

ethnically homogenous communities so as to avoid costs resulting from heterogeneity (15), and that heterogeneity of preferences among groups can promote lower contributions toward public goods on the level of entire countries (16). In addition, differences in returns to public goods can determine the interaction between ethnic diversity and the collective action necessary in order to bring about economic cooperation (17).

Our experimental findings thus replicate previous findings on the importance of the ability to sanction as a strong determinant of levels of public goods contribution. Our results enhance these previous findings by highlighting the need to focus on institutional contexts and by underlining the way that institutions condition both the role of ethnic diversity and the role of sanctions in public goods contribution. Although in the real world diversity is often associated with the danger of conflict, making economic and social cooperation difficult to achieve, our work suggests that institutions may play an important role in creating environments in which diversity can be bridged and sanctions can be implemented

in order to promote well-ordered societies and better-functioning markets.

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Supporting Online Material

www.sciencemag.org/cgi/content/full/334/6061/1392/DC1
SOM Text
Fig. S1
Tables S1 to S5
References and Notes

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Capacity Building Helps Pastoral Women Transform Impoverished Communities in Ethiopia

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Poverty, drought, and hunger devastate people on Africa's rangelands. We used an action-oriented approach from 2000 to 2004 to build capacity among thousands of pastoralists to diversify livelihoods, improve living standards, and enhance livestock marketing. The process included collective action, microfinance, and participatory education. Poor women previously burdened by domestic chores became leaders and rapidly changed their communities. Drought occurred from 2005 to 2008. We assessed intervention effects on household drought resilience with a quasiexperimental format that incorporated survey-based comparisons of treatment groups with ex post controls. Interventions led to major improvements in trends for quality of life, wealth accumulation, hunger reduction, and risk management. Human capacity building can be a driver for change, generating hope and aspirations that set the stage for the use of new information and technology.

Historically, African pastoral societies had low densities of people, large livestock herds, and access to vast grazing lands. This allowed for subsistence food production (e.g., milk and meat), accumulation of animal wealth, and sustainable use of natural resources. Unfortunately, this situation has changed (1, 2). Pastoralists today are often poverty stricken and beset by hunger. Efforts to "develop" pastoralism have had little success (3–5). Human population growth, overgrazing, annexation of key resources

by outside entities, physical insecurity, and underinvestment in pastoral areas contribute to declining per capita food production, reduced vegetation cover, increased soil erosion, loss of herd mobility, and more marginalized people. Multiyear droughts pose grave threats to pastoralists because crop failures and massive death losses of animals escalate into crises for food availability, income generation, and asset preservation. Technical options to increase food production or lessen pressure on natural resources remain elusive, largely because of environmental and social constraints. Alternatively, nontechnical options focused on human capacity building could have positive effects through livelihood diversification that improve risk management (2). Diversification could emphasize more involvement in commercial livestock production and non-

livestock microenterprises to balance traditional livestock production. This could help communities become more resilient when coping with drought (6).

Once considered a prime example of sustainable pastoralism in eastern Africa, the Borana pastoral system of semiarid southern Ethiopia (Fig. 1) exemplifies the changes noted above. The people have become poorer and more vulnerable due to population growth and lack of development investment, a trend exacerbated by impacts from multiyear droughts in 1983–1985, 1991–1993, 1998–1999, and 2005–2008. Each drought resulted in the deaths of about half of all livestock, losses having a cumulative value in the hundreds of millions of U.S. dollars (7). More details concerning the people and system dynamics are given in (8) (study area). The main objective of this research was to determine whether pastoral livelihoods on the Borana Plateau could indeed be diversified in a sustainable fashion to lessen or reverse the downward spiral at the household level.

Starting in 2000, we used an action-oriented, participatory approach to engage the pastoral community to refine problem diagnosis, chart pathways for change, and identify and implement interventions. This integrated the ideas, skills, and resources of numerous partners (i.e., pastoralists, researchers, development practitioners, educators, and donors). The process is described in (8) (treatment background). In short, the acute need for livelihood diversification was confirmed, a problem that required capacity building. Stepwise capacity-building interventions were undertaken (Fig. 2), including: (i) inspiring the Ethiopians to improve their circumstances by exposure to problem-solving methods and linking them to forward-thinking, successful peers in northern

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Kenya; (ii) establishing collective-action groups to consolidate community leadership and create new social safety nets; (iii) improving literacy and numeracy through nonformal (participatory) education so that rudimentary banking and book-keeping procedures could be adopted; (iv) promoting a savings culture and a means of managing financial resources through microfinance; (v) instilling best practices in the creation and management of small businesses through micro-enterprise training; and (vi) helping generate financial capital by connecting collective-action groups to expanding livestock markets.

