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Commentary

REDIRECTING RESEARCH FOR WILD TURKEYS USING GLOBAL POSITIONING SYSTEM TRANSMITTERS

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Abstract: For decades, very-high-frequency (VHF) radiotelemetry has been used by researchers to study various aspects of wild turkey (*Meleagris gallopavo*) ecology and behavior. Although VHF telemetry has provided immeasurable benefits to wild turkey management through research projects across the species range, advancing technology now has created the opportunity to greatly extend telemetry studies and advance our knowledge base. Recent development and testing of global positioning system (GPS) technology integrated with VHF transmitters for wild turkey research has provided wild turkey researchers and managers the ability to standardize data collection at temporal resolutions and spatial scales that were not possible previously. We offer several examples of initial field studies using micro-GPS on wild turkeys, outline general descriptive results from these studies, and provide our perspective on how wild turkey research should proceed after adding GPS to our technological toolbox. Our objective is to provide ideas to generate discussions that will propel research and management efforts and refine management of habitats and wild turkey populations.

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In 1992, James Dickson wrote, "To manage wild turkeys more effectively, we need solid, quantitative information from research on a variety of areas" (Dickson 1992). Since that time, research on wild turkeys has addressed many topics, including habitat selection at broad spatial scales (Goetz and Porter 2005) and brood habitat use at fine spatial scales (Jones et al. 2005). Likewise, studies have focused on potential density dependence in wild turkeys (*Meleagris gallopavo*) (McGhee and Berkson 2007) to density-independent factors that can cause variation in populations (Schwertner et al 2005). Recent suggestions have included genotyping technologies to estimate population size (Latch et al. 2005). Across all studies, the primary objective has been to gather quantitative information referenced by Dickson (1992) with the ultimate goal of improving management and conservation of wild turkey populations. The above-mentioned studies, as well as the extensive literature on wild turkeys, have provided insight on ecology, behavior, population size and structure, population distribution, and the host of biotic and abiotic factors that affect wild turkey populations at a variety of spatial scales.

OUR PURPOSE

Our impetus for this article is simple. We offer that, although a compendium of knowledge about wild turkeys exists, wild turkey research has begun to ascribe to Aardvark and (to a lesser extent) Arcadian principles (Hunter 1989) where (1) research has focused on questions for which we already have determined relevant answers or (2) implementation by managers of the results of our research is difficult. For example, we have a wealth of knowledge regarding individual survival across the species range (Godwin et al. 1991, Miller et al. 1998, Pack et al. 1999, Humberg et al. 2009), but no detailed knowledge of how factors such as flock structure and flock size, individual behaviors, and group movement trajectories through the

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landscape affect individual survival. We have detailed microhabitat vegetation characteristics around nest site locations (Badyaev et al. 1995, Randel et al. 2005), yet we have been unable to relate, or even identify, those female behaviors that are used during nest site selection that may mitigate against nest loss or female mortality. We have collected huge quantities of spatial information, generating a spectrum of predictions for wild turkey habitat use and selection at the macro scale. Yet, we have been unable to use the data to create and manage habitats to buffer against population instability or even declines in areas where wild turkeys historically were strong.

We posit that the current state of wild turkey research, and hence our understanding of wild turkey ecology and management, has stagnated, thereby reducing our ability to provide both local- and population-level solutions and tangible management recommendations in the face of increasingly complicated land management scenarios. We recommend that managers and researchers consider a realignment of research efforts and focus, recognizing that such efforts necessitate either new information or methodological advances previously unavailable. Rarely do opportunities for significant increases or improvements present themselves. Our objective is to briefly describe one recent technological advance supporting our focus on research realignment. Although challenging, it is our opinion that this advance perhaps has allowed us to reach the point where an opportunity to reinvent wild turkey research is available. Therefore, we can afford to adjust our focus from that of basic description to a more mechanistic understanding of how individual behavioral decisions influence population-level trajectories. We are treating this commentary as an opportunity to stimulate future discussion on a research framework that will promote effective management of wild turkey populations in the face of uncertainties that are challenging managers.

WHAT HAS CHANGED?

The first methodological advance that provided researchers the ability to collect specific data on wild turkeys began with the very-high-frequency (VHF) transmitter (Nenno and Healy 1979). The standard for data acquisition on wild turkeys, VHF allowed us to monitor wild turkey state, location, and movements on a regular basis. Any further advance in technology is expected to increase our ability to better understand wild turkey biology and establish management actions (Dickson 1992). Recent development of a practical GPS backpack unit for wild turkeys (Guthrie et al. 2010) provides additional opportunities to study wild turkey population ecology. There has been a significant application of GPS technology by wildlife ecologists studying in animal ecology (Cagnacci et al. 2010), but applications of GPS to avian species have been limited, usually focusing on high-frequency (multiple locations per minute), short-duration (<7 days) studies (Wilson et al. 2002, Wegge et al. 2007). Satellite telemetry (e.g., Argos platform transmitting terminal) most often is used for research on large-scale migration (Meyburg 2001, Bobek et al. 2008), making it generally ineffective at addressing relevant questions pertaining to management of wild turkey populations.

