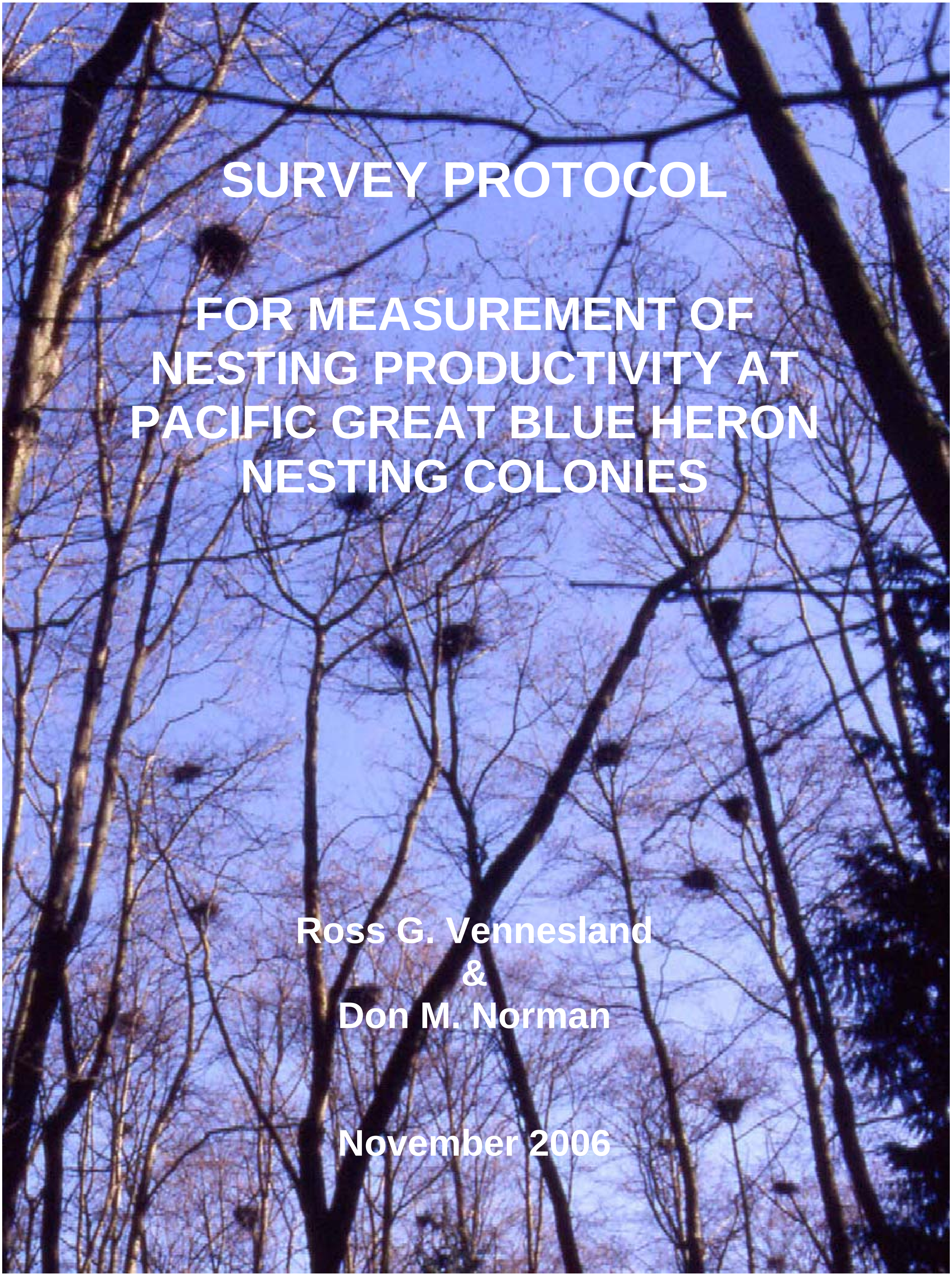

SURVEY PROTOCOL

FOR MEASUREMENT OF NESTING PRODUCTIVITY AT PACIFIC GREAT BLUE HERON NESTING COLONIES

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The Heron Working Group is a consortium of individuals from university, government and conservation organizations interested in the conservation of the Pacific Great Blue Heron (*Ardea herodias fannini*).

The primary goal of the group is to ensure a viable and self sustaining population of Pacific Great Blue Herons within their current range in Canada and the USA, and within their historical range where habitat still exists or can be restored, through the protection and management of individual herons, their populations and habitat.

The group collaborates on designing research and census protocols, conservation advice, seeking funding support, and providing information through our web site, which can be accessed at: www.heronworkinggroup.org.

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INTRODUCTION

The Great Blue Heron (*Ardea herodias*) is a wading bird that is found across North America. Most northern nesting populations migrate south for the winter, except on the northwest Pacific Coast from Washington to Alaska (Payne 1979, Hancock and Kushlan 1984, Butler 1992, Butler 1997). Great Blue Herons in this region are considered a distinct subspecies (*A.h. fannini*) of the continental form (*A.h. herodias*) (Hancock and Elliot 1978, Payne 1979). The *fannini* subspecies is colloquially known as the Pacific Great Blue Heron (Butler 1997).

Most of the 6,000 to 12,000 Pacific Great Blue Herons occur in south-coastal British Columbia and north-coastal Washington State (Butler 1997, Gebauer and Moul 2001). Primary threats to the Pacific Great Blue Heron are from Bald Eagle (*Haliaeetus leucocephalus*) depredation, habitat loss, and human disturbance (Norman et al. 1989, Butler 1997, Gebauer and Moul 2001, Butler and Vennesland 2000, Vennesland 2000, Vennesland and Butler 2004). In Canada, the Pacific Great Blue Heron has been listed as a subspecies of 'Special Concern' by the *Committee on the Status of Endangered Wildlife in Canada* (COSEWIC 2001) because of its specialized nesting habitat requirements, threats to its' nesting colonies from humans and Bald Eagles, and population declines on Breeding Bird Surveys from 1966 to 1994 (Downes and Collins 1996, Butler 1997). For the same reasons, in British Columbia the Great Blue Heron has been Blue-listed (considered 'vulnerable') (CDC 2003), and in Washington State has been placed on the Washington Department of Fish and Wildlife Priority Habitats and Species list.

The purpose of this document is to summarize relevant background information on the Pacific Great Blue Heron and outline a standard survey protocol for the documentation of reproductive productivity at Pacific Great Blue Heron colonies in British Columbia and Washington State. This protocol will assist in ensuring consistent data collection within and among regions.

SURVEY INFORMATION SOURCES

Moul et al. (2001) outlined methodology used in the collection of field data from 1988 to 1999 on the coast of British Columbia, including the treatment of collected data. Vennesland (2000) provided methods for intensive studies of heron colonies, addressing nesting biology as well as the effects of researcher, predator, and human disturbances. The British Columbia government produced a survey protocol outlining general methods for the collection of field data on Great Blue Herons (RISC 1998) and selected recommendations from this document have been appended to this protocol (Appendix 1). The B.C. Ministry of Environment (Conservation Data Centre; CDC 2001) maintains colony data in a province-wide database located in Victoria. The Washington Department of Fish and Wildlife maintains colony data in a statewide database located in and managed by the headquarters office in Olympia.

A variety of information can be obtained by visiting the website of the Heron Working Group, located at www.heronworkinggroup.org. The website provides information on the Heron Working Group, heron biology, contacts, publications, links and FAQ's.

LEGAL PROTECTION AND HABITAT CONSERVATION

In British Columbia, the Great Blue Heron, its' nests and eggs are protected year-round from persecution (Section 34), hunting (Section 26[1]), and harassment (Section 27[3]) by the British Columbia *Wildlife Act* (1982; updated 1999), as well as through Article 11:3 of the *Migratory Birds Convention Act* (1994) and Sections 5(4) and 6(a) of the *Migratory Birds Regulations* (Butler and Baudin 2000). A few scare/kill permits were provided up to 1998 to reduce heron depredation of hatchery fish stocks, but these have since been revoked (R. Butler, pers. comm.). In addition, the British Columbia *Forest Practices Code Act* (1995) and *Forest and Range Practices Act* (2004) has guidelines to protect heron colonies (*e.g., the Identified Wildlife Management Strategy)* on Crown Land (Vennesland and Summers 2004). On private land, the British Columbia government advises land users how to best protect wildlife with documents such as the Environmental Best Management Practices for Urban and Rural Land Development in British Columbia (or 'Develop with Care') series produced by the Ministry of Environment (B.C. MoE 2005). Additionally, municipalities have considerable control over the land base within their jurisdiction with the capability of zoning land for different uses, identifying Development Permit Areas, among other regulatory powers.

In Washington State, Great Blue Herons are classified as protected wildlife under WAC 232-12-014 (3). Eggs and nests are protected from unlawful taking under RCW 77.15.130, Section 14; however, this law is not explicit in its protection of nests when they are unoccupied outside of the nesting season. Great Blue Herons are classified as a Priority Species in Washington State – heron nesting habitat is considered a Priority Habitat. A federal permit from the U.S. Fish and Wildlife Service is required by anyone anytime they intend to destroy eggs or nests; or capture, relocate, disturb or kill great blue herons for damage control. Such a permit may be granted only when extreme damage is occurring and only after all other non-lethal control techniques have proven to be unsuccessful. The state of Washington has no legal provision for protecting heron habitat. Great Blue Heron habitat protection in Washington State takes place under local city and county wildlife habitat or critical area ordinances. Washington Department of Fish and Wildlife can advise local governments and developers how to best protect heron colonies by providing consultation and the Priority Habitats and Species Management Guidelines produced by the Washington Department of Fish and Wildlife (WDFW 2006).

In both countries, Non-Governmental Organizations are active in conserving this species. In Canada, NGOs have been pivotal in the conservation of several nesting sites, including the McFadden Creek colony on Saltspring Island (see www.ec.gc.ca/press/heron_b_e.htm) and the Great Blue Heron Nature Reserve in Chilliwack (see www.chilliwackblueheron.com), to name just two examples.