By 2004, this process had resulted in the creation of 59 collective-action groups on the Borana Plateau with a total membership of 2300. Capacity building for individuals took 3 years on average. Women made up 76% of the founding members of collective-action groups, and they quickly assumed leadership positions. This was surprising given the subservient domestic roles that women traditionally occupy in this society [(8), study area].

Although the collective-action groups were governed by illiterate women with scant previous leadership or business experience, members saved money and successfully managed thousands of microloans. Groups also supplied thousands of livestock to export markets [(8), treatment background]. Eleven of the stronger groups each received grants (US \$3270) from a donor to help capitalize livestock trade. Members of groups receiving trading grants sold more animals than

did members of groups not receiving grants [(8), treatment background].

As the project matured, a major drought occurred during 2005–2008 resulting in the deaths of 40 to 60% of all livestock, heightening stress on the society. This situation gave us an opportunity to assess effects of the capacity-building package on livelihoods, well-being, and coping abilities of project participants during a crisis using a quasi-experimental approach. We implemented a survey in 2008 among 180 randomly selected residents in the Liben and Moyale Districts [(8), sampling and target population] (Fig. 1). Sixty respondents (30 per site) came from each of three treatment levels: capacity building (including all aspects of Fig. 2), capacity building plus the trading grant (henceforth referred to as CBG), and traditional peers (henceforth referred to as controls). The controls lived in the same areas as the others but had not been involved with the project [(8), treatment background and supporting online text].

It was hypothesized that capacity building would fundamentally alter the well-being of people through diversified livelihoods, increased incomes, and reduced hunger (because of an increased ability to purchase food) relative to the controls. Adding trading grants would give further advantage to CBG members by playing a catalytic role in boosting livestock marketing, generating more income, and reducing hunger to a greater degree. Sites were not expected to influence treatment effects. Liben and Moyale

were chosen because they had all three treatment levels present.

Data collection involved asking respondents to identify trends (i.e., improving, no change, or declining) for 18 personal, household, community, and agricultural attributes and providing categorical answers to questions concerning change in wealth status, incidence of hunger, use of income, and future livelihood strategies. The time frame for trend analysis covered the previous three drought years. Two statistical approaches assessed treatment effects, logit models for ordinal responses, and chi square for homogeneity of proportions [(8), survey design and statistics]. The prediction for ordinal responses was when the odds were compared of reporting improved circumstances among respondents from various treatment pairs for each of the 18 attributes, CBG > capacity building > controls. The prediction concerning responses for directional change in self-assessed household wealth status (i.e., poor ↔ middle class ↔ wealthy) was also CBG > capacity building > controls (i.e., households having residents who received capacity building would show improved wealth status). The prediction for incidence of household hunger was controls > capacity building > CBG. Members of CBG and capacity-building treatments were predicted to report more sources of money to buy food relative to controls. Members of CBG and capacity-building treatments were predicted to exhibit greater interest in further pursuit of livelihood diversification or intensification strategies relative to a focus on traditional practices by controls.

To summarize, our impact assessment here is quantitative. Other aspects of impact assessment—such as changes in the roles and status of women, the intricacies of managing group dynamics, or overcoming cultural barriers to innovation—are better depicted using qualitative findings, and these are highlighted elsewhere [(8), treatment background, (9)].

Descriptive statistics (table S1) illustrate that survey respondents were typically middle-aged, married women living in sedentary households within a day's walk of town. There were some men. All had only a few livestock. Traditional