For wild turkeys, our primary research interest centers on identifying use and non-use of specific habitat types related to the timing of seasonal events (reproductive ingress, breeding, nesting, and brooding activities, reproductive egress and non-breeding periods). Thus, short-duration, high frequency systems and large-scale migration systems outlined above would not suffice for capturing the broad scale of behaviors that a wild turkey exhibits during an annual cycle. With this in mind, and in collaboration with Sirtrack Wildlife Tracking Solutions (Havelock North, New Zealand), we tested a micro-GPS (μGPS) unit backpack system for use on wild turkeys (Guthrie et al. 2010). The μGPS developed for wild turkeys can be used to collect locations on preset intervals during the course of 1 or multiple annual cycles and encapsulates a VHF mortality-switch transmitter for regular determination of wild turkey status.

The μGPS had to meet several specifications outside of the normal size and structural requirements to be applicable for use on wild turkeys. The unit had to be able to perform in a variety of environments, withstanding damage from daily movements through multiple vegetative communities without compromising data collection. Spatial accuracy had to be high, such that locations could be tied to microhabitat features and hence demography. Our accuracy needs negated use of satellite telemetry because measurement accuracy would be 250 m at best. Finally, the unit had to be able to collect data for short-duration and high-intensity bouts to evaluate factors such as disturbance to wild turkeys associated with hunting, as well as longer durations under lower intensity bouts so that individual and group variation in seasonal movements could be monitored.

After field testing of the units (Guthrie et al. 2010) and some additional work with these units, we subsequently are using this opportunity to outline a few examples of the type and detail of information we have collected successfully from wild turkeys in Texas and Louisiana. We also outline potential questions and future applications of GPS for furthering our understanding of wild turkey ecology and management, and we challenge researchers to refine future programs that are addressing questions relevant to improving management of wild turkey populations.

FIELD EXAMPLES

Female Reproductive Phenology: Nesting Activities

What are the metrics that should be used for determining habitat selection? Habitat selection metrics have relied upon spatial information from preincubation and incubation periods (Badyaev et al. 1996*b*, Chamberlain and Leopold 2000, Schaap et al. 2005), nest location-specific data (Chamberlain and Leopold 2000, Randel et al. 2005), or prior knowledge (Badyaev and Faust 1996) to identify areas selected for nesting. One of our primary interests and ongoing areas of research is that of the habitat sampling hypothesis: that females assess habitat quality and availability during dispersal and localized searching before selecting the nesting location (Badyaev et al. 1996*a,b*, Chamberlain and Leopold 2000). This is believed because longer movements and wider sampling have been correlated with increased nest success in eastern wild turkeys in Arkansas (Badyaev et al. 1996*b*, Thogmartin 2001).

To illustrate a possible application of using GPS, we captured and fitted an adult female Rio Grande wild turkey (*Meleagris gallopavo intermedia*) with a μGPS tag (ID 3704) on a private ranch in Duval County, Texas. Between capture (6 February) and 19 February, the μGPS collected 2 points per day and 2 points at night. On 20 February, the μGPS schedule changed to collect 1 point every 30 min between 0600 hours and 2000 hours because this date was the earliest that we noted initiation of activities associated with reproduction, such as female dispersal from winter ranges and increased male-on-male aggression (B. A. Collier, unpublished data), and we expected nest site selection and nesting to begin in earnest in March. In addition, we programmed the μGPS to collect 1 point every 2 hr from 2000 hours to 0600 hours to identify roost locations. Between 20 February and 17 March 2010, the female maintained a small (~25-ha) range with daily excursions <0.5 km/day. On 17 March, she dispersed from her pre-nesting range 5.1 km to the north, followed by an additional 2.2-km movement to the north on 18 March where nesting commenced (Fig. 1a). The female laid 12 eggs, and assuming 1 egg/day (Healy 1992), she began laying at this site within 24 hr of arrival as incubation was initiated on 30 March. Between 18 March and 30 March, she exhibited an interesting pattern of daily movements between 2 roosting locations within 1 km of her nest (Fig. 1b–1). Movements during this 12-day period suggest that the female was sampling her available habitats (sensu Badyaev et al. 1996*b*, Chamberlain and Leopold 2000), except that she already had initiated nesting and was laying during this entire period (see Fig. 1 for locations that intersect with the nest location). To document behaviors like those shown by this female without the use of GPS, an observer would have to monitor the marked female exclusively, multiple times each day (1 location/30 min in this study) and assume that observation did not influence individual behavior and that estimated locations were accurate.

We speculate that the activities described above could be considered nest site buffering, wherein the female is traversing the area surrounding her nest location determining whether other females are nesting nearby and evaluating potential feeding and loafing areas for poults should nesting be successful. Likewise, moving throughout the environment surrounding her nest may prevent predators from queuing in on the location of her nest before incubation begins. These hypotheses are all plausible for these localized movements that require evaluation, and we suspect other plausible hypotheses could be posited that could be evaluated empirically using GPS.

Female Reproductive Phenology: Brooding Movements

Female 3704 was successful and hatched on 26 April 2010 (consistent with an approximately 28-day incubation period). She remained at the nest site until 27 April (Fig. 2a–e) and then made the first foray with her poults, traveling approximately 200 m south with her brood, spending the next 3 days and nights within an area of approximately 3 ha (Fig. 2e–g). On 30 April, the female and her brood made another distinct movement of approximately 300 m north back toward the nest site and remained in that area until she was predated on 4 May 2010 (Fig. 2h–l). It seems (not unexpectedly) that the female's movements differed relative to the presence of poults. When she was traveling alone, her movements were wide ranging and rapid, becoming truncated when poults initially hatched and slowly increasing as poults aged.

