An Electric Fence for Increasing the Nesting Success of Freshwater Turtles: Additional Installation and Maintenance Recommendations

Gregory A. Geller

County Hwy C, North Freedom, Wisconsin 53951 USA (ggeller54@gmail.com)

Please refer to the publication (GELLER, G.A. 2012. Reducing predation of freshwater turtle nests with a simple electric fence. Herpetological Review 43:398-403.) or contact me for fence development background data, costs, performance, or additional information.

Overview.— Fences incorporate one electrified ("hot") 17-gauge fencing wire set at a height of 10 inches above the substrate serviced by a solar-powered charger (e.g., Parmak DF-SP-LI, 1.4 joules, Fig. 1) and two non-electrified strands of 5/32-inch-diameter, green vinyl clothesline (containing a wire core to reduce rabbit [Leporidae] damage) set directly below at six and eight inches (Fig. 2). A lightweight wire fence (e.g., garden fencing designed to exclude rabbits) underlies the entire perimeter to ensure electrical grounding. Attached bait packets potentially aid the exclusion of smaller raccoons and other predators.

Figure 1. Solar fence charger

Figure 2. Fencing scheme: hot line at 10 inches above substrate, wire-core clotheslines at 6 and 8 inches, bait packet, lightweight wire fence grounding screen (here, without design enhancements, see text, pg. 4).

Basic site preparation and installation. — Preliminary to fence installation, clear the planned perimeter of coarse vegetation with a metal garden rake and level, as needed, using a length of two-by-four lumber, then tamp to a reasonable firmness by foot. Lay a non-clad, light wire fence (e.g., 28-inch, Red Brand® Poultry and Rabbit fence) on this prepared perimeter, with the smaller mesh to the outside, and secure firmly to the substrate with staples at least 8 inches in length, hand-made from stiff wire (6-inch landscape fabric staples do not work well enough for this purpose on sandy substrates). Roll out the fence screen such that it springs up, not down, during installation to facilitate a closer attachment to the substrate and reduce the need for as many wire staples. Use fencing wire to sew together adjoining pieces of this ground fence (hereafter referred to as the screen ground) to ensure a continuous electrical grounding connection. Construct the electric fence itself with standard metal support rods and plastic insulators and position midway over the screen ground.

Support the fencing rods at corners and significant bends in the perimeter by looping short lengths of fencing wire around nearby supporting metal t-posts to allow for significant hand tensioning of the strands. A t-post close to the terminus of the fence, nearest the charger, is also used as a tie-off for the rope strands (see Fig. 3). Attach electric fence warning signs to each side of the fence at ≤ 50-foot intervals.

Install the fence charger on a wooden post approximately 10 feet from a chosen fence corner. Run a length of insulated electric fencing hook-up wire (Fig. 3 “A”) from the output terminal (red) of the charger (Fig. 3 “B”) through, and slightly beyond, a plastic clamp support (made for electric fencing tape; Fig. 3 “C”) attached to a t-post a couple of feet from the fence corner. (Note: all connection points with hook-up wires need to be stripped of the covering insulation.) Attach this hook-up wire to one end of an electric tape splicer (a small, metal rectangle with square holes; Fig. 3 “D”) and wrap/secure the start of the electrified line (“hot”) to the other end of the splicer, elevated off the ground surface and away from the t-post via the plastic clamp. Route the hot line through the top corner insulator (Fig. 3 “E”), complete the perimeter, exit this same insulator, and securely reconnect to the tape splicer.

Securely tie the green clothesline to this same t-post (Fig. 3 “F”), route through the upper 8inch insulators beginning at the starting corner, drop to the lower 6-inch insulators at the completion of this first series (Fig. 3 “G”), route through the 6-inch insulators and then exit the starting corner and securely tie again to the t-post. Alternately, clotheslines can be attached as separate series, one above the other, with each starting and ending at the t-post. (Note: in many cases, clothesline lengths will have to be spliced together to accommodate the perimeter distances. Try to purchase as long a length as possible to avoid unnecessary splices.)

Connect a single length of insulated hook-up wire to the screen ground (Fig. 3 "H"; which is continuous under entire fence perimeter but not shown as such in the figure) by stripping ~ 1 inch of the wire coating from one end and coiling tightly around (use pliers) any screen ground wire, typically near the starting corner. Run this hook-up wire to an eight-foot, galvanized ground rod (Fig. 3 "I") and connect using a standard attachment clamp (at this connection ~ 1 inch of the hook-up wire will need to be stripped of its insulation) and then connect to the ground terminal (black) of the charger (Fig. 3 "J"). Turn the charger on, check for audible clicking of the electrical pulses, and confirm output voltage with testing meter (typically ~ 6–9 kilovolts [KV]).