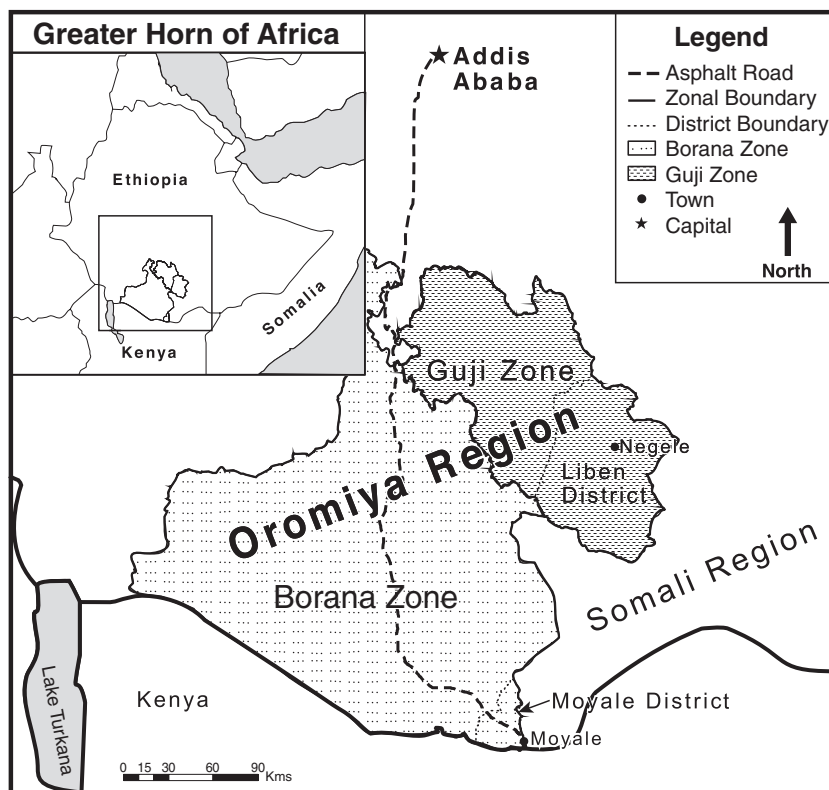


Fig. 1. Study area.

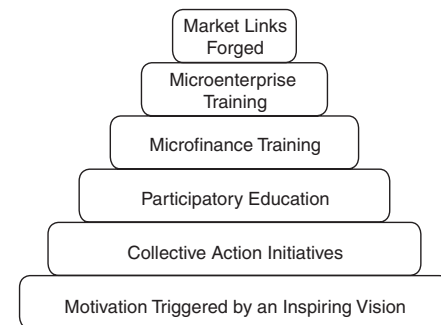


Fig. 2. Step-wise capacity-building interventions, starting from the bottom up. Modified from figure 7.2 in (30) and reproduced here with permission from Earthscan.

peers were screened and confirmed as suitable ex post controls [(8), treatment background and supporting online text].

Compared with control respondents at Liben, respondents with capacity building perceived positive shifts (logit; $P \leq 0.010$) in trends for all 18 attributes (Table 1). The same comparison for Moyale revealed positive effects (logit; $P \leq 0.050$) in trends for five attributes (10). Improvements in skills and knowledge, comfort of the home, quality of life, access to credit, and involvement in small business were common among the respondents in the capacity-building treatment at both sites compared with that for control respondents. Although CBG did not create additional impact relative to that for capacity building over the controls in Liben, it did so in Moyale; the number of improved trends for CBG versus controls increased from 5 to 11 (logit; $P \leq 0.050$). The CBG respondents in Moyale also reported improvement in trends for seven attributes compared with that for capacity building alone (logit; $P \leq 0.050$) (Table 1).

The chi-square analyses were performed on pooled site data to accommodate occasionally sparse cell counts. Treatment affected change in wealth status over time (table S2). The percentage of respondents noting positive change in

wealth status significantly varied (chi square; $P \leq 0.016$) among all comparisons for CBG (63% noting improved wealth status), capacity building (41%), and controls (18%). Treatment also affected household hunger incidence (table S3). Although the percentage of respondents noting that household hunger was "common" did not differ (chi square; $P = 0.678$) between CBG (22%) and capacity building (15%), both were lower (chi square; $P \leq 0.001$) than controls (60%).

Treatment affected use of income and assets when buying food (table S4). Although patterns for capacity building and CBG did not differ (chi square; $P = 0.070$), they both differed from controls (chi square; $P \leq 0.001$). Dominant choices for controls were to use income to buy food from animal sales (as traditionally practiced) or charcoal/firewood sales if they were very livestock-poor. The capacity-building and CBG respondents, in contrast, used business profits (36 to 39% of respondents, respectively) to buy food in addition to using income from animal sales (29 to 50% of respondents). Twelve percent of CBG respondents used cash savings to buy food. Nearly 90% of all respondents noted that when an animal was sold to buy food, leftover money was used to purchase a smaller

(younger) replacement animal. Others said that leftover money was saved in a bank account.