Female 3704 obviously did not follow the habitat selection process posited by Badyaev et al. (1996*b*) and Chamberlain and Leopold (2000), wherein dispersal is followed by habitat sampling and then selection and nesting. Females are assumed to select nests by using roughly the above-described outline, but rarely have we been able to accumulate relevant data to accurately identify movements during this period. Currently, it is unknown where pre-nesting movements by females fall on the hierarchical scale of habitat selection. However, female 3704 generally selected early successional grassland with interspersed mesquite (*Prosopis* spp.) thornscrub cover over the surrounding areas of dense thornscrub void of grassland habitat.

Male Movements

Frequently, studies evaluating movements of male wild turkeys have focused on movements between wintering and breeding sites (Badyaev et al. 1996*a*, Holdstock et al. 2006) or have been used to identify seasonal ranges or flock movements (e.g., Lint et al. 1992; Godwin et al. 1994, 1995; Grisham et al. 2008). Although research on male movements has assisted with identifying movement patterns and tying those movements to demography, behavioral decisions that impact demography probably are being made at a finer resolution. Specifically, the typical radiotracking study using VHF telemetry in which several locations are recorded weekly on each male are common (e.g., Wright and Vangilder 2005, Grisham et al. 2008), but are inadequate to advance our collective knowledge about male movement ecology and the ecological implications of those movements.

After testing the μGPS units to ensure that they would function adequately under the dense canopy conditions found in bottomland forests of southern Louisiana (Guthrie et al. 2010), we deployed units on 3 adult males captured on 5 March 2010. Our goal was to evaluate male movements before spring hunting season on a study area with strictly controlled hunter numbers, but unlimited hunter access. One male was harvested on 22 March, which afforded us the opportunity to evaluate short-term movements before and during the initiation of hunting. After capture, male 240 used an area of ~400 m^2 for several days (Fig. 3a, b). A youth hunting day occurred on 10 March, and a hunter and his guide were informed that several tagged males were in the area where male 240 roosted. On 10 March, male 240 moved ~1,000 m north and roosted in a different location (Fig. 3c). Throughout 11 and 12 March, the male used an area ~300 m^2 (Fig. 3d, e). On March 13, male 240 moved 800 m farther north (Fig. 3f) before exhibiting short-distance, linear movements daily until 17 March (Fig. 3h, i). On 17 March, the open hunting season

