J. Raptor Res. 42(1):53–57

A Simple Artificial Burrow Design for Burrowing Owls

John H. Barclay
Albion Environmental, Inc., 1414 Soquel Avenue, No. 205, Santa Cruz, CA 95062 U.S.A.

Key Words: *Burrowing Owl*; Athene cunicularia; *artificial burrow*; *conservation*; *management*; *nest box.*

Western Burrowing Owl (*Athene cunicularia hypugaea*) population declines have increased the interest in strategies for management and conservation of the species (James and Espie 1997, Millsap et al. 1997, Holroyd et al. 2001). Among these strategies has been the construction of artificial burrows (AB) to increase nest burrow availability (Collins and Landry 1977, Poulin 2000, Smith and Conway 2005), mitigate effects of development projects (Trulio 1995, Smith and Belthoff 2001a), conserve individual colonies (Hjertaas 1997, Barclay 2007), facilitate reintroductions (Leupin and Low 2001, Martell et al. 2001, Poulin et al. 2006), enhance conservation (Wellicome et al. 1997, Smith et al. 2005), and enable research on aspects of breeding biology not easily studied in natural burrows (Henny and Blus 1981, Haug et al. 1993, Wellicome 1997, 2005, Poulin and Todd 2006). Maintaining populations of fossorial mammals is fundamental to maintaining nesting habitat for Burrowing Owls; however, AB can be an effective tool to facilitate Burrowing Owl management, conservation, and research.

Holroyd et al. (2001) recommended standardizing AB design and installation as a technique to enhance conservation of western Burrowing Owls. I describe a simple AB design that can be used for Burrowing Owl research, management, and conservation. Smith and Belthoff (2001b) experimentally tested Burrowing Owl choice of AB chamber size and tunnel diameter in Idaho, and my design conforms to Smith and Belthoff's (2001b) findings, using inexpensive, commercially available materials that require minimum modification to assemble into a functional AB. This design also includes a provision to protect the AB entrance so that when properly installed, the entrance is resistant to damage from agricultural machinery and live-