BIOLOGY

DESCRIPTION

The Great Blue Heron is the largest wading bird in North America, and measures about 60 cm in height, 97 to 137 cm in length, and 2.1 to 2.5 kg in mass (Butler 1992). The wings are long and rounded, the bill is long, and the tail is short (Butler 1992). Great Blue Herons fly with deep, slow wing beats and with their necks folded in an S-shape. Plumage is mostly a blue-grey colour and adults have a white crown.

COLONY CHARACTERISTICS

Great Blue Herons are normally arboreal nesters and colonies are typically situated in forests near to (usually < 15 km from) suitable foraging areas (Butler 1991, 1992, 1997). Nests are large stick platforms, usually 2 m to 30 m above ground (Butler 1997). Nesting usually occurs at sites that are relatively free from disturbance by human activities, but sometimes occurs in developed areas.

Colonies are located in both urban and rural areas, using relatively contiguous forest, fragmented forest and solitary trees (Butler 1997). The most common tree species used for nesting are Red Alder (*Alnus rubra*), Black Cottonwood (*Populus balsamifera*), Bigleaf Maple (*Acer macrophyllum*), Sitka Spruce (*Picea sitchensis*) and Douglas Fir (*Pseudotsuga menziesii*) (Gebauer and Moul 2001). See Gebauer and Moul (2001) for a list of tree species used.

For south-coastal British Columbia in 1999, Vennesland (2000) and Vennesland and Butler (2004) reported a colony size range of 1 to 400 active nests, with a mean of 62 active nests (SD = 94, N = 31) and a median of 26 nests. The largest heron colony on record in Washington State is the Southwest Bachelor Island rookery in Clark Co adjacent to Ridgefield NWR on the Columbia River. In 1973 it reportedly had 773 active nests. The 2001 observation for this colony on file with the Washington Department of Fish and Wildlife reports 557 active nests. Washington State has many other heron colonies ranging from 2 to over 400 nests (P. Thompson WDFW pers. comm.).

Colony locations are dynamic, especially in areas of high disturbance (Butler 1992, Vennesland 2000, Vennesland and Butler 2004). Some colonies are used for many years (*e.g.*, Shoal Island, Pacific Spirit Park and Point Roberts; all >25 years), but most colonies, especially those with fewer than 25 nests, are relocated every few years (Gebauer and Moul 2001). A site will be re-used by individual herons that failed in their first nesting attempt if other herons are present and if there is sufficient time to complete a nesting cycle. If the entire colony abandons and there is sufficient time to complete a nesting cycle, herons will occasionally return as a group to the same or different colony site in the same or subsequent year. Herons will sometimes return to a site after several years of no use (Moul et al. 2001).

NESTING CHRONOLOGY

In south-coastal British Columbia and Washington State, nesting is initiated between February and April (Butler 1992, Butler 1997, Vennesland 2000, P. Thompson WDFW pers. comm., Pam Cahn, unpubl. data). The initiation period is defined as the period of courtship before eggs are laid, and can last for over two months at some colonies (Vennesland 2000). In general, males arrive at the colony site and establish territories, followed about a week later by the females (Butler 1991). Courtship and nest repair and/or building take from several days to about two months (Butler 1991, Vennesland 2000). Monogamous pairs are established for the season (Simpson 1984), and an average of four eggs is laid at about two-day intervals (Vermeer 1969, Pratt 1970). The incubation period is defined as the period after eggs are laid but before eggs hatch, and can last for a variable period due to staggered laying and re-nesting attempts (Vennesland 2000). Clutch size ranges from one to eight, with three to five being typical (Ehrlich et al. 1988, Campbell et al. 1990). Incubation begins soon after the first egg is laid and results in asynchronous hatching (Butler 1992). Hatching occurs after about 27 days of incubation (Butler 1992). The period after hatching but before young fledge is defined as the fledgling or chick rearing period. Young are reared on the nest for about 60 days, fed mostly fish caught near the colony site (Krebs 1974, Simpson 1984).

Herons require about 95 days to complete a nesting cycle, but regularly take much longer than this if re-nesting or other delays occur. For example, Vennesland (2000) reported that the nesting season for individual heron colonies in south-coastal British Columbia in 1999 ranged from 88 to 167 days, with a mean of 127 days (SD = 23, n = 12 colonies). Thus, herons can potentially breed more than once if their first attempt fails. Heron nesting sites can be relocated rapidly because nests can be built in three days and eggs can be laid within about one week (Butler 1997).

NESTING SUCCESS AND PRODUCTIVITY

In south-coastal British Columbia and Washington State, the number of fledglings raised in a nest varies from 0 to 4 (Butler 1992, 1997). Historically, the productivity of herons across North America has ranged from 1.3 to 2.70 fledglings per nesting attempt, and from 2.0 to 3.0 fledglings per successful nesting attempt (reviewed by Butler 1997, see also Pratt 1970, Vos et al. 1985). The mean nesting productivity for the Great Blue Heron in south-coastal British Columbia in more recent years has been the lowest of any studies in North America and other years in British Columbia (Vennesland 2000, Vennesland and Butler 2004). Productivity values for south-coastal B.C. over recent years include: 0.82 fledglings per active nest, and 1.98 fledglings per successful nest in 1999 (Vennesland 2000, Vennesland and Butler 2004), 0.82 fledged young per active nest and 1.84 fledged young per successful nest in 2002 (Vennesland 2003), and 1.3 fledglings per active nest and 1.7 fledglings per successful nest in 2004 (McClaren 2005).

HUMAN DISTURBANCE OVERVIEW

Colonial nesting birds can be sensitive to human disturbance near colonies. Reviews of the effects and mitigation of human disturbance in birds, and especially waterbirds, are provided in Parnell et al. (1988), Hockin et al. (1992), Rodgers and Smith (1995), Nisbet (2000), and Vennesland (2000). In particular, Hockin et al. (1992) found that 36 of 40 studies reported reduced nesting productivity due to human disturbance. The effects of disturbance depend on the timing, frequency and magnitude of antagonistic activity and the sensitivity of the birds being stimulated (Roberts and Ralph 1975, Ellison and Cleary 1978, Tremblay and Ellison 1979, Hill et al. 1997, Vennesland 2000, Vennesland and Butler 2004). The concentrated nature of colonial nesting birds can increase their susceptibility to disturbance (Vos et al. 1985, Parnell et al. 1988, Rodgers and Smith 1995).

Human activity disturbs nesting Great Blue Herons (Werschkul et al. 1976, Simpson and Kelsall 1978, Vos et al. 1985), and has been linked to reduced nesting productivity (Forbes et al. 1985b, Vennesland and Butler 2004, Vennesland 2000; reviewed by Parnell et al. 1988). Carlson and McLean (1996) found that the distance of heron colonies from human activity and the width or efficacy of the buffer zone around colonies were positively related to nesting productivity (buffer zones included vegetation, water and fencing). Watts and Bradshaw (1994) reported herons nesting further from human development than would be expected by chance, and Parker (1980) observed that colony size increased with distance from roads. It is not clear if these same patterns apply to herons on the heavily developed south coast of B.C.

Several studies have linked the abandonments of Great Blue Heron colonies to human activity, including housing and industrial development, highway construction, logging, vehicle traffic, and repeated human intrusions (Bjorklund 1975, Mark 1976, Werschkul et al. 1976, Simpson and Kelsall 1978, Kelsall and Simpson 1979, Forbes et al. 1985b, Leonard 1985, Vennesland and Butler 2004; see also reviews by Parnell et al. 1988, Hockin et al. (1992), Rodgers and Smith 1995, Nisbet 2000, Vennesland 2000).

In B.C., Vennesland (2000) found that humans were likely involved in 4 of 14 abandonments from 1998 to 1999, but the effect of humans also could not be separated from the effect of eagles that was much more pervasive (meaning there is likely an interaction between these two disturbance stimuli). Forbes et al. (1985a) concluded that 17 of 27 colony abandonments occurred due to human activity near the colony-site, including tree cutting, flooding, vehicle use and researcher activity. Simpson (1984) documented construction work that resulted in adult herons leaving nests and ended with a large loss of nestlings to eagles. Simpson and Kelsall (1978) found that housing construction near to a colony in Sechelt in 1978 resulted in the abandonment of about 73% of nests. One study has hypothesized that forest fragmentation caused by humans is allowing easier access to sites by predators such as eagles (Vennesland 2000, Butler and Vennesland 2004), which could at least partly explain the presumed interaction between these disturbance sources mentioned above.

Herons tolerate some human activity near nesting areas (Mark 1976, Kushlan 1979, Webb and Forbes 1982, Butler 1997, Vennesland 2000), and show more tolerance for repeated mechanical disturbances than for pedestrian traffic (Vos et al. 1985, Carlson and McLean 1996, Rodgers and Smith 1995, Vennesland 2000), depending on the timing, frequency and magnitude of the stimulus and the sensitivity of the birds (Roberts and Ralph 1975, Ellison and Cleary 1978, Tremblay and Ellison 1979, Hill et al. 1997, Vennesland 2000, Butler and Vennesland 2004).

Some colonies of Great Blue Herons in B.C. have become acclimatized to routine human activities, but others have not. Herons nesting in Stanley Park in Vancouver and Beacon Hill Park in Victoria seem unconcerned with the frequent human pedestrians and vehicles directly below their nests (Butler 1997, Vennesland 2000). However, colonies in more rural settings may respond to disturbances at a great distance. At a sensitive colony on Vancouver Island (Quamichan Lake, Duncan), adult herons flushed from their nests when a researcher approached within 200 m before eggs had been laid, 100 m after eggs had been laid, and 10 m after chicks were present (Butler 1991). Vennesland (2000) reported that nesting herons at sensitive sites responded when a researcher approached within 100 m. Herons at sensitive sites might respond at the first sighting of intruders (Vennesland 2000). It must be kept in mind that although no noticeable response is observed by herons at some urban sites, productivity at these locations has been negatively correlated with the local level of human activity (Vennesland 2000, Vennesland and Butler 2004). Thus, our surveys may not be properly determining heron response. In other words, we may see no response but herons may still be disturbed (Vennesland 2000).