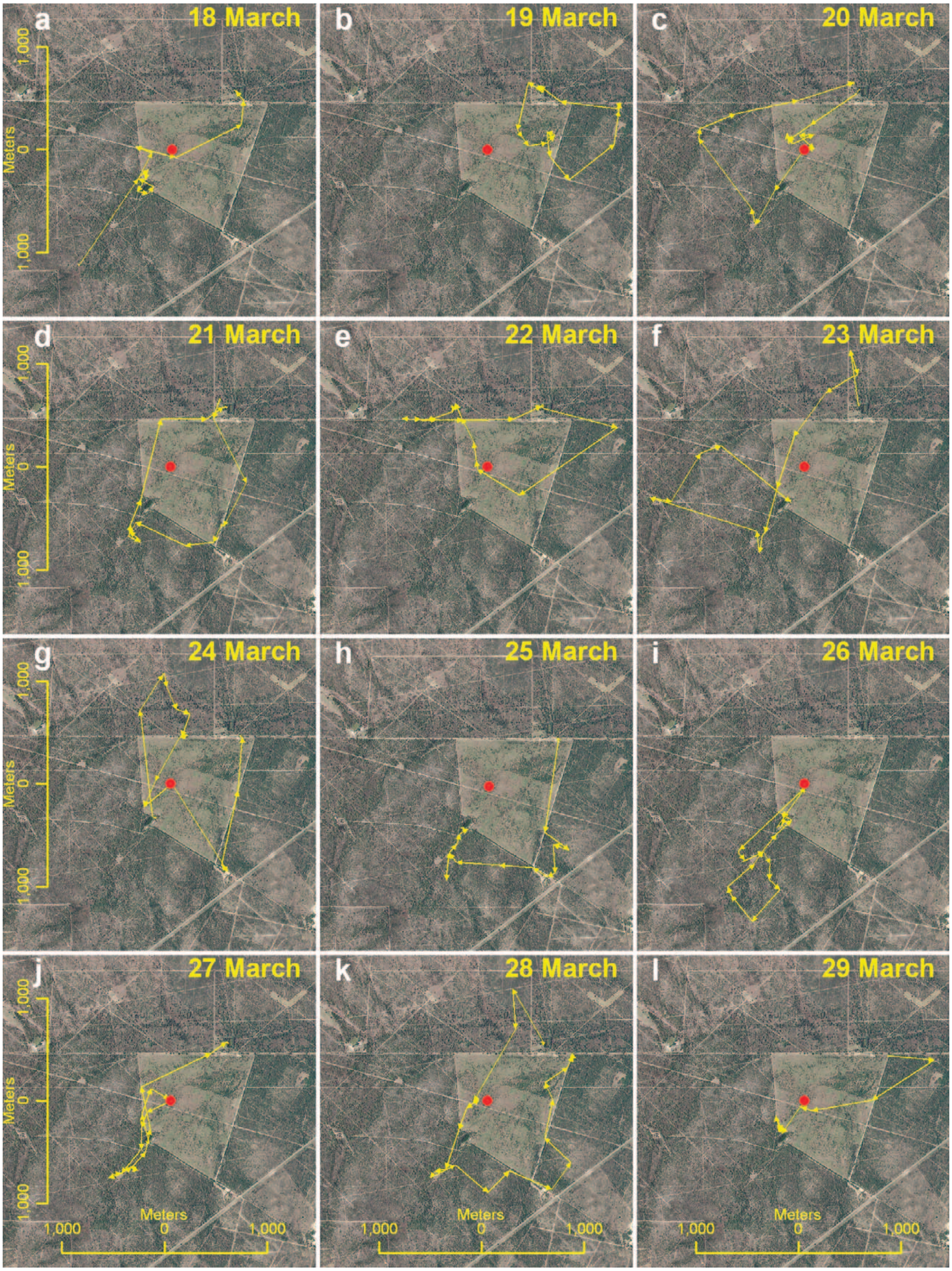

Figure 1. Pre-incubation movements of Rio Grande wild turkey female 3704 that was captured and tagged with a μGPS in Duval County, Texas, during 2010. Upon arrival at the focal area on 18 March 2010 and initiating a nest (see red dot in panels), the female exhibited a novel movement trajectory during the pre-incubation and laying period preparing for incubation (beginning on 30 March 2010).

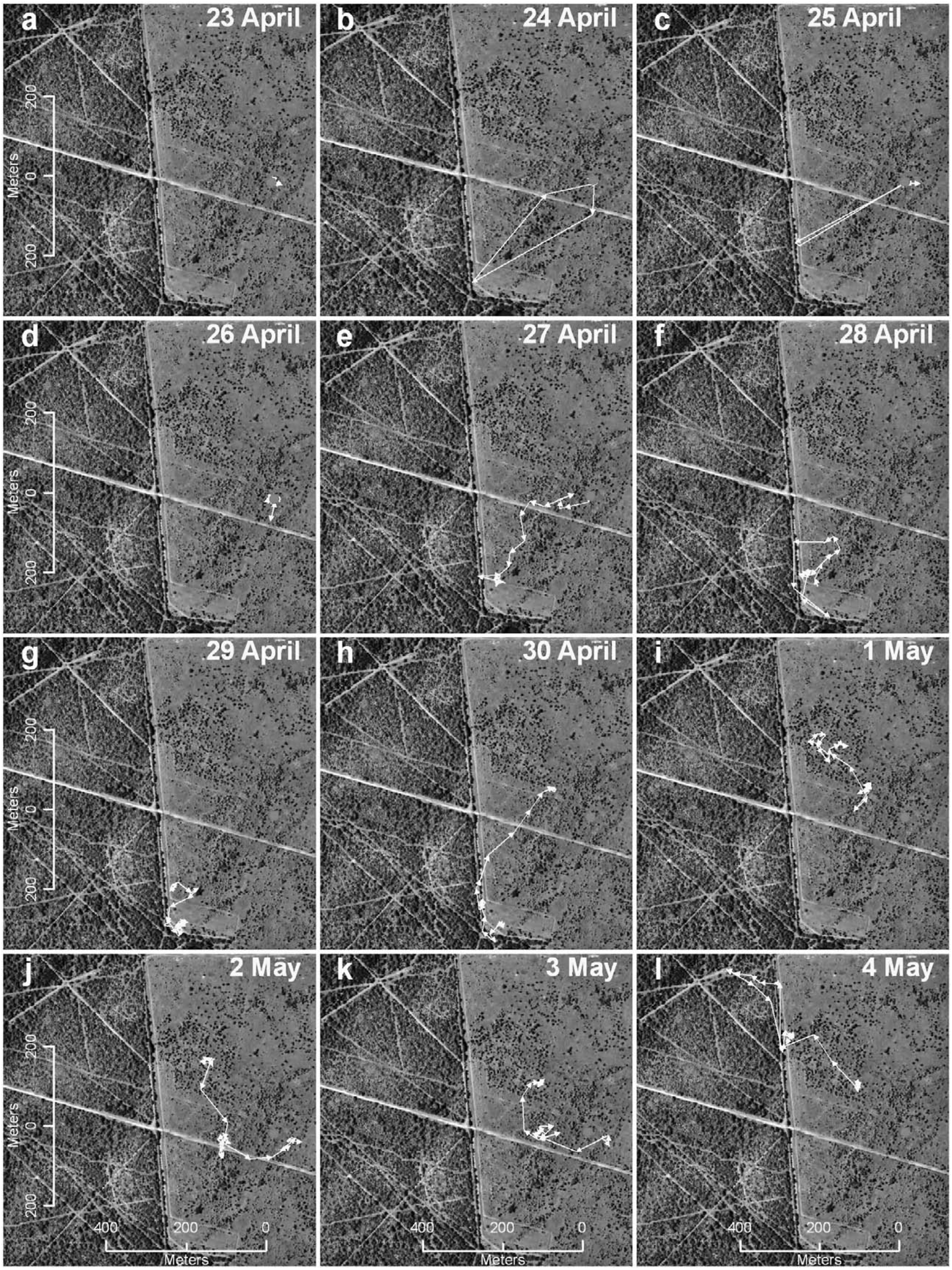

Figure 2. Activity pattern of Rio Grande wild turkey female 3704 tagged with a μGPS immediately before hatch (26 April 2010; e) and the subsequent post-hatch movement patterns of 3704 with her brood during the next week, up to her predation on 4 May 2010 (l).