[1] Email address: jbarclay@albionenvironmental.com

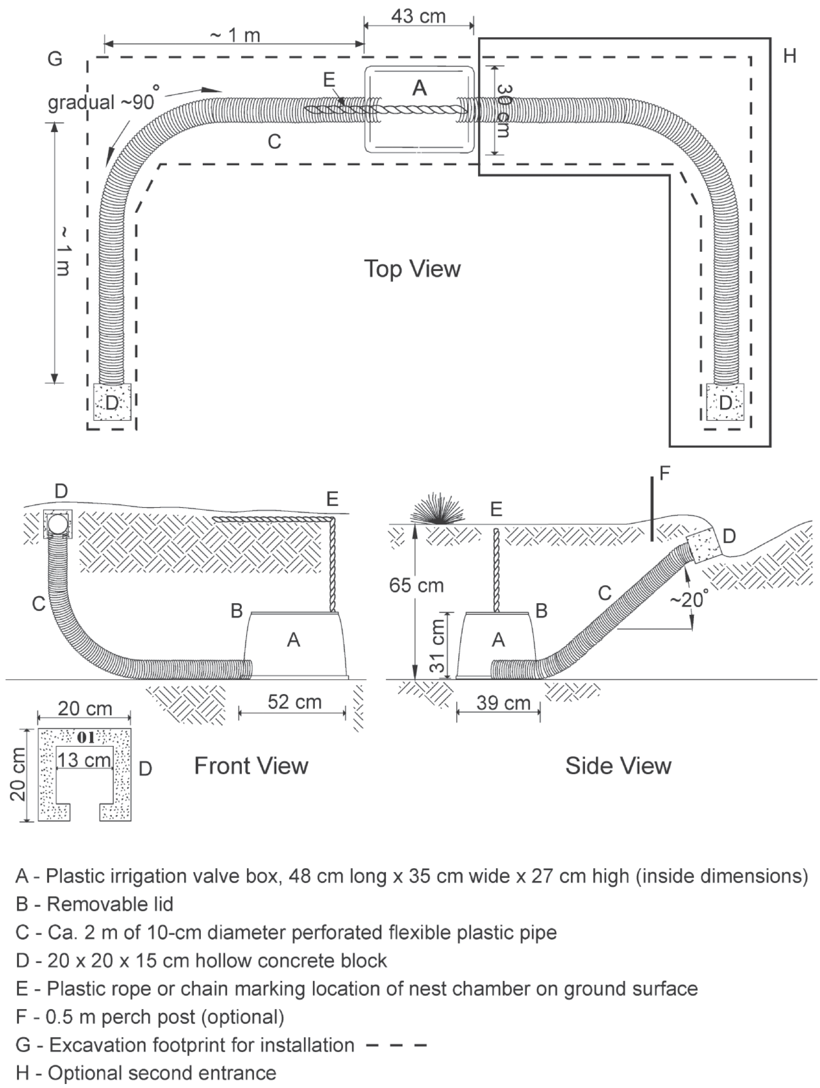

Figure 1. Materials and installation of an artificial burrow for Burrowing Owls in northern California, 1992–2006.

stock (Smith and Belthoff 2001b). Previous AB designs using wooden nest boxes are subject to rotting and collapse and can be time-consuming to construct (Collins and Landry 1977, Olenick 1987, Poulin 2000). Plastic buckets or pails installed as nest boxes (Faminow 1997, Smith et al. 2005) are subject to collapse from settling and shifting soil and do not provide the larger nest chamber (1750 cm^2) that Burrowing Owls in Idaho selected (Smith and Belthoff 2001b). My design further standardizes AB design (Holroyd et al. 2001), although additional research may reveal other improvements to this design.

METHODS

Materials and Construction. This AB is constructed from three commercially available components: a nest chamber made from an extruded plastic irrigation valve box with a removable lid (48 cm long × 35 cm wide × 27 cm high [interior dimensions], Orbit WaterMaster, model 53212, Salt Lake City, UT), 2 m of flexible, perforated plastic drain pipe with interior diameter of 10 cm (Olenick 1987), and one 20 × 20 × 15 cm hollow concrete block (i.e., an ''end block'') to anchor the tunnel pipe at the soil surface (Fig. 1). These materials are available at construction supply stores or irrigation equipment suppliers for approximately $20 (U.S.) per AB. Artificial burrows constructed according to this design provide 1680 cm^2 of nest chamber area and a 10-cm diameter tunnel, the diameter that was selected by Burrowing Owls in Idaho (Smith and Belthoff 2001b). The bottomless valve box provides a natural soil substrate in the nest chamber.

Because irrigation valve boxes with rigid sides (4–6 mm) are designed to be installed in the ground (ordinarily with the removable top flush with the ground surface) they will not deform from pressure exerted by settling soil. Compaction can distort and reduce the usable space inside a nest box made from less-rigid buckets or pails not designed to be installed underground (Faminow 1997). The materials for this AB will not deteriorate as will an AB chamber made from wood (Collins and Landry 1977, Olenick 1987, Poulin 2000). Advantages of AB compared to natural burrows include their resistance to collapse after heavy rain (Botelho and Arrowood 1996) and protection from mammalian predators (Faminow 1997, Wellicome et al. 1997). Valve boxes made of cast concrete (i.e., a ''Christy box'') can also be used for an AB chamber, but they are much heavier, cumbersome to transport, and more difficult to modify for the junction with the tunnel pipe. The only modification needed to prepare the materials I selected to make an AB is to cut an opening to accommodate the tunnel pipe in the bottom of one of the 35-cm wide sides of the valve box (Fig. 1). For safety reasons, it is essential to cut the tunnel opening from inside the valve box with a hand-held electrical jig or scroll saw, not a reciprocating cut-off saw. Because of the molded lip around the outside perimeter of the valve box there is an increased risk of breaking saw blades and personal injury if the cut is made from outside the box. The cut should be marked on the inside surface of the box using a short length of 10-cm pipe as a template. A two-entrance AB can be made by cutting a second opening in the opposite side of the valve box (Fig. 1).

