistent.

First, we compared the self-reported travel distance/time against the values in the State of Michigan Department of Transportation origin-destination distance matrix. If inconsistency existed, we checked questionnaires for coding errors. In 125 cases, coding or data problems were corrected in home county, destination county, and self-reported distance variables. In some cases, it is obvious that people reported round-trip distances where one-way distance was actually asked. In 41 cases. we could not resolve the inconsistencies. and the data were discarded.

Second. we checked home county against the zip code variable. 16 people had improper values assigned to their home county variable according to their zip codes. Other information, such as travel distance and time, was also used to confirm the corrections.

Third: the destination counties of some people do not provide angling opportunities for the species for which they fished. Me checked this inconsistency between fish species and destination county. and made 30 corrections of coding errors.

the competing risks participation model, (1) we further delete, from the MNL, sample: observations missing either the age duration data[12] or the explanatory variables: and (2) me include the non-participant. To predict total trips in the season: however, only the explanatory variables are needed, so trip predictions are available for a slightly larger sample, N_{PRED}, than N_{PART}.

Table VI.1 presents the classification of the individuals in the MDNR sample and their use in this study. Groups 0 and 1 are the non-participants, people who took no trip from April 1, 1983 up to the time they returned the survey. [13] Groups 2 to 4 are the "pseudo participants" because their trips were longer than 16 days and/or were not for the purpose of fishing, and consequently were considered inappropriate for inclusion in a welfare analysis of recreational fishing Groups 5 to 9 are the "true" participants in our analysis. The MNL sample N_{MNL} consists of groups 6 to 9. The participation analysis sample N_{PART} consists of groups 1, 3, 4, and 9. Since we do net need age data for total trips prediction. sample N_{PRED} contains people in group 8 in addition to those in sample N_{PART}

Tables VI.2 to VI.4 present the means and standard deviations of angler characteristics for the Day, Wkn, and Vac duration samples that we use for estimation. The means for N^{*} are similar to those for the analysis samples. The variables are as follows.

- *HHY* is the annual household income in dollars
- *WkHrs* is the individual weekly work hours. It has a value of 40 if an individual had a full-time job, and 20 for a part-time job. If a second job was also held by the individual, 40 or 20 is further added for full-time and part-time, respectively.
- *Wage* is the individual pre-tax wage rate per hour. It is calculated as the individual's annual income divided by the annual work hours (= WkHrs x 52). If less than \$3.25, it is set to the minimum wage rate of \$3.25 per hour. The

[12] Calculated from last trip date and survey return date.

[13] A respondent is classified as a non-participant only if all relevant trip information is missing, including destination site, trip length, fish species sough, and trip date.

post-tax wage rate used in the estimation is obtained by multiplying the pre-tax wage by the individual's tax rate, calculated according to individual income bracket.

- *HmDest* is the one-way distance in miles between an angler's home and his/her chosen fishing destination.
- *Instate* is a (0,1) dummy variable. It is assigned 1 if the angler resided in the state of Michigan: and 0 otherwise.

Fish Catch Rate Data from the MDNR Creel Survey

Michigan's Great Lakes sport fishery has been monitored by the MDNR Fisheries Division with a statewide contact creel census program since 1983.[14] The objective of the program is to obtain a continuous record of sport catch, catch rate, and catch composition in the Great Lakes and important anadromous river fisheries. Though sampling efforts and study areas are different each year, the creel census methodology remains the same.

The Michigan creel census is based on a stratified design, using simple random sampling within strata. Strata include port fished, month, weekday-weekend (holiday), and mode of fishing. Catch and effort estimates are made for each cell in the stratified design and then combined to give monthly and seasonal figures.

The catch rates used in the analysis are calculated from the angler-party interview data collected for each area sampled. In the creel survey, an angler party is defined as one or more anglers who fished together. Angler parties are interviewed at the end of their fishing trips at various boat launching ramps, marinas, piers, and along the shoreline. Anglers are queried as to the mode of fishing (i.e., boat, shore, pier, open ice, or shanty ice) they just used, where they fished, how long they fished, what they

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[14] Information about the census operations can be obtained from the MDNR technical reports written by Rakoczy and Rogers (1987) for the 1986-87 census operations, and Rakoczy and Lockwood (1988) for the 1985-86 year.

fished for, the numbers (by species) of fish they caught, and the number of fishing trips they made or intended to make that day. Additional data are also collected on each angler in the party, such as age and sex of the angler, zip code or county of residence, and the types of angling methods used (casting, still fishing, trolling, etc.). These data are recorded on an angler interview form by census personnel.

The catch rates used in our analysis are broken down by species and by month for each county (the site unit in the analysis.) We combined the data on total catch by species and total angler- hours data for ports in a county to calculate the average hourly catch rates.

When estimating the site choice model for inland lake and inland stream product lines, we did not use catch rate data because of endogeneity between catch rates and participation. (As we explain below, me substituted measures of the quantity of water resources, differentiated by quality.) For the inland PLs, participation appears to adjust slowly to changes in catch rates: previous catch rates appear to drive current participation. Whereas last month's catch rate may have been high, inducing high participation rates, the current catch rate may be low due to the high participation rate last month. However, due to the slow adjustment process, current participation may still be high. (Thus perverse results would occur with catch rates as explanatory variables in the equations.) This is a special phenomenon for areas with limited resources: which can be depleted by too many anglers. It is unlikely that angler participation could have such an effect on large resources like the Great Lakes and their major tributaries.