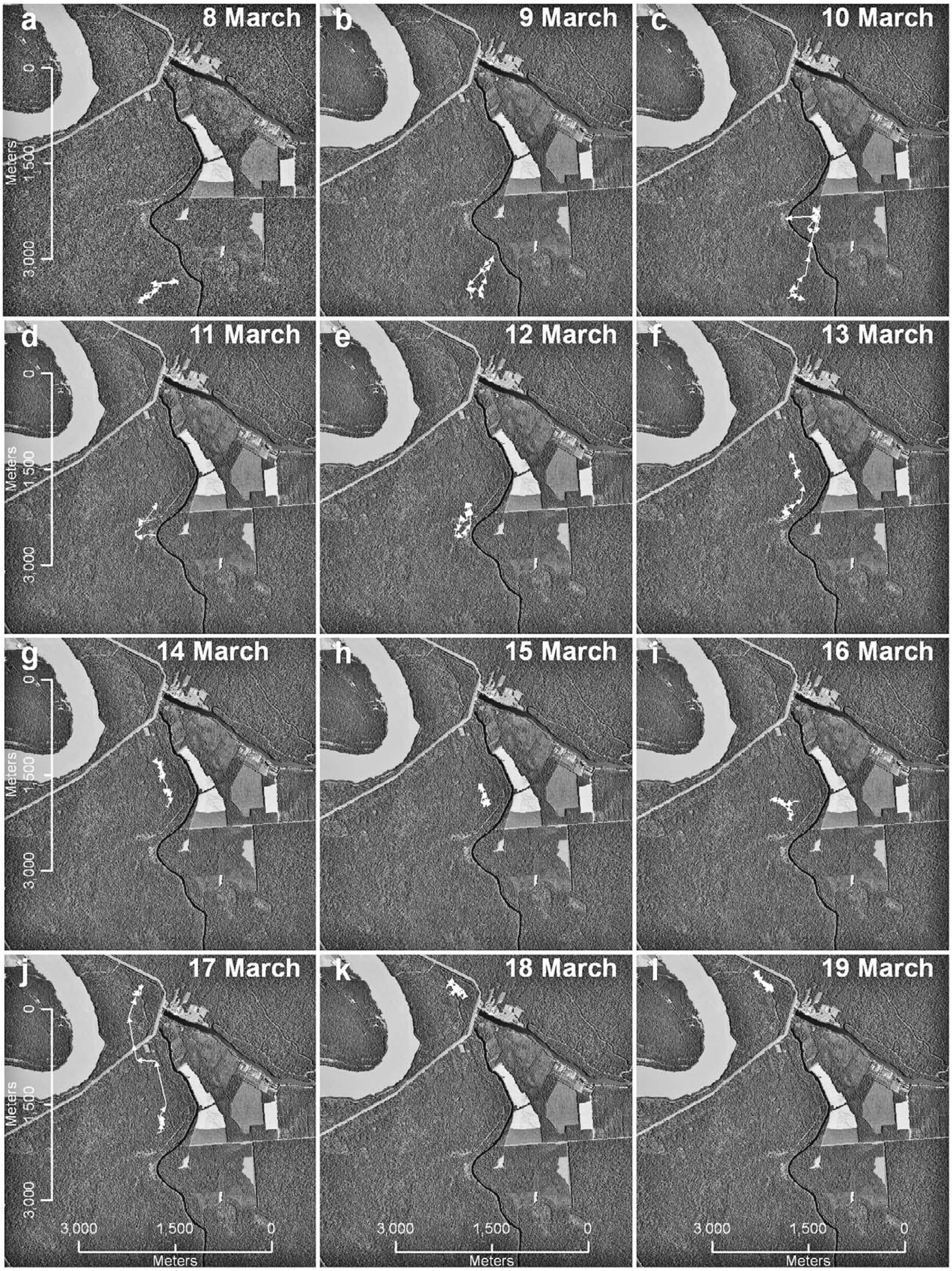

Figure 3. Twelve-day activity pattern of an adult male eastern wild turkey (240) tagged with a μGPS in a bottomland hardwood forest in Iberia Parish, Louisiana. During the time frame, the adult male made several long-distance movements (~1 every 3 to 4 days) coupled with highly localized use of space between these longer distance movements.

began, during which up to 50 hunters selected through a lottery system were allowed to hunt. On that same day, male 240 traveled ~2,000 m north (Fig. 3j) before settling and consistently using an area ~250 m^2 daily until he was harvested on 22 March.

Admittedly, we were surprised by the lack of movements exhibited by male 240 within a single day, particularly given our knowledge of male movements during spring (Godwin et al. 1994) and the general notion that wild turkeys are highly mobile (Healy 1992). In essence, this adult male spent entire days within a 0.03-a area, indicating that he was able to forage, loaf, and roost successfully within such a small area. However, the linear movements exhibited by this male to the north were noteworthy, and although it is entirely speculative, seemed to coincide with the initial presence of hunters within his environment. If one were to use the locations gathered on this male to estimate space use, the findings largely would confirm what we already know; males use considerable space during spring (Godwin et al. 1994, 1995). However, the extensive amounts of data generated by the μGPS provided an assessment of daily and period-specific movements that are truly noteworthy and, more importantly, could generate new research ideas and hypotheses capable of being tested solely with GPS telemetry.

