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Note

A Component System for Broadcasting Sound for Research and Management

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ABSTRACT We designed, deployed, and evaluated a sound broadcast system for use in an experiment investigating response of songbirds to conspecific vocalizations in habitat selection; the system was functional, flexible, and allowed for easy assembly, customization, and repair. Broadcast of sound in the field can enable study of animal response to predators, conspecifics, heterospecifics, noise, and other stimuli and is being considered for a variety of management applications. However, no published method is available for building a sound broadcast system from readily available components for use in the field. © 2011 The Wildlife Society.

KEY WORDS bird song, broadcast system, conspecific attraction, heterospecific attraction, noise, vocal cues.

Broadcasting sound in the field has been used for investigating animal habitat selection and behavioral responses to noise, predators, conspecifics, and heterospecifics (Ward and Schlossberg 2004, Hahn and Silverman 2006, Betts et al. 2008, Fletcher 2008) and has been suggested for management applications such as attracting birds to restored habitat areas (Ahlering and Faaborg 2006, Hahn and Silverman 2007). Current ecological research requires a sound broadcasting system to simulate a variety of sounds for conducting manipulative experiments or testing potential management approaches. However, no published method is available for constructing a sound broadcast system with readily available components for use in the field, requiring researchers and managers to spend time and expense designing, building, and testing their own systems. We developed and field-tested a portable, component system for broadcasting sound in the field that can be used by other researchers and managers for a variety of applications.

STUDY AREA

Our study was conducted in Coryell and Bosque Counties, in the Leon River watershed, encompassing approximately 140,000 ha near the junction of the Lampasas Cut Plains and the Northern Blackland Prairie ecoregions (Griffith et al. 2004). Our study sites were located on private land where the primary land use is agriculture, mainly livestock ranching (U.S. Census Bureau 2005).

METHODS

We field-tested the broadcast system during an experiment investigating the response of songbirds to conspecific vocalizations. We used vocalizations of the federally endangered golden-cheeked warbler (*Dendroica chrysoparia*) in sample units across a range of vegetation characteristics considered optimal to suboptimal habitat, to determine if habitat selection for golden-cheeked warblers is influenced by vocal location cues provided by conspecifics. We used the broadcast system for about 5 hr daily for up to 8 weeks. The primary components of the broadcast station were a power source, timer, audio player, amplifier, and speaker. We used a battery (12 V, 12 A), digital timer, portable compact disc (CD) player, and a portable speaker with a built-in amplifier for each component. We selected a rechargeable 12-V direct current (DC) 12-A battery (Werker 12 V 12 A AGM battery with 0.250 terminal, Batteries Plus, LLC, Hartland, WI) because it provided sufficient power to run the audio player and speaker we selected for an estimated 48-hr of active broadcasting. The battery was small and light enough that a researcher on foot could transport several batteries at a time into the field to change batteries during routine maintenance checks; each battery weighed 3.7 kg and measured 14.5 cm × 9.25 cm × 9.5 cm. We used a programmable digital timer (Diehl digital timer, Borg General Controls LLC, Elk Grove, IL) because it allowed for easy programming for up to 56 unique cycles/week or 8 cycles daily. The timer contained an internal power source and thus did not drain power from the external 12-V battery.

We used a portable CD player (multiple models) for the audio player because it allowed us to permanently set the play button or switch in the on position. This play setting enabled the CD player to resume the play function after the power cycled off and back on; without this capacity, after the timer cut power to the device and then resumed power to the player, the player would not activate the play function without the play button being manually depressed. We used a combination of adhesive tape, wooden dowels, and rubber stoppers to set the play button in the on position, depending on the configuration of the buttons on each CD player model. We were unable to find other portable audio players, such as mp3 players, that could be permanently set in the on position. Additionally, we found that we could easily create CDs with the appropriate audio tracks using free audio