Finally, treatment affected future livelihood strategy (table S5). The distribution of responses significantly varied (chi square; $P \leq 0.009$) among CBG, capacity building, and the controls; 90% and 67% of respondents from CBG and capacity-building treatments, respectively, intended to pursue further diversification or intensification. In contrast, 77% of control respondents said either that they did not know what to do or that they were not changing from traditional practices.

Predictions that effects of CBG or capacity building alone would exceed those of the controls were generally confirmed. Prominent among CBG or capacity-building respondents was a renewed sense of control, purpose, and hope in their lives. Respondents from both CBG and capacity-building treatments perceived an increase in wealth and a reduction in hunger relative to that for controls; more income and assets allowed for more food purchases (11, 12). Project participants shifted their livelihood strategies to include more small-business activities and diversification, yet the traditional emphasis on herd building was maintained, as shown by the practice of buying replacement stock with money remaining after food purchases. The mix

Table 1. Odds ratios, derived from a proportional odds logit model, for attribute trends as reported by individuals in three treatment levels (CBG, CB, and controls) at two study sites (Liben and Moyale). Each entry is the odds of reporting an improved or increased situation for the first-listed treatment

level relative to the second-listed treatment level. For example, in the top row for Liben, the CB respondents were nearly 55 times as likely as control respondents to report increased skills and knowledge over the previous 3 years. *** $P \leq 0.001$; ** $P \leq 0.01$; * $P \leq 0.05$.

Attributes	Liben			Moyale		
	CBG versus CB	CBG versus control	CB versus control	CBG versus CB	CBG versus control	CB versus control
<i>Personal, household, and community</i>						
Skills and knowledge	1.0	52.9***	54.8***	8.8**	74.7***	8.5***
Confidence in the future	0.6	33.6***	54.0***	2.4	4.3**	1.8
Ability to solve problems	1.0	40.5***	40.5***	5.3**	9.3***	1.8
Ability to recover from crisis	0.6	91.7***	142.6***	2.2	4.0**	1.8
Community support	1.6	58.0***	93.0***	11.6***	19.0***	1.6
Comfort of the home	1.5	55.1***	35.6***	25.0***	61.5***	2.5*
Human health	1.0	19.2***	18.5***	4.0*	3.1*	1.3
Interest in child education	0.6	10.0***	17.9***	1.5	0.7	0.5
Quality of life	0.6	66.2***	102.3***	2.2	8.2***	3.8**
<i>Financial</i>						
Cash income	1.9	51.6***	96.3***	9.8***	8.9***	0.9
Credit access	0.8	48.5***	64.6***	1.1	11.1***	10.1***
Involvement in livestock marketing	1.6	103.5***	66.6***	0.6	0.8	1.4
Involvement in small-business activity	0.6	30.2***	52.1***	3.8*	10.7***	2.9*
<i>Livestock and crops</i>						
Number of cattle owned	3.3*	37.1***	11.2***	0.8	0.2**	0.3*
Number of small ruminants owned	1.5	16.5***	11.2***	0.6	1.5	0.9
Animal health	1.7	13.1***	21.8***	1.7	0.8	1.4
Access to forage	1.0	18.1***	18.1***	1.7	0.6	1.0
Cultivation of cash crops	1.3	9.3***	7.1**	1.9	0.6	0.3*

of livestock and nonlivestock investment that underpins livelihood diversification makes sense given the need to create complementary income and asset sources to improve risk management.

We interpret these findings, overall, as evidence that the capacity-building package helped people become more resilient and better manage risks associated with the 2005–2008 drought. The interventions assisted people at a time when the social-ecological system was put to a severe test.

Contrary to our expectations, site appeared to affect the relative impact of CBG over capacity building; the prediction $\text{CBG} > \text{capacity building}$ was only partially supported at Moyale. In retrospect, many factors could undermine sustained impact from one-time trading grants, including poor money management or inefficient marketing by CBG. Conversely, capacity-building groups having superior performance in savings accumulation or marketing efficiency could attain or eclipse achievements of CBG. The situation is complex because CBG and capacity building varied with respect to the quality of group leadership and the discipline or cohesion among group members.