Great Lakes Coldwater Species Catch Rates

Five salmonid species are considered important for the Great Lakes coldwater product line: chinook salmon, coho salmon, lake trout! rainbow trout, and brown trout. The feasible open-water fishing months are April to October. All 41 Great

Lakes counties provide angling opportunities for this product. line.[15] Map VI.2 shows the location of these Great Lakes counties.

Though not the most abundant Great Lakes species, various species of salmonids are the target of most Great Lakes sport fishing anglers. During the 1985 open-water fishing season, the Lake Michigan salmonid catch was composed of 59% chinook salmon, 13% coho salmon, 16% lake trout, 5% rainbow trout, 6% brown trout, and less than 1% of other salmonids.[16] For the 1986 fishing season: the percentages were 57%, 15%, 15%, 4%, and 8%, respectively. The other Great Lakes have similar catch compositions.[17] Therefore, chinook salmon is the most important salmonid in terms of the numbers of fish harvested. Lake trout and coho salmon are the second and third most numerous salmonid in the Great Lakes sport catch. Table VI.5 reports the means and standard deviations of the catch rates for these Great Lakes salmonid species.

Anadromous Run Species Catch Rates

The same salmon species (chinook, coho, and rainbow) as those of Great Lakes coldwater are adopted here for the anadromous run product line in the Great Lakes river systems. Feasible fishing months are April, May, September, and October only, during which periods salmon migrate down to and back from the Great Lakes. Salmon anadromous run angling is possible in 44 Michigan counties, including most Great Lakes counties and a few inland counties.[18] Map VI.3 indicates the location of these

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[15] Fishing in the five northernmost Lake Superior counties is, however, still restricted by ice in April, and therefore is only available for six months from May to October. They are Baraga (5), Gogebic (27), Houghton (31), Keweenaw (42), and Ontonagon (66).

[16] Such as pink salmon, Atlantic salmon, brook trout, and spake.

[17] For example, the percentages were 53%, 4%, 33%, 3%, and 7% for Lake Huron in the 1986 season.

[18] The inland counties included are Eaton (23), Ingham (33), Ionia (34), Kent (41), Lake (43), and Newaygo (62). Great Lakes counties excluded are Keweenaw (42), Monroe (58) and Tuscola (79).

anadromous run counties.

Chinook salmon is still the most abundant salmonid in the anadromous run catch, followed by rainbow trout and coho salmon. The catch rates are higher during the fall runs (September and October) than the spring runs (April and May). Table VI.6 reports the means and standard deviations of the catch rates for the anadromous run salmon species.

Great Lakes Warmwater Species Catch Rates

The fish species included in the Great Lakes warmwater product line are: yellow perch, walleye, northern pike, smallmouth bass, and carp.[19] Feasible fishing months are April through October. 40 out of the 41 Great Lakes counties are available for the Great Lakes warmwater fishing.[20]

Yellow perch is the most numerous in the Great Lakes catch of all species, coldwater or warmwater. For instance: it made up 68% (69%) of ail the fish caught in Lake Michigan during the 1985 (1986) fishing season.[21] Table VI.7 shows that the yellow perch catch rate is more than ten times that of any other warmwater species

Data on Other Characteristics of Site Quality

Data from state and federal sources are used to derive site quality indicators. Site properties that are generic to all product lines include

- *AOC* is a dummy variable that indicates whether a county has been designated as an 'Area of Concern' for toxic contamination by the International Joint Commission 21 out of the 83 Michigan counties are designated Areas of Concern, as shown in map VI.5.

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[19] 'Carp' includes freshwater drum, catfish, and sucker. The 'smallmouth bass' category also includes largemouth bass, bluegill, and pumpkin.

[20] Luce county (48) is excluded due to its extremely low catch throughout all months of the season.

[21] The percentage was as high as 79% for Lake Huron and 88% (including walleye) for Lake Erie during the year 1986.

- % *Forest* measures the percentage of county land that is forested. This variable is used as a proxy for natural beauty.

- A continuous integer-valued variable *Feature* contains the number of unique natural features, such as Pictured Rocks National Lakeshore and Sleeping Bear Dunes National Lakeshore. Only 14 Michigan counties have special landscape features.

Site Data for Great Lakes Counties

Site data specific to the Great Lakes product lines (both coldwater and warmwater) include the following for the 41 Great Lakes counties.

- Number of parking spaces *(GLprkg)* in GL counties. Only 2 GL counties do not have parking facilities.

- Number of harbors *(GLhrbr)* in GL counties. Only 4 GL counties do not have any harbor for boat mooring.

- Number of slips for boat mooring *(GLslip)* in GL counties.

- Number of ramps for boat launching *(GLramp)* in GL counties. 38 out of the 41 GL counties have ramps.

Table VI.8 reports the means and standard deviations of the Great Lakes product line site characteristics.

Site Data for Anadromous Run Counties

Site data specific to the 44 anadromous run product line counties include

- For anadromous run angling, the presence of a lake in an anadromous stream *(ANlake)* provides opportunities for the use of a boat, in addition to the shore angling available in all 44 counties. Only 10 anadromous run counties have lakes. [22]

Table VI.9 reports the means and standard deviations of the anadromous run site data.