Impacts of Disturbance on Movements

As a final example, we were interested in the potential response of male wild turkeys to human (i.e., hunter) disturbance when birds were on the roost because we could find no published literature on this topic, although a similar experiment has been conducted in Virginia and West Virginia (Gary Norman, Virginia Department of Game and Inland Fisheries, personal communication). We conducted an experimental disturbance of μGPS-tagged individuals on a private ranch in Duval County, Texas. We captured 8 adult male Rio Grande wild turkeys in March 2009 (Guthrie et al. 2010) and tagged each with a μGPS unit, collecting data at intervals ranging from 1 location every 10 min to 1 location every hour between 0600 hours and 2000 hours. For each of these males, we triangulated their positions regularly (>3 locations/wk) using VHF telemetry and collected roost locations (>2/wk). We designed an experiment where birds were left undisturbed for $\geq$7 days before we initiated a treatment (i.e., simulated hunter disturbance). Because we could plan the disturbance, we set up the μGPS units to collect 1 location every 10 min from 26 March 2009 to 1 April 2009 between 0500 hours and 1100 hours and 1500 hours and 1900 hours. The night before the experiment (28 March 2009), we conducted a roost check to ensure that the μGPS-tagged birds were all roosting in the same general location. The next morning (29 March 2009), we simulated hunting by having an individual arrive at the roost site approximately 1 hr before sunrise and purposefully create a disturbance intended on forcing the individuals off the roost (red line in Fig. 4c). When disturbed, each bird (Fig. 4c) fled southeast of the roost approximately 300 m, but did not follow the same movement pattern thereafter. For example, males 3057 and 3058 were known to travel together each day (B. A. Collier, unpublished data) and showed a similar movement pattern pre- and post-disturbance. However, male 3080 began moving with 2 other males with which he often traveled (data not shown). Interestingly, disturbing the roost site did not seem to have any immediate impacts that caused these males to avoid that particular roost site in subsequent days (Fig. 4d). Similar results were found in the Virginia and West Virginia study with flushed birds roosting similar distances to control birds the night after disturbance. However, the μGPS equipment provided added information that was unavailable to the Virginia and West Virginia study, namely, detailed movement patterns immediately after and days after flushing. It is plausible that different responses would be observed if this experiment was conducted over successive days (more disturbance to roost) or after more intensive disturbance in the form of calling or shooting at birds. Furthermore, these responses may have varied on eastern wild turkeys due to potential differences in roost site fidelity between subspecies, population densities, and roost site availability between geographic regions (Healy 1992). Nonetheless, our results offer evidence that roost use by individual males is worthy of more detailed investigation using GPS telemetry.

TOPICS OF INTEREST

We see an unlimited list of potential areas where future research using GPS technology could better define how wild turkeys use space and how their behavior drives population dynamics. Below, we briefly outline 3 topic areas that encompass many future research questions needed to ensure sustainable wild turkeys populations across their geographic range.

Relating Space Use and Movements to Habitat Distribution

What are the ecological correlates that will allow us to better understand how wild turkeys are distributed across the landscape? Currently, wild turkey populations exist in clusters at the local scale, but these clusters exhibit an irregular, patchy distribution at the landscape scale. Perhaps wild turkey populations exist in a meta-population context, where subpopulations are separated based on some set of environmental characteristics. Clearly, we lack knowledge on the scale at which habitat selection occurs and how that selection process varies over time as vegetative communities change. We assume that the process of selection occurs at the microhabitat (vegetative, local) scale (Day et al. 1991, Chamberlain and Leopold 1998, Randel et al. 2005) and that such an interpretation of landscape-level selection inherently is dependent upon the distribution and interspersion of various habitat types at the local scale, given their current successional state. Subsequently, the ecological questions of interest become those that relate the local-scale selection process (e.g., nest site selection by individual females) to specific sets of quantitative habitat characteristics for use in predicting additional locations where similar conditions occur. For example, it is likely that wild turkey habitat selection and hence space use is influenced by multiple factors at