Installation. I installed 150 AB of this design in northern California in such a way that they resemble the configuration of natural burrows and maintain level soil surfaces that do not inhibit mowing and other local land management practices (e.g., livestock grazing). An AB may be installed aboveground by assembling the components on the ground and piling soil on top of the burrow(s) to create a mound or berm to cover multiple burrows (Collins and Landry 1977). However, small steep-sided mounds or berms can inhibit mowing immediately around the burrow entrance, which promotes taller vegetation, thereby reducing the owls' ability to see and, thus, the habitat suitability (Haug et al. 1993).

The hole for an AB may be dug with hand tools, with a tractor-mounted excavator (i.e., a backhoe), or with a trenching machine. The excavation is L-shaped with the nest chamber at the end of the bottom of the ''L'' and the tunnel extending to the top of the ''L'' (Fig. 1). The excavation for the nest chamber should be approximately 2 m long, 40 cm wide, and 65 cm deep, which will result in the top of the nest box being situated approximately 34 cm below the soil surface (Fig. 1). The depth should be adjusted depending upon local soil conditions, especially drainage. A second excavation, 1 m long and 20 cm wide, perpendicular to the nest chamber hole, should be dug to accommodate the remaining length of the tunnel. This excavation should slope gradually up to the soil surface where the entrance is placed (Fig. 1). Soil at the inside of the intersection of the two excavations should be removed with hand tools to enable a gradual 90° bend in the tunnel pipe (Fig. 1). For a two-entrance AB, a second excavation should be made perpendicular to the hole for the nest box, so the resulting excavation is U-shaped, with the nest box at the bottom of the U (Fig. 1).

The AB is assembled by inserting the tunnel pipe into the cutout in the valve box from below, and placing the assembly in the bottom of the primary excavation. The tunnel pipe is inserted into the cutout such that ca. 5 cm of the pipe extends into the box (Fig. 1). If the cutout is precise, the tunnel pipe will fit snugly into the cutout with the walls of the box fitting between ribs of the pipe, thus securing the pipe and box together. Soil should be placed under and around the sides of the pipe-box connection so that the pipe is not dislodged when the excavation is backfilled with soil.

The hollow concrete end block placed over the end of the pipe at the soil surface anchors the entrance of the pipe in place and minimizes damage by mowing equipment, livestock, or mammalian predators. The concrete block provides a more secure and more enduring way to anchor and protect the tunnel entrance than do stakes holding the pipe in place (Faminow 1997). In my experience, after a few years, AB installed without this feature became unusable for Burrowing Owls because the entrances were crushed or dislodged (Smith and Belthoff 2001b). Soil erosion around an unprotected AB tunnel pipe can eventually cause the pipe to protrude from the ground in such a way to inhibit access by nestling owls (Smith et al. 2005). The block is positioned so its face is approximately 15° from vertical (Fig. 1). This creates a shallow basin, similar to the basin that usually forms around the entrance of a natural burrow (Poulin et al. 2005), and minimizes damage by heavy equipment rolling directly on the edge of the block. It is also important to install the entrance block such that the top edge of the block is 8–10 cm below the soil surface (Fig. 1), which provides additional protection against damage by heavy machinery. To facilitate the recording of nesting data, I spray-painted an identifying number or letter on the face of the block using a stencil (Fig. 1).

Attaching a 1.5-m length of nonbiodegradable rope or chain to the hole in the removable lid facilitates location of the nest chamber if the AB must be accessed to monitor reproduction and/or band owlets (Fig. 1). The nest box may be located by finding the marker rope or chain and digging with hand tools along it to the lid of the box. In areas frequently mowed, it is important to bury ropes $\leq$5 cm below the surface so they will not become entangled in and cut by mowers.