Although Moyale and Liben were similar in terms of human population and the general importance of livestock markets, they differed with respect to ethnic conflict, drought intensity, and potential competition among livestock traders [(8), sampling and target population]. Both ethnic conflict and intense drought closed livestock markets in Moyale for extended periods, and this led to large infusions of food aid that distorted local commerce. This was not the case in Liben, which was relatively peaceful and endured only moderate drought. By virtue of its border location, Moyale is also home to a network of entrenched livestock traders who can compete with collective-action groups for marketable animals. Liben, in contrast, had an expanding livestock market accommodating a wider array of traders. The important point is simply that societal and ecological variation between sites influenced the expression of capacity-building interventions. The more favorable situation at Liben allowed members of both CBG and capacity building to greatly prosper relative to the controls. Constraints at Moyale, however, muffled effects for capacity building relative to controls, but the strongest CBG groups still prevailed.

Treatment effects in Liben were not only very pronounced but also more diverse than anticipated. Although we expected primary effects of capacity building or CBG on many personal and financial variables, we did not foresee such a cascade of strong secondary effects on human health, livestock health, access to forage supplies, or cash-crop production (Table 1). When asked why this cascade occurred, respondents said that having more income and savings allowed them to purchase health inputs for people and animals, procure supplemental animal feeds, and invest in commercial vegetable production and dairy processing schemes. Strong group leadership, in combination with expanded extension services, also contributed to development synergisms (13). Liben may illustrate a best-case outcome for what this capacity-building package can deliver. The Liben situation also agrees with observations that women's empowerment can improve multiple aspects of household welfare (11, 14, 15).

Our interventions (Fig. 2) occurred in a logical sequence that gradually built capacity for people to problem-solve. We initially had no roadmap, but rather learned over time with project stakeholders. We are unaware of similar efforts in pastoral areas. There is research from urban or farming systems, however, that confirms the utility or generalizability of each intervention in a development process. For example, the initial inspiration and role modeling provided by the Kenyans to the Ethiopians [(8), treatment background] was vital because it gave the Ethiopians a vision of an alternative future. Rapid change then resulted from peer networking among opinion leaders, a principle of diffusion theory (16). Collective action has been shown to be an effective development vehicle, especially for poor women (17, 18). Sustained success in microfinance can depend on participants having literacy and numeracy skills, as well as microenterprise training (19, 20). Well-designed microfinance products can enhance the ability to manage risk, empower women, and strengthen community ties (15, 21, 22), although the evidence remains incomplete on several fronts (23). Finally, linking microcredit with market access can enhance incomes for Ethiopian farmers (24), but drought can be a constraint (25).

Careful capacity-building processes can provide durable, cost-effective, and low-risk options for improving the human condition in marginal lands. This echoes the view that filling gaps in human development is the key for progress in Africa's pastoral areas (26). Inputs such as trading grants may add value to capacity building in some circumstances. The cost of our capacity-building process was about U.S. \$1 per person per month over 3 years (9). The low cost is due to the reliance on participatory education and peer networking. Although some passive diffusion of the package has occurred, active extension is required for maximum effectiveness [(8), treatment background]. The greatest future challenges include how to reliably deliver effective capacity-building modules more broadly to the pastoral population, as well as how to sustain commercial livestock sales given the vicissitudes of markets and the crippling effects of drought (9).

A continued focus on technical solutions to rangeland problems by national or international research bodies assumes that technology is the driver for progress. We argue, rather, that here human development is the driver and technology provides the tools (27). Human development provides the vision, desire, and opportunity to improve lives, and technology can then serve evolving aspirations. This process was best illustrated by the groups at Liben using available

technology once they felt confident and financially secure. More recently, group members have begun to use mobile phones to acquire electronic information on livestock prices and early warnings of drought.

Research approaches affect observations and conclusions. Our action-oriented process perturbed this social system, revealing the potential of women as leaders and entrepreneurs. Changes in gender roles have been rapid [(8), treatment background, (9)]. Survey research lacking perturbations describes the status quo. In such studies, men are often identified as pioneers of livelihood diversification with women overlooked (28).

Development scholars can strive to broaden the academic agenda by including more societal engagement as part of project research design (29). This can generate reliable scientific knowledge, as well as build human capacity at multiple levels. Our experience confirms that careful strengthening of human, social, and financial capital can rapidly improve lives and help transform communities in remote, harsh environments where the technical options to boost productivity remain elusive.