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[22] They are Benzie (10), Berrien (11), Charlevoix (15), Houghton (31), Leelenau (45), Manistee (51), Mason (53), Muskegon (61), Oceana (64), and Ottawa (70).

Site Data for Inland Coldwater Counties

Since this product line is the combination of inland lake coldwater and inland stream coldwater, variables pertaining to both are included. Those 73 counties that offer inland coldwater angling opportunities are shown in map VI.4.

Inland Lakes

Three types of inland lakes are available for recreational angling: coldwater-only lakes, warmwater-only lakes, and two-story lakes. A two-story lake has an upper layer of water that is warm enough to support warmwater fish species, while the water below is cold enough for coldwater angling to be possible. Data from MDNR allow us to measure the acres of lakes in the separate categories. For the inland lake coldwater product line, only the coldwater lake measures are used. A total of 67 Michigan counties have coldwater lakes for trout fishing.

- Acres of the coldwater-only lakes *(ILcdacre)* in the county.
- Acres of the two-story lakes *(IL2story)* in the county.
- Total acres of the coldwater lakes *(ILtotcd)* in the county. This variable is the sum of the above two variables.
- Acres of the coldwater lakes with fishing consumption advisories *(CntmLC)* in the county. Only two counties have contaminated coldwater lakes.[23]

Inland Streams

Inland cold streams can be classified by their fish quality and tributary status. A cold stream may be classified as top quality main stream, top quality tributary stream, second quality main stream, or second quality tributary stream. 69 Michigan counties are available for inland stream trout angling.

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[23] They are Houghton (31) and Marquette (52).

Variables pertaining to this specific product line are

- Six counties are listed in the *Michigan Fishing Guide 1983*, section 'Quality Fishing,' as having streams on which fly fishing is allowed to improve the quality of fishing.[24] A dummy variable *IScdFly* is used to indicate this possibility.
- Miles of top quality main streams *(IScd1main)* in county.
- Miles of top quality tributary streams *(IScd1trib)* in county.
- Miles of second quality main streams *(IScd2main)* in county.
- Miles of second quality tributary streams *(IScd2trib)* in county
- Miles not elsewhere classified *(IScdNEC)* in county.
- Miles of coldwater streams contaminated *(CntmSC)* in county. Only two counties have contaminated streams. [25]

Table VI.10 reports the means and standard deviations of these lake and stream variables.

Sire Data for Inland Lake Warmwater Counties

All 83 Michigan counties have warmwater lakes. The fishing resource variables used are

- Acres of the warmwater-only lakes *(ILwwacre)* in the county.
- Acres of the two-story lakes *(IL2story)* in the county.
- Acres of the warmwater lakes with fishing consumption advisories *(CntmLW)*. Only three counties have non-zero values.[26]

Table VI.11 reports the means and standard deviations of these lake acres variables.

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[24] These counties are Crawford (20), Lake (43), Missaukee (57), Oakland (63), Oscoda (68), and Wexford (83).

[25] They are Marquette (52) and Osceola (67).

[26] They are Allegan (3), Houghton (31), and Ottawa (70).

Site Data for In1and Stream Warmwater Counties

Like inland coldwater streams, the inland warmwater streams can also be classified by their quality and tributary status. A warmwater stream could be top quality main stream. top quality tributary stream, second quality main stream, or second quality tributary stream. All 83 Michigan counties have warmwater streams. Variables specific to this product Line include

- Miles of top quality main streams *(ISww1main)* in county.
- Miles of top quality tributary streams *(ISww1trib)* in county.
- Miles of second quality main streams *(ISww2main)* in county.
- Miles of second quality tributary streams *(ISww2trib)* in county.
- Miles not elsewhere classified *(ISwwNEC)* in county.
- Miles of warmwater streams contaminated *(CntmSW)* in county. A total of 12 counties have contaminated warmwater streams. [27]

Table VI.12 reports the means and standard deviations of these stream miles variables.

