Great blue herons (Ardea herodias) in northwestern Montana: Nesting habitat use and the effects of human disturbance

Jill Parker
The University of Montana

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GREAT BLUE HERONS (ARDEA HERODIAS)
IN NORTHWESTERN MONTANA:
NESTING HABITAT USE AND THE
EFFECTS OF HUMAN DISTURBANCE

By
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B.S., Yale College, 1977

Presented in partial fulfillment of the requirements for the degree of
Master of Science
UNIVERSITY OF MONTANA
1980

Approved by:

Chairman, Board of Examiners

Dean, Graduate School

Date
ABSTRACT

Parker, Jill, M.S., Spring 1980

Great Blue Herons (Ardea herodias) in northwestern Montana: nesting habitat use and the effects of human disturbance (82 pp.)

Director: B. Riley McClelland

To assess the impact of human disturbance on reproductive success and to determine the necessary components of Great Blue Heron (Ardea herodias) habitat, 22 heron colonies on 4 rivers were studied during 2 breeding seasons. Most of the colonies were found in old-age cottonwood bottomlands, but a few were in drier, coniferous sites. The trees used by nesting herons were always significantly larger than the trees not used, and mean nest tree dimensions decreased as colony size increased. Reproductive success in a colony was not affected by the number of breeding birds in the colony.

The isolation from roads apparently influenced colony size. Isolation from the river was most important in early spring, when recreationists were frequently instrumental in colony abandonment. The distance from housing did not affect the size of colonies. Herons appeared less influenced by disturbance and more tenacious in colonies near productive areas.

Large colonies known to exist in 1969 had splintered into small, but numerous, colonies, most of which were only occupied 5-10 years. This frequent movement on the part of the herons may reflect deterioration in the quality of available habitat and an increased extent of human interference.
ACKNOWLEDGEMENTS

I am grateful to the National Wildlife Federation, Sigma Xi, and the Montana Cooperative Wildlife Research Unit for their financial and logistical support of this study.

My committee members Drs. Riley McClelland, Bart O'Gara, and Richard Hutto deserve special thanks for their constructive suggestions and assistance during the course of the project.

I am greatly indebted to Dennis Billings, who generously donated his data, and to Marcy Bishop, who donated her data and her time, and who encouraged me in this project.

Members of the Flathead Audubon Society merit thanks for their cooperation in locating colonies. Mark McNay was invaluable in contributing his time as a pilot and furnishing first aid in the air. I am also grateful to Sewall Young for his enthusiastic assistance in the field.

Lastly, I would like to thank Doug McKenna, my uncomplaining and unpaid field assistant and friend, and my parents for their unstinting encouragement of all my endeavors.
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CHAPTER I
INTRODUCTION

In Montana, the Great Blue Heron (*Ardea herodias*) is primarily a bird of riparian habitat. Twenty-two of the 26 known colonies in northwestern Montana are on 4 major rivers (3 of the others are on lakes and 1 is on a reservoir). The heron's needs are conflicting increasingly with man's as the quality and quantity of riparian habitat diminish in the wake of land development, livestock grazing, channelization, and diversions. Along streams, forests have been cleared to make way for pastures and subdivisions. Vegetation and fallen logs along some stream banks have been removed and replaced with concrete, rock, or even old cars, to reduce the incidence of flooding and erosion. Livestock have depleted some streamside vegetation, trampled overhanging banks and increased the siltation of the water. Grazing and channelization have often ruined the streambed habitat of aquatic insects and fish, affecting the animal populations dependent on those organisms.

Rivers are not easily protected: pollution, damming, or drainage anywhere in the watershed has repercussions on the main river. Recreationists are difficult to control, especially when the rivers flow through private property.

Great Blue Herons are easily disturbed, and usually nest colonially in areas isolated from roads and human settlement. Little is known about the movement of Great Blue Heron colonies or what causes them
to abandon traditional nest sites, although human interference is often implicated (Cameron 1906, Miller 1943, Ives 1972, Bjorklund 1975, Mark 1976). Being primarily piscivorous, the heron exists at the top of a food chain, where it is affected by disruptions further down the chain and where it is subject to the accumulation of toxic substances in its tissues. Because herons are large and nest in colonies, they are particularly conspicuous during the nesting season and vulnerable to vandalism. Destruction of habitat affects entire colonies, rather than a few birds. Logging, drainage, and road construction may destroy existing colonies and reduce the number of alternative sites.

A Great Blue Heron study conducted in 1969-1970 by Dennis Billings (former graduate student of the University of Montana, who collected data but did not publish his findings) provided a unique opportunity to assess ecological changes in heronries in response to increasing human pressure in the last 10 years.

The objectives of this study were:
2. To describe the Great Blue Heron habitat in northwestern Montana.
3. To assess the impact of human activities on the breeding success of herons in northwestern Montana.
4. To provide guidelines for the management of the Great Blue Heron.
CHAPTER II
METHODS

Locating Colonies

Dennis Billings' description of previous colony locations was used to locate colonies in 1978; members of the Flathead Audubon Society provided a more complete list of current heronries in the Flathead and Swan valleys. Flights over the Bitterroot, Clark Fork, Flathead, and Swan rivers, made in the spring of 1978 before the trees leafed out, confirmed references made by Billings or the Flathead Audubon Society and assured that all new colonies were found.

Mainland colonies were usually reached on foot, and island colonies by raft or canoe.

Habitat and Colony Description

During the fall of 1978 and the early spring and late summer of 1979, habitat measurements were made in the colonies.

The habitat of each colony was analysed by a procedure described in James and Shugart (1970). Five 0.04-ha circular plots (11 m radius) were randomly selected in each colony. Within each plot, I recorded the height, species, and diameter at breast height (dbh) of each tree, from which I could then calculate canopy height, frequency (relative abundance of species), density (trees/ha), and dominance (percent of total basal area). Within each circle, 2 transects perpendicular to each other were laid out, and the number of shrub stems intersecting
the lines were counted. The number of stems in the 5 plots x 24.7 was an estimate of the number of shrub stems/ha. To determine the percent canopy cover, I held a tube vertically over my eye and noted the presence or absence of canopy at the center of the circle outlined in the sky. This was done at 20 evenly spaced locations along the 2 transects in each plot.

I recorded the dbh and species of each nest tree, and measured its height and the height of each nest with a Spiegel Relascope. The distances between outlying nest trees at the 4 corners of the heronry were used to calculate heronry size. The distances to the river, to the nearest road, and to the nearest housing were measured from the colony's center.

Collection of Reproductive Data

During the spring, I could census each nest at a distance of approximately 100 m, with a 20-power telescope. The maintenance of this distance, at a time of year when the birds flush easily, was essential for an accurate census of nest occupation. After the trees leafed out in late May, I was forced to move to within approximately 50 m. By this time, I had a good idea of each nest's activity, and the herons that did flush returned quickly. I was usually separated from the birds by brushy cover and/or a channel of water.

Censusing began each year in late March, when the migrant herons returned to the nest sites, and continued until all the young had left the nests in late July. Each colony was censused every 2 weeks.

All nests in a colony were checked individually at each visit. Any
nest incubated for 4 weeks was termed "active", regardless of whether eggs hatched. A "successful" nest was one that fledged at least 1 young.

Because nestlings sitting in a nest were often impossible to see and nestlings out on limbs often could not be assigned to any particular nest, accurate counting of one nest's young was possible only when the young were being fed by a parent. Censusing based on observations of adults returning to each nest in a colony usually took half a day.

In the larger colonies, some of the nests were completely obscured when the trees leafed out. Accurate censusing at those times was not possible. The number of young fledged from the hidden active nests was extrapolated from the success rate of the visible nests.

The 1978 breeding data, collected on a part-time basis only, were incomplete. The 1979 data were complete, encompassing all 22 colonies from March through July.

Data Analysis

Much of the data analysis was accomplished through various SPSS (Statistical Package for the Social Sciences) computer programs (Nie et al. 1975). Significant results were those with a probability level of 0.05 or less.
CHAPTER III

STUDY AREA

The 22 colonies under observation were among 26 that occurred along 4 major rivers within a 16,000 km$^2$ area in the northwest corner of Montana (Fig. 1). Heronries are referred to by the name of the closest town or landmark (precise locations are given in Appendix A).

Five heron colonies were located along a 50 km stretch between Victor and Missoula in the agricultural valley of the Bitterroot River. The population of the valley is 32,000 (1977 census), concentrated in 7 small towns along the River. The stream's mean annual discharge (at Darby) is 26.4 m$^3$/sec; extensive irrigation diversions lower the summer flow (at Darby) to 5.7 m$^3$/sec. (U.S.G.S. Survey 1978).

The Clark Fork of the Columbia River, with an average discharge of 85.4 m$^3$/sec (below Missoula), supported 3 Great Blue Heron colonies in the 130 km stretch between Deerlodge and Missoula. The major sources of employment in the valleys of the Clark Fork are timber and agriculture; the largest urban center on the River is Missoula (population 34,000).

The Clark Fork and the Bitterroot valleys receive an average annual precipitation of 34 cm; the average temperature is 6° C.

The Flathead River (below Kerr Dam) discharges an average 333 m$^3$/sec. There were 3 heron colonies on the upper Flathead River above Flathead Lake, 1 colony on the Lake itself, and 6 on the lower Flathead below the Lake. A reservoir on the Ninepipe National Wildlife Refuge, 16 km from the lower Flathead River, sustained the largest colony during this
Figure 1. 1979 heronry locations in northwestern Montana.
study. The upper Flathead flows through the cities of Columbia Falls (population 3,100) and Kalispell (population 16,000) before emptying into the Lake, while the lower Flathead flows only through several small towns on the Flathead Indian Reservation. The average temperature at Kalispell is 6°C, and the average annual precipitation is 43 cm.

The Swan River Valley is a narrow, heavily-timbered valley unsuited for agriculture. The Valley receives an unusually high amount of precipitation (68 cm annually) and supports vegetation dissimilar to that elsewhere in the study area. Nowhere else in northwestern Montana did herons nest in lodgepole pine (Pinus contorta) or spruce (Picea spp.). The River south of Swan Lake is largely unsettled. North of the Lake, the Valley widens, becoming more suitable for agriculture and more populated. The River (with a mean annual discharge of 32.9 m^3/sec) sustained 3 of the heron colonies in this study, 1 on the lower and 2 on the upper Swan.

The channels of the upper Flathead, Clark Fork, Bitterroot, and Swan rivers are broad streambeds of glacial outwash and alluvium. Meanders, side channels, sloughs, gravel bars, and log jams characterize these streams. Black cottonwood (Populus trichocarpa) is the dominant tree, and most of the heronries in these valleys were found in Populus woodlands. Side channels and other irregularities are relatively infrequent on the lower Flathead, where the stream has cut deeply into the bedrock, creating a narrow channel bordered by cliffs. The climate on the lower Flathead is drier and windier than on the upper Flathead, and only a thin belt of vegetation borders the River on each bank. The
dominant trees are ponderosa pine (*Pinus ponderosa*) and western juniper (*Juniperus occidentalis*). All the heron nests on the lower Flathead were in ponderosa pine.

Three of the 22 colonies were in National Wildlife Refuges, 4 were on state-owned land, and 6 along the lower Flathead occurred within the Flathead Indian Reservation. The other 9 were on privately-owned land.
CHAPTER IV
BILLINGS' 1969-1970 HERON STUDY

In 1969, University of Montana graduate student Dennis Billings undertook a research project on Great Blue Herons in western Montana. His primary objectives were to locate all colonies in the state, determine the reproductive status of a few, and relate reproductive success to pesticide concentrations in eggs and body tissues. Although Billings worked on the project for 2 years, his data were never compiled into thesis form.

After locating 43 active colonies, 14 inactive colonies, and 3 of unknown status (Appendices B and C), Billings narrowed his observations to 3 large colonies: 2 along the Bitterroot River, at Victor and Florence, and 1 on the lower Flathead River, at Moiese.

Billings visited each of the 3 colonies at 10-day intervals from the start of the breeding season in April until mid-July, when the young fledged. At each visit, Billings climbed the nest trees or adjacent trees, and counted the number of eggs or young in each nest. Addled eggs, eggshells, and dead birds were removed for pesticide analysis. Billings measured shell thicknesses with a micrometer, and tissues were sent to the Fish and Wildlife Service, Denver, for chemical analysis.

Distribution

Billings located 18 colonies on the Bitterroot, Clark Fork, Flat-
head, and Swan rivers (Fig. 2). Precise locations of these colonies and others Billings found elsewhere in Montana are listed in Appendices B and C.

