Penalties for Violations: Any person violating any of the emergency restrictions set forth above shall be subject to the following fines:

- First Violation: $25
- Second Violation: $59
- Third Violation: $100
- Subsequent Violations: $200

No special permits will be issued for the purpose of irrigating newly installed landscaping, lawns and/or trees.

自然的唤醒时刻：旱獭警报

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编辑注：作者是生态学和进化生物学的博士，研究旱獭在北美洲的活动。

旱獭在寻找食物时，经常发出召唤声。这些叫声的目的是什么？它们是否有助于旱獭？这项研究有助于我们更好地了解这些动物。旱獭的这些行为可能是在保护自己的家园。

Did you ever find yourself hiking or riding around the backcountry wondering, why on earth are those marmots screaming at the top of their lungs? I had the same question a few years ago. The loud whistle-like chirps that our local yellow-bellied marmots emit when they are scared are referred to as alarm calls. I’ve spent much of a career studying the structure and function of these vocalizations. Why would someone want to study rodent squeaks? One reason is because they illustrate an evolutionary paradox.

Alarm calls, because they are so loud and easily localizable, should make it easier for predators to locate a caller. I routinely locate marmots after hearing them call. Coyotes do the same thing. Calling is thus a risky behavior because it may increase the likelihood of a caller getting killed. The paradox is why should an individual do something risky when it could just as easily quiet its way into the burrow. There are several possible solutions to this problem.

First, callers could direct their calls to the predator. Most predators require stealth to locate a caller. I recently took marmots and noting how they communicated risk; their calls do not denote specific predators. I did not find this. Rather, in all of the eight species I studied, I found that there are a remarkable diversity of ways that marmots can communicate risk.

Second, callers could direct their calls to conspecifics—other members of their own species. Calls directed to conspecifics could have several possible functions. They could create pandemonium. Imagine you’re a predator and you’re trying to focus on an elusive prey and suddenly your entire visual field erupts in running prey. Kinda hard to stay focused on your initial target, huh? Well that’s the idea behind the pandemonium hypothesist by calling, callers get other individuals to run around making it hard for the predator to kill the caller. A modification of this could be seen when animals hearing an alarm call then call in response. Researchers have watched marmots move away from the entire meadow as soon as an alarm call is heard.

Third, callers could direct their calls to specifically warn conspecifics. This function involves a slightly different emphasis because it involves doing something risky to help others. Darwinian logic says that such behaviors should not evolve unless the caller benefits in some way from doing this. If the conspecifics warned are relatives, callers may obtain indirect fitness (i.e., by calling, they will save the genes they share with their relatives). Some species engage in complex Darwinian algebra where they vary the likelihood of calling as a function of the exact degree of relatedness to vulnerable conspecifics. Call most if you’re warning your kids. Call a bit to warn nieces and nephews or cousins. Call less when you warn second cousins. Don’t call to warn strangers.

With all of these possible functions, what do yellow-bellied marmots do? My research has demonstrated that callers do warn relatives, but mostly it’s mothers warning their vulnerable offspring. Mothers uniquely call more often the vulnerable offspring have emerged above ground. Older cousins don’t increase the likelihood of calling then, nor do uncles or aunts. Calling, in yellow-bellied marmots, is primarily a form of maternal care. But other marmots do call. And sometimes marmots keep calling long after you think they should have stopped (ever been woken up in the morning by a marmot that calls, and calls and calls?). These patterns are consistent with the idea that marmots are communicating risk to their predators. I’ve yet not been able to identify the degree to which marmot alarm calls discourage attack (anybody got a trained coyote?), but by studying patterns of calling in 20 species of rodents, a student and I discovered that alarm calls initially evolved to communicate to the predators. Most likely to signal that they’ve been detected and thus that the predators should move on. The conspecific warning functions of calling likely evolved after this initial function.
Nature’s wake-up call

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Why would marmots be interested in the individual identity of callers? Some birds (like penguins) and mammals (like bats or seals) leave their young in a creche (a communal day care center) while they go off to forage. Upon return-
ing to the creche, they must re-unite with their young. There are good reasons in such systems for individuals to have distinctive vocalizations and for having the ability to differentiate individuals based solely on their vocalizations. But what about in alarm calling systems? Marmots don’t alarm call that much. They’re not territorial advertisement calls. Why would a marmot care who called?

We all know Nervous Nellies and Cool Hand Luries—individuals that are afraid of everything or virtually nothing. Moreover, Nervous Nelly is probably more likely to give false alarms, by calling in response to things that may not be threatening. If marmots per-
dictably varied in how likely they were to emit calls, then it would make sense for those who by responding would potentially interrupt a meal, to decide how to respond based on the callers’ reliability.

We set out to test the hypothesis that marmots are concerned about caller reliability by artificial-
ly making a hypothetical marmot a reliable caller, and making another marmot an unreliable caller. We did this by dragging RoboBadger out of retirement. We then broadcast alarm calls from one individ-
ual immediately after a tarp over RoboBadger was removed. Mar-
mots learned that calls from this individual were reliably associated with the presence of a nasty preda-
tor. We created an unreliable caller by broadcasting alarm calls from another individual on another occasion when RoboBadger was covered by a tarp. We found that upon later hearing calls from the reliable individual, mar-
mots looked up, but then quickly resumed eating (they spend a lot of time eating). Moreover, we found that when they later heard calls from the unreliable individ-

ual, they spent a lot of time inde-
dependently assessing the true risk.

This was a rather unexpected discovery because we expected that the reliable callers would elicit more independent investigation and that the unreliable individual would be ignored (remember the fable about the boy who cried wolf?). What we discovered, in fact, was a very different way that reliability matters in alarm-calling systems. Thus, the marmots expanded our knowledge about the diversity of ways that alarm-
calling systems could work.

How could individuals differ in their reliability? When we trap marmots they often defecate. We collect their feces and freeze them. Later, when marmots are hibernat-
ing, we extract hormonal metabo-
listies from their feces. Glucocorti-
coïds, like cortisol and corticos-
terone, are referred to as ‘stress hormones’ because they are emit-
ted when animals must fight or flee an impending threat. While these hormones are likely elicited when we handle marmots, digest-
ed hormones in marmot feces reflect the physiological state long before our trapping event. We used these hormones as an indica-
tor of the baseline levels of stress that different individuals had. It turns out that when an indi-
vidual was trapped and alarm called in the trap (they sometimes do this), they had systematically higher levels of glucocorticoid metabolites in their feces than on another occasion when they did not alarm call in the trap. Thus, systematic differences in baseline levels of stress hormones could explain why some marmots are Nervous Nellies while others are Cool Hand Luries.

So the next time you or your dog scares a marmot and she begins to alarm call, or the next time you’re throwing a snowball at a marmot who has just stolen your lunch after you’ve summited a high peak, I hope you’ll have a greater appreciation for the diver-
sity of animal signals and how marmots have played an impor-
tant role in our understanding of the diversity of animal communi-
cation.