Vennesland (2000) has provided the only experimental evidence of habituation to non-threatening human disturbance in herons. In this study, a low level stimulus was used (one human pedestrian walking slowly towards colonies of herons) to experimentally test for the presence of habituation. This study concluded that herons do indeed habituate to low level non-threatening human disturbance, though a significant behavioural pattern not affected by habituation (*i.e.*, a seasonally determined effect) was also noted. The presence of a seasonal effect means that tendencies towards habituation may be overwhelmed by the timing of nesting, especially early in the nesting season (*i.e.*, early in the season 'investment' in the nesting attempt is low and re-nesting opportunities are high). Thus, even with such a low-level stimulus, caution must be exercised near colonies. Furthermore, heron response in this study did not differ between seasons, implying that habituation to even common stimuli, such as human pedestrians, might be a yearly phenomenon and each year the herons need to be become re-accustomed to the stimuli. Finally, as outlined previously our survey methodologies may not be adequately describing heron response – herons may be more disturbed than we can identify (Vennesland 2000).

More specific information on human disturbance relating directly to researchers visiting heron colonies is provided further in the *Disturbance at Heron Nesting Sites* section.

FIELD SURVEY PROTOCOL

This field survey protocol is based upon methods developed in British Columbia by Moul et al. (2001), Vennesland (2000), and RISC (1998), as well as draft Standard Operating Procedures (SOPs) produced in Washington State by Norman and Krausmann (1999).

This field survey protocol is organized into 4 sections, including:

- General Great Blue Heron Colony Monitoring,
- Colony Characterization: Nest Tree Tagging and Colony Mapping,
- Human Disturbance at Nesting Colonies, and
- Monitoring Nesting Productivity.

Each section has a data sheet associated with it and these sheets are included in this protocol (Appendix 2). All four data sheets should be used each year.

This survey protocol has been developed for British Columbia and Washington State to ensure that:

- data collection at all heron colonies is performed in a similar fashion,
- data collection is complete,
- observers are aware of the potential disturbance they create,
- observers record heron response to their entrance into colonies,
- colony observers are familiar with the etiquette and general nature of recording data while monitoring colonies, and
- volunteers are adequately trained.

Other draft SOPs have been produced in Washington State for more specific research questions that are not incorporated into this field survey protocol include: SOP 5 – Arrival Departure Determination, SOP 6 – Colony Floor Searching, SOP 7 – Tree Climbing, SOP 8 – Chain of Custody and Sample Preparation for Analysis, SOP 9 – Foraging Efficiency, and SOP 10 – Foraging Area Observations (Norman and Krausmann 1999).

General Great Blue Heron Colony Monitoring

This section includes general information for project organization, project initiation, colony monitoring and data recording. The data sheet associated with this section (Data Sheet #1 – Annual Colony Visits Summary) is meant to serve as a summary of the season's research, including a summary of all nests observed, their status on each visit, and final determination of nesting success or failure. The use of this data sheet in relation to the others provided in other sections is described in detail in the *Colony Survey Data Sheets* section.

Personnel

- A biologist with experience in surveying Great Blue Heron colonies should lead survey crews.
- Other personnel must be experienced with or trained in the identification of Great Blue Heron nests, eggs, nestlings, fledglings and adults, as well as common predators.

Equipment

- Standardized data sheets, as provided in this document, should be used for data collection.
- Clipboard with protective cover for data sheets (or use "write in rain" paper).
- A tape recorder might be useful for when observations need to be recorded quickly (*e.g.*, during disturbance observations).
- All appropriate government agencies should be contacted to inquire about permit needs for specific sites and/or activities (in Canada, the B.C. Ministry of Environment or the Canadian Wildlife Service; in the U.S., the Washington Department of Fish and Wildlife – see contacts at www.heronworkinggroup.org).
- A spotting scope of at least 15x magnification and binoculars should be available for observations of heron nests.
- Orienteering equipment, such as compass, rangefinder and/or GPS, if colony or tree locations need to be collected, or if the colony is in a remote area.
- Dark coloured clothing should be worn in the field and similar clothing should be worn on each visit, as safety permits.
- Many sites have standing water at some point during the season, so rubber boots or hip waders might be needed.
- Tree marking materials should be obtained to identify individual trees. Appropriate government agencies should be contacted for advice on appropriate methods (see *Colony Characterization: Nest Tree Tagging and Colony Mapping* section).

Identification of Colony Locations

Colonies in British Columbia and Washington State have been located through many sources, including private landowners, naturalist groups, government agencies and academic institutions (Butler 1997, Vennesland 2000, Gebauer and Moul 2001, Moul et al. 2001).

In British Columbia, the provincial Ministry of Environment is currently responsible for monitoring nesting herons and holds the primary heron colony database (CDC 2003) (after Moul 1999a, Moul 1999b, Moul et al. 2001). All inventory data collected in British Columbia should follow the format of this database, including names and codes associated with colonies (see Moul et al. 2001 for reference).

The Washington Department of Fish and Wildlife is responsible for monitoring nesting herons in Washington State. Heron colony data are maintained in a statewide database located and managed in the headquarters office of the Washington Department of Fish and Wildlife in Olympia. Data for Washington State heron colonies are submitted to Washington Department of Fish and Wildlife on standard Wildlife Observation Forms.

Permission to Access Colonies

Permission from landowners must be arranged prior to an intended visit date, and all possible information on the site should be obtained from local government officials and conservation organizations. A letter thanking the landowner should be sent after each visit or at the end of the season. Permits obtained to salvage or collect should always be with the survey crew.

General Monitoring Information

All relevant literature on Great Blue Heron field methods, life history and behaviour (see *Survey Information Sources* and *Literature Cited* sections) should be reviewed before any survey work commences.

Scoping out the colony is valuable, especially if it can be completed when birds are not present. Knowledge of the tolerance of Great Blue Herons to disturbance at specific colonies should be known prior to the first visit when herons are present. This can usually be obtained from local residents, previous reports, government agencies or conservation groups, and is further outlined here in the *Human Disturbance at Nesting Colonies* section. Great Blue Herons should not be approached during nuptial displays prior to copulation and egg laying or the birds may abandon the colony. Therefore, if a project may occur, be sure to visit the colony in the winter, before late January when the earliest colonies become active. Visits to a colony without herons present will allow data collection without time constraints, multiple persons can be used, trees can be tagged and preliminary maps can be drawn (see *Colony Characterization: Nest Tree Tagging and Colony Mapping* section). Once birds are incubating, the colony edge can be approached (see *Human Disturbance at Nesting Colonies* section) to determine how easily disturbed the herons are at that colony. As a general rule, if any vocal response is heard to the approach, the researcher should go no closer to the colony (see *Human Disturbance at Nesting Colonies* section).

To ensure unnecessary human disturbance is avoided, the *Human Disturbance at Nesting Colonies* section should be reviewed in detail before visiting colonies. In general, time spent under the colony should be minimized or avoided. Movements should be slow and deliberate, without loud noises (*e.g.*, from snapping branches) or sudden movements. If necessary, a travel route should be cleared and the best angles for nest observation should be determined prior to colony initiation (see *Biology* section for dates) and preferably during winter (see *Colony*

Characterization: Nest Tree Tagging and Colony Mapping section). Trails should only be cleared at sites where the public cannot gain access. Determining which nests are active by observing incubation (see *Biology* section) is essential in estimating productivity (see *Monitoring Nesting Productivity* section), but can be performed late in incubation, especially if herons are easily disturbed.

All trees with nests in the colony should be permanently marked in some fashion to allow tracking in following years, preferably with a map marked with locations from a known landmark (see *Colony Characterization: Nest Tree Tagging and Colony Mapping* section). Care should be taken to avoid damage to trees when marking them. Colonies should not be entered early in the nesting season (see *Human Disturbance at Nesting Colonies* section). The number of nests in each tree should be noted during each visit, as the number of nests may increase or decrease over the season in the colony. Trees with more than one nest should have each nest marked by height and compass reading from the centre of the tree.

Colony Survey Data Sheets

Data from every visit should be recorded on the Annual Colony Visits Summary Data Sheet (Data Sheet #1). Prior to the initiation of heron surveys, it is advantageous to map the colony using Data Sheet #2 (Colony Tree Tagging and Mapping). Once herons are present, on each visit a Colony Disturbance Summary Data Sheet (Data Sheet #3) and a Colony Nesting Productivity Data Sheet (Data Sheet #4) should be filled out. These four data sheets are included in this protocol (Appendix 2), and the use of Data Sheets #2, #3, and #4 are explained in more detail in the following sections.

Data Sheet #1 records all of the other data sheets that have been used through the season, and summarizes any nest survey data. It is meant to serve as a summary of the season's research, including a summary of all nests observed, their status on each visit, and final determination of nesting success or failure. This sheet is also to be used to record any other information gained on colony visits, such as disturbances, names of people met, car licenses, other bird species observed (record under *Comments* section), and weather. The total number of sheets of information gathered, including all other data sheets, must be entered on this sheet. Even short visits should be recorded. Immediately after reviewing the day's data sheets and validating the numbering of all of the data sheets used, copies should be made and stored in a safe place. Maps used from a previous date can be photocopied and written on with a different coloured pen or pencil to indicate that day's observation, thus saving time to redraw the map each visit.

Data Sheet #1 is not meant to be taken into the field; rather, it should be kept in the office and updated after each visit to a colony site. Nevertheless, it might be advantageous to take a copy of Data Sheet #1 into the field for reference. At the end of the season, the data sheet should be provided to the appropriate regulatory agency as a cover sheet on top of copies of all other data sheets used in the field through the season.