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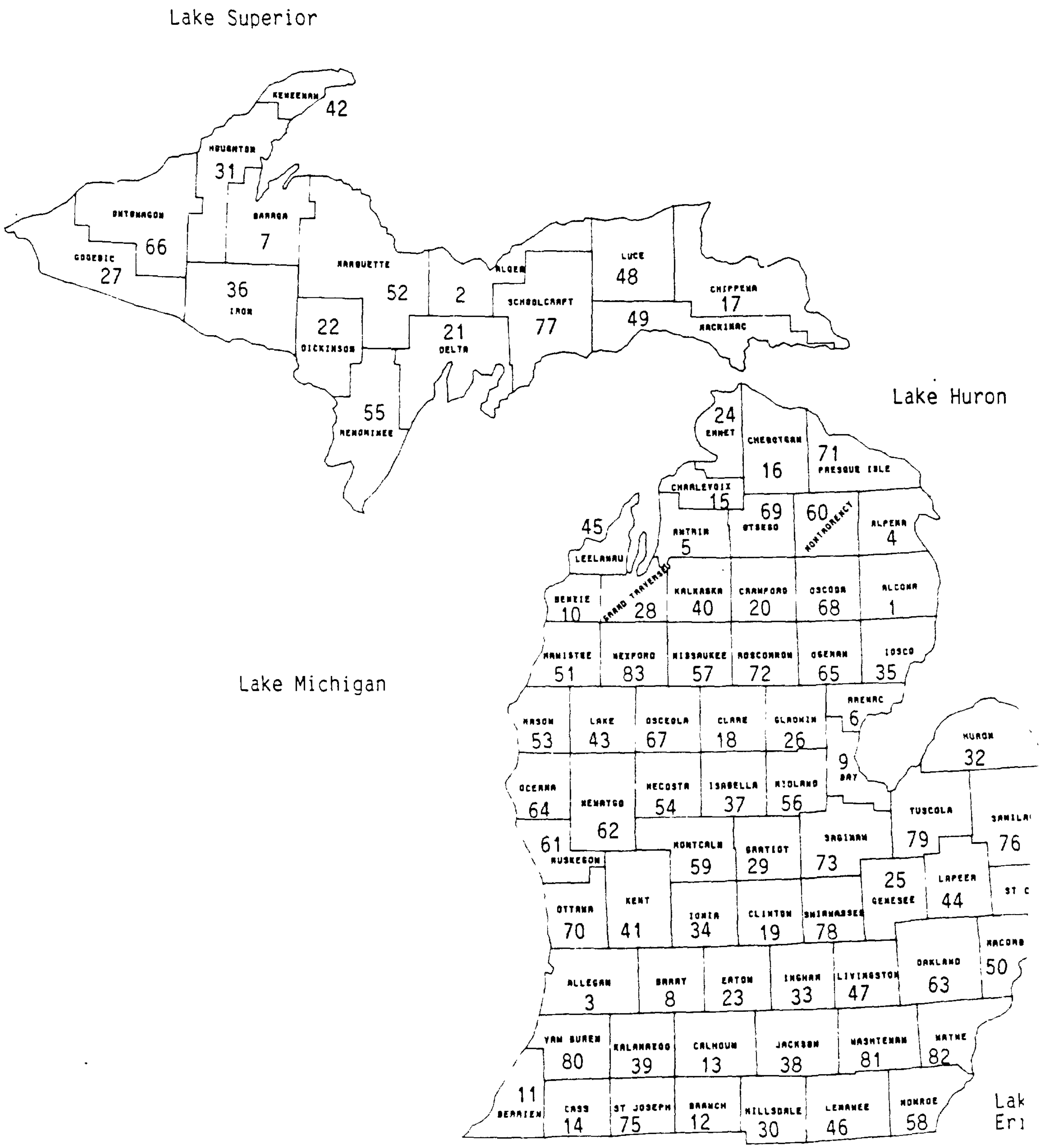
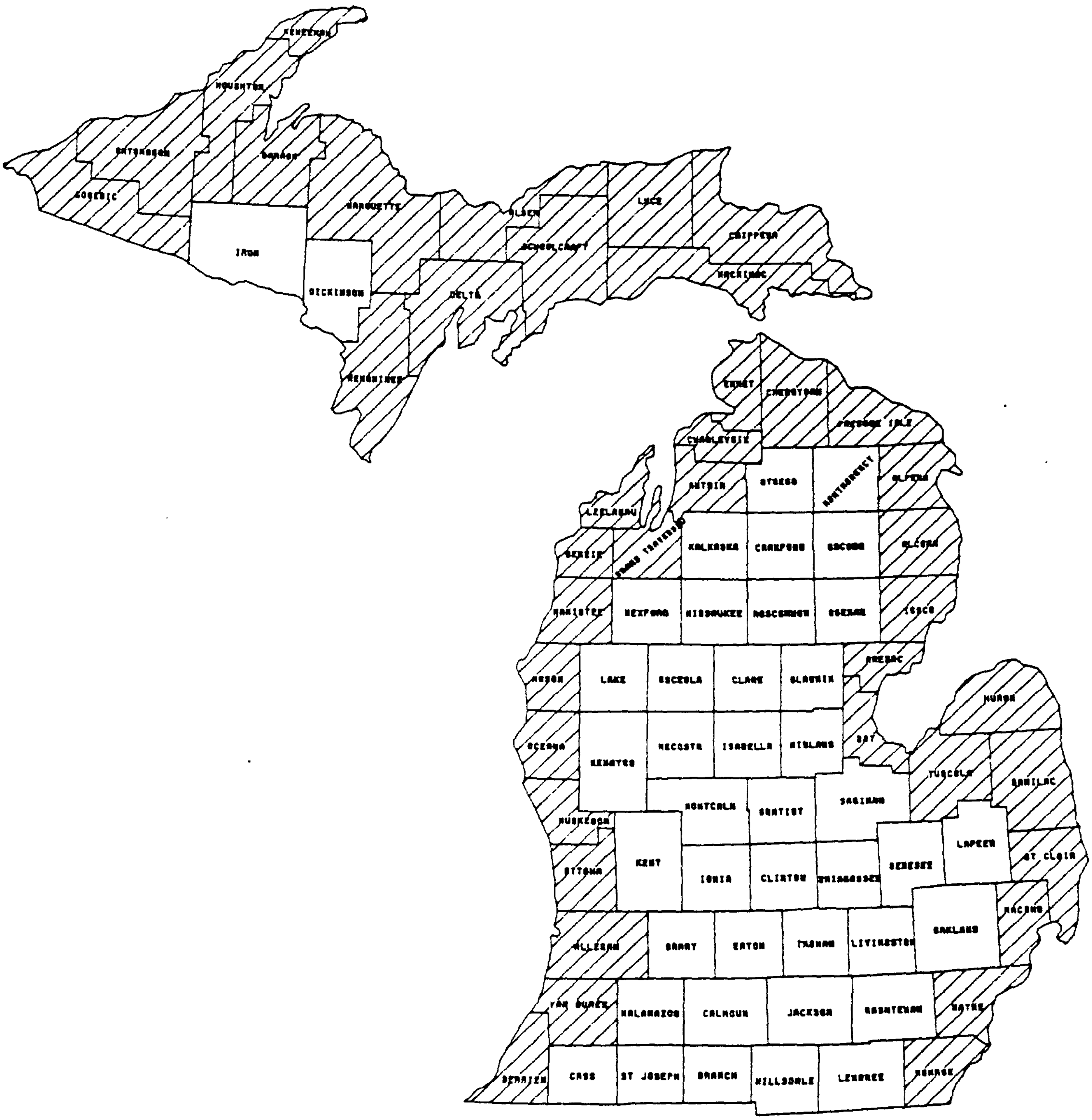
[27] They are Allegan (3), Bay (9), Berrien (11), Clinton (19), Gratiot (29), Isabella (37), Kalamazoo (39), Livingston (47), Midland (56), Monroe (58), Saginaw (73), and Shiawassee (78). Many of these counties are in the Saginaw Bay area.