**Reproductive Activity**

Heron's nested in cottonwoods on the Bitterroot and in ponderosa pines on the Flathead (Table 1). The nests in the ponderosa were concentrated in relatively few trees.

Herons arrived at the 3 colonies between 20 and 30 March, and laid eggs in mid-April. The mean clutch size at Moiese was 4.3 (n=92 nests), and ranged from 2 to 7 eggs. The young hatched during the second week in May, and fledged by 15 July. An average 1.43 young per active nest fledged over the 2-year period.

Billings' blind-building activities in late March 1970 at Moiese, caused many herons to desert, reducing the colony from 95 to 8 nesting pairs within 2 weeks. The missing birds were later found nesting nearby on the Ninepipe National Wildlife Refuge.

**Pesticide Analysis**

Seven subcutaneous fat samples from young Great Blue Herons taken at the Moiese colony contained DDE residues ranging from 1.8 to 11.8 ppm (wet weight). Levels of DDE in 7 addled eggs, also from Moiese and ranging from 0.31 to 1.06 ppm, did not correspond well with shell thicknesses (Table 2). Neither DDE nor PCB levels (the latter were not quantified) analysed from eggs and fat tissues were thought to be significant by the Denver Fish and Wildlife personnel who conducted the analysis (J.O. Keith, pers. comm. to Billings). DDE levels below
Table 1. General description of Billings' colonies.
(BC) Black cottonwood    (PP) Ponderosa pine

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<td># nest trees</td>
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<td>18</td>
<td>14</td>
<td>14</td>
<td>25</td>
<td>25</td>
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<td># nests</td>
<td>36</td>
<td>36</td>
<td>45</td>
<td>35</td>
<td>122</td>
<td>118</td>
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<td>Mean #nests/tree</td>
<td>2.0</td>
<td>2.0</td>
<td>3.2</td>
<td>2.5</td>
<td>4.9</td>
<td>4.7</td>
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<tr>
<td># active nests</td>
<td>29(81*)</td>
<td>28(78*)</td>
<td>33(73*)</td>
<td>22(63*)</td>
<td>95(78*)</td>
<td>8(7*)</td>
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<tr>
<td>Total # young fledged</td>
<td>66</td>
<td>54</td>
<td>34</td>
<td>33</td>
<td>95</td>
<td>25</td>
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<tr>
<td>Mean # young fledged/active nest</td>
<td>2.3</td>
<td>1.9</td>
<td>1.0</td>
<td>1.5</td>
<td>1.0</td>
<td>3.1</td>
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* % of nest used

Table 2. DDE levels and shell thicknesses for 7 addled eggs collected from nests at Moiese.

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<tr>
<td>2. Infertile</td>
<td>0.37</td>
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</tr>
<tr>
<td>3. Infertile</td>
<td>0.38</td>
<td>0.38</td>
</tr>
<tr>
<td>4. Fertile</td>
<td>0.66</td>
<td>0.43</td>
</tr>
<tr>
<td>5. Fertile</td>
<td>0.67</td>
<td>0.39</td>
</tr>
<tr>
<td>6. Fertile</td>
<td>1.01</td>
<td>0.38</td>
</tr>
<tr>
<td>7. Fertile</td>
<td>1.06</td>
<td>0.35</td>
</tr>
<tr>
<td>Mean</td>
<td>0.64</td>
<td>0.38</td>
</tr>
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Figure 2. 1969 heronry locations in northwestern Montana.
30 ppm do not appear seriously to affect the ontogeny of heron eggs (Vermeer and Reynolds 1970, Henny and Bethers 1971).

Over 200 eggshells collected from 15 colonies in western Montana had thicknesses ranging from 0.27 to 0.43 mm. The average thickness (0.32 mm) was below the pre-DDT average of 0.40 mm for Great Blue Herons in southern Canada (J.J. Hickey, pers. comm. to Billings), but it exceeded the critical level of 0.24 mm, below which eggshells are unlikely to survive incubation intact (Wilburn 1972, Cooke et al. 1976).

**Banding Returns**

Billings banded 140 nestlings at Moiese during May and June 1969. Three were later recovered in Mexico, and another was recovered east of Kalispell, Montana (Table 3). The dates of death were unknown.

The bird recovered near Kalispell had dispersed northward after fledging, a characteristic found in many heron species (Palmer 1962). The 3 Mexican recovery locations are remarkably close to one another on the Pacific coast: Guasave is 200 km south of Etchojoa, and Villa Union is 350 km south of Guasave. This may be an indication that birds raised in a colony winter in the same area, despite post-fledging dispersals and the fact that herons rarely migrate in groups (Bent 1926, Palmer 1962, Partch 1972).

**Food Habits**

Billings identified prey items primarily from food pellets regurgitated by young birds, but also from the stomachs of a few dead...
birds, and from the remnants found in the nests and on the ground. Fish comprised 88\% of the heron diet, with rodents and insects making up the remainder (Table 4).
Table 3. Banding dates, recovery dates, and recovery locations of 4 immature herons banded in the nest at Moiese.

<table>
<thead>
<tr>
<th>Banding date</th>
<th>Recovery date</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 May 1969</td>
<td>7 April 1970</td>
<td>Etchojoa, Sonora, Mexico</td>
</tr>
<tr>
<td>31 May 1969</td>
<td>13 May 1970</td>
<td>Guasave, Sinaloa, Mexico</td>
</tr>
<tr>
<td>31 May 1969</td>
<td>28 October 1969</td>
<td>Kalispell, MT</td>
</tr>
<tr>
<td>5 June 1969</td>
<td>? January 1971</td>
<td>Villa Union, Sinaloa, Mexico</td>
</tr>
</tbody>
</table>

Table 4. Prey items collected at 3 colonies. The sources are: (N) nests; (G) ground; (R) regurgitated; and (S) stomachs.

<table>
<thead>
<tr>
<th>Prey</th>
<th>N</th>
<th>G</th>
<th>R</th>
<th>S</th>
<th>Total</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sucker (Catastomus spp.)</td>
<td>1</td>
<td>19</td>
<td>7</td>
<td>3</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>Pumpkinseed (Lepomis gibbosus)</td>
<td>-</td>
<td>1</td>
<td>9</td>
<td>-</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>Longnose dace (Rhinichthys cataractae)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>10</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>Trout (Salmo spp.)</td>
<td>-</td>
<td>3</td>
<td>4</td>
<td>-</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Other fish spp.</td>
<td>-</td>
<td>6</td>
<td>4</td>
<td>-</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>Muskrat (Ondatra zibethica)</td>
<td>-</td>
<td>4</td>
<td>1</td>
<td>-</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Vole (Microtus spp.)</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Insects</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>2</td>
<td>35</td>
<td>25</td>
<td>13</td>
<td>75</td>
<td></td>
</tr>
</tbody>
</table>

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CHAPTER V
RESULTS

Heronry Vegetation

Habitat characteristics varied considerably between colonies (Tables 5 & 6, Appendix D). For example, canopy cover varied from 3 to 74%, and basal area ranged from 7 to 45 m²/ha. Heronries were found primarily in cottonwood bottomlands, with a few in conifer stands on the Swan and lower Flathead rivers.

Nest tree measurements were the only vegetation parameters that correlated with heron reproductive data: the numbers of nests, active nests, and successful nests (pair-wise correlations). The mean nest tree dbh was the only variable that differed significantly between active and inactive colonies (t-test or Fisher-Behrens test). The average dbh in the inactive colonies was larger than that of the active colonies.

Nest tree species

Nest tree species and nest tree dbh were the only vegetation parameters that differed significantly from river to river (t-test). All the ponderosa pine nest trees (with the exception of 1 on the Bitterroot River) were located on the lower Flathead River; the lodgepole pine was restricted to 2 heronries on the Swan River; and the spruce to another colony on the Swan. Fifty-five percent of the colonies were in black cottonwoods, 9% in black cottonwood and lodgepole pine, 32%
Table 5. Vegetation parameters of the heronries, based on the 0.04-ha circle census technique (James and Shugart 1970). (bc) black cottonwood; (pp) ponderosa pine; (lp) lodgepole pine; (s) spruce.

<table>
<thead>
<tr>
<th>Heronry</th>
<th>Dominant Tree Sp.</th>
<th>Trees/ Ha</th>
<th>Basal Area (m²/ha)</th>
<th>% Canopy Cover</th>
<th>Mean Canopy Height (m)</th>
<th>Mean dbh (cm)</th>
<th>Predominant Dbh Range (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lolo</td>
<td>bc</td>
<td>153</td>
<td>32</td>
<td>74</td>
<td>20</td>
<td>48</td>
<td>56-69</td>
</tr>
<tr>
<td>Florence</td>
<td>bc</td>
<td>133</td>
<td>30</td>
<td>65</td>
<td>21</td>
<td>51</td>
<td>56-69</td>
</tr>
<tr>
<td>Lee Metcalf</td>
<td>bc</td>
<td>30</td>
<td>7</td>
<td>3</td>
<td>18</td>
<td>51</td>
<td>25-38</td>
</tr>
<tr>
<td>Stevensville</td>
<td>bc</td>
<td>168</td>
<td>23</td>
<td>51</td>
<td>16</td>
<td>38</td>
<td>25-69</td>
</tr>
<tr>
<td>Victor</td>
<td>bc</td>
<td>143</td>
<td>37</td>
<td>64</td>
<td>26</td>
<td>53</td>
<td>41-53</td>
</tr>
<tr>
<td>Kelly Island</td>
<td>bc</td>
<td>168</td>
<td>40</td>
<td>56</td>
<td>22</td>
<td>51</td>
<td>56-69</td>
</tr>
<tr>
<td>Drummond</td>
<td>bc</td>
<td>232</td>
<td>45</td>
<td>73</td>
<td>12</td>
<td>41</td>
<td>8-15</td>
</tr>
<tr>
<td>Jens</td>
<td>bc</td>
<td>183</td>
<td>41</td>
<td>39</td>
<td>20</td>
<td>51</td>
<td>41-53</td>
</tr>
<tr>
<td>Buffalo Rapids pp</td>
<td>pp</td>
<td>232</td>
<td>32</td>
<td>35</td>
<td>14</td>
<td>30</td>
<td>8-15</td>
</tr>
<tr>
<td>Moiese</td>
<td>pp</td>
<td>203</td>
<td>26</td>
<td>46</td>
<td>15</td>
<td>36</td>
<td>8-23</td>
</tr>
<tr>
<td>Dixon</td>
<td>pp</td>
<td>49</td>
<td>18</td>
<td>15</td>
<td>22</td>
<td>61</td>
<td>71-102</td>
</tr>
<tr>
<td>Perma Dump</td>
<td>pp</td>
<td>79</td>
<td>18</td>
<td>16</td>
<td>15</td>
<td>43</td>
<td>8-15</td>
</tr>
<tr>
<td>Perma 1</td>
<td>pp</td>
<td>207</td>
<td>24</td>
<td>53</td>
<td>17</td>
<td>38</td>
<td>25-38</td>
</tr>
<tr>
<td>Perma 2</td>
<td>pp</td>
<td>178</td>
<td>16</td>
<td>48</td>
<td>12</td>
<td>25</td>
<td>8-15</td>
</tr>
<tr>
<td>Ninepipe</td>
<td>bc</td>
<td>133</td>
<td>16</td>
<td>17</td>
<td>14</td>
<td>33</td>
<td>8-15</td>
</tr>
<tr>
<td>Evergreen</td>
<td>bc</td>
<td>128</td>
<td>18</td>
<td>59</td>
<td>22</td>
<td>41</td>
<td>41-53</td>
</tr>
<tr>
<td>Owen Souerwine bc</td>
<td>bc</td>
<td>124</td>
<td>34</td>
<td>49</td>
<td>24</td>
<td>56</td>
<td>56-69</td>
</tr>
<tr>
<td>Rose Creek</td>
<td>bc</td>
<td>257</td>
<td>26</td>
<td>71</td>
<td>19</td>
<td>32</td>
<td>25-38</td>
</tr>
<tr>
<td>Ferndale North lp</td>
<td></td>
<td>69</td>
<td>7</td>
<td>8</td>
<td>19</td>
<td>32</td>
<td>25-38</td>
</tr>
<tr>
<td>Ferndale South bc</td>
<td></td>
<td>153</td>
<td>17</td>
<td>48</td>
<td>17</td>
<td>36</td>
<td>25-38</td>
</tr>
<tr>
<td>Swan River s</td>
<td></td>
<td>158</td>
<td>9</td>
<td>66</td>
<td>16</td>
<td>23</td>
<td>25-38</td>
</tr>
<tr>
<td>Soup Creek bc</td>
<td></td>
<td>173</td>
<td>20</td>
<td>36</td>
<td>16</td>
<td>30</td>
<td>18-23</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>152</td>
<td>24</td>
<td>45</td>
<td>18</td>
<td>41</td>
<td>25-38</td>
</tr>
</tbody>
</table>