COLONY CHARACTERIZATION: NEST TREE TAGGING AND COLONY MAPPING

Prior to the nesting season, routes to the colony and observation blinds should be established. See *General Great Blue Heron Colony Monitoring* section for general visitation guidelines. All trees should be marked prior to birds arriving to breed. Contact the appropriate government agency for advice on appropriate marking methods (in Canada, the B.C. Ministry of Environment or the Canadian Wildlife Service; in the U.S., the Washington Department of Fish and Wildlife – see contacts at www.heronworkinggroup.org). If there is a possibility of trees being harvested, or if there might be persons in the colony illegally, marks should be placed close to the ground, on a consistent side, and hidden out of sight. Copper nails should not be used (aluminum is a better choice). If nails are used, they should not be hammered completely into the tree to ensure that the tree does not grow scar tissue that might cover the tag.

Nests visible in the early part of the season are often not visible later in the spring when the leaves have completely emerged. Being able to recognize nests over time is essential for tracking productivity of nests over the 12-15 weeks of the incubation and chick rearing periods (see *Biology* section for dates). Because trees leaf out, nests fall down and new nests are built, it is essential to have nest locations identified in trees with multiple nests, and described in trees with one nest but also the potential for new nests. Fallen nest trees should be marked on appropriate data sheets and maps for future reference.

Drawings should be made of trees with more than one nest. Maps of individual trees can be drawn from an oblique or underside viewpoint, depending on the point of observation. Each map, which may have more than one set of nesting trees, should indicate north with a circled N and an arrow pointing to geographic north. Each map should also show all the points where the observer views nests (mark with an X). Written information on nest location, size, location in tree, and ordinal direction from trunk of tree should also be included. Diagrams should show details of the trunk.

The tree number and nest number should be indicated on the map in different colours, with squares around tree numbers, and triangles around the number of nests. Descriptions should be written down and should not be based on other nest locations as nests blow down and new nests are constructed or empty nests are occupied later in the season. Data is to be recorded on Data Sheet #2.

Tree DBH should be gathered to help establish the minimum and maximum sizes of trees that herons will nest in, and to give an idea of preference within a colony. Height is also important but requires additional equipment, specifically, a clinometer.

Tree Health Designations

As part of an effort to track tree health over time, and document the impact of heron nesting on trees, a simple tree health status system has been devised. This information designates trees on a 0 to 4 scale.

0 dead tree

1 barely alive
2 major branch damage
3 some evidence of branch damage
4 showing no evidence of branch damage.

Note double trunks, and tag trees with double or greater than two trunks if the separation is clear in the canopy or if nests can be more easily distinguished by separate tree numbers. Leaning or deformed trees should be noted.

HUMAN DISTURBANCE AT NESTING COLONIES

Care should be taken to minimize disturbance to herons when visiting colonies. Human disturbance, including non-intrusive pedestrian activity, has been associated with reduced nesting success and productivity (Butler 1997, Vennesland 2000, Gebauer and Moul 2001, Vennesland and Butler 2004). Disturbance at heron colonies is thus a significant issue. See the *Biology* section of this report for a overview of human disturbance effects.

The purpose of this section is to provide specific information for biologists to ensure proper procedure is followed while obtaining nesting data, salvaging samples from the colony, or collecting samples from nests. Important differences in heron response to disturbance occur at different times of the season. Differences also exist between heron colonies, depending on the frequency and type of disturbance, nest height, time of day, and available ground cover. This section reviews the criteria for deciding whether a researcher can enter a colony, and when the researcher must leave. Because corvids are opportunistic egg and nestling predators, decisions to leave a colony must be made quickly and without hesitation. Crows have destroyed heron nesting attempts during bald eagle incursions that cause herons to leave the nest (Butler 1997).

Many studies have demonstrated the importance of disturbance to herons, but few of these studies have indicated the reactions of herons to intrusions. See Vennesland (2000) and Vennesland and Butler (2004) for information from a study that has recorded heron response and reviews disturbance in general. There are a series of behaviours that occur prior to flushing from the nest that can provide an indication that disturbance is occurring (Vennesland 2000). This section describes those responses. If trees are to be climbed, there will undoubtedly be disturbance and certain protocols must be followed to avoid colony impact. These are outlined briefly in this section and in more detail in draft Washington State SOP 7 - Tree Climbing (Norman and Krausmann 1999; available from Heron Working Group). Use Data Sheet #3 (Colony Disturbance Summary) for recording responses. Decisions about activities at colonies may be dictated by the level of disturbance, and must be weighed against the information that can or cannot be gathered outside the nesting season or from a viewing point outside the colony.

Responses of Herons to Disturbance

When nesting herons perceive a threat from the approach of an intruder, they generally defend their nesting attempt with a steady escalation in alarm. At first, herons become alert and silent, but as a perceived threat continues to increase they vocalize, first with repetitive “chortle” (Moul 1990) or “cluck” (Vennesland 2000) calls, and followed by loud screams, depending on the level of perceived threat (Vennesland 2000). Herons will also hop off their nests or flush from the nest site, but generally not before issuing ‘chortle’ calls (Vennesland 2000). Herons often circle above nest trees until a threat has ended. It must be noted, however, that herons might not always show a progression in alarm. Herons might immediately flee their nest sites at sensitive colonies, early in the nesting season, or during unusual, loud or rapid disturbances (Vennesland 2000). Disturbance of nesting herons can result in the predation of heron eggs or young (Butler 1997). Wildlife managers or project leaders need to consider the potential damage to colony success when scheduling visits to colonies.

Colony response should be tested and recorded using Data Sheet #3 (Colony Disturbance Summary). The various responses by birds are as follows (record all responses that occur):

1. *No response*. Birds ignore the observer. They may stare and subsequently look elsewhere, as other activities occur in the colony.
2. *Stare*. Birds view is fixed on the observer. This is particularly noticed when birds peer over the nest at an observer in the colony.
3. *Chortle or cluck*. The first sign that birds are disturbed is a low nasal “cluck” (Vennesland 2000), or "chortle" (Moul 1990). This activity may be continuous or start and stop as movement of the researcher occurs.
4. *Stand*. Incubating birds rise off the nest, or move around in the nest.
5. *Off nest*. Birds leave the nest, but stay on a branch nearby.
6. *Scream*. After chortling, the next progression in vocal alarm is screaming. This is a very loud vocalization and usually occurs with, or immediately prior to, flushing. Researchers must never cause this disturbance as it shows extreme stress (such as during a successful predator attack).
7. *Flush/Return*. Birds fly away, typically as individuals, circle and return to the nest. Researchers must never cause this disturbance, as it can lead directly to colony abandonment.
8. *Flush/Leave*. Birds fly away as a group and do not return until observer leaves the colony. Researchers must never cause this disturbance, as it is likely to cause colony abandonment.

Colony Entrance Guidelines

The initiation date of incubation (defined in *Biology* section) can usually be observed from outside the colony. It should be noted that herons at some colonies may respond at a great distance early in the season (>100 m at sensitive sites; Vennesland 2000). Ideally, this work should be done late in the day, when birds are quiet and less likely to leave the nest, and when daily activity of avian predators is over. Colonies should only be entered when necessary for a specific research objective and only when a qualified researcher is present (see *General Great Blue Heron Colony Monitoring* section). Because nest initiation may occur over several weeks in a colony, entrances into colonies should be delayed until several nests are at least 3 weeks through incubation or >75% of the pairs are incubating. Entrance into the colony might be required to calculate the number of active nests if all of the nests cannot be seen from outside the colony (see *Monitoring Nesting Productivity* section). However, such a total colony count is best performed immediately after the nesting season (August of September), or late in the nesting season when herons are least sensitive.

Movements in an active colony should be slow and methodical. Avoid stepping on branches. When birds begin to chortle or cluck, stop and do not move until it stops. It is very important that researchers exit from the colony immediately if more than one heron leaves its nest; especially during incubation, in the first two weeks after hatching, and in poor weather. Take advantage of windy weather to disguise movements. When eggs or small nestlings are present, make efforts to work on warm windless days to minimize exposure from inclement weather. Talking should be avoided or conducted in a low tone without sharp sounds.

Specific Timing Restrictions

If heron colony research is a disturbance issue at a site (this should be assumed unless known otherwise), certain research activities might not be possible, especially in the colony initiation and incubation periods (see table below; periods defined in *Biology* section). Colonies can be active very early in the season (early February; Gebauer and Moul 2001), and colony abandonment has occurred due to colony entrance during this period (Parnell et al. 1988). Colonies differ greatly in tolerance and should be properly investigated prior to reproductive studies or tree climbing. A lot of information can be gained from visits to the colony during winter when herons are not present and from wildlife agencies and other organizations (see *General Great Blue Heron Colony Monitoring* section).

Nesting Stage	Research Activity	Entrance Criteria
Nest building and prenuptial period	• Observation for first date of incubation	• Absolutely no entrance into colony • Observe from maximum distance • Ensure no response from herons to your presence at any distance
Incubation (early)	• Observation for first date of incubation • Monitoring for nest predation • Studies of incubation	• Absolutely no entrance into colony • Observe from maximum distance • Ensure no response from herons to your presence at any distance
Incubation (middle)	• Count number of active nests • Monitoring for nest predation Climbing for fresh eggs • Studies of incubation	• Work on windless warm days • Leave if predators appear in area • Stop movement if chortle or cluck
Incubation (late)	• Count number of active nests • Monitoring for nest predation • Studies of incubation	• Work on windless warm days • Leave if predators appear in area • Stop movement if chortle or cluck
Hatching	• Egg hatching in nests	• Work on windless warm days • Stop movement if chortle or cluck
Small nestlings (2-4 weeks)	• Reproductive success • Nesting productivity • Count number of active nests • Monitoring for nest predation	• Work on windless warm days • Stop movement if chortle or cluck • Leave in rainy weather
Large nestlings (5-7 weeks)	• Reproductive success • Nesting productivity • Count number of active nests • Salvage activities • Monitoring for nest predation	• Stop if chicks move off nests • Leave in rainy weather • Salvage activities should occur in late afternoon

For more detailed info on disturbance see:

- Nisbet, I. C. T. 2000. Disturbance, habituation, and management of waterbird colonies. Waterbirds 23: 312-332.
- Parnell, J. F., D. G. Ainley, H. Blokpoel, B. Cain, T. W. Custer, J. L. Dusi, S. Kress, J. A. Kushlan, W. E. Southern, L. E. Stenzel and B. C. Thompson. 1988. Colonial Waterbird Management in North America. Colonial Waterbirds 11:129-345.
- Rodgers, J., J.A. and H. T. Smith. 1995. Set-back Distances to Protect Nesting Bird Colonies from Human Disturbance. Conservation Biology 9:89-99.
- Vennesland R.G. 2000. The effects of disturbance from humans and predators on the breeding decisions and productivity of the Great Blue Heron in south-coastal British Columbia. Master of Science thesis, Simon Fraser University, B.C.