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editing software (e.g., Audacity® Version 1.2.6, http://audacity.sourceforge.net, accessed 1 Feb 2008). We used a portable amplified speaker (9-V mini audio amplifier, Radio Shack Corporation, Fort Worth, TX) with a built-in amplifier because it enabled broadcast of bird song at a volume that could be heard 100–300 m away without distortion. We did not measure the volume of the broadcast units using a standard measure for decibels at a 1-m distance; in our trial study system and in systems in which broadcast units may be deployed, the medium can vary widely in attenuation of sound, and the target distance of audibility for the focal species may vary, and thus a measure at a 1-m distance from the broadcast system may not be biologically relevant. We assessed sound levels using the audible distance to human observers, because variability of the slope and woodland structure meant that the sound attenuated differently across sites and because human hearing perception (i.e., frequency, and to a lesser extent, loudness) is similar to that of passerines (Dooling 1980, 1982) and thus served as a reasonable representation for our purposes. We used an audio cable with a ground loop isolator (ground loop isolator and 6-in. gold-plated premium shielded mono Y-cable, Radio Shack Corporation) to connect the amplified speaker to the CD player. We used the ground loop isolator to remove unwanted electrical current, rather than a more basic audio cable, to minimize audio distortion and feedback.

Because the battery generated 12-V DC power, we used a power converter (Universal Car Cord Adapter, Original Power, Duluth, GA) with multiple settings to convert battery current input to the required current output for each component (i.e., 9 V for speakers and 4.5 V or 6 V for CD players) and multiple plug tips to match the power line-in outlet for each device. The power converter cables terminated in plug-ends that fit into standard car power sockets. We used socket adapters (12-V DC car power accessory outlet, Radio Shack Corporation), which receive the plug-ends from the power converters on one end and provide a negative and positive wire for subsequent connections on the other. We used the socket adapter, rather than customizing the power converter by removing the plug-end, stripping the wires, and making subsequent connections directly from the power converter wires, to facilitate easy assembly or replacement of individual faulty parts in the field without special tools or equipment. We used insulated jumper leads (35.3 cm [14-in.] insulated test or jumper leads) to connect the negative and positive wires from the socket adapter to the battery and timer as needed (Fig. 1). Using jumper cables to connect electrical components, rather than permanently soldering connections, enabled easy assembly, addition, and removal of components.

We assembled broadcast units in the field. We placed each assembled unit in a 36-cm × 24-cm × 16-cm lidded plastic container with 4 holes drilled in the side where we placed the speaker to allow sound to travel out of the box without being muffled or distorted. We used inexpensive plastic storage boxes found at any home supply store. All components of the broadcast system were contained in the plastic box, protecting wires from damage by rodents and excess exposure to the

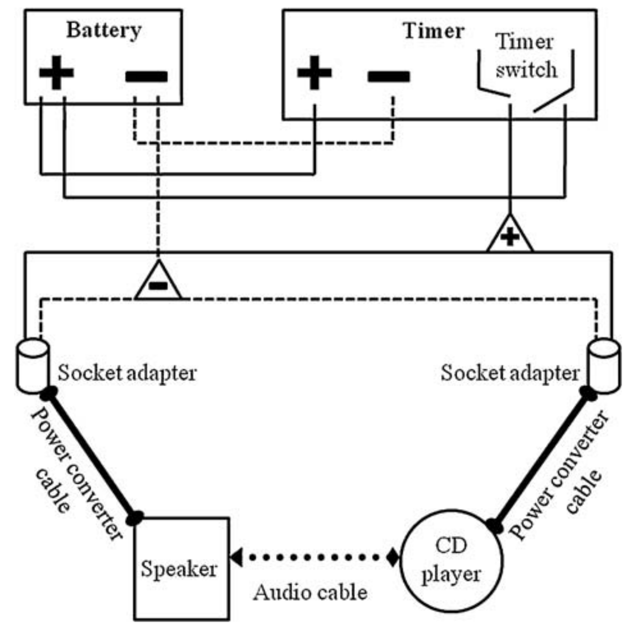

Figure 1. Diagram representing the components and connections of our broadcast system. Plus and minus signs represent positive and negative leads, wires, or connections. Solid lines indicate positive connections made with jumper leads and/or wires from socket adapter. Dashed lines indicate positive connections made with jumper leads and/or wires from socket adapter. Other components are labeled as described in text: battery, timer, socket adapter, power converter cable, speaker, audio cable, and compact disc (CD) player.