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Table 6: Heronry parameters. (bc) black cottonwood; (pp) ponderosa pine; (lp) lodgepole pine; (s) spruce

<table>
<thead>
<tr>
<th>Heronry</th>
<th>Size (h)</th>
<th>#Nest Trees</th>
<th>Nest Tree Sp.</th>
<th>Mean Nest Tree bh (cm)</th>
<th>Mean Nest Tree Height (m)</th>
<th>Mean Nest Height (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lolo</td>
<td>.19</td>
<td>5</td>
<td>bc</td>
<td>73</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>Florence</td>
<td>.36</td>
<td>4</td>
<td>bc</td>
<td>73</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>Lee Metcalf</td>
<td>.006</td>
<td>2</td>
<td>bc</td>
<td>79</td>
<td>25</td>
<td>23</td>
</tr>
<tr>
<td>Stevensville</td>
<td>2.3</td>
<td>42</td>
<td>pp</td>
<td>59</td>
<td>27</td>
<td>23</td>
</tr>
<tr>
<td>Victor</td>
<td>.24</td>
<td>6</td>
<td>bc</td>
<td>79</td>
<td>32</td>
<td>29</td>
</tr>
<tr>
<td>Kelly Island</td>
<td>.29</td>
<td>18</td>
<td>bc</td>
<td>69</td>
<td>30</td>
<td>22</td>
</tr>
<tr>
<td>Drummond</td>
<td>.14</td>
<td>13</td>
<td>bc</td>
<td>69</td>
<td>30</td>
<td>22</td>
</tr>
<tr>
<td>Jens</td>
<td>.15</td>
<td>14</td>
<td>bc</td>
<td>64</td>
<td>24</td>
<td>22</td>
</tr>
<tr>
<td>Buffalo Rapids</td>
<td>.01</td>
<td>3</td>
<td>pp</td>
<td>112</td>
<td>31</td>
<td>31</td>
</tr>
<tr>
<td>Moiese</td>
<td>.14</td>
<td>10</td>
<td>pp</td>
<td>65</td>
<td>25</td>
<td>23</td>
</tr>
<tr>
<td>Dixon</td>
<td>.03</td>
<td>3</td>
<td>pp</td>
<td>88</td>
<td>30</td>
<td>26</td>
</tr>
<tr>
<td>Perma Dump</td>
<td>.001</td>
<td>2</td>
<td>pp</td>
<td>101</td>
<td>29</td>
<td>26</td>
</tr>
<tr>
<td>Perma 1</td>
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<td>6</td>
<td>pp</td>
<td>67</td>
<td>28</td>
<td>23</td>
</tr>
<tr>
<td>Perma 2</td>
<td>.0001</td>
<td>1</td>
<td>pp</td>
<td>102</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>Ninepipe</td>
<td>4.0</td>
<td>26</td>
<td>bc</td>
<td>49</td>
<td>17</td>
<td>15</td>
</tr>
<tr>
<td>Evergreen</td>
<td>.72</td>
<td>23</td>
<td>bc</td>
<td>47</td>
<td>26</td>
<td>23</td>
</tr>
<tr>
<td>Owen Souerwine</td>
<td>.38</td>
<td>15</td>
<td>bc</td>
<td>72</td>
<td>30</td>
<td>29</td>
</tr>
<tr>
<td>Rose Creek</td>
<td>.36</td>
<td>9</td>
<td>bc</td>
<td>64</td>
<td>25</td>
<td>23</td>
</tr>
<tr>
<td>Ferndale North</td>
<td>1.5</td>
<td>7</td>
<td>bc</td>
<td>41</td>
<td>22</td>
<td>19</td>
</tr>
<tr>
<td>Ferndale South</td>
<td>.45</td>
<td>5</td>
<td>lp</td>
<td>58</td>
<td>27</td>
<td>23</td>
</tr>
<tr>
<td>Swan River</td>
<td>.002</td>
<td>3</td>
<td>lp</td>
<td>42</td>
<td>22</td>
<td>20</td>
</tr>
<tr>
<td>Soup Creek</td>
<td>.20</td>
<td>3</td>
<td>bc</td>
<td>85</td>
<td>26</td>
<td>23</td>
</tr>
<tr>
<td>Average</td>
<td>.53</td>
<td>10</td>
<td>--</td>
<td>71</td>
<td>27</td>
<td>23</td>
</tr>
</tbody>
</table>

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in ponderosa pine, and 1% in spruce. Of the 220 nest trees, 83% were black cottonwood, 12% ponderosa pine, 4% lodgepole, and 1% spruce (Table 7). The heronries in black cottonwood had more nest trees, more nests, and more nest per tree than the conifer heronries (t-test).

**Nest tree size**

The mean dbh of nest trees was 71 cm (Table 6). This was similar to the mean dbh observed by the Seidenstickers (1968) in eastern Montana. When the nest tree dbh's were compared by species, ponderosa pine had significantly larger dbh's than the other species, and the cottonwoods had larger dbh's than the lodgepole and spruce (t-test).

Nest tree height (average 27 m) and nest height (acreage 23 m) showed the least amount of variation of all the parameters measured (Table 6). Neither varied significantly between different tree species (t-test).

Nest trees in western Montana were similar in height to those observed by Henny and Bthers (1971) and Werschkul et al. (1977) in Oregon, but were somewhat taller than in eastern Montana (Seidensticker et al. 1968), Minnesota (Mathieson and Richards 1978), and British Columbia (Mark 1976), where nest trees averaged 21 m, 19 m, and 17 m respectively.

For all colonies, dbh and height of nest trees were significantly larger than those of the surrounding trees (t-test). Furthermore, the mean nest tree dbh decreased with an increase in the number of nests (Figure 3). Nest tree height and nest height also decreased significantly with larger colony size.
Table 7. Description of heron nest trees by species

<table>
<thead>
<tr>
<th>Tree Species</th>
<th># Nest Trees</th>
<th># Nests</th>
<th>Avg. # Nests/tree</th>
<th>Mean Dbh (cm)</th>
<th>Mean Ht. (m)</th>
<th>Meant Nest Ht. (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Cottonwood</td>
<td>182 (83%)</td>
<td>506</td>
<td>2.8</td>
<td>64</td>
<td>27</td>
<td>23</td>
</tr>
<tr>
<td>Ponderosa Pine</td>
<td>26 (12%)</td>
<td>53</td>
<td>2.0</td>
<td>78</td>
<td>28</td>
<td>25</td>
</tr>
<tr>
<td>Lodgepole Pine</td>
<td>9 (4%)</td>
<td>12</td>
<td>1.3</td>
<td>39</td>
<td>24</td>
<td>21</td>
</tr>
<tr>
<td>Spruce</td>
<td>3 (1%)</td>
<td>7</td>
<td>2.3</td>
<td>42</td>
<td>22</td>
<td>20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>220</strong></td>
<td><strong>578</strong></td>
<td><strong>2.6</strong></td>
<td><strong>64</strong></td>
<td><strong>26</strong></td>
<td><strong>23</strong></td>
</tr>
</tbody>
</table>

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Figure 3. Relationship between the mean nest tree dbh in a colony and the number of nests.

$r = -0.43$
$p = 0.02$
Dead and dying nest trees

Many of the nest trees were characterized by dead or dying branches, particularly where nests were located. Nineteen percent of all the nest trees were dead or dying. In 1979, 7 nests containing eggs or young blew out of nest trees; 3 (43%) were in dead or dying trees.

Several nests in a dead cottonwood at the east end of the Drummond heronry, used in 1978, were abandoned after a brief period in 1979. All the nest trees on the east end were dead, and after the abandonment, new nests were discovered in smaller, live trees at the colony's west end. Some of the Kelly Island herons also shifted westward out of dying trees into live-top trees.

Heronry Breeding Data

Because the 1978 reproductive data (Appendix E) were incomplete, only 1979 data (Table 8) were used in the statistical analyses. Data from both years, when applicable, are included in the discussion. The data for both years are also given by river (Appendix F).

Arrival times

Birds began to arrive at the Flathead and Swan colonies a week later (week of 20 March) than at the more southerly Bitterroot and Clark Fork colonies (week of 13 March), and they remained 1 week behind in the breeding cycle throughout the season. Small colonies were occupied a week later than large colonies on the same river (birds arrived at large Flathead and small Bitterroot colonies at the same time). The breeding cycle in small colonies was initiated no later than in the
Table 8: Reproductive data by heronry, for the 1979 breeding season.

<table>
<thead>
<tr>
<th>Heronry</th>
<th># Nests</th>
<th># Active Nests</th>
<th># Successful Nests</th>
<th>Total # Young</th>
<th># Young/Active Nest</th>
<th># Young/Successful Nest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lolo</td>
<td>8</td>
<td>2(25%)</td>
<td>2</td>
<td>4</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Florence</td>
<td>11</td>
<td>10(91%)</td>
<td>6</td>
<td>14</td>
<td>1.4</td>
<td>2.3</td>
</tr>
<tr>
<td>Lee Metcalf</td>
<td>7</td>
<td>6(86%)</td>
<td>5</td>
<td>10</td>
<td>1.7</td>
<td>2.0</td>
</tr>
<tr>
<td>Stevensville</td>
<td>90</td>
<td>52(58%)</td>
<td>45</td>
<td>106</td>
<td>2.0</td>
<td>2.4</td>
</tr>
<tr>
<td>Victor</td>
<td>9</td>
<td>0(0%)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Kelly Island</td>
<td>86</td>
<td>43(50%)</td>
<td>34</td>
<td>64</td>
<td>1.5</td>
<td>1.9</td>
</tr>
<tr>
<td>Drummond</td>
<td>26</td>
<td>25(96%)</td>
<td>20</td>
<td>52</td>
<td>2.1</td>
<td>2.6</td>
</tr>
<tr>
<td>Jens</td>
<td>39</td>
<td>0(0%)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Buffalo Rapids</td>
<td>7</td>
<td>0(0%)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Moiese</td>
<td>15</td>
<td>2(13%)</td>
<td>2</td>
<td>5</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Dixon</td>
<td>9</td>
<td>0(0%)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Perma Dump</td>
<td>6</td>
<td>4(67%)</td>
<td>4</td>
<td>5</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Perma 1</td>
<td>14</td>
<td>3(21%)</td>
<td>3</td>
<td>3</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Perma 2</td>
<td>1</td>
<td>0(0%)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Ninepipe</td>
<td>79*</td>
<td>79( *)</td>
<td>69</td>
<td>172</td>
<td>2.2</td>
<td>2.5</td>
</tr>
<tr>
<td>Evergreen</td>
<td>77</td>
<td>52(68%)</td>
<td>42</td>
<td>92</td>
<td>1.8</td>
<td>2.2</td>
</tr>
<tr>
<td>Owen Souerwine</td>
<td>31</td>
<td>22(71%)</td>
<td>16</td>
<td>33</td>
<td>1.5</td>
<td>2.1</td>
</tr>
<tr>
<td>Rose Creek</td>
<td>18</td>
<td>9(50%)</td>
<td>7</td>
<td>12</td>
<td>1.3</td>
<td>1.7</td>
</tr>
<tr>
<td>Ferndale North</td>
<td>10</td>
<td>5(50%)</td>
<td>5</td>
<td>14</td>
<td>2.8</td>
<td>2.8</td>
</tr>
<tr>
<td>Ferndale South</td>
<td>13</td>
<td>12(92%)</td>
<td>10</td>
<td>27</td>
<td>2.3</td>
<td>2.7</td>
</tr>
<tr>
<td>Swan River</td>
<td>7</td>
<td>6(86%)</td>
<td>6</td>
<td>15</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Soup Creek</td>
<td>15</td>
<td>14(93%)</td>
<td>12</td>
<td>21</td>
<td>1.5</td>
<td>1.8</td>
</tr>
<tr>
<td>Total</td>
<td>578</td>
<td>346(60%)</td>
<td>288</td>
<td>649</td>
<td>1.9</td>
<td>2.3</td>
</tr>
</tbody>
</table>

* Ninepipe had a total of 148 heron and cormorant nests in 1979; determining which were heron nests, aside from those occupied by herons, was impossible.