Tree Climbing

Tree climbing within sight of an active heron colony is an extremely invasive disturbance stimulus. Climbing to active heron nests can present a novel and intense disturbance for the birds and must not be undertaken unless approved by government managers and preferably never at colonies sensitive to human intrusions. If climbing is deemed necessary for a specific research objective, property owners (or site managers), local wildlife authorities, and the Heron Working Group (www.heronworkinggroup.org) should be consulted. See draft Washington State SOP 7 – Tree Climbing (available from Heron Working Group) for detailed guidelines on tree climbing near heron colonies.

Climbing should never occur before the mid point of the incubation period or when potential predators are nearby. See *Biology* section for a description of potential predators. Spurs should not to be used because of the damage they cause to trees. Nestlings should never be returned to a nest – heron nestlings that have fallen from nests do best if delivered to a wildlife rescue facility. Professional climbers should be employed if trees need to be climbed, and climbers should be trained and equipped to avoid the defensive behaviour of heron nestlings. Climbers should wear face protection. Caution should be exercised because some heronries may have unsound trees.

MONITORING NESTING PRODUCTIVITY

The major parameters of interest for long term monitoring of Great Blue Herons are colony size (*i.e.*, the number of active nests), nesting success (*i.e.*, the proportion of nests successful in fledging young, or conversely the level of abandonment) and nesting productivity (*i.e.*, the number of young fledged per successful and per active nests).

Inventory Intensity and Chronology

Moul et al. (2001) recommended that colony visits in south-coastal British Columbia be spaced through the season to ensure that nesting chronology is efficiently tracked. The simplest way to do this is to mark a sample of active nests early in the season and then return at least four more times later in the season to count the number of young and any new nests. Additional visits might be necessary to increase the accuracy of observations or address specific research questions. For example, Moul et al. (2001) recommended a minimum of six visits to colonies through the season, while Vennesland (2000) visited colonies up to 40 times per season for an intensive study of heron nesting and the effects of disturbance.

Despite research linking the number of hours of low tide in the spring with heron colony nest initiation (Butler 1997), yearly and regional variation in colony synchrony and re-nesting make planning the number of visits to a heron colony difficult. Colonies may move, and if data are required for the nesting season, preliminary trips must be made to the colony area to learn when incubation has begun. Often two to three trips are necessary for this determination alone. The use of local residents may be possible if they can be trained.

The sensitivity of herons to disturbance varies from colony to colony (Rogers and Smith 1995, Vennesland 2000). There are changes in tolerance depending upon the type of disturbance, time of the nesting season, the number of visits, the length of time of visits, the time of day of visits, and the extent of activities during visits. For making comparisons between colonies, these data need to be recorded and matched if possible. If colonies vary in tolerance level, activities may need to be curtailed in the more sensitive colonies, particularly during colony initiation, incubation, and chick rearing periods (see *Biology* section for definitions). Brooding is a concern here because exposing nestlings to the cold can lead to increased mortality (see *Human Disturbance at Nesting Colonies* section). Colonies should not be entered during the initiation or early incubation periods (see *Human Disturbance at Nesting Colonies* section).

For measuring productivity, a first visit in early April should get the first nesting pairs. Some colonies begin nesting earlier in the season (*e.g.*, early February; Vennesland 2000, Gebauer and Moul 2001) so additional visits might be needed earlier in the season (especially for determination of incubation initiation). Review records from previous years to ascertain when nesting begins locally. Phone calls to landowners early in the season might assist in determining colony activity. Visits to colonies might need to be staggered because the date of nesting initiation can be variable among colonies. Second, third and fourth visits in April, May and June will get the number of new nests and provide preliminary counts of the number of fledglings and successful nests. A fifth and final visit in July would finalize the number of fledglings and get the number of late nesters that were successful. At some sites (*e.g.*, colonies sensitive to disturbance or inaccessible sites), winter visits will be necessary to count the total number of nests after leaves have fallen.

Visits to colonies should be rotated through available daylight hours to account for time of day differences in heron behaviour (Vennesland 2000). In general, visits to colonies should not occur at low tide because many herons will not be in the colony (Butler 1997), but if the research focus is on nestlings alone visits during low tides might be advantageous to minimize disturbance to adults.

The table below outlines examples of study schedules with the number of visits required and questions that can be asked with that survey intensity. For projects that only require information on whether colonies are active or not, whether they initiated nesting and then abandoned (see next section), or the size of colonies (*i.e.,* number of nesting pairs), one or two surveys during the nesting season will suffice. To minimize disturbance, these visits should occur during the chick rearing period, similar to the third and fourth visits stipulated above for intensive projects. Because heron colonies have varied chronologies, survey timing should be well planned based on telephone calls, past research and any other available information. Surveys conducted too early or too late in the season at this low level of intensity could provide inaccurate data.

No. of visits	Possible questions to address	Approximate scheduling*
1-2	Was the colony active? Did the colony abandon after initiating nesting (based on eggshells or feces)? How much incubation occurred? Did any hatching occur?	1. June
3	Was the colony active? Did the colony abandon after initiating nesting (based on eggshells or feces)? Did any hatching occur? How many nests were successful?	1. April 2. May 3. June
5	Was the colony active? Did the colony abandon after initiating nesting (based on eggshells or feces)? Did any hatching occur? How many nests were successful? How many young were fledged from each nest? What disturbances occurred?	1. March/April 2. May 3. Early June 4. Late June 5. July

*these dates are estimates only – visits should be based on local conditions (see *Monitoring Nesting Productivity* section)

Sampling of Nests

The simplest way to sample nests for viewing through the nesting season is to draw a diagrammatic view of the colony, or part of the colony, from a proximate location, and number all visible nests and other landmarks such as distinctive trees and objects. Polaroid pictures or other instant photographic techniques might be useful alternatives. It should be kept in mind that many nests seen early in the season will not be visible later in the season once trees have leafed out, so sample sizes of nests should be maximized. Sample size will depend on colony size – observe all nests at small colonies (<25 active nests), and take sub-samples at larger colonies.

Samples should also be taken expecting a high level of nest abandonment. It is not uncommon for half or more of all active nests at a colony to abandon during the season. Choose nests randomly whenever possible.

The hatching of eggs needs to be identified to enable estimations of fledging dates for colonies, and therefore the chronology of future visits. Moul et al. (2001) identified hatching events by observing nestlings, hearing nestlings calling at nests (a light chatter), observing the presentation of sticks to mates (if near to expected hatching date) and by collecting hatched eggshells from under nests (only at colonies acclimatized to humans). Eggshells are thrown from the nest at the time of hatching (Butler 1992, 1997). Note: hatching dates within colonies can be variable (Vennesland 2000), so more than one visit might be desirable if hatching dates for individual nests are needed.

Following the estimation of a hatch date for each colony (probably the second visit), the earliest expected fledging date (eight weeks later) should be calculated and three colony visits should be scheduled to occur when nestlings are estimated to be about five, seven and nine weeks old (Moul et al. 2001). In trees with more than one nest, care should be taken to determine that nestlings have not walked along branches to another nest. Often, the number of nestlings cannot be accurately counted until an adult brings food to the nest and all of the nestlings beg for food and surround the nest to feed. Care needs to be taken as smaller chicks are commonly hidden in the nest. Finally, additional visits might be needed to observe late nesting pairs.

A final colony visit might be needed in the fall to count nests after herons have left for the season and leaves have fallen from the trees. This task should not be left too late as feces that can provide useful information on nest use are washed away by rainfall. Each visit to count fledglings (probably third to fifth visits) should be used to adjust the estimated number of fledglings for each nest to account for changes in brood size or observation ability.

Eggshells can provide valuable information on colony activity. As introduced in the previous section, if only one or two visits to a site are possible information can be gained only on whether the colony was active or abandoned, colony size, incubation and hatching. Eggshells can provide information on whether or not egg laying occurred and whether any eggs hatched or were predated (Vennesland 2000). Predated eggshells are usually smashed or have a hole cut into them along the longitudinal axis of the egg, whereas hatched eggshells are always opened on the latitudinal axis near the top of the egg (such as when a soft-boiled chicken egg is eaten).

If the identification of re-nesting attempts is a research objective, individual nests must be carefully followed. As above, samples should be chosen assuming a high rate of nest abandonment. Vennesland (2000) and Vennesland and Butler (2004) observed individual nests with samples of 3 to 26 nests at 13 of 31 colonies in 1999, and used the following information to track the behaviour of individual nesting pairs. A heron standing on a nest with no visible nestlings was considered to be initiating or re-initiating a nesting attempt or to have recently hatched nestlings. A heron lying flat on the nest was considered to be incubating eggs or brooding recently hatched nestlings. Nestlings were considered to have fledged when seen on the branches near the nest site or when near an estimated six weeks old (Butler 1997, Moul et al.

2001; see Appendix 3 for nestling illustrations). Caution should be exercised when assuming specific nest behaviours because heron posture can sometimes be misleading (Vennesland 2000).

Data Recording

Nesting data should be recorded on Data Sheet #4 (Colony Nesting Productivity). This form is designed to reduce the amount of time recording data while inside a colony. Often two observers can reduce time at the colony by observing nests from several locations, especially if many nests have young being fed (the best time to count the number of chicks). A map of the colony should be photocopied to help orient the observer. A copy of Data Sheet #1 (Annual Colony Visits Summary) should be brought into the field so that the observer has the most recent set of nest information for reference. The observation point can be noted at the top of the data sheet or in the first column, if more than one point is used within the colony (often the situation). The codes to be used for that column should be located on the maps of the colony, and on Data Sheet #1, the Annual Colony Visits Summary data sheet. The next column indicates the tree number, the next column the nest number, and following that, a description of the nest location if there is more than one nest in the tree (preferably with a numbered list based on mapped locations if available – see *Colony Characterization: Nest Tree Tagging and Colony Mapping* section). In those cases when all trees are not visited or examined, the space must be indicated with a "not observed/seen" or NS.

