dinate females in 13 groups [see (*24*)]. For each 3-month period, we scored whether or not each female conceived (3 months is close to the minimum interbirth interval) and fitted these data to a binomial distribution. Weight was calculated as the mean of all morning weights for each female during each 3-month period (excluding weights during pregnancy). Generation was defined relative to the dominant: littermates and siblings were considered to be of the same generation; daughters and nieces were allocated to the next generation. Relatedness was calculated from each helper to the pups it cared for using pedigrees derived from microsatellite analysis (*6*) and was a direct measure of consanguinity (0.5 for full sibs, 0.25 for half sibs and grand-offspring, 0.25 or 0.125 for aunts, and 0.125 or 0.0612 for cousins). Group sizes were categorized as 2 to 6, 7 to 11, 12 to 16, and >16 members (excluding pups). Rainfall, weight, age category, generation relative to the dominant, and the presence of unrelated males all had a positive significant effect on the probability of a subordinate conceiving in any 3-month period. Subordinate breeding was less common when rainfall was 0 to 50 mm than for 51 to 100 mm or >100 mm. Though age and weight are closely correlated ($r = 0.72$, $n = 350$, $P < 0.001$), our analysis showed that for a given weight, subordinate females under 2 years old were more likely to breed than were older subordinates.

15. H. K. Reeve, S. T. Emlen, L. Keller, *Behav. Ecol.* **9**, 267 (1998).
16. T. H. Clutton-Brock, *Trends Ecol. Evol.* **13**, 288 (1998).
17. Our analysis compares the proportion of subordinate females that became pregnant 0 to 3, 3 to 6, 6 to 9, and 9 to 12 months after a change in the identity of the dominant female, with the expected number of conceptions occurring within 10 days of the previous conception, calculated on the assumption that subordinate conceptions were randomly distributed throughout the breeding season (from August to May).
18. Rainfall has no significant effect on the probability that dominants will breed in any 3-month period ($\chi^2 = 4.68$, df = 2, $P = 0.12$) [see (*24*)].
19. L. Keller, H. K. Reeve, *Trends Ecol. Evol.* **9**, 98 (1994).
20. To investigate the factors influencing dispersal by subordinate females, we constructed two GLMMs using data from 59 females in 11 groups involving 33 dispersal events. In model A, we used all instances of dispersal (whether or not they were permanent) and scored whether each female dispersed or stayed in the group. Dispersal events within a week of each other were not considered to be separate. In model B, we considered only females that left the group permanently. In each case, the data were fitted to a binomial model, and the dispersal event was fitted as a random term because of repeated sampling of individuals. Only females of breeding age (over 10 months) were included. "Breeding history" incorporated two categories reflecting whether or not females had bred previously in their natal group. The significant term in model A was age (older individuals were more likely to disperse than younger ones). A number of measures of group size were investigated, including all individuals over 10 months and all individuals over 6 months; only the results for the former are shown in Table 2. Group size had no significant effect on dispersal rates, and dispersal was as common in small groups as in large ones.
21. Group size (the number of individuals, excluding pups) reduces the mortality of dependent (<3 months) pups and subadults/adults (animals over 6 months old) [see (*24*)] in groups of less than 11 animals (Pearson's regressions: $T_{1,87} = -3.55$, $P < 0.001$ for pups; $T_{1,36} = -2.29$, $P < 0.03$ for animals over 6 months). In contrast, group size has no effect on mortality in groups of over 11 animals ($T_{1,51} = -0.44$, $P = 0.66$ for pups; $T_{1,30} = -0.99$, $P = 0.33$ for animals over 6 months). The frequency of subordinate reproduction does not vary with group size and is as high in groups of ≤11 as in groups of >11 (Table 1).
22. T. H. Clutton-Brock *et al.*, *Proc. R. Soc. London Ser. B* **265**, 2291 (1998).
23. In only 51% of litters born to subordinates do individuals survive to emergence, as compared to 85% of litters born to dominants. Most losses occur in the 2 days after birth and are probably caused by infanticide: Mortality is disproportionately high during the 48 hours after birth. In over half of the 10 cases in which females have been seen to kill pups, the killer was the dominant female and was the grandmother of the pups she killed. In all other cases, killers were closely related females, including sisters and aunts of the subordinate female that bred. The probability that subordinate litters will survive to emergence is not significantly related to the mother's age or weight, to the number of helpers present in the group, or to rainfall in the month that the litter was born. After emergence, there is no difference in survival to 3 months between pups born to dominants and subordinates (68.1% ± 8.7 versus 69.8% ± 3.6) [see (24)].
24. Supplementary information is available on *Science* Online at www.sciencemag.org/cgi/content/full/291/5503/478/DC1.
25. We thank the National Parks Board of the Republic of South Africa for permission to work in the Kalahari Gemsbok Park and for their hospitality at Nossob, the staff of the park for their support, and Mr. and Mrs. H Kotze for permission to work on their land at Van Zyl's Rus. The study would not have been possible without the support of members of the Mammal Research Institute, University of Pretoria (including J. Skinner, J. du Toit, and M. Haupt); of the Institute of Cell, Animal and Population Biology, Edinburgh (including J. Pemberton and T. Marshall); and of over 40 assistants, students, postdocs, or visitors who contributed to data collection. For advice, access to data, assistance, or comments we thank S. Doolan, J. Nel, L. Kruuk, J. Barnard, S. White, T. Coulson, T. Jackson, F. Ratnieks, and R. Woodroffe. In planning and carrying through the work, we benefited from the guidance of D. Macdonald and S. Creel. The research is funded by grants from the Natural Environment Research Council and the Biotechnology and Biological Sciences Research Council.