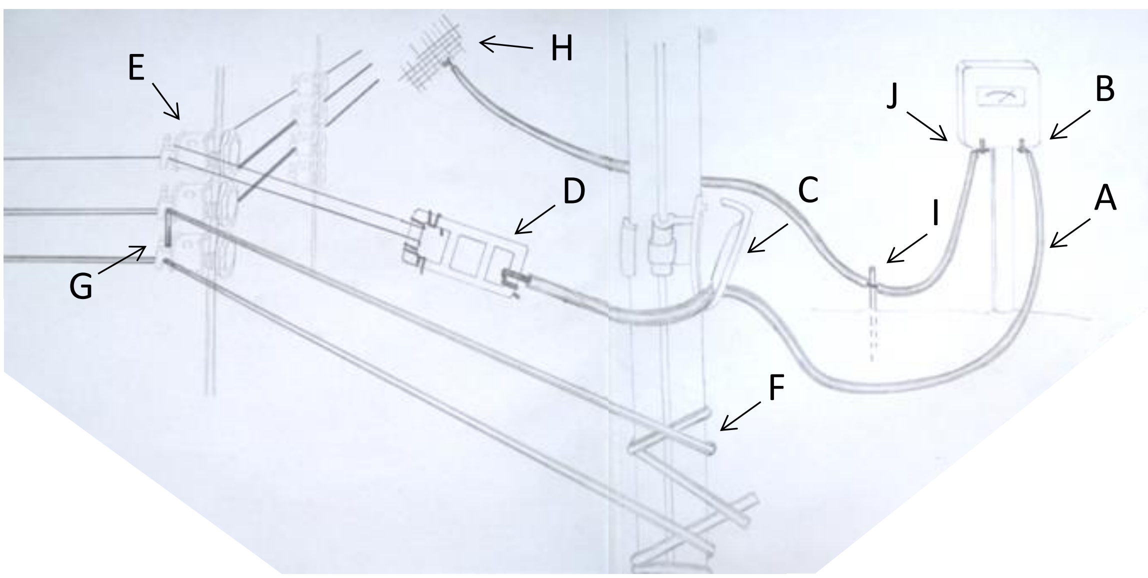

Figure 3. Fence components and connections diagram. (See text for details. Not all components drawn to same scale.)

ADDITIONAL IMPLEMENTATION AND MAINTENANCE SUGGESTIONS

Fence Installation and Maintenance.— Maintenance of fence strand height settings is necessary for effective raccoon exclusion. Some preparation of the ground surface at the fence perimeters will likely be necessary to allow setting the fence strands at reasonably uniform heights (as above). Provide for remaining substrate slope changes with adequate numbers of fencing rods or by filling in low areas so that the ground-to-strand distances are consistent and held to design specifications. If the topography at a core nesting area makes it difficult to maintain uniform ground-to-strand distances, it may be advisable to find easier ("flatter") working conditions peripheral to this area to establish the fence perimeter.

Another approach to enhance fence height uniformity is to lay in a running length of 2x6" or 2x8" treated lumber, on edge, centered under the entire, planned fence perimeter and flush with the ground surface (Bob Hay, *pers. comm*.). Ideally these components have ~ 3/8-inch holes already drilled at pre-planned positions (e.g., every 12 feet) to allow the fencing rods to be inserted through them (inserted spade down, up through the lumber during burial). Once the soil is repacked around the buried lumber, pound the fencing rods into the soil to working heights (~ 15 inches above substrate). After this, landscape fabric (≥ 3-ft wide) can be laid down, centered over this structure, by carefully puncturing the fabric with the inserted fencing rods as it is lowered to ground level. The screen ground fence is then installed atop the landscape fabric, using wire staples, as described. By significantly reducing fence height variations and eliminating weeding needs under the perimeter, these additions greatly reduce (but do not eliminate) the need for regular site-check visits and idealize the fence design.

Periodic inspections at prudent site-specific intervals, based on experience, are necessary to check the working condition of the charger, clear the fences of any debris (prevent shorting) and otherwise maintain the fences at proper working condition. Weekly inspections were found more than adequate for the relatively small-length fences used in the original study (perimeter lengths of ~ 100 feet). Once installed, fence strands seldom needed height re-positioning, however, a screwdriver placed into the wire loops at the t-posts supporting the corner fencing rods and rotated can be used to draw the fence wires and rope lines taut and restore reasonably firm tension when necessary. Another design enhancement to maintain line heights is to use cut lengths on ½inch PVC pipe as spacers between the insulators holding the three fence strands.