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large colonies on the same river. Werschkul et al. (1977) described a similar phenomenon.

Nest selection

The higher nests in a tree were generally occupied before the lower nests. Competition for nests in the tops of trees has been observed by other researchers working with herons. Nesting high off the ground is generally viewed as a means of minimizing the dangers of predation (Owen 1960, Henny and Bethers 1971, Ives 1972, Wilburn 1972, Burger et al. 1977).

The first birds to arrive in a colony did not cluster in adjacent nests but occupied nests throughout the colony. Nests occupied in 1978 were usually occupied again in 1979. Occasionally, a nest empty in 1978 was occupied in 1979, and vice versa. These switches frequently occurred in adjacent nests, suggesting that the same male was involved in both years.

In early spring, some of the herons did not appear to associate with any one nest, although they frequented the nest site. Other birds acquired nests, only to abandon them 2 weeks into the breeding season. These birds may have been immatures (herons do not breed until the second year) or adults without a mate. The sexually inactive birds were probably driven off by the sexually active adults as the breeding season progressed (Wilburn 1972).

Use of heron nests by other species

Seven heronries were used by Canada Geese (Branta canadensis) (Appendix A). The geese generally nested in a relatively inactive
sector of a colony, away from the herons, and no conflicts between geese and herons were observed. Canada Geese have been known to supplant herons from heron nests (Knight and Erickson 1978).

The abandoned colony at Jens was occupied by a pair of Great Horned Owls (*Bubo virginianus*) in 1979. Great Horned Owls used a heron nest at Ninepipe in proximity to active heron nests, apparently without causing alarm, even though some young herons may have been preyed upon (Marcella Bishop, pers. comm.). Great Horned Owls have been observed elsewhere nesting in heron colonies, without alarming the herons, although they are frequently implicated in the death of herons (Cottrille and Cottrille 1958, Page 1971, Wilburn 1972, Knight and Erickson 1978).

Red-tailed Hawks (*Buteo jamaicensis*) used a heron nest in the abandoned Victor colony in 1979. Another pair nested at Stevensville in an unused nest, in proximity to active heron nests. The hawks frequently scared off herons that flew too close.

Nine heronries had active Osprey (*Pandion haliaetus*) nests close by, usually within 100 m and often within several m of heron nests. Many Osprey-heron interactions were observed, with the Ospreys always the aggressor. Competition with Ospreys may have been the cause of abandonment of a small heron colony (3 nests) on Flathead Lake (Marcella Bishop, pers. comm.). At another Flathead Lake colony, assailing Ospreys occasionally have wounded or killed adult herons (John Tibbs and Richard Hutto, pers. comm.s).

Double-crested Cormorants (*Phalacrocorax auritus*) nest side by side with Great Blue Herons, apparently peacefully, at Ninepipe National
Wildlife Refuge. The cormorants arrive in the spring a month later than the herons and use empty heron nests or construct their own.

An immature Bald Eagle (*Haliaeetus leucocephalus*), landing at an empty nest in the Evergreen heronry, caused the herons to flush and circle overhead, screeching. A mature Bald Eagle in the Owen Souerwine heronry did not cause alarm. The young eagle may have been in the habit of striking or pursuing herons for their fish; similar incidents between Bald Eagles and herons have been documented by Bayer (1979).

In this study, herons always appeared on the defensive when interacting with other bird species using heron nests or nesting nearby.

**Predation**

In 1978, a black bear (*Ursus americanus*) was observed in a nest tree eating young herons in a Swan Valley colony (Ed Foss, pers. comm.). Raccoons (*Procyon lotor*) or their sign have been seen in the vicinity of many of the heronries. The remains of young birds were frequently found beneath the nest trees, although no specific predator could be implicated.

Feeding

Herons did not feed often on the main river channels, but appeared to prefer the slower-moving or still waters of the side channels, sloughs, reservoirs, and irrigation ditches. The water levels in most of these feeding sites fluctuated widely over the course of the spring and summer, and many of them dried up completely by July.

Herons most frequently were seen feeding solitarily, although groups of 2 were common, and groups of 3 or 4 were occasionally seen. Members of a group did not feed in proximity to one another but were spaced at least 5 m apart and usually farther, suggestive of Krebs' (1974) "modified flocks", in which members are spaced to avoid disturbing the prey.

Hatching dates

The earliest hatching began about 14 May on the Bitterroot and Clark Fork, and 20 May on the Flathead and Swan rivers.

Reproductive success

The number of active nests was fairly constant for a particular colony size; it correlated well with the number of nests present (Figure 4). A similar relationship held between the numbers of successful and active nests (Figure 5). The % of successful nests was apparently not dependent on the number of birds in a colony; nor was there an optimum colony size in terms of fledging success (the number of young per active nest or the number per successful nest). Fledging success did not correlate well with reproduction or vegetation parameters, probably because of the large variance associated with small sample sizes. The
Figure 4. Relationship between the number of active nests and the total number of nests in a colony.

\[ r = 0.96 \]
\[ p < 0.01 \]
Figure 5. Relationship between the number of nests used and the number of nests from which young fledged.
small colonies had a wide range of fledging success (1.0 - 2.8 young per active nest), whereas the large colonies were less variable (1.5 - 2.3 young per active nest). Some of the small colonies, with fledging successes calculated from only a few nests, were represented by overly large or overly small fledging success. Comparisons between the 1978 and the 1979 data for any particular small colony lend support to this interpretation.

From 13 to 96% of the nests in an active colony were used; the average was 60% (Table 8). Sixty to 100% of the active nests in a colony fledged young; the average success rate was 83%. Only small colonies attained 100% success. Here again small sample sizes may have affected the results.

The 1979 fledging success for northwestern Montana was 1.88 young per active nest, or 2.25 young per successful nest (Table 8). Fledging successes on the different rivers proved significantly different in 1 instance only: the Swan River colonies had higher fledging success than the lower Flathead colonies (t-test).

Disturbance

My arrivals at the heronries never failed to flush some birds, although I rarely approached closer than 50 m. In March and early April, the birds readily left the nests. Later on, incubating birds usually did not take flight but crouched low in the nests. If they did flush, they circled overhead and quickly returned. During the summer months, when the nests were concealed by foliage and the adults returned only to feed the young, my presence did not appear to affect
The average distance to a colony from a dirt or paved road was 0.62 km; from a paved road 1.25 km; from housing 0.71 km; and from water 79 m (Table 9). Only the distance from water differed significantly between active and inactive colonies (t-test or Fisher-Behrens test). Active colonies were on the average 90 m away from the water, and inactive colonies were 43 m away.

The number of active nests, along with the other reproduction parameters (with the exception of fledging success), correlated well with the distance from each colony to the nearest dirt or paved road (pair-wise correlation, Figure 6). The distances from housing or from the river did not appear to affect colony size.

Sixty percent (n=3) of the inactive colonies, compared to 29% (n=5) of the active colonies, were visible from highways. Two of the 5 active colonies were on National Wildlife Refuges. Fledging success in the other 3 was significantly lower than in those 12 colonies not visible from highways (t-test). The number of nests did not differ significantly.

The effects of disturbance and vegetation on the number of active nests was investigated with a step-wise multiple regression analysis. Independent variables were added singly until the explained variance increased by less than 2%. Sixty-six percent of the variation in the number of active nests could be explained by the distance from the nearest road, nest height, and plot tree dbh (Table 10). Regressions run on the number of nests or successful nests or total number of young resulted in equations with the same variables.
<table>
<thead>
<tr>
<th>Heronry</th>
<th>Distance from Road (km)</th>
<th>Distance from House (km)</th>
<th>Distance from Water (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lolo</td>
<td>0.4</td>
<td>0.4</td>
<td>2</td>
</tr>
<tr>
<td>Florence</td>
<td>0.7</td>
<td>0.5</td>
<td>47</td>
</tr>
<tr>
<td>Lee Metcalf</td>
<td>0.3</td>
<td>0.3</td>
<td>800</td>
</tr>
<tr>
<td>Stevensville</td>
<td>0.9</td>
<td>0.5</td>
<td>55</td>
</tr>
<tr>
<td>Victor</td>
<td>0.3</td>
<td>1.7</td>
<td>122</td>
</tr>
<tr>
<td>Kelly Island</td>
<td>0.6</td>
<td>0.6</td>
<td>12</td>
</tr>
<tr>
<td>Drummond</td>
<td>1.0</td>
<td>0.5</td>
<td>57</td>
</tr>
<tr>
<td>Jens</td>
<td>0.5</td>
<td>1.2</td>
<td>41</td>
</tr>
<tr>
<td>Buffalo Rapids</td>
<td>1.2</td>
<td>1.1</td>
<td>30</td>
</tr>
<tr>
<td>Moiese</td>
<td>0.3</td>
<td>0.7</td>
<td>9</td>
</tr>
<tr>
<td>Dixon</td>
<td>0.3</td>
<td>0.2</td>
<td>15</td>
</tr>
<tr>
<td>Perma Dump</td>
<td>0.4</td>
<td>0.7</td>
<td>3</td>
</tr>
<tr>
<td>Perma 1</td>
<td>0.6</td>
<td>2.6</td>
<td>14</td>
</tr>
<tr>
<td>Perma 2</td>
<td>0.4</td>
<td>0.5</td>
<td>8</td>
</tr>
<tr>
<td>Ninepipe</td>
<td>0.8</td>
<td>0.7</td>
<td>1</td>
</tr>
<tr>
<td>Evergreen</td>
<td>1.2</td>
<td>0.5</td>
<td>8</td>
</tr>
<tr>
<td>Owen Souerwine</td>
<td>0.9</td>
<td>0.8</td>
<td>100</td>
</tr>
<tr>
<td>Rose Creek</td>
<td>0.5</td>
<td>0.4</td>
<td>15</td>
</tr>
<tr>
<td>Ferndale North</td>
<td>0.5</td>
<td>0.4</td>
<td>30</td>
</tr>
<tr>
<td>Ferndale South</td>
<td>0.5</td>
<td>0.4</td>
<td>17</td>
</tr>
<tr>
<td>Swan River</td>
<td>0.5</td>
<td>0.4</td>
<td>150</td>
</tr>
<tr>
<td>Soup Creek</td>
<td>0.9</td>
<td>0.6</td>
<td>3</td>
</tr>
<tr>
<td>Average</td>
<td>0.62</td>
<td>0.71</td>
<td>70</td>
</tr>
</tbody>
</table>
Figure 6. Relationship between number of active nests and colony distance from nearest dirt or paved road.
Table 10. Results of step-wise multiple regression analysis. The B column lists the constants in the regression equation associated with the variables. The last 2 columns show the increases in the correlation coefficient $R$ and the coefficient of determination $R^2$, with the addition into the equation of the corresponding variable.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Independent Variable</th>
<th>B</th>
<th>$R$</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td># active nests</td>
<td>Distance from road</td>
<td>52.5</td>
<td>.54</td>
<td>.29</td>
</tr>
<tr>
<td></td>
<td>Nest height</td>
<td>-4.25</td>
<td>.74</td>
<td>.55</td>
</tr>
<tr>
<td></td>
<td>Plot tree dbh</td>
<td>0.794</td>
<td>.81</td>
<td>.66</td>
</tr>
<tr>
<td></td>
<td>Constant</td>
<td>50.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CHAPTER VI
DISCUSSION

Heronry Vegetation

Although heronries were found in many different habitats, the typical northwestern Montana heronry was situated in a riverine bottomland, in a dense stand of large trees (usually cottonwoods) 25-30 m high and with an average dbh of 70-80 cm. Other characteristics included dense canopy (50-70% canopy cover) and understory (15000 shrub stems/ha).

Nest tree species

The tree species selected by herons for nesting was nearly always the dominant species in the bottomland (Tables 5 and 6). All the large colonies were in cottonwoods. The canopy of the conifers was denser than that of the cottonwoods and less suitable for holding nests, although some of the ponderosa pines (in particular those in Billings' study) were large and ample enough to hold numerous nests. The superior holding capacity of the cottonwoods was not the only reason cottonwood colonies had more nests; the average number of nest trees in cottonwood colonies was greater than the average number in conifer colonies, indicating that the herons either preferred the cottonwood habitat or avoided the conifer habitats.