RESULTS AND DISCUSSION

Occupancy and Nest Success in Artificial Burrows. Occupancy of AB of this design by Burrowing Owl pairs at the beginning of the nesting season at Mineta San Jose International Airport (SJC) in northern California from 1992–2006 averaged 32%; 155 occupied AB of 479 AB-years (an AB-year is an AB available for one nesting season; Barclay 2007). Occupied burrows were those where two adults were observed on more than one occasion during the nesting season. The percentage of occupied AB of this design at SJC from 1992–2006 where ≥1 nestling was raised was 84% (130 of 155 occupied AB) compared to 75% for occupied natural burrows (109 of 146 occupied natural burrows, Barclay 2007).

Maintenance of Artificial Burrows. This AB design requires very little maintenance, especially if Burrowing Owls regularly use them. Owls usually perform shallow maintenance excavation in front of occupied burrow entrances that produces a basin and apron of cast soil that is typical of natural burrows (Poulin et al. 2005, Fig. 1). Approximately 10% of AB of this design at SJC (500 AB-years) required annual maintenance because valley pocket gophers (*Thomomys bottae*) filled the tunnels and nest chambers with soil. Soil in the first 0.5 m of the tunnel was removed with hand tools. Tunnels and nest boxes that became completely filled were removed and replaced.

Modifications. This design may be built with a 15-cm diameter tunnel or with two entrances, both of which provide additional escape cover for nestlings (Poulin et al. 2005). However, the larger-diameter tunnel will not fit in the concrete block, which is an important feature of this design. Furthermore, larger diameter tunnels may make the nest chambers more accessible to small mammalian predators. A compromise modification that provides a larger diameter entrance, yet maintains the 10-cm tunnel diameter, would be the attaching of a commercially available pipe-diameter-reduction fitting to the tunnel entrance. Such a fitting has a 15-cm diameter opening that narrows to 10 cm to fit in the tunnel pipe (J. Lincer pers. comm.). Another modification to provide a larger diameter entrance and yet also protection against digging mammals is the installation of the entrance end of the tunnel pipe inside a 1.5-m piece of rigid plastic pipe with a 15-cm diameter. The narrower pipe is partially inserted into the wider pipe, leaving 0.5 m of the wider pipe at the tunnel entrance. The smaller pipe is held in place inside the larger pipe by filling the space between the two pipes with aerosol foam insulation applied through 1-cm holes drilled along the length of the larger pipe (G. Clark pers. comm.).

Another modification to protect the entire AB from excavation by feral dogs or other canids is to cover the entire AB (chamber, tunnel and entrance) with a piece of chain-link fence. The fence is laid flat in a shallow (8–10 cm) excavation over the entire AB and 0.75 m on all sides and covered with soil. The opening in the fence where it rests over the tunnel entrance should be enlarged with hand tools.

Access to the nest chamber by mammals digging from below (Poulin 2000) may be minimized by covering the bottom of the nest chamber with 1.3 × 2.5 cm welded wire screen prior to installation. Concern that the tunnel opening inside the nest chamber may become obstructed with soil and nest decoration material can be addressed by installing the pipe such that there is ≤4 cm between the bottom of the pipe and the bottom of the nest box; this can be accomplished by cutting a deeper (≤14 cm) opening in the nest box. Cleaning of tunnel pipes that are frequently filled with soil by pocket gophers may be facilitated by building the AB with a shorter tunnel (1.5 m). Repeated access to the nest chamber to monitor reproduction can be eased by placing a woven plastic bag (e.g., the type used to package livestock feed) filled with sand or small gravel on top of the nest chamber lid before the excavation is backfilled, thus minimizing the amount of soil that must be moved to inspect the nest chamber at each visit.