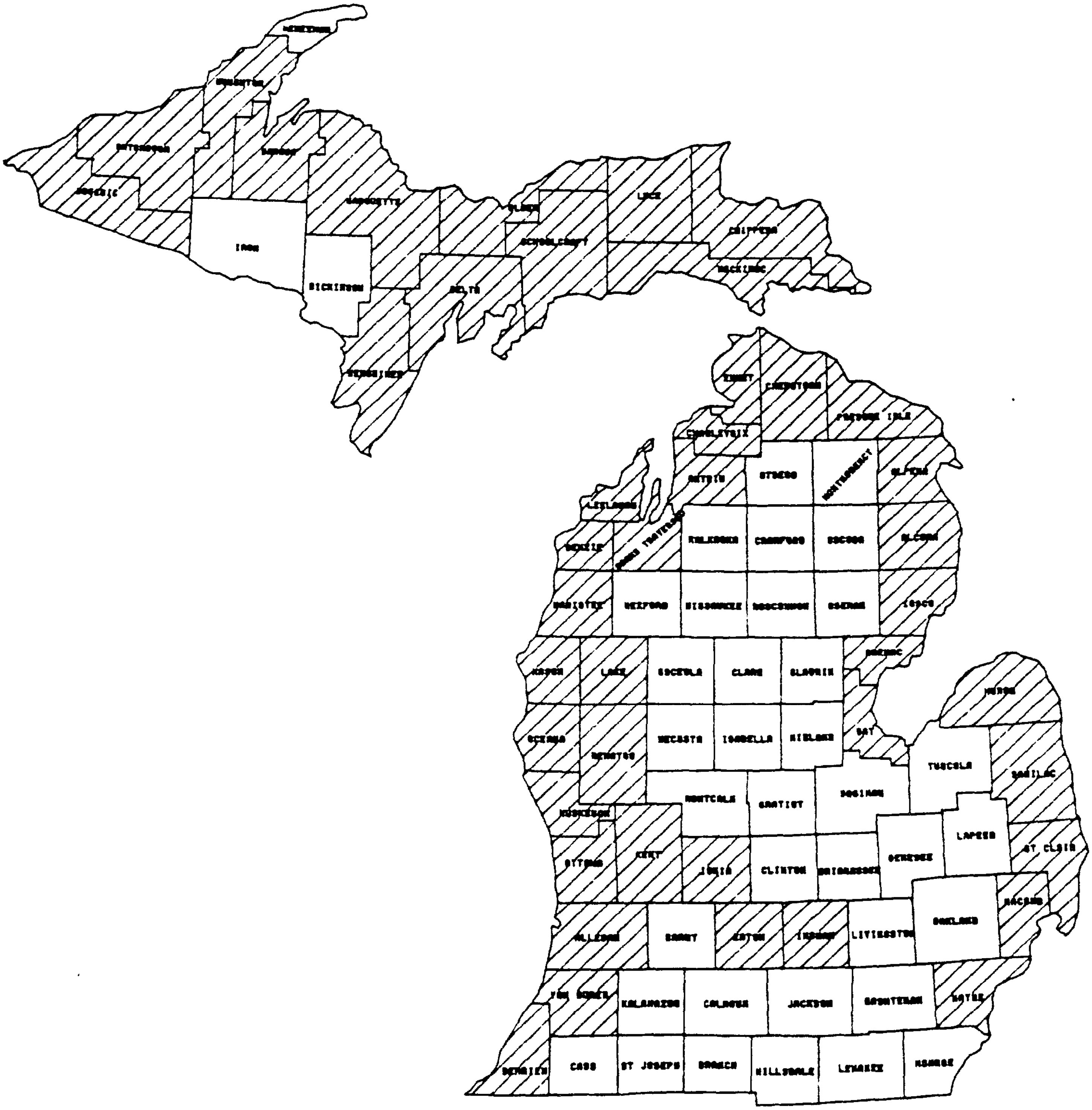
Map VI.l: State of Michigan counties



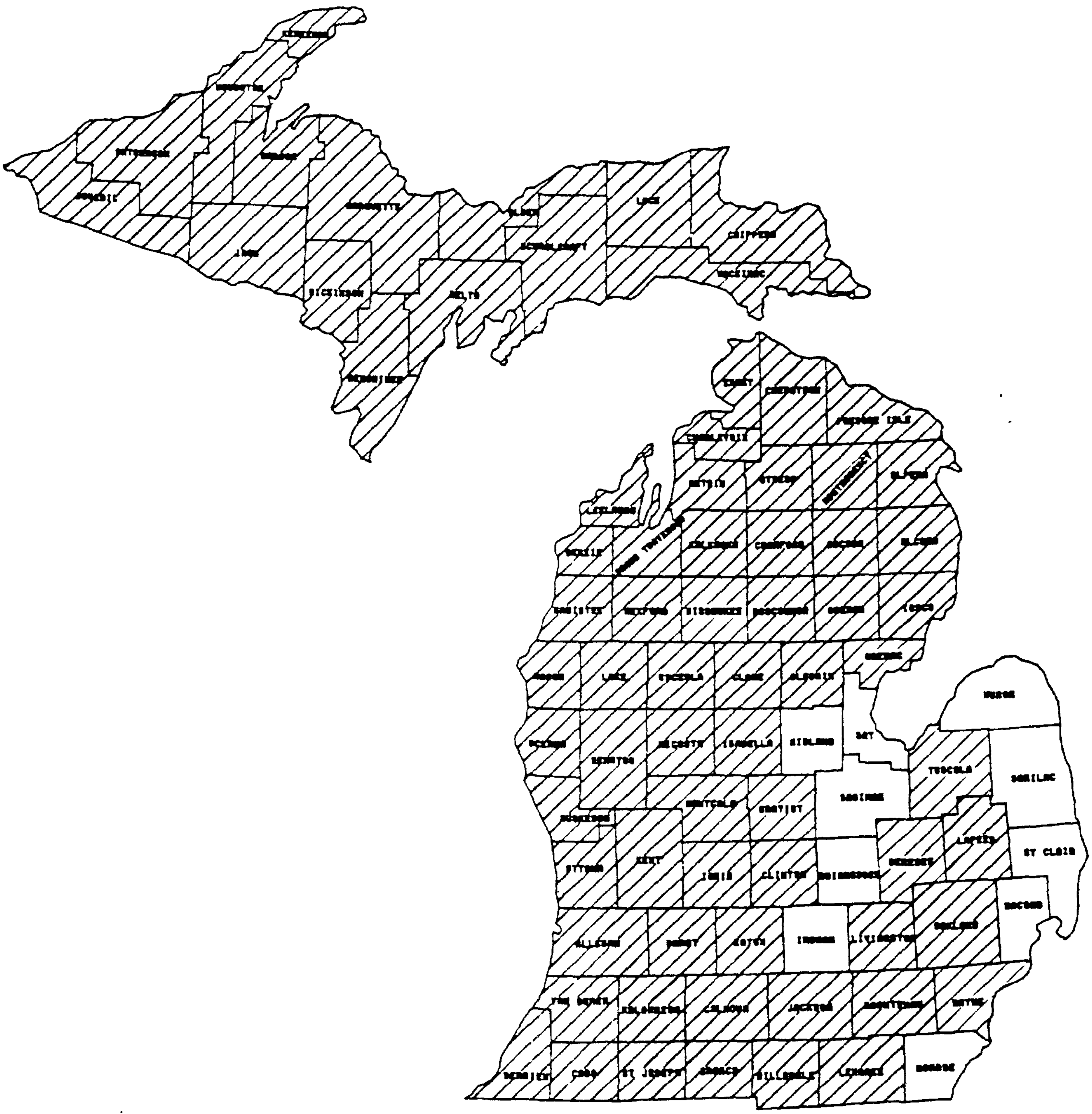
Map VI.2: Great Lakes product line counties