Nest tree size

The average dbh of the nest trees was highly variable from colony to colony. Nest height, however, was relatively constant, and presumably
of some importance in tree selection by the herons. The noticeable exception to tall nest trees was at Ninepipe National Wildlife Refuge, a highly productive reservoir and marsh, where the only trees available were 17 m tall. The vast majority of the heron nests in this study were in the top 20% of the trees' height.

Within a given stand, herons selected the largest trees available, as indicated by: 1) nest tree dimensions were significantly larger than those of the plot trees; and 2) as colony size increased, the mean nest tree size decreased. Tall trees became less available as a heronry grew, and the birds that arrived late in the spring were forced to nest in smaller trees, thereby decreasing the mean nest tree dimensions. Why herons selected the largest possible trees is not known. Big trees, with correspondingly thicker and more durable branches than smaller trees, may provide greater nest support over time. Nests in large trees are probably less vulnerable to mammalian predation than nests in smaller trees.

**Dead and dying nest trees**

Dead branches offer less nest support and protection (especially important in high winds and on hot days) than do live branches. When branches break and nests blow out, a tree is usually abandoned. A heron colony may move as much as 7.6 m a year in the direction of healthy trees (Kerns and Howe 1967).

A paucity of suitable nest trees is one reason for heronry abandonment (Miller 1943, Fahey 1968, Vermeer 1969). Although the number and
size of trees did not appear to be a limiting factor in this study's inactive colonies, it may become one in several active colonies faced with tree shortages. The Drummond heronry, in a small cottonwood stand surrounded by cattle pastures and the river, shifted its center of activity in 1979, but cannot continue this trend indefinitely. A similar phenomenon is occurring at the Ninepipe National Wildlife Refuge, where a large concentration of herons and cormorants have killed most of the few trees available. The herons on the Lee Metcalf National Wildlife Refuge were isolated in a lone, dying cottonwood. At the northern Ferndale colony, a logging operation removed all but the nest trees, which were dying lodgepole pines and 1 dead cottonwood. The herons will soon have no alternative but to abandon these sites.

The fragmentation of riparian habitat, resulting from clearing for grazing and development, has reduced the lifespan of most colonies. Instead of moving statically within an area as the trees replace themselves, the herons are forced to move frequently between small, isolated stands where the trees are killed or damaged faster than they are replaced.

**Heronry Breeding Data**

**Colony size**

The average number of nests (n=26) in northwestern Montana colonies was lower than most other averages in North America. The average colony size in Manitoba was 57 nests (Vermeer 1970); in the Chippewa National Forest, Minnesota, 52 nests (Mathieson and Richards 1978); on the Oregon coast, 70 (Werschkul et al. 1977); and in Quebec, 35 nests (DesGranges...
and Laporte 1979). In 1 instance, colonies were of sizes comparable to those in northwestern Montana; in Alberta, heronries averaged 21 nests (Vermeer 1969). Lack (1954) and Vermeer (1970) attributed differences in colony size to different feeding conditions. Montana and Alberta are in the dry, northern region of the inland breeding range of the Great Blue Heron (Palmer 1962), and may represent extremes in terms of climate and productivity.

Use of heron nests by other species

Great Blue Herons are not highly territorial, and will tolerate many other species in the colonies, despite probable predation and other interspecific conflicts (Mehner 1951, Cottrille and Cottrille 1958, Hedeen 1967, Temple 1969, Knight and Erickson 1978). Cormorants, Canada Geese, hawks, owls, and Ospreys may all benefit from the nest construction of herons.

Predation

Ten of the 22 colonies were on permanent islands, and 3 others were on islands during peak flow. Herons are often thought to nest on islands to avoid mammalian predators (Vermeer 1969). The herons in the study nested as high above the ground as possible, another means of minimizing predation. However, the % of successful nest in each colony was high and fairly constant between heronries, suggesting that predation was not heavy.

Reproductive success

The 1979 fledging success of 1.88 young per nesting pair in northwestern Montana was close to the 1.91 level thought necessary to maintain
a stable population (Henny 1972). Nine of the 17 active colonies had mean fledging successes below 1.91, and 8 had higher rates (although small colonies are often misrepresented by the mean fledging successes, they are as apt to be misrepresented on the high as on the low side).

The 1979 fledging success of 2.25 young per successful pair in northwestern Montana was higher than rates observed in California and Quebec, and lower than rates in Oregon, Alberta, and Nova Scotia (Table 11). Many of the California and Quebec sites represented disturbed or heavily populated areas (Pratt 1970, 1972; Ives 1972; DesGranges et al. 1979). Werschkul et al. (1976) found fledging success to be lower in a disturbed colony than in 3 out of 4 undisturbed sites.

The best indication of colony health may be the percentage of nests used, irrespective of fledging success or colony size. Fledging success fluctuates from year to year with the weather and varying feeding conditions, and colony size is frequently limited by a lack of suitable nest trees. In any particular year, fledging success may help pinpoint the cause of mortality or abandonment. In a few instances where fledging success was high but a large percentage of nests were unused (Lolo, Moiese), it appeared that the heronry was in the process of being abandoned, but for reasons other than low food availability or predation, such as disturbance. Starvation and predation were more likely to be limiting factors when fledging success was low (Florence, Perma Dump, Perma 1, Rose Creek), regardless of how many nests were used (DesGranges and Laporte 1979).

The average % of nests used in this study (60%) was considerably
Table 11. Colony size and fledging success from various sources.

<table>
<thead>
<tr>
<th># active nests in colony</th>
<th># fledged/successful nest</th>
<th>Comments</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 44 - 62</td>
<td>2.1</td>
<td></td>
<td>Pratt 1970, 1972 California</td>
</tr>
<tr>
<td>2. 55</td>
<td>2.0</td>
<td>Some disturbance</td>
<td>Ives 1972 California</td>
</tr>
<tr>
<td>3. 55</td>
<td>2.61</td>
<td></td>
<td>Henny and Beters 1971 Oregon</td>
</tr>
<tr>
<td>4. 33</td>
<td>2.20</td>
<td>Disturbed</td>
<td>Werschkul et al. 1976</td>
</tr>
<tr>
<td>161</td>
<td>2.70</td>
<td>Undisturbed</td>
<td>Oregon</td>
</tr>
<tr>
<td>88</td>
<td>2.53</td>
<td>Undisturbed</td>
<td></td>
</tr>
<tr>
<td>86</td>
<td>2.58</td>
<td>Undisturbed</td>
<td></td>
</tr>
<tr>
<td>97</td>
<td>2.18</td>
<td>Undisturbed</td>
<td></td>
</tr>
<tr>
<td>5. 1 - 55</td>
<td>2.51</td>
<td>27 colonies</td>
<td>Vermeer 1969 Alberta</td>
</tr>
<tr>
<td>6. 1 - 135</td>
<td>2.15</td>
<td>38 colonies</td>
<td>DesGrangers et al. 1979 Quebec</td>
</tr>
<tr>
<td>7. 42</td>
<td>3.09</td>
<td></td>
<td>McAloney 1973 Nova Scotia</td>
</tr>
</tbody>
</table>
lower than the percent in western Oregon (91%; Werschkul et al. 1977) and Quebec (83%; DesGranges et al. 1979), and may indicate a lower degree of stability in the Montana heronries.

Disturbance

**Distance from roads**

Visibility of a colony and vulnerability to vandalism and other human intrusions are directly related to the colony's isolation from roads.

In the mid-1960's, several vandals were seen shooting herons out of the nest trees of a large colony near Drummond on the Clark Fork (William and Margaret Wallace, pers. comm.). The colony was subsequently abandoned, and in 1978 there were 2 smaller colonies in the same general area. One of these 2 colonies, at Jens, was inactive in 1978 and 1979, but had a surprisingly large number of nests (n=39), implying that the birds deserted the colony abruptly as a result of a precipitous event, and not by degrees over several years. Shooting may still be a problem in Montana, on the Clark Fork, and in the lower Flathead Valley where trout hatcheries and trout farms are numerous and where herons had low reproductive success in 1978-1979.

Four of the 6 colonies on the lower Flathead were visible from highways. Two of these were inactive in 1979, and the other 2 had the lowest fledging success and were among the smallest colonies in this study.

The number of nests in a heronry may decrease with proximity to roads because of a lack of suitable habitat near roads due to develop-
ment. In this study however, there were no correlations between nest tree and plot tree dimensions or the number of available trees and distance from roads (pair-wise correlations). Few of the small colonies close to roads appeared limited by nest trees (Perma 1, Rose Creek, Ferndale South, Soup Creek).

The average distance from a paved road to a colony was 1.25 km, remarkably similar to the 1.26 km average distance documented in the Chippewa National Forest, Minnesota (Mathieson and Richards 1978).

**Distance from river**

Four of the 5 inactive colonies and many of the small colonies were close to the water's edge. Colony size may not have correlated well with the distance from the river, because of differences in recreational use of the 4 rivers. The Swan and upper Flathead rivers were not as heavily used as the Bitterroot, Clark Fork, and lower Flathead rivers.

All the colonies on the lower Flathead were close to the River and highly visible from the water. A total of 9 pairs nested in 3 active colonies on the lower Flathead in 1979. Ten years ago, at least 95 pairs nested on the same river (Billings). The habitat did not change, but recreational use of the river increased markedly. Because the vegetation was restricted to a narrow band along both banks, the birds had no alternative but to nest close to the water. As river use increased over the 10 years, the population of herons shifted from the river to a reservoir on the Ninepipe National Wildlife
Refuge 16 km away. Canada Geese have also shifted off the river onto
the reservoir with increased recreational use of the river, according
to U.S. Fish and Wildlife biologist Bob Twist (Stromnes 1979).

Seven pairs on the lower Flathead at Dixon were observed incubating
eggs through mid-May 1978. When I returned to the site in mid-June,
the colony was deserted. During the interval, approximately 150 people,
in 1 day alone, had canoed past the heronry (the float trip, sponsored
by the Flathead Forum Committee in response to 5 dam proposals by the
Army Corps of Engineers, was an effort to draw support for maintaining
the river in its pristine state).

The number of active pairs at the Lolo heronry on the Bitterroot
River decreased from 7 pairs in 1978 to 2 pairs in 1979. Eight km
upstream, at Florence, the number of active pairs increased from 4 to
10 pairs in the same period. The Lolo colony, initiated in 1975 on
publicly-owned land (Pomeroy 1975), is a popular site with fisherman
and beaver-trappers. The Florence colony was on private land farther
back and less visible from the River. Because of human activity at
the Lolo site, I believe that most of the birds deserted the colony
and moved to Florence. The Lolo colony may have been initiated by a
splinter group from the Florence colony, which was much larger in 1969
than it was in 1979.

Recreational use of the rivers in the study area, except in the
instances described, was light and did not appear to affect the location
or size of heronries.
Distance from housing

Heronry can apparently habituate, within limits, to proximate housing. A heronry near a house is more likely to be on private property and less disturbed by people passing through. Housing is not necessarily a source of disturbance in itself, but may be associated with roads and the clearing of habitat. A colony on the upper Flathead was replaced by housing within the last 10 years. The Rose Creek colony on the Flathead is quickly being surrounded by housing, and in 1978-1979 only half of the nests were used.

Other sources of disturbance

Early spring. Billings' blind construction at the Moiese colony in March 1970 caused 95 pairs to abandon the site and establish a new heronry on the Ninepipe National Wildlife Refuge. Fishermen near the Lolo colony in April 1979 caused most of the birds to move to the Florence colony. People on the Flathead River at the Dixon heronry in May 1978 probably caused its abandonment, despite the lateness of the season. Campers near a California heronry in March caused some herons to abandon the site (Ives 1972).

My presence was always a greater source of disturbance in early spring than later, even though I maintained a 100 m distance in the spring and had to move in closer as the breeding season progressed. I never went near the nest trees when herons were present and I always kept my distance when censusing to avoid disturbing the birds and to get accurate counts -- I do not feel I was a significant source of disturbance.
March, April, and early May are a critical period for herons; during this period they will easily abandon a nest site if sufficiently disturbed. As the nesting season progresses, and eggs are laid and hatched, the birds become less prone to leave. This is one reason the number or % of active nests is a better indication of overall colony health than is the colony fledging success.

**Dams.** Changes in Flathead Lake's water level, manipulated at Kerr Dam, killed the trees in 1 heronry that was situated 10 years ago at the north end of the Lake.