elements. We fastened each broadcast unit to a shrub or tree using duct tape. We made routine maintenance checks at each broadcast unit at least once every 7 days. Because of the potential safety risks of poor or incorrect wiring, including sparks, smoke, or fire, we conducted multiple 1- to 2-hr training sessions to train seasonal field technicians to conduct assembly, deployment, and maintenance activities.

RESULTS

The 12-V 12 A battery powered the systems for 60–70 hr of active broadcasting on the first use and after several cycles of draining and recharging. Most batteries used in 2008 remained functional in 2009; <10% of batteries in 2008 would not hold a charge in 2009, but we were able to replace these under warranty at no additional cost. Because we did not experience extreme cold conditions, we were unable to assess the function of these batteries at low temperatures. The batteries functioned reliably within the range of temperatures we observed (i.e., 4–40°C). Sound from broadcast systems could be heard clearly at a distance of 100–300 m, depending on terrain and vegetation structure, without distortion or loss of sound quality.

We experienced some equipment failure in the first set of units we deployed in 2008 due to inundation of the plastic containers during a heavy rain event. We found that all parts were still functional after drying except 4 of 20 timers and 4 of 20 CD players. Consequently, we drilled holes in the bottom of each container to allow excess moisture to drain, preventing future inundation of equipment.

Subsequent equipment failure was primarily due to moisture. The digital timer and the CD player had the highest susceptibility to malfunction due to moisture, accounting for most of the equipment failures during wet periods. In 2008, we experienced approximately 20% failure of CD players and timers but <15% failure for all other components despite heavy rainfall and high humidity conditions. In half of the failures caused by moisture, components regained full functionality after being removed from the field and allowed to dry. In 2009, we had drier weather conditions and experienced ≤10% failure in the 36 units deployed over 2 8-week periods. Again, most failures occurred after infrequent rainfall events, and CD players and digital timers again accounted for most of these failures. Several components that showed low or no failure (0–5%) in 2009 included the ground loop isolator and shielded mono Y-cable, universal car cord power adapter, 12-V DC car power accessory outlet, and the mini amplified speakers. Additionally, 3 broadcast systems were swarmed by red imported fire ants (*Solenopsis invicta*), but the systems continued to function. Ants did not damage any equipment and once we removed them from the components and moved the system to a nearby location, the system continued to function normally.

Cost per broadcast unit was about $160.00, with additional overall costs of <$100.00 for 2 battery rechargers, electrical tape, and duct tape. We were able to reuse all equipment from 2008 in both experimental periods in 2009, with the exception of the few failed parts we described above. We trained field technicians inexperienced in electronics and wiring to assemble and maintain broadcast system and found that most technicians could successfully assemble and make minor repairs and replacements to the units after 3–4 hr of training conducted in several shorter sessions, and all technicians were able to complete these basic duties after 5–6 hr of training. Once trained, field technicians were able to assemble broadcast units in the field in 5 min/units; finding a suitable substrate (i.e., tree branch or shrub) and fastening broadcast units to the substrate took 5 min/units. Maintenance visits (once per week) and battery changes (once every 2 weeks) were also executed in 5–10 min/units. In 2009, we experienced 1 occasion when a field technician, under supervision because it was during an early training session, incorrectly wired the equipment and thus created sparks. The technicians responded as trained, immediately disconnecting all wires, and no injury or equipment damaged was sustained.