In the column for nest activity, record ‘Y’ for active or ‘N’ for inactive. If active, indicate the nest status using the following notations:

STD	Adult STanDing.
INC BR	INCubating or BRooding - a heron is in a continuous crouched position, either incubating eggs or brooding recently hatched nestlings. An additional clue that a nest has eggs is egg turning behaviour.
YNG	YouNG are in the nest. Record number and age of chicks in separate columns.
NV	Not Visible. Activity is unknown, usually because cannot see into nest.
FN	Failed Nest. Record reason for failure if known. This is a very difficult status to determine and should only be used when failure has been observed or inferred based on multiple observations.

Following the documentation of nest status, record the number of adults present and the number of young present. If young are present and can be observed, record the age of the nestlings based on two-week periods (‘1’ for 1-2 weeks old, ‘2’ for 2-4 weeks old, ‘3’ for 4-6 weeks old, and ‘4’ for 6-8 weeks old). See Appendix 3 for illustrations of nestling stages referenced here.

Finally, nest activity codes should be recorded on all behaviours observed from adults or nestlings. Examples of common activities include:

1AS or 2AS 1 or 2 Adult(s) Standing on the nest.

ASN	Adult Standing Near the nest.
EX	An exchange of adults, either to relieve incubation or deliver food to nestlings.
COP/MATE	Behaviour indicating pair bonding.
STICK	A stick being brought to the nest.
FIGHT	Young fighting in the nest.
WING	Young are exercising their wings (begins about 2 weeks prior to fledging).

Definitions of Productivity

Active Nest: Typically a nest where an adult has been seen on at least one occasion. Caution should be exercised in this determination because single birds standing on the nest may be unpaired, or merely stealing sticks from an abandoned nest, and some first year birds may visit the colony and take up residence on an old nest without nesting. Furthermore, many studies may require more stringent determination of activity, such as requiring incubation before a nest is considered active. Researchers should thus make sure to record exactly how activity was determined, so that different interpretations can be used in analyses of collected data if required. For projects observing nests only once late in the season, the presence of feces or eggshells under a nest is a sign that the nest has been active.

Successful Nest: A nest that produces at least one fledgling.

Failed Nest (FN): An active nest observed to be incubating that produces no fledglings. A nest can be abandoned, predated, knocked down, or have problems in incubation, hatching or raising of the chicks. It is often impossible to determine the cause of failure in a few visits, but if known it should be recorded. If a new nest is initiated after a nest is lost, it should be noted that the new nest could be a re-nesting attempt. The presence of fresh (*i.e.*, from the current year) and unhatched eggshells under a nest is an indication that it was incubating, but failed. However, researchers must be sure that no hatched eggshells are present in addition to unhatched eggshells. See *Sampling of Nests* section for detail on the difference between hatched and depredated eggshells.

Number of Young (Fledglings): This is the maximum number of chicks observed when the chicks were at least 4-6 weeks old or older (see diagrams in Appendix 3 for aging of young). Note that because there is loss of chicks by brood reduction and falls from the nest, this number is used if detailed status of the chicks is not known later in the season. The number of chicks may decrease by one and even increase by one or more at the period of fledging when young birds are moving around, making productivity measurements complicated. If there are known losses of chicks to eagle predation, or if eggs have been lost but the remaining clutch fledges, this should be noted. Note that sometimes fledged young may roost off the nest in the same or different tree.

Locating new colonies

New colonies can be located using public solicitation posters (Vennesland 2003), aerial photos or flights, communications with local naturalist groups or government agencies, reviewing of historical reports, and heron behaviour. Behavioual indicators include herons flying with sticks in their bills, courtship displays, and flight paths from foraging grounds. See Butler (1992), Butler (1997), and Ehrlich (1988) for reviews of courtship displays and vocalizations. Compass bearings of herons leaving foraging grounds and returning to their colonies can be used to locate unknown sites (Kenyon 2006). Bearings that are not consistent with known colonies can be investigated for the presence of a colony. This method has discovered three confirmed colonies, and suggested that more colonies were active in the Strait of Georgia in 2002 than were previously known (Kenyon 2006).

All new colonies should be reported to the responsible wildlife agency – in Canada, either the B.C. Ministry of Environment or the Canadian Wildlife Service of Environment Canada, and in Washington State, the Washington Department of Fish and Wildlife in Olympia. Contact information for these agencies is available from the Heron Working Group website, located online at www.heronworkinggroup.org.

POST SURVEY PROTOCOL

DATA STORAGE

In British Columbia, heron inventory data is stored with the Conservation Data Centre of the Ministry of Environment in Victoria (CDC 2003) (after Moul 1999a, Moul 1999b, Moul et al. 2001). Methodology for the treatment of data is outlined in Moul et al. (2001).

In Washington State, heron inventory data is stored with the Washington Department of Fish and Wildlife at the WRDS office in Olympia, WA. Data should be sent to Olympia, with copies to regional offices. For surveys conducted for the department, survey data should be vetted through the regional office before being submitted to Olympia.

Contact information for these agencies is available from the Heron Working Group website, located online at www.heronworkinggroup.org.

Where possible, original data sources should be kept on hand and stored in a way that preserves individual nest variation in case statistical modeling is desired in the future.

DATA RELEASE

Care should be taken when releasing data on heron colonies. Responsible wildlife agencies should be consulted before any data is released. In general, information on landowners is considered private and should not be released unless specifically approved by the appropriate agency and/or the landowner.

For data requests in British Columbia, contact the Conservation Data Centre at www.env.gov.bc.ca/cdc/contact.html or by phone at (250) 356-0928. Note that this phone call can be made toll free through Enquiry BC by calling (250) 387-6121 in Victoria, (604) 660-2421 in Vancouver or 1 (800) 663-7867 elsewhere in B.C.

For data requests in Washington State, visit wdfw.wa.gov/hab/release.htm or call the data request line at (360) 902-2543. The requester must read and sign a statement that includes the following language:

"By receiving fish and wildlife information from the Washington Department of Fish and Wildlife (WDFW) you incur an obligation to use it in a way that does not cause undue harm to our public fish and wildlife resources. All fish and wildlife species are vulnerable to harm from human activities. Harm can occur directly (*e.g.*, when an animal is harassed or injured) or indirectly (*e.g.*, when a nest tree is felled or a wetland is drained). Harm can occur unintentionally, even by those who value the fish and wildlife resources (*e.g.*, repeated visits to a heron rookery which flushes the birds from the nest and exposes the eggs to cold weather and predators)."

LITERATURE CITED

B.C. MoE. 2005. *Environmental Best Management Practices for Urban and Rural Land Development in British Columbia*. B.C. Ministry of Environment, Victoria, B.C. < www.env.gov.bc.ca/wld/BMP/bmpintro.html> (1 April 2006).

Bjorklund, R. G. 1975. *On the Death of a Midwestern Heronry*. The Wilson Bulletin 87:284-287.

Butler, R. W. 1991. *Habitat Selection and Time of Breeding in the Great Blue Heron (Ardea herodias)*. Ph.D. dissertation, University of British Columbia.

Butler, R. W. 1992. *Great Blue Heron*. In 'The Birds of North America,' Vol. 25, eds. A. Poole, P. Stettenheim, and F. Gill (1-20). Philidelphia: Academy of Natural Sciences; Washington, DC: American Ornithologists' Union.

Butler, R. W. 1997. *The Great Blue Heron*. Vancouver, Canada: University of British Columbia Press.

Butler, R.W. and P. Baudin. 2000. *Status and Conservation Stewardship of the Pacific Great Blue Heron in Canada*. In 'Proceedings of a Conference on the Biology and Management of Species and Habitats at Risk,' ed. L.M. Darling (247-249). Wildlife Branch, Ministry of Environment, Lands and Parks and University College of the Cariboo. February 1999, Kamloops, B.C.

Butler, R. W. and R. G. Vennesland. 2000. *Commentary: Integrating Climate Change and Predation Risk with Wading Bird Conservation Research in North America*. Waterbirds 23(3): 535-540.

Campbell, R.W., N.K. Dawe, I. McTaggert-Cowen, J.M. Cooper, G.W. Kaiser and M.C.E. McNall. 1990. *The Birds of British Columbia, Volume 1. Introduction, Loons through Waterfowl.* Royal B.C. Museum and Environment Canada, Canadian Wildlife Service.

Carlson, B. A. and E. B. McLean. 1996. *Buffer Zones and Disturbance Types as Predictors of Fledging Success in Great Blue Herons, Ardea herodias*. Colonial Waterbirds 19:124-127.

CDC [online]. 2003. *Conservation Data Centre*. B.C. Ministry of Environment, Victoria, B.C. < www.env.gov.bc.ca/cdc/> (1 April 2006).

COSEWIC. [online]. 2002. *Committee on the Status of Endangered Wildlife In Canada*. Environment Canada, Ottawa. <www.cosewic.gc.ca/> (1 April 2006).

Downes, C. and B. Collins. 1996. *The Canadian Breeding Bird Survey, 1966-1994*. Canadian Wildlife Service Program Notes No. 105. Ottawa: Canadian Wildlife Service.

Ehrlich, P.R., D.S. Dobkin and D. Wheye. 1988. *The Birder's Handbook: a Field Guide to the Natural History of North American Birds*. Simon and Schuster Inc., Toronto, Canada. 875pp.

Ellison, L. N. and L. Cleary. 1978. *Effects of Human Disturbance on Breeding Double-crested Cormorants*. Auk 95:510-517.

Forbes, L. S., K. Simpson, J. P. Kelsall and D. R. Flook. 1985a. *Reproductive Success of Great Blue Herons in British Columbia*. Canadian Journal of Zoology 63:1110-1113.