**Logging.** The northern Ferndale heronry was cleared 2 years ago of all trees, except the nest trees (the pasture is now used for grazing cattle). After the logging, the colony became visible from a road, and canopy cover and basal area were reduced to a minimum. The nest trees, among the smallest sampled in all 22 colonies, were mostly dying lodgepole pines that held 1 nest apiece. Many of the birds moved across the river to the south side. At least 10 nests on the north side were active in 1978; only 5 were active in 1979. Correspondingly, the number of pairs on the south side increased from 8 to 12 in the same period. Surprisingly, the 2 Ferndale colonies had consistently high fledging successes both years. The heronry on the south side is located in an area presently being developed by several owners clearing the land and building houses. In several years, the birds may be gone.

Ten years ago, a large colony of 100 nests on the upper Flathead River was destroyed in a logging operation. The site was near what
state biologists call the "Salmon Hole", a large, highly productive pool in a side channel of the river. Since that time, despite heavy recreational use of the area, another colony (Owen Souerwine) became established on an island across from the original site.

The 2 colonies on the Lee Metcalf and Ninepipe National Wildlife Refuges were on or close to productive marshlands. Ninepipe was heavily used by fishermen in the late spring and summer, and both refuges were very near highways. The Swan River National Wildlife Refuge, situated in marshland, was the only place herons nested in spruce trees, some of the smallest trees sampled in the study area.

The Kelly Island heronry, on land owned by the Department of Fish, Wildlife, and Parks, was heavily frequented by fishermen, hunters, and ornithologists. Only 50% of the nests were active in 1979.

Werschkul et al. (1977) found nest density and nest occupancy to be lower in disturbed than in undisturbed colonies. Unfortunately, there was no unequivocal way to differentiate between disturbed and undisturbed colonies in northwestern Montana: all the colonies were disturbed to some extent and by different factors. The relatively low percentage of nests occupied in nearly all the colonies may be attributable to disturbance.

Isolation and suitable habitat are not the only criteria in heronry site selection -- hence the wide variability in colony vegetation parameters. Unmeasured variables, like availability of food, may be critical in influencing the location of a heronry and the tenacity of the herons.
Regression equation

The distance from the nearest road was the most important measured factor that influenced heronry size. The mean plot tree dbh was also significant as an indication of the number of nests a site can support. Since herons tend to maximize their nest heights, the mean nest height is another good index of colony size; it decreases steadily as fewer optimal sites become available.

Tree height decreased with colony size in a similar study done by Werschkul et al. (1977), who found estuary size and tree height to be most important in the prediction of colony sizes on the Oregon coast.

Comparisons with Billings' Data

Colony distribution, size, and lifespan

The number of herons on all the rivers except the lower Flathead increased since 1969 (Table 12). The increase was accompanied by a notable extension of the population into the Swan Valley, where the birds nested in small trees like lodgepole and spruce.

In 1969, Billings located 17 colonies (1 more was created in 1970); 11 of these were active and held at least 427 nests (Table 12). In 1979, the same study area had 24 colonies, 19 of which were active, with 526 nests. In addition to these heronries, unconfirmed reports of 1 or 2 nest "colonies" were common in the 1978-1979 study. The 10-15% augmentation in northwestern Montana's heron population may be a result of enlightened public concern for nongame wildlife and a decrease in vandalism. Billings' figures may have been unnaturally low as a result
Table 12. 1969 - 1979 comparisons in colony distribution and size. The number of nests refers to the active colonies only.

<table>
<thead>
<tr>
<th>River</th>
<th># active colonies</th>
<th># nests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bitterroot</td>
<td>3</td>
<td>97</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>116</td>
</tr>
<tr>
<td>Clark Fork</td>
<td>2</td>
<td>82</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>112</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>142</td>
</tr>
<tr>
<td>Lower Flathead</td>
<td>3</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ninepipe NWR</td>
<td>1</td>
<td>79</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>106+</td>
</tr>
<tr>
<td>Upper Flathead</td>
<td>4</td>
<td>134</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>?</td>
</tr>
<tr>
<td>Swan</td>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>427+</td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>526</td>
</tr>
</tbody>
</table>
of previous years' weather; Lack (1954) found Grey Heron (Ardea Cinerea) numbers in Great Britain to decrease markedly after a harsh winter, and then recover rapidly. The number of colonies increased considerably in the 10 years, but the mean active colony size decreased from approximately 40 to 28 nests (Figure 7). The number of large colonies did not decline so much as the number of small colonies increased. If the study area's optimal sites for herons all had been filled by Billings' time, additional herons in the 1970's would be forced into marginal habitat where only little groups could be sustained. However, no difference in habitat was apparent between old and new colonies, or between large and small colonies (t-tests).

Several of the old heronry sites on the upper Flathead have been logged or developed. Only 9 of Billings' 18 original colonies exist today, and 6 of those are inactive or considerably reduced in size (Florence, Victor, Jens, Moiese, Perma Dump, Flathead Lake). Several colonies, particularly on the upper Flathead, were initiated and abandoned in the interval between the 2 studies (Bishop 1977, Larry Thompson pers. comm.). Other new colonies (Lolo, Rose Creek) are in the process of being abandoned.

Montana heronries, particularly the small ones, are somewhat short-lived. Colonies have been known to last up to 50 years in Ohio (Moseley 1936), 34 years in Pennsylvania (Miller 1943), 27 years in Minnesota (Kerns and Howe 1967), and 20 years in Illinois (Bjorklund 1975). In Montana, the herons appear to move frequently, in response to disturbance and development, and rarely stay in one place long enough to build up an extensive heronry.
Figure 7. Comparison between 1969 and 1979 colony sizes.
The decrease in colony size and age and the increase in the number of colonies may be due to the fragmentation of riparian habitat, and the loss of extensive woodlands able to sustain large and long-lived colonies.

Reproductive success

The 3 colonies Billings studied still existed in 1979 but were greatly reduced in size, and 1 was inactive. The Florence colony's fledging success did not change in 10 years. The Moiese colony, which did well the last year Billings censused it and the 2 years I censused it, did poorly during Billings' first year, when the colony was large. The low fledging success in 1969 may have resulted from Billings' activities at the nests -- where he collected food samples and addled eggs, and banded young -- and may have contributed to the birds' abandonment of the site the next spring. The Victor colony's 1969-1970 reproductive performance did not suggest any reason for its future abandonment.

The overall fledging success was 1.24 young per active nest in 1969 and 1.93 in 1970. The 1969 fledging success was considerably below and the 1970 success was just at the 1.91 level required to maintain a stable population (Henny 1972). Some of the 1979 colonies had fledging successes similar to those observed by Billings. His low overall average, based on a sample size of 3 colonies, may not have accurately represented the study area.

Heron numbers within the study area appeared to increase in the decade between the 2 studies, despite the low reproductive success in both investigations. These contradictory results may be explained in
4 ways: 1) Billings' 3 colonies may not have been representative of the entire study area; 2) the herons may have had better reproductive success in the years not studied. This is unlikely, since reproduction in all 4 years studied was mediocre, and I do not feel that study methods had a significant impact on the birds; 3) the expanding population may be due to an influx of herons from outside the study area, particularly since the study area's boundaries were largely arbitrary; 4) the increase in the number of nests does not necessarily imply an increase in the number of herons, especially if the number of nests used decreased. This last figure was difficult to ascertain from Billings' small sample size. The average percentage of nests active in Billings' 3 colonies (55%) was similar to my overall average (60%); but if the unusual second year's data from Moiese (the year of abandonment) is omitted, Billings' activity increases to 76%.

Management Implications

In 1969 there were no active heronries on wildlife refuges in the study area; in 1979 there were 3. All 3 of these colonies were on or near productive marshlands. Herons are more tenacious in productive sites than elsewhere, despite heavy disturbance. Most refuges are closed to off-road recreationists during the early months of the breeding season, and this may be critical in maintaining a heron population. As the clearing and development of Montana's riparian land continues, so will the importance of wildlife refuges as a source of suitable and productive heron habitat.

When identifying sites that should be managed for herons, large
stands (4 ha or more) of old-age cottonwoods, 80 m or more removed from
a river, at least 0.75 km from a road, and close to marshland, should
receive highest priority. Trees of all sizes near marshes should be
left standing.

The most critical objective of any management plan should be to
insulate the colony in early spring. An established heronry should be
surrounded by a permanent 25 m buffer zone closed to humans all year,
in turn encompassed by a 0.25 km zone off-limits from March through
mid-May.

The heron population and the nesting habitat should be monitored,
with a census every 5 - 10 years, to check and regulate trends in
decreasing numbers or deteriorating habitat. A few colonies could serve
as an index of the well-being of the entire population by being censused
at shorter time intervals, perhaps every 2 - 3 years. This study and
Billings' study can serve as baselines with which to compare results
in future years.

In areas where heron numbers have decreased due to loss of habitat,
a recovery of the population may be facilitated by the construction of
large nesting platforms, particularly a large group of platforms at
different heights, if suitable nest trees are lacking. Stocking ponds
with fish and building small impoundments would create additional
feeding habitat.

By drawing herons into an area, one also attracts other species --
Canada Geese, cormorants, owls, hawks, Ospreys -- that use heron nests.
Because heron colonies move frequently and often unpredictably, management plans must encompass entire river systems, and not just isolated segments. Riparian habitat is impossible to isolate; the health of a river and its adjoining lands are contingent on the stability of the entire watershed.

**Conclusion**

Great Blue Herons in northwestern Montana appear to be holding their own reproductively. Fledging success is probably determined mainly by food availability. The number of nests in a colony depends to a large extent on the seclusion of the site (distance from roads) and on the availability of large trees. The most common causes of heronry movement are loss of isolation and suitable nest trees.

Herons show a strong preference for isolated, old-age stands of cottonwoods, yet they are extremely adaptable in their selection of nest sites. Herons in small colonies do no worse reproductively than herons in large colonies, and small colonies have become increasingly common over the last 10 years. We may be witnessing a period of behavioral modification by an adaptable species, in the wake of land development by man. Differences in data from one decade are obviously not sufficient for drawing conclusions about behavioral changes. More studies should be conducted, preferably in the same study area and at regular intervals.

Continued land clearing can aggravate intra- and interspecific conflicts, particularly in the competition for nest sites (Bjorklund.
et al. 1967). A heron's strategy towards predation is primarily one of avoidance; it nests high off the ground and on islands, and has no developed anti-predatory behavior. The likelihood of nest predation increases when a dearth of large trees forces some herons to nest low in trees or on the ground. Wetland drainage and channelization of river water are also detrimental in reducing the productivity of areas supporting herons.

The adaptability of most species, when confronted with the changes wrought by man, is slow at best. Careful management of large tracts of riparian and wetland habitat is essential as human development expands, to ensure the perpetuation of such species as the Great Blue Heron.
CHAPTER VII
SUMMARY

Great Blue Herons in northwestern Montana nested primarily in stands of old-age cottonwoods in riparian bottomlands, but they were also found in drier, coniferous sites on the Flathead and Swan rivers. Nest trees had a mean dbh of 71 cm and a mean height of 27 m. The average colony size was 0.53 ha, or 26 nests. Sixty percent of the nests in the study area were active or used by breeding adults, and 83% of the breeding pairs were successful in fledging young. The mean fledging success was 1.88 young per active nest, or 2.25 young per successful nest. Many other bird species in the colonies were tolerated by the herons, although several interspecific conflicts were observed.

Colonies were on the average 70 m from the water, 0.62 km from the nearest road, and 0.71 km from housing. The number of nests in a colony correlated well with the distance from roads, decreasing with proximity to roads. The active colonies were significantly farther removed from the river than were the inactive colonies. Housing did not affect colony size or activity.

The number of herons in the study area grew 10-15% between 1969 and 1979. The mean colony size decreased in the same period, primarily because of a large increase in the number of small colonies. The lifespan of colonies in northwestern Montana was 5 - 15 years, with the smaller colonies being shorter-lived.
REFERENCES CITED


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APPENDIX A

Distribution of Colonies in 1978 and 1979
Distribution of colonies studied in 1978 and 1979 on the Bitterroot, Clark Fork, Flathead, and Swan rivers. Locations are taken from U.S. Geological Survey maps. Other bird species nesting in the colonies: (CG) Canada Goose; (GHO) Great Horned Owl; (RTH) Red-tailed Hawk; (O) Osprey; (DC) Double-crested Cormorant.