Screen ground maintenance may also be occasionally required, mostly in the first few weeks after installation to ensure a firm attachment to the substrate as the system molds to perimeter contours. Installation of additional wire holding staples may be periodically needed, as well as broom sweeping or gently raising and lowering the screen ground to re-expose it after significant rains, etc., especially if landscape fabric is not used. Inspection after heavy rains is also recommended to correct any erosion problems.

Longer perimeters increase the chances for predator breaches due to more chances for inconsistencies in strand height-to-substrate spacing, electrical shorting via fallen branches, rain wash gullies, etc., and thus require more attention to maintenance. Smaller, well-protected nesting areas are preferred to larger, less protected ones, unless due stewardship can be ensured. In many cases, protection of large nesting areas may be enhanced by using several smaller exclosures rather than one, all powered by one charger and connected in “parallel” (i.e., each with its own hot line connection to the metal tape splicer via a running length of insulated hook-up cable; not one after another in “series”).

Fence Charger Unit and Screen Ground System. — High charger KV outputs are generally recommended for predator exclusion fences and the solar 1.4 joule Parmak units used in the original study performed well for this purpose. Care should be taken to utilize chargers that maintain constant pulse discharge rates, not those that reduce the pulse rate at night. While this power-saving measure suffices to contain livestock, it may allow greater fence breaching by nocturnal mammalian predators.

Users should also note that high KV readings on a fence tester unit do not always translate into the shock perceived by a predator. In addition to the initial pulse strength (~ joules) delivered by the charger, the type of material in fence contact (e.g., fur, soft tissue) and grounding conditions from the land to the ground rod (e.g., type of substrate, moisture) determine shock effectiveness. Turtle nesting sites are often well drained and droughty, being typically located on sandy loam or sand substrates: a situation that poses well-known problems for grounding electric fences. Extensive data from pilot studies and off-site experiments demonstrate that the screen ground, while adding to the initial set-up labor, is necessary to conduct an effective shock on substrates with a significant dry sand component. Nesting substrates other than sands, commonly holding more moisture and being more electrically conductive, may reduce the need for grounding screens. Nonetheless, this fence grounding system has efficiencies in being continually and reliably effective at transmitting the full discharge potential of the charger under a wide range of substrate and soil moisture conditions.

Fence Baiting. — Note: this practice is generally not needed to exclude adult raccoons; camera data from off-site fence tests show that raccoons can be shocked by this fence scheme without the use of bait. Given that raccoons are typically the most important mammalian predator of turtle nests, and since baiting adds costs and recurring effort to fence management, some users may wish to lessen the intensity of baiting (e.g., fewer bait stations) or forego using it entirely, depending on existing time and personnel constraints. However, the impact of this approach on nest survival needs to be assessed on a case-by-case basis and is likely context-dependent on the predator species frequenting the site.

Fence baiting may help in the exclusion of small or young raccoons and other small predators not likely to make contact with a hot line placed 10 inches above the substrate. The method here results in baits presented at ~ 4 inches above the ground while posing essentially no risk to turtles because of the positional unlikelihood of maintaining prolonged contact. As with the fence itself, initiating fence baiting a short period before the expected nesting period begins is recommended, as this may instill early fence avoidance behaviors in the local predator community and reduce the loss of the first turtle nests. Season-long fence baiting is the most comprehensive approach, as it best addresses possible differences in predator species presence through the season and potential predation during the hatching period.

In this method, two-inch-square pouches made of 1/8-inch galvanized hardware cloth wrapped vertically with a 3/4-inch-wide strip of aluminum foil (serving at a potential visual attractant) are used to "bait" the fence (Fig. 2). Pouches either contain materials (e.g., dry cat food) or have approximately ½ teaspoon of paste bait (e.g., "Grubstake" skunk bait, Jameson's Ultra Blend, Daisytown, Pennsylvania, USA) applied to the wrapped foil strip. The foil strips are wound around bait pouches such that an inch or so of excess provides a suspended roof over the applied bait. Pouches are attached to the hot strand, and thus electrified, by a short length of fencing wire wound around the electrified strand, then routed one inch away from the fence rod at the top insulator to prevent shorting and threaded through outside holes (already present) in the three insulators holding the fence strands. Another insulator positioned below these three, at four inches off the substrate, serves as a backing for the bait pouch and prevents electrical shorting. Bait pouches are attached to the connecting leads using ½-inch binder clips at ten- to thirteen-foot intervals and positioned close to the outside surfaces of the backing insulators.