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10. The predominant data pattern for Liben was for CBG and capacity-building members to indicate improving circumstances for each attribute over the previous 3 years, whereas control members typically indicated that “no change” had occurred. In some cases (i.e., level of community support, comfort of the home, quality of life, and small ruminants owned), control members additionally reported declining circumstances. The predominant data pattern at Moyale for five attributes where capacity building > controls was similar to the Liben pattern above. The data patterns for Moyale were more heterogeneous in general, with higher proportions of respondents from all treatments indicating worsening circumstances for all attributes compared with that reported for Liben. There were two instances at Moyale where controls > capacity building or controls > CBG ($P \leq 0.050$) (Table 1) (i.e., cattle owned and cash-crop

- cultivation). The data indicated that CBG and capacity-building respondents were more varied in their assessments as to whether these attributes were improving or declining, but control respondents more uniformly indicated “no change.” This difference is what led to statistical significance. We interpret this to illustrate that CBG and capacity-building members were in a more dynamic position of change than control members. The control members were more static, but this was in relation to a low base in terms of cattle numbers and minimal cash-crop cultivation to begin with. Unlike Liben, treatment effects for attributes such as human health or interest in children’s education were either weaker or lacking at Moyale. The data indicated that a majority of respondents from all treatments perceived improvements in access to health care and heightened interest in children’s education. This may reflect a higher level of public-service awareness among Moyale residents compared with that for Liben; Moyale town has been a commercial and administrative hub for a much longer time than has Negele town (in Liben).
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 13. Higher personal incomes and improved extension outreach by government were commonly implicated by members of CBG and capacity-building treatments in promoting the purchase of inputs to support animal health, human health, cash-crop production, and innovative forage-management systems. Capacity building has fostered more connectivity between local people and development agencies in Liben.
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Supporting Online Material

www.sciencemag.org/cgi/content/full/334/6061/1394/DC1
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SOM Text
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Movie S1

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Perceived Predation Risk Reduces the Number of Offspring Songbirds Produce per Year

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Predator effects on prey demography have traditionally been ascribed solely to direct killing in studies of population ecology and wildlife management. Predators also affect the prey’s perception of predation risk, but this has not been thought to meaningfully affect prey demography. We isolated the effects of perceived predation risk in a free-living population of song sparrows by actively eliminating direct predation and used playbacks of predator calls and sounds to manipulate perceived risk. We found that the perception of predation risk alone reduced the number of offspring produced per year by 40%. Our results suggest that the perception of predation risk is itself powerful enough to affect wildlife population dynamics, and should thus be given greater consideration in vertebrate conservation and management.

Predator effects on prey demography have traditionally been ascribed solely to direct killing in studies of population ecology and wildlife management, because the effect of direct

killing on prey numbers can be directly observed (1–3). An emerging alternative is that the effect of predators on prey numbers may be far greater than what can be attributed to direct killing alone, if the costs of antipredator responses reduce prey reproduction and increase deaths from other causes (1–7). Antipredator responses may include changes in habitat use, vigilance, and foraging behavior (1, 2, 4–9), or physiological changes (2, 3, 10, 11), any or all of which could con-

ceivably affect prey demography. Although long suggested by theory [e.g., (12, 13)], this alternative remains rarely considered in vertebrate conservation and management because of a lack of direct experimental evidence that the perception of predation risk alone is powerful enough to affect the population growth rate of free-living wildlife (1–4, 8). The population growth rate is determined by the number of offspring produced per year in addition to juvenile and adult survival, and the number of offspring produced per year is a function of the number of propagules (eggs or neonates) and their survival to the juvenile stage (14). Unless direct predation can be precluded as a possible cause of death, testing whether predators can affect prey survival independent of direct killing is not possible (1–3). Because eliminating direct predation for this purpose has proven very difficult, the effect of perceived predation risk on the survival of free-living wildlife remains experimentally untested, and only one previous experiment (6) has documented an effect on the number of propagules (1–4, 8).

Here, we report a 40% reduction in the number of offspring produced per year by wild, free-living female song sparrows (*Melospiza melodia*) in response to a field experiment in which we actively eliminated direct predation and manipulated perceived predation risk throughout an

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