Bitterroot River

1. Lolo. T11N R20W Sec 24 SE¼. Active
   Owner: State.
2. Florence. T10N R20W Sec 24 NE¼. Active
   Owner: ?
3. Lee Metcalf NWR. T10N R20W Sec 36 SW¼. Active
   Owner: U.S. F&W Service
   Other Species: 0
4. Stevensville. T9N R20W Sec 34 SW¼. Active
   Owner: Brian and Lisa Burgess.
   Other Species: CG, RTH, O
5. Victor. T8N R20W Sec 8 SE¼. Inactive
   Owner: Harry and Alice Day.
   Other Species: RTH

Clark Fork

6. Kelly Island. T13N R20W Sec 23 NE¼. Active
   Owner: MT Dept. of Fish, Wildlife and Parks.
   Other Species: CG
7. Drummond. T10N R12W Sec 6 NE¼. Active
   Owner: William Wallace.
   Owner: William Wallace.
   Other Species: GHO

Lower Flathead River

   Owner: Flathead Indian Reservation.
   Other Species: 0
    Owner: Flathead Indian Reservation.
    Other Species: 0
    Owner: Flathead Indian Reservation.
    Other Species: CG
    Owner: Flathead Indian Reservation.
   Owner: Flathead Indian Reservation.
   Other Species: 0
   Owner: Flathead Indian Reservation.
   Owner: U.S. F&W Service.
   Other Species: CG, GHO, DC

UPPER FLATHEAD RIVER

    Owner: Orlando and Dorothy Alstad.
    Owner: State.
    Other Species: CG, 0
18. Rose Creek. T27N R20W Sec 10 NE¼. Active.
    Owner: Doug Silverberg
    Other Species: CG, O

SWAN RIVER

    Owner: Lee Rost.
    Other Species: CG, 0
20. Ferndale South. T27N R18W Sec 22 SW¼. Active
    Owner: L.B. Slater.
    Owner: U.S. F&W Service.
    Owner: Swan River State Forest.

Other heronries in northwestern Montana, not in 1979 study:

BITTERROOT RIVER

    Owner: Clem and Edyth Larson.
    Not in study area.

FLATHEAD LAKE

    Owner: University of Montana.
SWAN RIVER

   Owner: Burlington Northern Railroad.
   Not in study area.

BLACKFOOT RIVER

26. Ovando. T14N R12W Sec 1 or 2? Active?
    Owner: ?
    Not in study area.
APPENDIX B

Distribution of colonies in 1969 and 1970
Distribution of colonies found by Dennis Billings in 1969 and 1970 on the Bitterroot, Clark Fork, Flathead, and Swan rivers.

<table>
<thead>
<tr>
<th>Nearest Town</th>
<th>Location</th>
<th>Nest tree species</th>
<th># Nests</th>
<th>Active</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BITTERROOT RIVER</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Corvallis</td>
<td>T7N R20W</td>
<td>Black Cottonwood</td>
<td>16</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>NW½ Sec 17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Victor</td>
<td>T8N R20W</td>
<td></td>
<td>6</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>NW½ Sec 33</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Victor</td>
<td>T8N R20W</td>
<td></td>
<td>5</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>NE½ Sec 29</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Victor</td>
<td>T8N R20W</td>
<td></td>
<td>36</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>SE½ Sec 8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Lee Metcalf</td>
<td>TION R20W</td>
<td></td>
<td>18</td>
<td>no</td>
</tr>
<tr>
<td>NWR</td>
<td>NE½ Sec 35</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Florence</td>
<td>TION R20W</td>
<td></td>
<td>45</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>NE½ Sec 24</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Lolo</td>
<td>T11N R20W</td>
<td></td>
<td>?</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>NE½ Sec 13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Lolo</td>
<td>T11N R20W</td>
<td></td>
<td>?</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>NE½ Sec 12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CLARK FORK</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Kelly Island</td>
<td>T13N R20W</td>
<td>Black Cottonwood</td>
<td>75</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>NE½ Sec 23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Jens</td>
<td>T10N R11W</td>
<td></td>
<td>7</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>Sec 24</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Deerlodge</td>
<td>5 km so. of Deerlodge</td>
<td></td>
<td>4</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>FLATHEAD VALLEY</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Moiese</td>
<td>T19N R21W</td>
<td>Ponderosa Pine</td>
<td>122</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>NW½ Sec 31</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Perma Dump</td>
<td>T18N R22W</td>
<td></td>
<td>20</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>NW½ Sec 17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Ninepipe</td>
<td>T19-20N R20W</td>
<td>Black Cottonwood</td>
<td>65</td>
<td>yes</td>
</tr>
<tr>
<td>NWR</td>
<td>Sec 3, 34</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flathead Lake</td>
<td></td>
<td></td>
<td>post-1969:100+</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sec 34</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Kalispell</td>
<td>3 km SE of Kalispell</td>
<td>Black Cottonwood</td>
<td>pre-1969:96</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>post-1969: 0</td>
<td></td>
</tr>
<tr>
<td>17. Evergreen</td>
<td>T29N R21W</td>
<td></td>
<td>?</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>SE½ Sec 35</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Nearest Town</th>
<th>Location</th>
<th>Nest Tree Species</th>
<th># Nests</th>
<th>Active</th>
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<tbody>
<tr>
<td>SWAN VALLEY</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18.</td>
<td>Road to Conifers</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td></td>
<td>Falls Creek</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX C

Distribution of colonies in 1969 and 1970, outside the study area
Distribution of colonies found by Dennis Billings in 1969 and 1970 in Montana, outside the study area.

**Rock Creek**

**Blackfoot River**
2. T14N R12W Sec 1 or 2. Active.

**Big Hole River**

**Beaverhead River**
7. Inactive.

**Jefferson River**

**Madison River**
10. Norris. Several km no. of where Rt. 289 crosses river. Inactive.
11. Three Forks. 5 km above Three Forks. Inactive.

**Gallatin River**

**Missouri River**
15. Townsend. T6N R1E Sec 1. Active. Shared with cormorants.
22. Snow Creek Bay. Active. Shared with cormorants.

**Red Rock River**

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Sun River

Yellowstone River
32. Blue Creek (may be Duck Creek). Mouth of creek. Activity unknown.

Big Spring Creek

Tongue River

Lake Bowdoin
Bowdoin National Wildlife Refuge:
35. Active. 32 adults in 1968. Nests are on the ground, on islands.

Medicine Lake
Medicine Lake National Wildlife Refuge:
38. T31N R56E Sec 12. Active

North Chinook Reservoir

Milk River

Nelson Reservoir
42. Island in reservoir. Active.
APPENDIX D

Summary of habitat analyses
Summary of habitat analyses by colony, based on 5 0.04-ha circular plots.

Tree species:  
(BC) Black Cottonwood (Populus trichocarpa)  
(BH) Black Hawthorne (Crataegus douglasii)  
(DF) Douglas Fir (Pseudotsuga menziesii)  
(GF) Grand Fir (Abies grandis)  
(LP) Lodgepole Pine (Pinus contorta)  
(PB) Paper Birch (Betula papyrifera)  
(PP) Ponderosa Pine (Pinus ponderosa)  
(S) Spruce (Picea spp.)  
(WJ) Western Juniper (Juniperus occidentalis)  
(WR) Western Redcedar (Thuja plicata)

The 4 figures in brackets after each tree species are:  
number of trees per ha, relative density (%), relative dominance (%),  
and frequency (%).

Size classes:  
A (7 - 17 cm)  
B (18 - 25 cm)  
C (26 - 40 cm)  
D (41 - 55 cm)  
E (56 - 71 cm)  
F (72 - 86 cm)  
G (87 - 104 cm)  
H (> 104 cm)

The 4 figures in brackets after each diameter size class are:  
number of trees per ha, relative density (%), relative dominance (%),  
and basal area in m² per ha.

1. Lolo  
153 trees/ha; total basal area 32 m²/ha; 27326 shrub stems/ha;  
canopy cover 74%; average canopy height 20 m (range 9-33 m).  
BC (153, 100, 100, 100)  
Trees by diameter size class:  
A (15, 1, 0.4, 0.1)  
B (25, 16, 2, 0.7)  
C (20, 13, 5, 1.5)  
D (30, 19, 16, 5.0)  
E (44, 29, 41, 12.8)  
F (15, 10, 21, 6.8)  
H (5, 3, 15, 4.6)

2. Florence  
133 trees/ha; total basal area 30 m²/ha; 28158 shrub stems/ha;  
canopy cover 65%; average canopy height 21 m (range 6-35 m).  
BC (108, 81, 95, 100)  
PP (25, 19, 5, 80)
Trees by diameter size class:
B (10, 7, 1, 0.3) E (49, 37, 46, 14.2)
C (30, 22, 7, 2.2) F (15, 11, 22, 6.8)
D (25, 19, 13, 4.1) G (5, 4, 11, 3.3)

3. Lee Metcalf National Wildlife Refuge
30 trees/ha; total basal area 7 m²/ha; 1482 shrub stems/ha;
canopy cover 3%, average canopy height 18 m (range 12-27 m).
BC (15, 50, 54, 60)
PP (15, 50, 46, 60)
Trees by diameter size class:
C (20, 67, 25, 1.5)
F (10, 33, 75, 4.5)

4. Stevensville
168 trees/ha; total basal area 23 m²/ha; 15284 shrub stems/ha;
canopy cover 51%; average canopy height 16 m (range 4-31 m).
BC (109, 65, 92, 100)
PP (59, 35, 8, 60)
Trees by diameter size class:
A (20, 12, 1, 0.2) D (40, 23, 29, 6.6)
B (30, 18, 4, 0.8) E (35, 21, 44, 10.0)
C (40, 23, 13, 2.9) F (5, 3, 10, 2.3)

5. Victor
143 trees/ha; total basal area 37 m²/ha; 21860 shrub stems/ha;
canopy cover 64%; average canopy height 26 m (range 6-30 m).
BC (143, 100, 100, 100)
Trees by diameter size class:
A (5, 3, 0.1, 0.04) E (30, 31, 23, 8.5)
B (5, 3, 0.4, 0.1) F (30, 21, 36, 13.5)
C (20, 14, 4, 1.5) G (10, 7, 17, 6.5)
D (44, 31, 20, 7.4)

6. Kelly Island
168 trees/ha; total basal area 40 m²/ha; 14079 shrub stems/ha;
canopy cover 56%; average canopy height 22 m (range 6-36 m).
BC (123, 74, 97, 100)
Pb (44, 26, 3, 60)
Trees by diameter size class:
A (25, 15, 1, 0.2) D (20, 12, 9, 3.3)
B (15, 9, 1, 0.4) E (69, 41, 52, 20.0)
C (10, 6, 2, 0.7) F (30, 18, 35, 13.5)
7. Drummond

232 trees/ha; total basal area 45 m²/ha; 16302 shrub stems/ha;
canopy cover 73%; average canopy height 12 m (range 4-27 m).

- BC (168, 72, 99, 100)
- PB (59, 26, 1, 40)
- BH (5, 2, 0, 20)

Trees by diameter size class:

<table>
<thead>
<tr>
<th>Diameter Size</th>
<th>Trees/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (69, 30, 1, 0.6)</td>
<td>E (30, 13, 19, 8.5)</td>
</tr>
<tr>
<td>B (25, 11, 2, 0.7)</td>
<td>F (35, 14, 35, 15.8)</td>
</tr>
<tr>
<td>C (30, 13, 5, 2.2)</td>
<td>G (10, 4, 14, 6.5)</td>
</tr>
<tr>
<td>D (30, 13, 11, 5.0)</td>
<td>H (5, 2, 13, 6.0)</td>
</tr>
</tbody>
</table>

8. Jens

183 trees/ha; total basal area 41 m²/ha; 16302 shrub stems/ha;
canopy cover 39%; average canopy height 20 m (range 11-32 m).

- BC (183, 100, 100, 100)

Trees by diameter size class:

<table>
<thead>
<tr>
<th>Diameter Size</th>
<th>Trees/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>C (44, 24, 9, 3.3)</td>
<td>F (15, 8, 18, 6.8)</td>
</tr>
<tr>
<td>D (84, 46, 38, 14.1)</td>
<td>G (5, 3, 9, 3.3)</td>
</tr>
<tr>
<td>E (35, 19, 27, 10.0)</td>
<td></td>
</tr>
</tbody>
</table>

9. Buffalo Rapids

232 trees/ha; total basal area 32 m²/ha; 2223 shrub stems/ha;
canopy cover 35%; average canopy height 14 m (range 5-39 m).