Plastic knives work well for scraping off the old paste baits and applying new material at bait replacement intervals. Bait change-out is facilitated by using a 5-gallon bucket as a materials and refuse carrier. While baits were changed out at two-week intervals regardless of intervening weather in during the original study, users may find experimentation with different intervals or bait materials of value, especially in the case of small mammalian predators, which were not effectively excluded from the study fences. Although efforts should be made to remove baiting-related refuse from nesting sites, fence baiting itself is not likely to attract additional raccoons or smaller predators to fenced areas (Bob Jameson, Jameson's Ultra Blend Scent Co., Daisytown, Pennsylvania, USA, *pers. comm*.). If hornets (Vespidae) actively search out and consume baits in late summer, the foil ends containing the applied bait can be placed within the pouches, preventing access. This method can also be used if high on-site temperatures cause the bait to slide off the foil strips.

Important: It is advisable to use nitrile gloves, or similar, when handling bait packets to counter potential rabies and other wildlife disease transmission risks.

Fence Implementation Timelines. — It is recommended that fences be enabled and maintained from a couple of weeks prior to the typical local turtle nesting period through the expected nest emergence period, if known. In northern climates, maintaining protection until ground freeze is a conservative approach that eliminates the need to determine hatching periods. It may also be prudent to re-enable the fences in early spring to enhance survival of hatchlings of species that overwinter in the nest when these are believed to have used the site. In more moderate climates, especially where nesting timelines are less seasonal and well-defined, it may be desirable to keep the fences enabled for longer periods, perhaps continually.

Alternately, while it was not tested in the original study, it may be possible to protect nests by covering nesting areas with mesh screening (e.g., 1 x 2-inch wire fencing) from the end of the laying period up to shortly before, or possibly even through, hatchling emergence in locations with well-defined nesting seasons. This would allow the fences to be disabled after the nesting period *per se*, resulting in reductions in maintenance labor and baiting materials costs.

While potentially effective in some settings as a protection method during this interval (S. Parren, Vermont Fish and Wildlife, *pers. comm*.) practitioners should nonetheless assess the value of this approach after considering evidence of hatchling entrapment or dispersal hindrance due to the overlying screening and other related negative effects, if any, found in practice.

Potential for Fence Design Improvements.—While the fences were generally effective in reducing raccoon access to turtle nests, the breaches that did occur suggest that improvements in the design would be desirable—probably mostly focused on small predators and involving baiting materials and replacement intervals. Ongoing considerations in any strand-spacing alterations need to encourage predators to make hand or other soft-tissue contact with the hot line by tempting them to go over, rather than under, all three strands. Thus, adding more lines above the one set at 10 inches is not advised as this may discourage over-the-top breach attempts.

Lowering the bottom clothesline strand to five inches, while leaving the hot line in place at 10 inches, may help discourage under-the-fence breaches by raccoons and enhance fence exclusion success, and would be especially practical where large species (e.g., snapping turtles [*Chelydra*], some *Pseudemys*) are not commonly present. In areas where the geographic races of raccoons tend to be small, it may be worthwhile to experiment with lowering the hot line to 9 inches above the ground and placing the clothesline strands at 5 and 7 inches (while keeping vigilant about large turtle impacts at these settings) or, where large turtle species are absent, placing the hot line at 8 inches and a single clothesline strand at 4½ or 5 inches. (Note: if the top line is too low for typically-sized local raccoons, individuals may simply walk over it without need to touch it with their hands, reducing the potential to deliver teaching shocks.)

The species composition of the local predator community, as well as the timing of their on-site presence, will influence protection results. For example, protection levels may differ from those obtained in the original study if skunks are commonly present during nesting periods. Likewise, predation by feral pigs (*Sus scrofa*), armadillos (*Dasypus novemcinctus*), foxes (e.g., *Vulpes vulpes*), fish crows (C*orvus ossifragus*) and other species (and size-differing geographical races) not encountered in the original study may also produce different results, again prompting locally tailored modifications of the fencing scheme.

Management Caveats.— **Given their critically important reproductive value, users must retain a focus on not endangering adult female turtles and be cautious about lowering the hot line below 10 inches.** Turtles in contact with electric fences may suffer pathological effects if shell depths exceed fence clearances such that non-relieved contact persists. By design, the placement of the hot wire at 10 inches off the substrate in the standard scheme greatly reduces the likelihood of pathological fence contact for all non-marine North American turtle species except alligator snapping turtles (*Macrochelys temminckii*) and sea turtles (Chelonioidea). For this reason, the fences described here should not be used where these species are known or suspected to occur, unless effective approach-blocking mechanisms (e.g., size-filtering barrier fences) can be installed.