Map VI.3: Anadromous run product line counties



Map VI.4: Inland coldwater product line counties



Map VI.5: Areas of Concern in Michigan

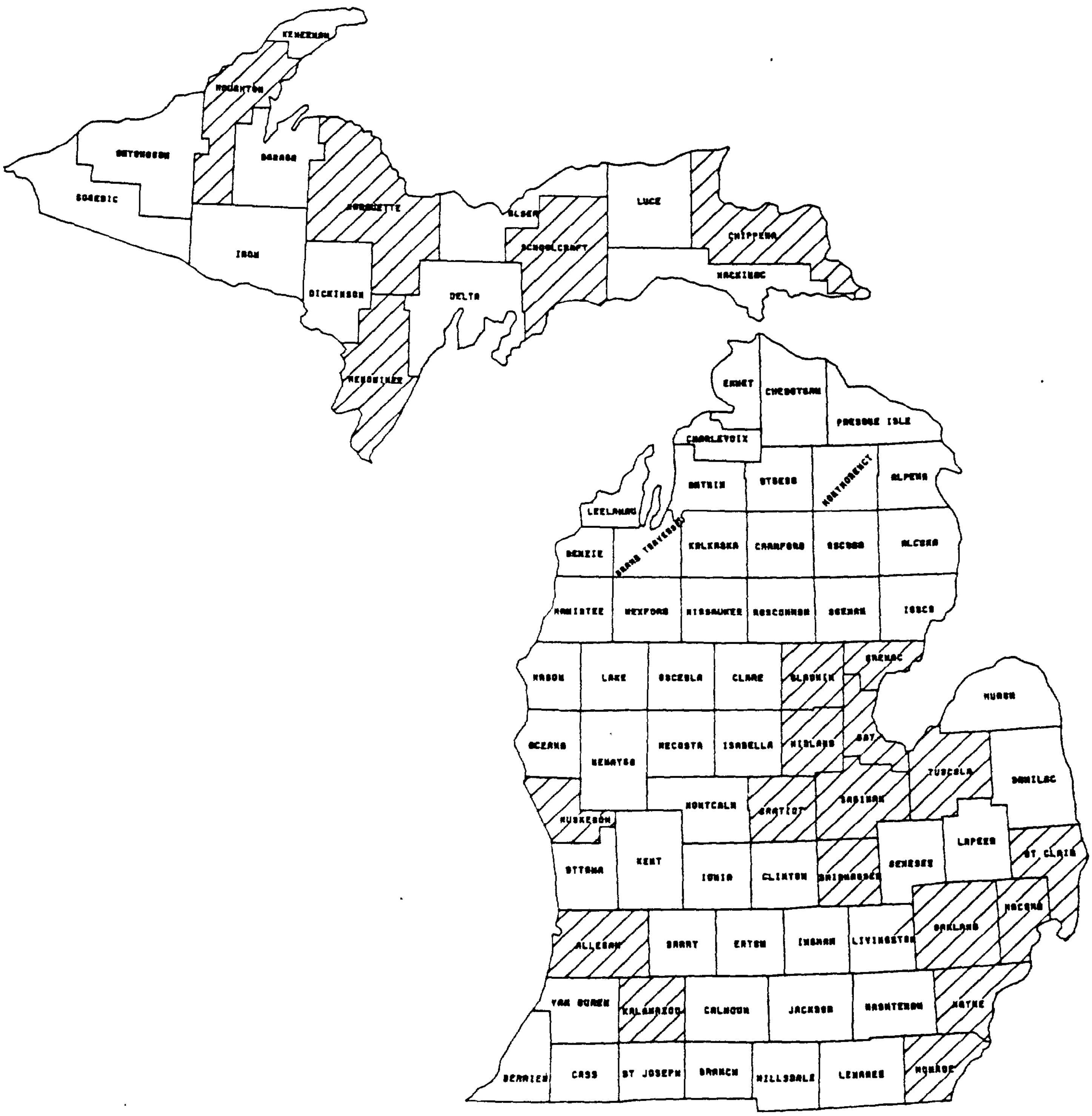


Table VI.1: Classification of sample observations

Group	N	Definition
Non-participants:		
0	738	No trip; no data for participation estimation
1	582	No trip; have data for participation estimation
Pseudo-participants:		
2	1707	Trip invalid, no data for participation estimation
3	137	Trip > 16 days; have data for participation estimation
4	148	Fishing not a trip purpose; have data for participation estimation
Participants:		
5	1817	Trip valid; missing data for MNL analysis
6	556	MNL sample (trip hours missing)
7	224	MNL sample (trip hours available)
8	358	MNL sample; have data for participation prediction only
9	4681	MNL sample; have data for participation estimation
Total	**10948**	**Full MDNR sample**

Table VI.2: Angler characteristics of the Day group

Sample	HHY	Wage	WkHrs	HmDest	Instate
N^*	25937.33	8.45	29.02	29.07	0.96
[N=4067]	(15002.19)	(7.46)	(18.95)	(39.48)	(0.20)
N_{MNL}	26407.20	8.65	28.61	29.23	0.96
[N=2666]	(15216.03)	(7.64)	(19.12)	(40.32)	(0.19)
N_{PART}	26656.12	8.98	29.74	28.01	0.96
[N=2370]	(15255.66)	(7.40)	(18.49)	(38.14)	(0.19)

Table VI.3: Angler characteristics of the Wkn group.

Sample	HHY	Wage	WkHrs	HmDest	Instate
N^*	30092.23	10.65	32.76	131.14	0.84
[N=1653]	(16049.09)	(7.93)	(16.76)	(93.36)	(0.37)
N_{MNL}	30106.46	10.64	32.27	131.05	0.83
[N=1228]	(15922.25)	(7.96)	(17.10)	(94.45)	(0.36)
N_{PART}	30209.84	10.85	32.98	132.17	0.85
[N=1108]	(15658.39)	(7.61)	(16.16)	(94.53)	(0.36)

Table VI.4: Angler characteristics of the Vac group.

Sample	HHY	Wage	WkHrs	HmDest	Instate
N^*	29357.35	9.71	29.40	235.16	0.73
[N=1915]	(15108.86)	(7.94)	(18.33)	(159.97)	(0.45)
N_{MNL}	29289.01	9.77	28.70	237.29	0.74
[N=1369]	(15004.55)	(7.94)	(18.45)	(164.07)	(0.44)
N_{PART}	29750.62	10.29	30.52	241.34	0.73
[N=1203]	(14970.86)	(7.53)	(17.44)	(163.41)	(0.44)

Note: Numbers in parentheses are standard deviations.