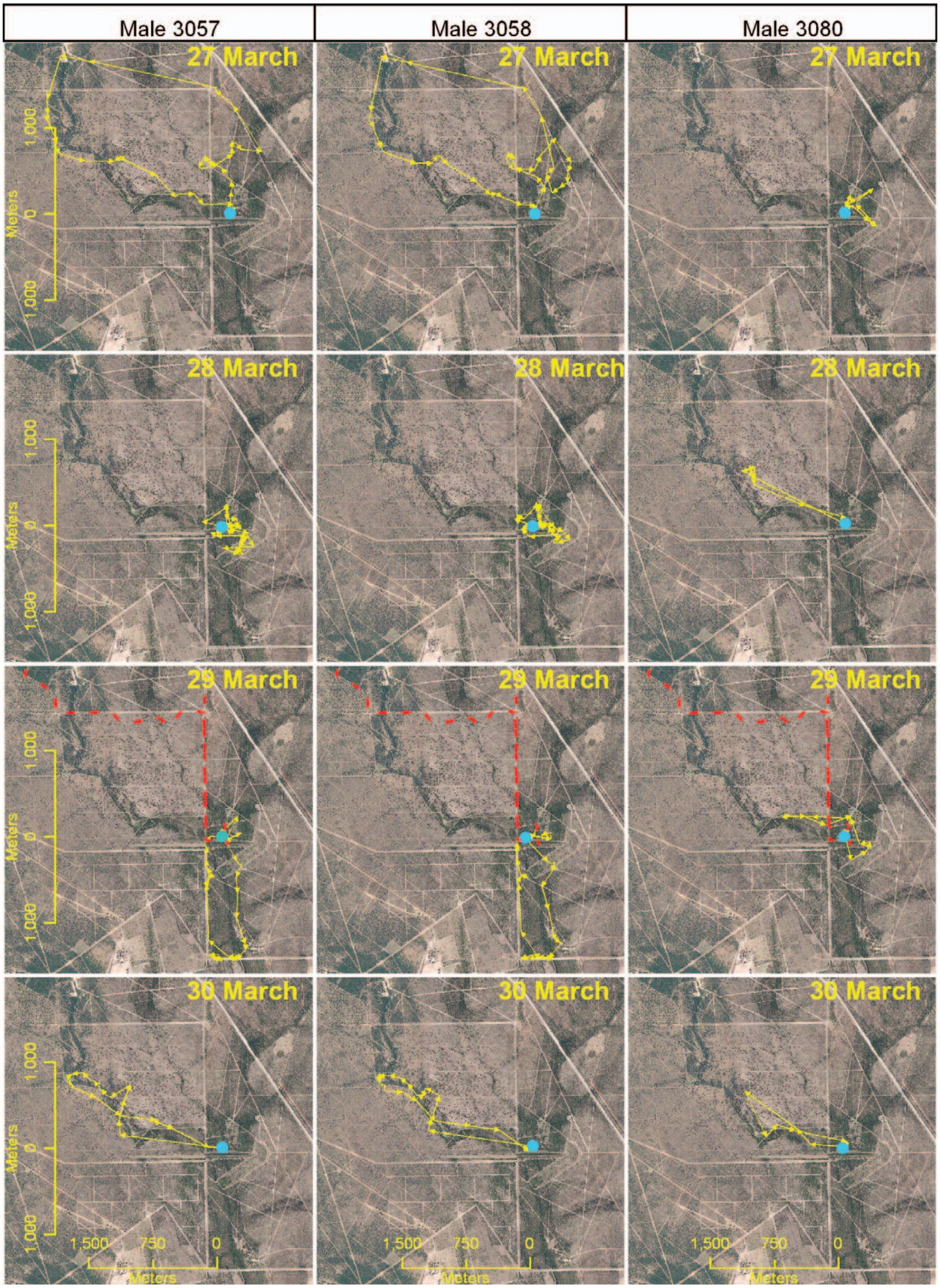

Figure 4. Four-day movement patterns of 3 adult male Rio Grande wild turkeys tagged with μGPS relative to their roost site location (blue dot). On 29 March 2010, we simulated a hunter (red dashed line) entering the roost location during the early morning (0600 hours) and creating a disturbance to evaluate the response of these individuals to roost disturbance.

multiple spatial scales. As an example, one tenable hypothesis that GPS will allow us to evaluate is that wild turkeys select habitats based on microhabitat characteristics and that wild turkey ranges are nothing more than the union of spatially distinct microhabitats and the associated space used when moving among these spatially distinct microhabitat locations. Thus, wild turkey ranges or landscape-level habitat selection may be nothing more than the sum of the microhabitats available, plus any ancillary space used when behavioral decisions necessitate movements between selected microhabitats within the landscape.

Individual Behavior and Demography

Most research efforts to identify habitat selection by wild turkeys have relied on estimation of ranges, ultimately relating the characteristics of those ranges to wild turkey demography (Holbrook et al. 1987, Palmer et al. 1993, Schaap et al. 2005, Holdstock et al. 2006). However, descriptive models such as these do not allow for inferences regarding the underlying behavioral processes that gave rise to the habitat selection pattern and hence to the demographic consequences (Beyer et al. 2010). We suggest that future work focus on the ecological implications of the behavioral decisions made by wild turkeys when moving through their environment, and how through time those individual decisions affect survival and recruitment rates of individuals and also populations. As an example, we know of no effort that has focused on individual decision processes regarding whether to move throughout the landscape as part of an identifiable group (e.g., flock; see Fig. 4, males 3057 and 3058) or whether to traverse the landscape as an individual. However, basic decisions such as this likely are the drivers underlying individual and hence population level demographic performance. What are the ramifications of traveling with a flock? Does flocking lead to increased antipredator strategies due to more sets of alert individuals and hence higher individual survival, or is the increase in flock size detrimental to individual member survival due to predator attraction to the large flock? Perhaps tendencies to flock or not are dependent in part on environmental conditions or food availability during that year. Thus, under good habitat conditions, individual movements (Fig. 1) are more optimal than flocking because individuals can be quieter and more secretive? Each of these represents a plausible hypothesis that, until the advent of GPS, we were unable to evaluate accurately.

Applied Restoration and Habitat Management

Any focus on applied management for wild turkeys will encompass, at least in part, both of the topics discussed above because none truly are mutually exclusive. However, in addition to better defining the relationship between wild turkey space use and demography, we see additional opportunities for evaluating immediate and long-term impacts of experimental manipulations on wild turkey populations. Manipulations could range from human disturbance studies such as those described above where birds are perturbed intentionally and responses are measured to studies where habitat manipulations occur and we monitor the same set of individuals over time to evaluate immediate and long-term responses to habitat manipulation. These data also may be useful to state agencies that set hunting regulations and land managers who set hunter quotas to maintain quality hunting experiences. State agencies also may find these data helpful to explain wild turkey ecology to the public and may serve as a basis for press release information about dynamics of fall and spring season harvests.