Forbes, L. S., K. Simpson, J. P. Kelsall and D. R. Flook. 1985b. *Great Blue Heron Colonies in British Columbia*. Unpublished Report, Canadian Wildlife Service, Delta.

Gebauer, M. B. and I. E. Moul. 2000. *Status of the Great Blue Heron in British Columbia*. Wildlife Working Report No. 102, British Columbia Ministry of the Environment, Lands and Parks, Wildlife Branch, Victoria.

Hancock, J. and H. Elliott. 1978. *The Herons of the World*. London: London Editions.

Hancock, J. and J. Kushlan. 1984. *The Herons Handbook*. New York: Harper and Row.

Hill, D., D. Hockin, D. Price, G. Tucker, R. Morris and J. Treweek. 1997. *Bird Disturbance: Improving the Quality and Utility of Disturbance Research*. Journal of Applied Ecology 34:275-288.

Hockin, D., M. Ounsted, M. Gorman, D. Hill, V. Keller and M. A. Barker. 1992. *Examination of the Effects of Disturbance on Birds with Reference to its Importance in Ecological Assessments*. Journal of Environmental Management 36:253-286.

Kelsall, J. P., and K. Simpson. 1979. *A Three-year Study of the Great Blue Heron in Southwestern British Columbia.* Proceedings of the Colonial Waterbird Group 3:69-79.

Kenyon, J.K. 2006. *Use of Vanishing Bearings to Locate New Wading Bird Colonies*. Waterbirds 29:203-210.

Krebs, J. R. 1974. *Colonial Nesting and Social Feeding as Strategies for Exploiting Food Resources in the Great Blue Heron (Ardea herodias)*. Behaviour 51:99-131.

Kushlan, J. A. 1979. *Effects of Helicopter Censuses on Wading Bird Colonies*. Journal of Wildlife Management 43:756-760.

Leonard, W. 1985. *Inventory of Great Blue Heron Nest Colonies in Southern and Western Puget Sound.* Unpublished Report. Washington Department of Wildlife, Olympia, Washington, USA.

Mark, D. M. 1976. *An Inventory of Great Blue Heron (Ardea herodias) Nesting Colonies in British Columbia*. Northwest Science 50:32-41.

McClaren, E.L. 2005. *Pacific Great Blue Heron Population Inventory and Monitoring Strait of Georgia, British Columbia 2004*. Unpublished report to the British Columbia Ministry of Environment, Nanaimo, B.C.

Moul, I.E. 1990. *Environmental Contaminants, Disturbance and Breeding Failure at a Great Blue Heron Colony on Vancouver Island*. Master of Science thesis, University of British Columbia, Vancouver, B.C.

Moul, I.E. 1999a. *The location and Status of Heron Colonies for the Georgia Basin Area of British Columbia, Region 1, Vancouver Island, 1998.* Unpublished report to B.C. Ministry of Environment, Lands and Parks, Surrey, B.C. 31pp.

Moul, I.E. 1999b. *The location and Status of Heron Colonies for the Georgia Basin Area of British Columbia, Region 2, Lower Fraser Valley, Sunshine Coast and Powell River Area, 1998.* Unpublished report to B.C. Ministry of Environment, Lands and Parks, Surrey, B.C. 29pp.

Moul, I. E., R. G. Vennesland, M. L. Harris, And R. W. Butler. 2001. *Standardizing and interpreting nesting records for Great Blue Herons in British Columbia*. Canadian Wildlife Service Progress Note No. 217, Canadian Wildlife Service, Ottawa. <www.cws-scf.ec.gc.ca/publications/> (1 April 2006).

Nisbet, I. C. T. 2000. *Disturbance, habituation, and management of waterbird colonies*. Waterbirds 23:312-332.

Norman, D. M., A. M. Breault and I. E. Moul. 1989. *Bald Eagle Incursions and Predation at Great Blue Heron Colonies*. Colonial Waterbirds 12:215-217.

Norman, D.M. and J. Krausmann. 1999. *Washington State Standard Operating Procedures for monitoring Great Blue Heron colonies.* Unpublished report to USFWS, Lacey WA. 45pp.

Parker, J. 1980. *Great Blue Herons in Northwestern Montana: Nesting Habitat Use and the Effects of Human Disturbance*. M.Sc. thesis, University of Montana.

Parnell, J. F., D. G. Ainley, H. Blokpoel, B. Cain, T. W. Custer, J. L. Dusi, S. Kress, J. A. Kushlan, W. E. Southern, L. E. Stenzel and B. C. Thompson. 1988. *Colonial Waterbird Management in North America*. Colonial Waterbirds 11:129-345.

Payne, R. B. 1979. *Ardeidae*. In 'Checklist of Birds of the World.' Eds. E.M. a. G.W.C. (193-244). Cambridge, MA: Museum of Comparative Zoology.

Pratt, H. M. 1970. *Breeding Biology of Great Blue Herons and Common Egrets in Central California*. Condor 72:407-416.

RISC 1998. *Inventory Methods for Colonial-Nesting Freshwater Birds: Eared Grebe, Red-Necked Grebe, Western Grebe, American White Pelican, and Great Blue Heron Standards for Components of British Columbia's Biodiversity No. 8, Version 2.* March 1998. Resources Inventory Standards Committee, British Columbia Ministry of Sustainable Resource Management, Victoria, B.C.

Robert, H. C. and C. J. Ralph. 1975. *Effects of Human Disturbance on the Breeding Success of Gulls*. Condor 77:495-499.

Rodgers, J., J.A. and H. T. Smith. 1995. *Set-back Distances to Protect Nesting Bird Colonies from Human Disturbance*. Conservation Biology 9:89-99.

Simpson, K. 1984. *Factors Affecting Reproduction in Great Blue Herons (Ardea herodias)*. M.Sc. thesis, University of British Columbia.

Simpson, K. and J. P. Kelsall. 1978. *Capture and Banding of Adult Great Blue Herons at Pender Harbour, British Columbia*. Proceedings of the Colonial Waterbird Group 1978:71-78.

Tremblay, J. and L. N. Ellison. 1979. *Effects of Human Disturbance on Breeding of Black-crowned Night Herons*. Auk 96:364-369.

Vennesland R.G. 2000. *The Effects of Disturbance from Humans and Predators on the Breeding Decisions and Productivity of the Great Blue Heron in South-coastal British Columbia*. Master of Science thesis, Simon Fraser University, B.C.

Vennesland R.G. 2003. *Coastal Great Blue Heron Inventory and Monitoring Project – 2002 Breeding Season Report*. Unpublished report to the British Columbia Ministry of Environment, Nanaimo and Surrey, B.C.

Vennesland, R.G. and R.W. Butler. 2004. *Factors Influencing Great Blue Heron Nesting Productivity on the Pacific Coast of Canada from 1998 to 1999*. Waterbirds 27(3): 289-296.

Vennesland, R.G. and K. Summers. 2004. *Great Blue Heron Species Account*. Identified Wildlife Management Strategy guidelines, Volume 2, B.C. Ministry of Environment, Victoria, B.C.

Vermeer, K. 1969. *Great Blue Heron Colonies in Alberta*. Canadian Field-Naturalist 83:237-242.

Vos, D. K., R. A. Ryder and W. D. Graul. 1985. *Response of Breeding Great Blue Herons to Human Disturbance in Northcentral Colorado*. Colonial Waterbirds 8:13-22.

Watts, B. D. and D. S. Bradshaw. 1994. *The Influence of Human Disturbance on the Location of Great Blue Heron Colonies in the Lower Chesapeake Bay*. Colonial Waterbirds 17:184-186.

Werschkul, D. F., E. McMahon, and M. Leitschuh. 1976. *Some Effects of Human Activities on the Great Blue Heron in Oregon.* Wilson Bulletin 88:660-662.

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APPENDIX 1 – General Considerations For Conducting Surveys

(adapted from RISC 1998)

COMMON ERRORS AND BIASES

The goal of most survey designs is to obtain precise and accurate estimates of numbers. An estimate that is free of random errors is said to be precise. Increasing sample size, standardizing methods and having researchers of similar experience and training can improve this. An estimate that is free of systemic errors is said to be accurate. Unlike random errors, systemic errors tend to bias results in one direction, *(i.e.*, either under-estimate or over-estimate). These errors are usually intrinsic to the method and are not reduced by increasing sample size. It is important to be aware of the source of errors and biases in any method so that they can be addressed and kept to a minimum.

EFFORT AND SPEED

Errors in an estimate are generally inversely related to effort and directly related to speed for any given method. It is important that these factors are standardized between observers and between sites and years to be able to produce comparable results. For this reason, be sure to record the time started and finished for each survey.

TIME OF DAY

Variation in activity levels and behaviour throughout the day often causes change in the detect-ability of birds, which may result in a time-of-day effect that biases the results of counts.

WEATHER

During wet, cold or windy weather, birds may be less active and less detectable. Observers also have trouble concentrating because of the uncomfortable conditions and are more prone to make errors.

BIRD DENSITY

Accurate counts of birds may be possible when the numbers of birds are not large. However, when numbers increase, estimation techniques have to be used and these have much larger errors than direct counts.

ESTIMATING NUMBERS IN LARGE FLOCKS

Every individual in a flock can be counted directly if flocks number no more than a few hundred birds. When the number of birds is greater than a few hundred birds, estimation procedures have to be used. The birds in a large flock may be estimated by counting a block of 10, 20, 50 or 100 birds and then estimating how many similar-sized groups make up the entire flock *(e.g.*, Butler *et al.* 1992).

OBSERVABILITY/VISIBILITY BIAS

Nests in deciduous trees may be especially difficult to see after April because of fresh foliage. Not all birds have the same observability. Factors that contribute to variability include size of the bird, behaviour of the bird *(e.g.*, tendency to fly away from observer, tendency to hide in vegetation) and colouration of bird. Visibility bias can also be caused by atmospheric and light conditions that affect the ability of the observer to detect birds. Factors such as heat haze, glare, precipitation, cloud cover, wind direction and wind speed can all contribute to bias.