DISCUSSION

Broadcast units functioned as well or better than expected in humid field conditions and variable temperatures, although we did not find estimates of reliability in the literature for other systems for comparison. Our broadcast system was easily constructed of readily available components and each unit was independently controlled, providing advantages over the only other detailed, published description we found of a broadcast system (Simons et al. 2007) or more complicated recording and playback systems (Celis-Murillo et al. 2009). Goals of these other devices were mainly for testing observer perception and bias in avian surveys, whereas we geared our system toward manipulative field experiments using sound.

Use of rechargeable batteries throughout multiple experimental periods was cost effective. Battery life on one charge of 60–70 hr exceeded the expected 48 hr. Because we were broadcasting sound for only 4–6 hr/day, we replaced batteries once per 14 days. However, if longer periods of broadcast activity are required, batteries can be changed more frequently, higher amperage batteries can be used, or solar panels can be attached to continuously recharge batteries. The most effective and efficient option will depend on the logistics of the research; lower amperage batteries require more frequent changes but are smaller and lighter, whereas more powerful batteries would require less frequent replacement but are larger and heavier to transport, and solar panels can be highly effective but require areas with ample sun exposure.

The mini-audio amplifier provided substantial distortion-free volume in a compact size and was also inexpensive. Although the volume and broadcast distance was suitable for our purposes, more powerful speakers are available and could easily be substituted into the system for studies that require simulation of louder sounds, such as noise impact studies. Using more powerful speakers may decrease the life of the battery on each charge.

Although the components we used were inexpensive, commercially available components not designed for outdoor use, we experienced a lower frequency of equipment failure than we expected. The major cause of almost all equipment failure we observed was moisture. In arid study regions, moisture is unlikely to pose a significant problem and we expect that equipment failure would be low in such systems. In study regions with frequent rain or high humidity, steps to limit moisture penetration in equipment would likely decrease the frequency of equipment failure. We found that drilling holes to allow drainage of excess moisture in the containers provided an improvement; however, several varieties of weatherproof containers available through field equipment suppliers can provide additional protection from rain and humidity. Plastic covers are also available for the digital timers to cover the face of the timer, which would likely decrease timer failure due to moisture, because moisture appeared to enter the timers primarily through the opening around each button on the timer face.

Cost per broadcast unit decreased with the number of units we required because most parts were available at lower rates in bulk. The addition of more powerful speakers or a weatherproof container would increase cost per unit. Because the main cause of failure was moisture and the remaining part functioned well over the 2-yr study, a weatherproof container may be a practical option, as it will increase purchase costs per unit but may decrease the cost of replacing failed equipment.

Seasonal field technicians learned the requisite skills quickly. We found it was beneficial to review procedures on multiple occasions even after technicians knew how to assemble the units to ensure that technicians felt secure in their skills when working independently and to reinforce the importance of taking time to connect wiring correctly to avoid creating sparks and how to quickly and safely disconnect the wiring if sparks generated. Weekly maintenance visits were sufficient to detect equipment problems; in our case equipment failure in a broadcast unit was not problematic because each experimental unit contained 3 broadcast units so that $\geq$1 unit was functional in the event of equipment failure in the third. However, the number of units deployed and the frequency of maintenance visits will depend on the specific objectives of the research and field conditions.

MANAGEMENT IMPLICATIONS

Broadcasting sound in the field is being considered for a variety of management applications, such as use of conspecific or heterospecific vocalizations for attracting birds to suitable habitat areas. Our broadcast system can be easily adapted for many applications by fitting the systems with components specific to research needs, such as louder speakers or longer time of broadcast duration by using a battery with more capacity or attaching solar panels. Researchers investigating animal response to a sound need means of conducting rigorous field experimentation and managers interested in applying research findings to management approaches will need a reliable and customizable broadcast system; we suggest our system could be the foundation for such systems.

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