The restoration of the wild turkey has been one of the most remarkable success stories in the history of wildlife management. Wild turkeys have been restored throughout their historical range, and huntable populations even exist outside of it (Kennamer et al. 1992). Despite these successes, some restoration attempts continue to fail. Although there is a broad knowledge base that guides restoration efforts and releases of wild turkeys on specific sites, we suggest that GPS telemetry now provides the opportunity for those planning restoration attempts to greatly refine their efforts and substantially augment available knowledge. Historically, monitoring of released birds has used VHF telemetry to document survival, habitat use, the importance of agricultural foods, and various behaviors (e.g., nest site selection) of released birds. GPS telemetry offers wild turkey managers the opportunity to collect immense amounts of data on each bird released and to subsequently evaluate the ecological implications of decisions individual birds make upon release. For example, now we can evaluate empirically the implications of specific habitat use patterns on survival and fitness of individual birds, with the knowledge that the behaviors of the individual bird are being documented accurately. Having this knowledge would allow refinement of future restoration attempts because managers would be able to plan release strategies based on known consequences of bird behavior in similar landscapes. We offer that managers could use knowledge gained from marking released birds with μGPS to optimize efforts associated with restoring birds to release sites. Likewise, subspecies for which little is known (e.g., Gould's wild turkey, *Meleagris gallopavo mexicana*) now are being researched using protocols implemented consistently for decades to study ecology of other subspecies with VHF telemetry. Using GPS telemetry would facilitate the collection of enormous amounts of data during short periods to rapidly increase the current state of knowledge and to allow timely decision making in planning for management of the subspecies.

The literature is replete with studies that document habitat use of wild turkeys in a variety of landscapes. Simply put, we've determined which habitats wild turkeys used seasonally and annually, and we have attempted to relate habitat use to every facet of wild turkey ecology. Numerous studies have reported on habitat use at fine spatial scales (e.g., selection of nest sites), spatial scales associated with already known behaviors of birds (e.g., habitats used within home ranges), and we have related bird distribution to habitat characteristics at broad spatial scales. Although not always stated succinctly within manuscripts that detail results of habitat use studies, the ultimate objective of these studies is to provide information to managers that will facilitate improved management of landscapes inhabited by wild turkeys. Are our results acted upon by managers? Often times, yes. We then design studies to evaluate effects of the management scenario and attempt to relate changes in habitat to shifts in use by wild turkeys. We offer that GPS telemetry provides the chance to advance beyond this scenario.

We now have the opportunity to assess habitat selection at numerous spatial scales while simultaneously creating new or manipulating existing habitats for wild turkeys. For example, we can extend our knowledge of bird behavior throughout the diel period by monitoring birds intensively (with no observer influence or need) throughout the day, and even night, to better understand exactly how birds use areas within their home range. Likewise, managers can focus efforts on addressing habitat requirements not considered previously (e.g., loafing habitats), and refine efforts focused on more traditional habitats used by wild turkeys (e.g., nesting, brooding). We offer a simple question to stimulate thought on the possibilities: How much time during a day does a wild turkey spend loafing? Wild turkeys are known to focus foraging efforts during relatively short-term bouts in the morning and afternoon (Hurst 1992), so presumably they spend much of their day resting in areas that must have critical importance to their survival and fitness. One would assume that wild turkeys choose to rest in areas they feel secure, yet, to our knowledge, no previous research has determined what habitats and vegetative structures wild turkeys select for this activity that consumes most of their day.

As another example, any researcher attempting to assess selection of habitats by broods has encountered the classic catch-22 inherent in monitoring birds with VHF where homing is involved (e.g., Jones et al. 2005). We'll spare you the citations of the numerous works that involved approaching brood hens after hatching to determine brood fate, as well as determining microhabitat characteristics associated with use by broods. Did the brooding female react to the approaching researcher? Certainly she did, and she potentially moved her brood in response. One of us (M. J. Chamberlain) once watched an entire brood cross a road in front of him while a field assistant stealthily approached from the opposite direction, attempting to determine how many poults remained with the female and assess the vegetation associated with use by the brood. The field assistant never saw the female or her brood. We offer that many previous works on brood ecology, specifically habitat use and movements, have been biased because of limitations imposed by VHF telemetry. As a result, we probably have measured where females took their broods after being disturbed, rather than where they chose to forage with poults and brood them securely (e.g., Fig. 2). GPS telemetry offers us the chance to assess brood movements and habitat selection in ways not previously possible, free of potential biases associated with observer influence. In each case, our intent is not to criticize previous work that laid the foundation for what we currently know about wild turkeys. Rather, we hope that the availability of GPS telemetry will stimulate thoughts as to how we could improve our collective knowledge of wild turkey ecology and change perspectives on how to effectively manage wild turkeys in the future.

WHAT DOES THE FUTURE HOLD?

Our hope for this article is simple. We encourage researchers to recast the direction of wild turkey research by using newly available GPS telemetry in situations where this tool could improve our knowledge base greatly regarding management of wild turkey populations.

One of the most frequent criticisms of research on specific study areas is the inability to extrapolate the results to other areas. Similarly, a frequent criticism of telemetry studies is the inability to compare results among studies because of obvious differences in telemetry protocols and sampling regimes. We offer that GPS telemetry bridges those gaps, allowing researchers, or even teams of researchers, to design replicated field studies across broad spatial scales with standardized telemetry data collection protocols. In so doing, researchers can collaborate to design statewide and regional studies with the scope necessary to address questions relevant to wild turkey management. Data collection schedules can be standardized across study areas to collect specific information consistently between studies, as well as studies structured such that local questions on topics such as hunting response or habitat management can be evaluated. These data can be incorporated into a common database for generating questions and providing answers at a particular spatial scale of interest, with additional data collected being available for addressing specific research questions at a local scale.

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