UN DISEÑO SIMPLE DE MADRIGUERAS ARTIFICIALES PARA *ATHENE CUNICULARIA*

RESUMEN.—Las madrigueras artificiales han sido empleadas para facilitar el manejo, la conservación y la investigación de *Athene cunicularia*. Para promover la estandarización de su diseño, diseñé una madriguera artificial simple, hecha con materiales poco costosos y comúnmente disponibles, que requieren pocas modificaciones. La madriguera artificial fue hecha usando una caja de una válvula de irrigación de 48 cm de longitud, 35 cm de ancho y 25 cm de alto (dimensiones internas), un tubo flexible de sifón plástico perforado de 2 m de longitud, y un bloque de concreto hueco de 20 × 20 × 15 cm que fue ubicado sobre la entrada del túnel para protegerla de daños causados por equipos agrícolas y ganado. La única modificación necesaria para construir una madriguera artificial utilizando estos componentes fue cortar una abertura de 10 cm de diámetro en un lado de la caja. Este diseño incorporó un túnel de 10 cm de diámetro y una cámara de nidificación más grande, similar a aquellas seleccionadas por *A. cunicularia* para nidificar en Idaho (Smith y Belthoff 2001, *J. Wildl. Manage.* 65:318–326). La construcción de la madriguera artificial consistió en ubicar los componentes ensamblados en una excavación de 65 cm de profundidad, y en llenar ésta con tierra para dejar una superficie del suelo nivelada por encima de la madriguera. La entrada a la madriguera artificial fue protegida insertando el tubo en un bloque de concreto que se instaló 8–10 cm por debajo de la superficie del suelo.

[Traducción del equipo editorial]

ACKNOWLEDGMENTS

I thank J. Diehl and S. D'Oro for preparing the figure. D. Plumpton made useful suggestions on an earlier draft of this paper. I appreciate the editorial suggestions of B. Smith and R. Poulin who reviewed an earlier draft and made many suggestions that improved this manuscript.

LITERATURE CITED

BARCLAY, J.H. 2007. Burrowing Owl management at Mineta San Jose International Airport. Pages 146–154 *in* J.H. Barclay, K. Hunting, J.L. Lincer, J. Linthicum, and T.A.

Roberts [EDS.], Proceedings of the California Burrowing Owl symposium, November 2003. Bird Populations Monographs No. 1. The Institute for Bird Populations and Albion Environmental, Inc., Point Reyes Station, CA U.S.A.

BOTELHO, E.S. AND P.C. ARROWOOD. 1996. Nesting success of western Burrowing Owls in natural and human-altered environments. Pages 61–68 *in* D. Bird, D. Varland, and J. Negro [EDS.], Raptors in human landscapes: adaptations to built and cultivated environments. Raptor Research Foundation and Academic Press, London, U.K.

COLLINS, C.T. AND R.E. LANDRY. 1977. Artificial nest burrows for Burrowing Owls. *N. Am. Bird Bander* 2:151–154.

FAMINOW, C.W. 1997. Predator-resistant nestboxes for Burrowing Owls. *Alberta Nat.* 26:8.

HAUG, E.A., B.A. MILLSAP, AND M.S. MARTELL. 1993. Burrowing Owl (*Speotyto cunicularia*). *In* A. Poole and F. Gill [EDS.], The birds of North America., No. 61. The Academy of Natural Sciences, Philadelphia, PA and the American Ornithologists' Union, Washington, DC U.S.A.

HENNY, C.J. AND L.J. BLUS. 1981. Artificial burrows provide new insight into Burrowing Owl nesting biology. *Raptor Res.* 15:82–85.

HJERTAAS, D.G. 1997. Operation Burrowing Owl in Saskatchewan. Pages 112–116 *in* J.L. Lincer and K. Steenhof [EDS.], The Burrowing Owl, its biology and management including the proceedings of the First International Burrowing Owl Symposium. Raptor Res. Rep. 9.

HOLROYD, G.L., RODRÍGUEZ-ESTRELLA, AND S.S. SHEFFIELD. 2001. Conservation of the Burrowing Owl in western North America: issues, challenges, and recommendations. *J. Raptor Res.* 35:399–407.

