comparative matrix that will eventually permit the recognition of generalizations concerning the role of time and energy in forming life-history patterns, but most of them have concerned only a part of the annual cycle (usually the breeding season). Thus, it is still impossible to discern what part of the annual cycle constitutes a bottleneck of energy or time that limits an animal's distribution or abundance, or jeopardizes its survival. Furthermore, all but a few of these investigations have neglected to distinguish obligatory energy expenditure (basal and thermostatic requirements), over which an animal has only minor volitional control, from expenditures in volitional or facultative activities. This results in a serious loss of information if, as we believe, volitional (behavioral) characteristics are more sensitive to selection than are obligatory physiological processes.

As an effort to augment the fund of information about annual variation in energy and time budgets, and to provide a format that is more responsive to ecological questions, we undertook a year-long investigation of free-living Black-billed Magpies (*Pica pica hudsonia*) in southeastern Washington. To facilitate separating and estimating obligatory and facultative energy expenditure, our methods featured a detailed month by month quantification of the magpie's microclimates and its activity budgets. The activity budgets were converted to components of the energy budget by methods to be detailed later, but in general depended on known relationships between timed activities in the field and the energy consumption of such activities measured in the laboratory. We abbreviate this and similar techniques using "time-activity-laboratory" data as the "TAL" method.

The Black-billed Magpie is a medium-sized ground-foraging bird whose behavior can be readily observed. It is a permanent resident throughout most of its range, where it may be subjected to harsh weather in both summer and winter. Its general biology (e.g., Linsdale 1937, Evenden 1947, Brown 1957, Jones 1960, O'Halloran 1961, Erpino 1968, Bock and Lepthien 1975) and its thermal physiology (Stevenson 1971) are fairly well known. These characteristics make the Black-billed Magpie very well suited to investigation by TAL methods.

POPULATION AND STUDY AREA

The population studied occupied a 646-ha area on the west end of the Washington State University campus, an area of gently rolling hills dissected by numerous small drainages that coalesce in its eastern half and eventually empty into Paradise Creek. The difference in valley bottom elevations between the south and north end is about 61 m. The western edge of the study area extended to the main campus, while the other three sides were bordered mainly by farmland (predominantly wheat). The study area is in the *Festuca-Symphoricarpos* and *Festuca-Rosa* vegetation zones of the steppe region of Washington (Daubenmire 1970) which when undisturbed is characterized by a mosaic of habitat types. The two types important to the magpie are the *Crataegus douglassii—Symphoricarpos albus* and *Crataegus douglassii—Heraculeum lanatum* types where *Crataegus* bushes afford nesting and roosting sites. The study area, however, is very disturbed and is a mixture of fields, poultry yards, pastures, farm buildings, pine plantations, fir plantations, groves of introduced exotics (honeysuckle, corrigana, lilac, apple, cherry), as well as some remnant groves of native brush (black hawthorne, *Crataegus douglassii*, predominantly, but mixed with snowberry, *Sym-*

phoricarpos albus, spirea, *Spirea betulifolia*, and service berry, *Amelanchier alnifolia*).

About 36 adult magpies occpied this area during the investigation. Six of them, previously marked with colored bibs bearing an identifying number, had been used by Johnson (1972) in an earlier investigation. When Johnson marked these birds (1970–1971), juvenals (birds yet to complete their first molt) received red bibs, and adults yellow bibs. Therefore, when field observations first started (April 1973) the three birds with red bibs were two to three years old, and the three with yellow bibs were more than three years old. Johnson had also marked mapgie populations in adjacent drainages, and during the winter when these joined with ours in a communal roosting flock, several other birds with bibs were seen. In the spring of 1974, only two red-bibbed and one yellow-bibbed birds were breeding in the study area. The other three either had been assimilated into another population during the winter flocking, had lost their bibs, or had been eliminated entirely. Therefore, it appears that the adult individuals in the observed population were resident not only to the Pullman area in general, but perhaps specifically to the study area. This population remained within a home range area as a loose flock, except during the reproductive season, when the adults dispersed over that same area as pairs on nesting territories.

RATIONALE AND METHODS OF THERMAL ANALYSIS

The thermal environment is the milieu in which all activity takes place. It is therefore one of the major selective forces in an organism's environment, and while there are many laboratory investigations describing physiological, morphological, and behavioral adjustments of birds to various thermal regimes (see Dawson and Hudson (1970) and Calder and King (1974) for recent reviews), few describe the set of thermal conditions available to an animal in its natural environment or the extent to which an animal may utilize a set of microclimatic differences to extend the full range of variation identified in the laboratory. For an animal as mobile as a bird there are several different thermal conditions available to it at any time, and it is important in evaluating time-activity and energy budgets not only to determine the character of these on a temporal basis but also to determine which of them are actively sought and occupied at certain times of the day or year. The ability to accept or reject various thermal environments may allow an animal to "assemble the environmental conditions necessary for survival and reproduction out of remarkably unlikely arrays of environmental factors" (Bartholomew 1958). It is in this context that the analysis of thermal energy exchange between organisms and their environment becomes important and makes it possible to quantify the relative roles of physiological, morphological, and behavioral adaptations in determining an animal's temporal spacing of activities (daily and seasonal), daily energy requirements, distribution within its habitat, and perhaps geographic distribution.

Winslow et al. (1936a, 1936b, 1937) made fundamental pioneering studies of "partitional calorimetry" in a controlled laboratory environment and estimated the radiative, evaporative, and convective heat transfer terms separately for men under a wide variety of thermal conditions. They (Winslow et al. 1937) described their controlled laboratory environment in terms of a single "operational tem-