- PP (94, 40, 90, 100)
- WJ (138, 60, 10, 80)

Trees by diameter size class:

<table>
<thead>
<tr>
<th>Diameter Size</th>
<th>Trees/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (109, 47, 3, 1.0)</td>
<td>E (20, 9, 16, 5.7)</td>
</tr>
<tr>
<td>B (30, 13, 2, 0.8)</td>
<td>F (5, 2, 6, 2.3)</td>
</tr>
<tr>
<td>C (20, 9, 4, 1.5)</td>
<td>H (15, 6, 51, 18.0)</td>
</tr>
<tr>
<td>D (35, 15, 16, 5.8)</td>
<td></td>
</tr>
</tbody>
</table>

10. Moiesse

203 trees/ha; total basal area 26 m²/ha; 2964 shrub stems/ha;
canopy cover 46%; average canopy height 15 m (range 6-30 m).

- PP (74, 37, 77, 100)
- WJ (99, 49, 10, 80)
- BC (30, 15, 10, 80)

Trees by diameter size class:

<table>
<thead>
<tr>
<th>Diameter Size</th>
<th>Trees/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (49, 24, 2, 0.5)</td>
<td>D (25, 12, 16, 4.1)</td>
</tr>
<tr>
<td>B (49, 24, 5, 1.4)</td>
<td>E (44, 22, 51, 12.9)</td>
</tr>
<tr>
<td>C (25, 12, 7, 1.8)</td>
<td>F (10, 5, 18, 4.6)</td>
</tr>
</tbody>
</table>

11. Dixon

49 trees/ha; total basal area 18 m²/ha; 13338 shrub stems/ha;
canopy cover 15%; average canopy height 22 m (range 6-32 m).
### 12. Perma Dump

- Total basal area: 18 m²/ha
- Shrub stems: 17,414
- Canopy cover: 16%
- Average canopy height: 15 m (range 6-30 m)

<table>
<thead>
<tr>
<th>Diameter Size Class</th>
<th>Trees</th>
<th>Canopy Cover</th>
<th>Canopy Height (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 10, 20, 1, 0.9</td>
<td>F 15, 30, 38, 6.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B 5, 10, 1, 1.4</td>
<td>G 15, 30, 56, 9.8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 13. Perma 1

- Total basal area: 24 m²/ha
- Shrub stems: 11,486
- Canopy cover: 53%
- Average canopy height: 17 m (range 6-31 m)

<table>
<thead>
<tr>
<th>Diameter Size Class</th>
<th>Trees</th>
<th>Canopy Cover</th>
<th>Canopy Height (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 25, 31, 1, 0.2</td>
<td>E 15, 19, 22, 4.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B 5, 6, 1, 0.1</td>
<td>G 10, 13, 34, 6.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C 15, 19, 6, 1.1</td>
<td>H 5, 6, 31, 6.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D 5, 6, 4, 0.8</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 14. Perma 2

- Total basal area: 16 m²/ha
- Shrub stems: 14,450
- Canopy cover: 48%
- Average canopy height: 12 m (range 6-30 m)

<table>
<thead>
<tr>
<th>Diameter Size Class</th>
<th>Trees</th>
<th>Canopy Cover</th>
<th>Canopy Height (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 84, 47, 5, 0.8</td>
<td>D 10, 6, 10, 1.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B 25, 14, 4, 0.7</td>
<td>G 5, 3, 20, 3.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C 49, 28, 23, 3.7</td>
<td>H 5, 3, 37, 6.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 15. Ninepipe National Wildlife Refuge

- Total basal area: 16 m²/ha
- Shrub stems: 12,968
- Canopy cover: 17%
- Average canopy height: 14 m (range 9-18 m)

<table>
<thead>
<tr>
<th>Diameter Size Class</th>
<th>Trees</th>
<th>Canopy Cover</th>
<th>Canopy Height (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 133, 100, 100, 100</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Trees by diameter size class:
A (40, 30, 2, 0.4) D (25, 19, 28, 4.1)
B (15, 11, 3, 0.4) E (10, 7, 19, 2.8)
C (35, 26, 17, 2.6) F (10, 7, 30, 4.5)

16. Evergreen
128 trees/ha; total basal area 18 m²/ha; 29640 shrub stems/ha;
canopy cover 59%; average canopy height 22 m (range 6-35 m).
BC (128, 100, 100, 100)
Trees by diameter size class:
A (5, 4, 0, 0.1) D (54, 42, 49, 9.1)
B (5, 4, 0, 0.1) E (20, 15, 31, 5.7)
C (49, 38, 20, 3.7) F (20, 16, 10, 3.3)

17. Owen Souerwine
124 trees/ha; total basal area 34 m²/ha; 12227 shrub stems/ha;
canopy cover 49%; average canopy height 24 m (range 12-35 m).
BC (124, 100, 100, 100)
Trees by diameter size class:
A (5, 4, 0, 0.1) E (49, 40, 44, 14.2)
B (5, 4, 0, 0.1) F (15, 12, 21, 6.8)
C (20, 16, 5, 1.5) G (10, 8, 20, 6.5)
D (20, 16, 10, 3.3)

18. Rose Creek
257 trees/ha; total basal area 26 m²/ha; 15191 shrub stems/ha;
canopy cover 71%; average canopy height 19 m (range 6-29 m).
BC (143, 56, 73, 100)
PB (114, 44, 27, 100)
Trees by diameter size class:
A (35, 13, 1, 0.3) D (20, 8, 14, 3.3)
B (25, 10, 3, 0.7) E (15, 6, 17, 4.3)
C (153, 60, 47, 11.4) F (10, 4, 18, 4.5)

19. Ferndale North
69 trees/ha; total basal area 7 m²/ha; 4076 shrub stems/ha;
canopy cover 8%; average canopy height 19 m (range 6-27 m).
LP (49, 71, 57, 100)
BC (20, 29, 43, 20)
Trees by diameter size class:
C (59, 86, 66, 4.4) E (5, 7, 21, 1.4)
D (5, 7, 12, 0.8)

20. Ferndale South
153 trees/ha; total basal area 17 m²/ha; 10374 shrub stems/ha;
canopy cover 48%; average canopy height 17 m (range 5-31 m).
Trees by diameter size class:
A (35, 23, 2, 0.1)    D (25, 16, 26, 4.1)
B (30, 19, 5, 0.8)    E (15, 10, 26, 4.3)
C (44, 29, 21, 3.3)   G (5, 3, 20, 3.3)

21. Swan River National Wildlife Refuge
158 trees/ha; total basal area 9 m^2/ha; 5187 shrub stems/ha;
canopy cover 66%; average canopy height 16 m (range 6-26 m).
S (138, 88, 89, 100)
PB (15, 9, 11, 60)
WR (5, 3, 0, 20)
Trees by diameter size class:
A (49, 31, 6, 0.5)    C (64, 41, 61, 4.8)
B (35, 22, 12, 1.0)   D (10, 6, 21, 1.7)

22. Soup Creek
173 trees/ha; total basal area 20 m^2/ha; 15561 shrub stems/ha;
canopy cover 36%; average canopy height 16 m (range 6-27 m).
BC (44, 26, 71, 80)
S (104, 60, 21, 100)
GF (25, 14, 8, 40)
Trees by diameter size class:
A (35, 20, 2, 0.3)    D (10, 6, 9, 1.7)
B (59, 34, 9, 1.7)    F (10, 6, 25, 4.5)
C (49, 29, 20, 3.7)   G (10, 6, 36, 6.5)
APPENDIX E

Reproductive data by heronry, for 1978
Reproductive data by heronry, for the 1978 breeding season.

<table>
<thead>
<tr>
<th>Heronry</th>
<th># Nests</th>
<th># Active Nests</th>
<th># Successful Nests</th>
<th>Total # Young Nests</th>
<th># Young/Active Nests</th>
<th># Young/Successful Nests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lolo</td>
<td>8</td>
<td>7 (88%)</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Florence</td>
<td>11</td>
<td>4 (36%)</td>
<td>4</td>
<td>7</td>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td>Lee Metcalf</td>
<td>7</td>
<td>7 (100%)</td>
<td>7</td>
<td>14</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Stevensville</td>
<td>101</td>
<td>53 (52%)</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Victor</td>
<td>13</td>
<td>0 (0%)</td>
<td>--</td>
<td>--</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Kelly Island</td>
<td>86</td>
<td>38 (44%)</td>
<td>27</td>
<td>43</td>
<td>1.1</td>
<td>1.6</td>
</tr>
<tr>
<td>Drummond</td>
<td>23</td>
<td>23 (100%)</td>
<td>21</td>
<td>44</td>
<td>1.9</td>
<td>2.1</td>
</tr>
<tr>
<td>Jens</td>
<td>41</td>
<td>0 (0%)</td>
<td>--</td>
<td>--</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Buffalo Rapids</td>
<td>10</td>
<td>0 (0%)</td>
<td>--</td>
<td>--</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Moiese</td>
<td>21</td>
<td>1 (5%)</td>
<td>1</td>
<td>3</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Dixon</td>
<td>10</td>
<td>7 (70%)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>---</td>
</tr>
<tr>
<td>Perma Dump</td>
<td>9</td>
<td>3 (33%)</td>
<td>3</td>
<td>5</td>
<td>1.7</td>
<td>1.7</td>
</tr>
<tr>
<td>Perma 1</td>
<td>12</td>
<td>3 (25%)</td>
<td>3</td>
<td>7</td>
<td>2.3</td>
<td>2.3</td>
</tr>
<tr>
<td>Perma 2</td>
<td>1</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Ninepipe</td>
<td>82*</td>
<td>82*</td>
<td>?</td>
<td>211*</td>
<td>2.6</td>
<td>?</td>
</tr>
<tr>
<td>Rose Creek</td>
<td>?</td>
<td>?</td>
<td>5</td>
<td>10</td>
<td>?</td>
<td>2.0</td>
</tr>
<tr>
<td>Ferndale North</td>
<td>11</td>
<td>?</td>
<td>10</td>
<td>22</td>
<td>?</td>
<td>2.2</td>
</tr>
<tr>
<td>Ferndale South</td>
<td>10</td>
<td>?</td>
<td>8</td>
<td>24</td>
<td>?</td>
<td>3.0</td>
</tr>
<tr>
<td>Swan River</td>
<td>6</td>
<td>?</td>
<td>2</td>
<td>5</td>
<td>?</td>
<td>2.5</td>
</tr>
<tr>
<td>Soup Creek</td>
<td>14</td>
<td>?</td>
<td>10</td>
<td>14</td>
<td>?</td>
<td>1.4</td>
</tr>
</tbody>
</table>

* Data for the 1978 breeding season at Ninepipe were provided by Marcella Bishop (pers. comm.).
APPENDIX F

Reproductive data by river
Reproductive data by river, for the 1978 and 1979 breeding seasons.

### 1978

<table>
<thead>
<tr>
<th>River</th>
<th># Colonies</th>
<th># Nests</th>
<th># Active Nests</th>
<th>Total # Young</th>
<th># Young/Active Colony Nest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bitterroot</td>
<td>5</td>
<td>140</td>
<td>71</td>
<td>21 in 31 nests</td>
<td>1.2</td>
</tr>
<tr>
<td>Clark Fork</td>
<td>3</td>
<td>150</td>
<td>61</td>
<td>87</td>
<td>0.8</td>
</tr>
<tr>
<td>Lower Flathead</td>
<td>7</td>
<td>138</td>
<td>89</td>
<td>161</td>
<td>1.3</td>
</tr>
<tr>
<td>Upper Flathead</td>
<td>3</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Swan</td>
<td>4</td>
<td>41</td>
<td>?</td>
<td>65</td>
<td>1.6</td>
</tr>
</tbody>
</table>

### 1979

<table>
<thead>
<tr>
<th>River</th>
<th># Colonies</th>
<th># Nests</th>
<th># Active Nests</th>
<th>Total # Young</th>
<th># Young/Active Colony Nest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bitterroot</td>
<td>5</td>
<td>125</td>
<td>70</td>
<td>134</td>
<td>1.2</td>
</tr>
<tr>
<td>Clark Fork</td>
<td>3</td>
<td>151</td>
<td>68</td>
<td>116</td>
<td>1.0</td>
</tr>
<tr>
<td>Lower Flathead</td>
<td>7</td>
<td>131</td>
<td>88</td>
<td>185</td>
<td>1.6</td>
</tr>
<tr>
<td>Upper Flathead</td>
<td>3</td>
<td>126</td>
<td>83</td>
<td>137</td>
<td>1.1</td>
</tr>
<tr>
<td>Swan</td>
<td>4</td>
<td>45</td>
<td>37</td>
<td>77</td>
<td>1.7</td>
</tr>
</tbody>
</table>