JAMES, P.C. AND R.H.M. ESPIE. 1997. Current status of the Burrowing Owl in North America: an agency survey. Pages 3–5 *in* J.L. Lincer and K. Steenhof [EDS.], The Burrowing Owl, its biology and management including the proceedings of the First International Burrowing Owl Symposium. Raptor Res. Rep. 9.

LEUPIN, E.E. AND D.J. LOW. 2001. Burrowing Owl reintroduction efforts in the Thompson-Nicola Region of British Columbia. *J. Raptor Res.* 35:392–398.

MARTELL, M.S., J. SCHLADWEILER, AND F. CUTHBERT. 2001. Status and attempted reintroduction of Burrowing Owls in Minnesota. *J. Raptor Res.* 35:331–336.

MILLSAP, B.A., M.I. BELLOCQ, AND M. MULLENIX. 1997. Pages 6–10 *in* J.L. Lincer and K. Steenhof [EDS.], The Burrowing Owl, its biology and management including the proceedings of the First International Burrowing Owl Symposium. Raptor Res. Rep. 9.

OLENICK, B. 1987. Reproductive success of Burrowing Owls using artificial nest burrows in southwestern Idaho. *Eyass* 10:38.

POULIN, R.G. 2000. Burrowing Owl nest box: construction and installation procedures. Saskatchewan Environment and Resource Management, Fish and Wildlife Branch, Regina, Saskatchewan, Canada.

——— AND L.D. TODD. 2006. Sex and nest stage differences in the circadian foraging behaviors of nesting Burrowing Owls. *Condor* 108:856–864.

———, ———, K.M. DOHMS, R.M. BRIGHAM, AND T.I. WELLICOME. 2005. Factors associated with nest- and roost-burrow selection by Burrowing Owls (*Athene cunicularia*) on the Canadian prairies. *Can. J. Zool.* 83:1373–1380.

———, ———, T.I. WELLICOME, AND R.M. BRIGHAM. 2006. Assessing the feasibility of release techniques for captive-bred Burrowing Owls. *J. Raptor Res.* 40:142–150.

SMITH, B.W. AND J.R. BELTHOFF. 2001a. Burrowing Owls and development: short-distance nest burrow relocation to minimize construction impacts. *J. Raptor Res.* 35:385–391.

——— AND ———. 2001b. Effects of nest dimensions on use of artificial burrow systems by Burrowing Owls. *J. Wildl. Manage.* 65:318–326.

SMITH, M.D. AND C.J. CONWAY. 2005. Use of artificial burrows on golf courses for Burrowing Owl conservation. *USGA Turfgrass Environ. Res. Online* 4(9): 1–6.

———, ———, AND L.A. ELLIS. 2005. Burrowing Owl nesting productivity: a comparison between artificial and natural burrows on and off golf courses. *Wildl. Soc. Bull.* 33:454–462.

TRULIO, L.A. 1995. Passive relocation: a method to preserve Burrowing Owls on disturbed sites. *J. Field Ornithol.* l66:99–106.

WELLICOME, T.I. 1997. Reproductive performance of Burrowing Owls (*Speotyto cunicularia*): effects of supplemental food. Pages 68–73 *in* J.L. Lincer and K. Steenhof [EDS.], The Burrowing Owl, its biology and management including the proceedings of the First International Burrowing Owl Symposium. Raptor Res. Rep. 9.

———. 2005. Hatching asynchrony in Burrowing Owls is influenced by clutch size and hatching success but not by food. *Oecologia* 142:326–334.

———, G.L. HOLROYD, K. SCALISE, AND E.R. WILTSE. 1997. The effects of predator exclusion and food supplementation on Burrowing Owl population change in Saskatchewan. Pages 487–497 *in* J.R. Duncan, D.H. Johnson, and T.H. Nicholls [EDS.], Proceedings of the second international symposium of the biology and conservation of owls of the northern hemisphere. USDA Forest Service Gen. Tech. Rep. NC-190, St. Paul, MN U.S.A.

Received 14 December 2006; accepted 26 July 2007