Table VI.5: Means and standard deviations of the GLcd catch rates

Month	N	Chinook	Coho	LakeT	Rainbow	BrownT
April	36	0.026	0.019	0.001	0.015	0.028
		(0.045)	(0.044)	(0.005)	(0.023)	(0.044)
May	41	0.030	0.018	0.065	0.010	0.009
		(0.053)	(0.045)	(0.106)	(0.025)	(0.016)
June	41	0.022	0.007	0.073	0.003	0.005
		(0.031)	(0.019)	(0.087)	(0.008)	(0.012)
July	41	0.044	0.003	0.056	0.001	0.003
		(0.041)	(0.006)	(0.085)	(0.004)	(0.013)
August	41	0.056	0.005	0.042	0.001	0.002
		(0.053)	(0.010)	(0.093)	(0.003)	(0.011)
September	41	0.039	0.018	0.014	0.004	0.001
		(0.030)	(0.046)	(0.043)	(0.012)	(0.004)
October	41	0.037	0.022	0.002	0.020	0.017
		(0.042)	(0.059)	(0.008)	(0.033)	(0.078)

Table VI.6: Means and standard deviations of the Anad catch rates

Month	N	Chinook	Coho	LakeT	Rainbow	BrownT
April	44	0.0	0.0	0.0	0.090	0.0
		(0.0)	(0.0)	(0.0)	(0.102)	(0.0)
May	44	0.0	0.0	0.0	0.079	0.0
		(0.0)	(0.0)	(0.0)	(0.088)	(0.0)
September	44	0.112	0.037	0.0	0.011	0.0
		(0.177)	(0.096)	(0.0)	(0.023)	(0.0)
October	44	0.107	0.021	0.0	0.039	0.0
		(0.163)	(0.039)	(0.0)	(0.054)	(0.0)

Table VI.7: Means and standard deviations of the GLww catch rates

Month	N	Y.Perch	Walleye	N.Pike	SM Bass	Carp
April	40	1.073	0.002	0.000	0.000	0.007
		(1.431)	(0.008)	(0.000)	(0.002)	(0.031)
May	40	0.524	0.034	0.005	0.004	0.009
		(0.735)	(0.051)	(0.011)	(0.011)	(0.021)
June	40	0.781	0.028	0.002	0.006	0.015
		(0.816)	(0.057)	(0.006)	(0.015)	(0.042)
July	40	0.570	0.048	0.003	0.004	0.021
		(0.589)	(0.104)	(0.007)	(0.007)	(0.070)
August	40	0.621	0.033	0.011	0.002	0.009
		(0.714)	(0.081)	(0.026)	(0.005)	(0.022)
September	40	0.921	0.023	0.002	0.004	0.010
		(1.073)	(0.066)	(0.006)	(0.013)	(0.030)
October	40	1.254	0.010	0.004	0.001	0.007
		(1.775)	(0.028)	(0.011)	(0.004)	(0.018)

Table VI.8: Descriptive statistics: Great Lakes site attributes

Variable	N	Mean	Std Dev.	Minimum	Maximum
%Forest	41	0.547	0.291	0.7	0.97
Feature	41	0.366	0.733	0.0	3.00
AOC	41	0.341	0.480	0.0	1.00
GLprkg	41	205.512	169.034	0.0	720.00
GLhrbr	41	1.683	1.105	0.0	5.00
GLslip	41	893.927	1633.222	0.0	7951.00
GLramp	41	8.707	10.530	0.0	44.00

Table VI.9: Descriptive statistics: Anad site attributes

Variable	N	Mean	Std Dev.	Minimum	Maximum
AOC	44	0.273	0.451	0.0	1.0
ANlake	44	0.227	0.424	0.0	1.0

Table VI.10: Descriptive statistics: LScd site attributes

Variable	N	Mean	Std Dev.	Minimum	Maximum
AOC	73	0.192	0.396	0.0	1.0
Feature	73	0.260	0.602	0.0	3.0
IScdFly	73	0.082	0.277	0.0	1.0
IScd1main	73	19.671	27.767	0.0	112.0
IScd1trib	73	24.877	29.705	0.0	144.0
IScd2main	73	59.000	79.890	0.0	478.0
IScd2trib	73	79.945	98.199	0.0	456.0
IScdNEC	73	3.630	5.934	0.0	30.0
CntmSC	73	0.315	2.101	0.0	17.0
ILtotcd	73	2817.712	6159.408	0.0	33942.0
CntmLC	73	17.233	138.062	0.0	1178.0

Table VI.11: Descriptive statistics: ILww site attributes

Variable	N	Mean	Std Dev.	Minimum	Maximum
AOC	83	0.253	0.437	0.0	1.0
Feature	83	0.229	0.570	0.0	3.0
ILwwacre	83	7652.084	6755.713	204.0	29219.0
IL2story	83	2414.048	5830.382	0.0	33897.0
CntmLW	83	50.096	265.674	0.0	1780.0

Table VI.12: Descriptive statistics: ISww site attributes

Variable	N	Mean	Std Dev.	Minimum.	Maximum
AOC	83	0.253	0.437	0.0	1.0
Feature	83	0.229	0.570	0.0	3.0
ISww1main	83	28.578	30.022	0.0	109.0
ISww1trib	83	21.711	28.624	0.0	115.0
ISww2main	83	22.639	35.032	0.0	181.0
ISww2trib	83	105.446	89.374	0.0	330.0
ISwwNEC	83	3.976	6.912	0.0	33.0
CntrnSW	83	3.042	10.170	0.0	55.0