OBSERVER VARIABILITY

Variability always exists among observers in experience, ability to identify and count birds at various distances, visual and auditory acuity, *et*c. When more than one person is involved in surveys, the members of the team should be of equal ability. If not, training is required. Data will not be comparable between observers of different quality. One method of minimizing bias is to rotate observers between or among surveys so that bias is distributed equally.

APPENDIX 2 – Data Sheets for Collection of Data on Nesting Productivity

Including:

Data Sheet #1 (Annual Colony Visits Summary)
Data Sheet #2 (Colony Tree Tagging and Mapping)
Data Sheet #3 (Colony Disturbance Summary)
Data Sheet #4 (Colony Nesting Productivity)

Great Blue Heron Data Sheet #1 - Annual Colony Visits Summary

Colony Name: ____________________ **Colony Code:** ____________

Date: ____________________ **No. of Visits:** ____________

Observers: ______________________________

Weather: ______________________________

GPS Coordinates: ______________________________

Comments: ______________________________

____

____

No. Data Sheets Used in Season:

- ______ Summary
- ______ Tree Mapping
- ______ Disturbance
- ______ Reproductive Productivity
- ______ Arrival/Departure
- ______ Colony Floor Search
- ______ Climbing

Individual Nest Information				1st Visit			2nd Visit			3rd Visit*			Nest Success Summary		Comments
				Date:___________			Date:___________			Date:___________					
From Where	Tree No.	Nest No.	Nest Location	Nest Status	No. Young	Age of Young	Nest Status	No. Young	Age of Young	Nest Status	No. Young	Age of Young	Y/N	No. Fledged	

QA by ____ Date _______

***Note: for further visits use additonal sheet(s)**

Great Blue Heron Data Sheet #2 - Colony Tree Tagging and Mapping

Colony Name: ______________________________
Colony Code: ____________________
Date: ____________________
Arrival Time: ____________ **Departure Time:** ____________
Observers: ______________________________
Weather: ______________________________
Comments: ______________________________
____
____
____

Common Tree Species:	Health codes:
A - Red Alder	**0** - dead tree
M - Bigleaf Maple	**1** - poor cond.
C - Black Cottonwood	**2** - major branch damage
DF - Douglas Fir	**3** - minor branch damage
RC - Western Red Cedar	**4** - no damage
SS - Sitka Spruce	
B - White Birch	
H - Western Hemlock	

Tree Tag No.	Nest No.	Nest Location	Tree Species	DBH (cm)	Ht (m)	Health Code	Comments

QA by ____ Date _______

Note: for further nests and trees use additonal sheet(s)

Great Blue Heron Data Sheet #3 - Colony Distubance Summary

Colony Name: **Colony Code:**

Date: **Arrival Time:** **Departure Time:**

Observers: **Weather:**

Comments:

RESEARCHER DISTURBANCE:

Approach (1st Response):

Time:

Distance:

No. Nests Responding:

_______ None
_______ Chortle then quiet
_______ Chortle constant
_______ Stand/off nest
_______ Scream
_______ Flush and return
_______ Flush and remain off

Action taken:

Approach (2nd Response):

Time:

Distance:

No. Nests Responding:

_______ None
_______ Chortle then quiet
_______ Chortle constant
_______ Stand/off nest
_______ Scream
_______ Flush and return
_______ Flush and remain off

Action taken:

Colony Entry (at edge):

Time in:

Time out:

No. Nests Responding:

_______ None
_______ Chortle then quiet
_______ Chortle constant
_______ Stand/off nest
_______ Scream
_______ Flush and return
_______ Flush and remain off

Action taken:

Notes:

DISTURBANCE EVENTS IN COLONY:

Time:

Intrusion Type:

Activity:

No. Nests Responding:

_______ None
_______ Chortle then quiet
_______ Chortle constant
_______ Stand/off nest
_______ Scream
_______ Flush and return
_______ Flush and remain off

Comments:

Time:

Intrusion Type:

Activity:

No. Nests Responding:

_______ None
_______ Chortle then quiet
_______ Chortle constant
_______ Stand/off nest
_______ Scream
_______ Flush and return
_______ Flush and remain off

Comments:

Time:

Intrusion Type:

Activity:

No. Nests Responding:

_______ None
_______ Chortle then quiet
_______ Chortle constant
_______ Stand/off nest
_______ Scream
_______ Flush and return
_______ Flush and remain off

Comments:

Time:

Intrusion Type:

Activity:

No. Nests Responding:

_______ None
_______ Chortle then quiet
_______ Chortle constant
_______ Stand/off nest
_______ Scream
_______ Flush and return
_______ Flush and remain off

Comments:

QA Review by _____ Date _________

Note: for further events use additonal sheet

Great Blue Heron Data Sheet #4 - Colony Reproductive Productivity

Colony Name: ____________ **Colony Code:** ____________

Date: ________ **Visit No:** ________ **Previous Visit Date:** ________

Arrival Time: ________ **Departure Time:** ________

Observers: ____________

Weather: ____________

Comments: ____________

Nest Status Codes	Nest Activity Code eg's
STD - adult standing	**1AS/2AS -** 1 or 2 adult stand
INC - incubation	**ASN -** adult stand near
YNG - young in nest	**EX -** adult exchange
NV - birds not visible	**COP -** copulatory behaviour
FN - failed nest	**STICK** - stick brought to nest

Young Age Codes

1 - 1 to 2 wks old	**3 -** 4 to 6 wks old
2 - 2 to 4 wks old	**4 -** 6 to 8 wks old

Observer Location	Tree No.	Nest No.	Nest Location	Nest Active? (Y/N)	Nest Status	No. Adults	No. Young	Age of Young	Nest Activities	Comments

QA Review by _____ Date ________

Notes: see survey protocol for explanations of fields; for further nests use additional sheet

APPENDIX 3 – Nestling Illustrations

(with approximate scale in inches)

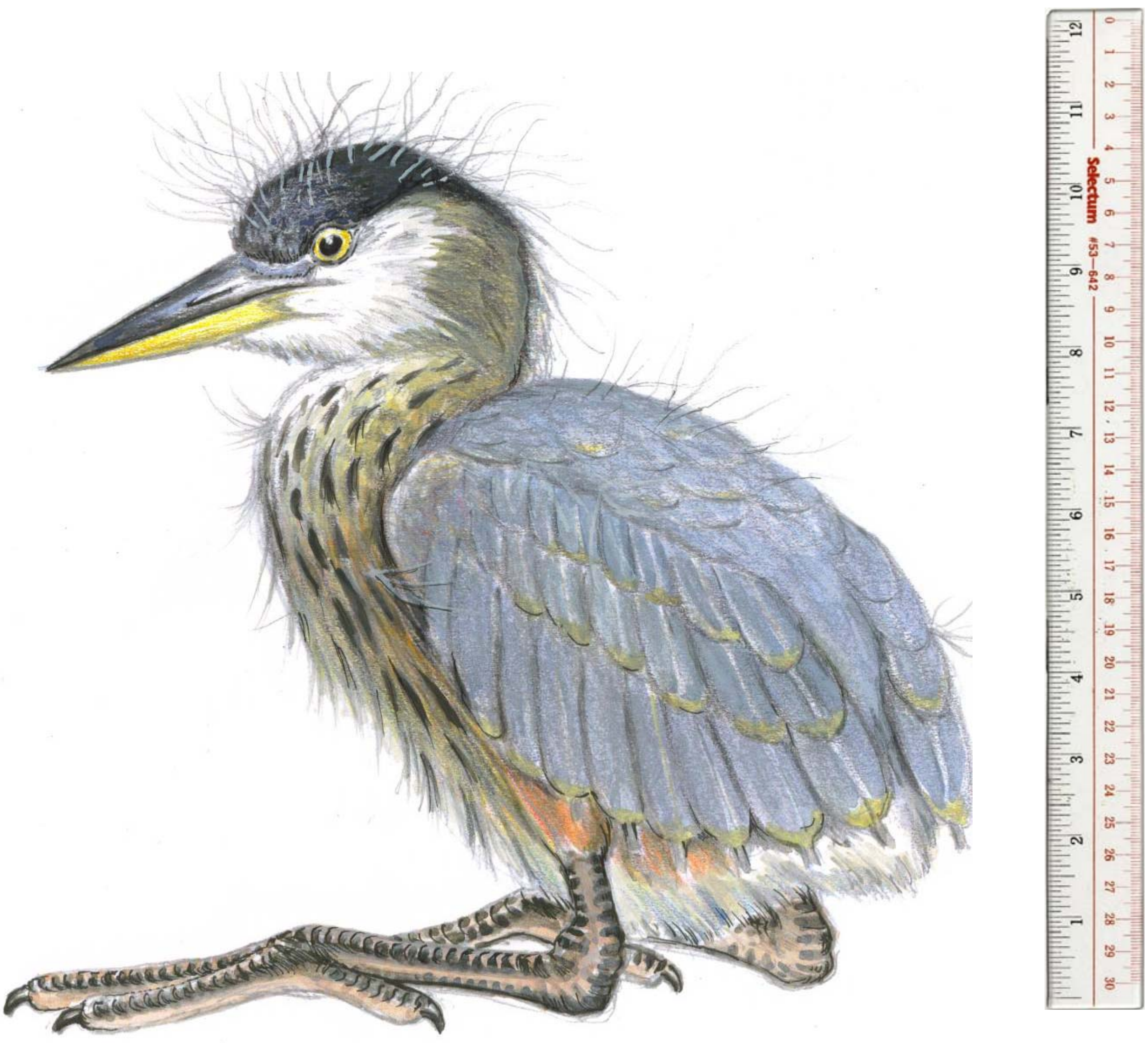
Including:

Age 1-2 weeks
Age 2-4 weeks
Age 4-6 weeks
Age 6-8 weeks

All illustrations are by Donald Gunn

1-2 WEEKS OF AGE
(Illustration by Donald Gunn)

2-4 WEEKS OF AGE
(Illustration by Donald Gunn)



4-6 WEEKS OF AGE
(Illustration by Donald Gunn)

6-8 WEEKS OF AGE
(Illustration by Donald Gunn)