17 July 2000; accepted 20 November 2000

Variation Among Biomes in Temporal Dynamics of Aboveground Primary Production

Alan K. Knapp and Melinda D. Smith

Interannual variability in aboveground net primary production (ANPP) was assessed with long-term (mean = 12 years) data from 11 Long Term Ecological Research sites across North America. The greatest interannual variability in ANPP occurred in grasslands and old fields, with forests the least variable. At a continental scale, ANPP was strongly correlated with annual precipitation. However, interannual variability in ANPP was not related to variability in precipitation. Instead, maximum variability in ANPP occurred in biomes where high potential growth rates of herbaceous vegetation were combined with moderate variability in precipitation. In the most dynamic biomes, ANPP responded more strongly to wet than to dry years. Recognition of the fourfold range in ANPP dynamics across biomes and of the factors that constrain this variability is critical for detecting the biotic impacts of global change phenomena.

Regional and global patterns in aboveground net primary production (ANPP) and their determinants have long interested ecologists (*1*, *2*). More recently, interest has intensified as projected global changes in climate, nitrogen deposition, and land use (*3*) threaten to alter ecosystem carbon and energy flow. Because alterations in ANPP can influence virtually all ecosystem processes, detecting directional changes in productivity (*4*) against the backdrop of natural variability is important. However, a critical limitation to detecting temporal change is a lack of knowledge of the inherent interannual variability in ANPP in biomes. This variation has been quantified indirectly (*5*), but only now, with the maturation of the Long Term Ecological Research (LTER) network of sites across North America, are long-term data available to assess temporal dynamics in ANPP for a variety of biomes.

Here we present a synthesis of these long-term data to address two questions. First, what are the patterns of interannual variability in ANPP for desert, arctic/alpine, grassland, and forest biomes? Previous estimates of ANPP were unavoidably based on small sample sizes, short time periods, or indirect techniques (*1*, *2*, *6*) with no measure of variability. We summarize ANPP data from 11 sites widely distributed across North America, with an average sampling period of 12 years. These data allow us to calculate more robust ANPP estimates as well as to quantify temporal variability in ANPP across a large productivity gradient.

The second question is, do established climatic predictors of mean ANPP across biomes [precipitation and temperature (*2*)] also

---

Division of Biology, Kansas State University, Manhattan, KS 66506, USA.

predict interannual variability in ANPP? Mean annual precipitation, for example, is a good predictor of ANPP across North America, but is interannual variability in precipitation related to temporal variability in ANPP? Within arid biomes, this relationship has been substantiated (*7*), but at larger scales, evidence suggests that no relationship exists (*8*). If the latter is true, then projections of ecosystem responses to climate change, particularly alterations in precipitation (*9*), may need revision. Although actual evapotranspiration (AET) is a strong predictor of patterns of ANPP across large regions (*1*, *6*), we selected annual precipitation to address this question (*10*) because this variable is also strongly related to ANPP (*2*), and accurate precipitation records are readily available for all biomes.

Analysis of long-term data compiled from 11 terrestrial LTER sites (*11*) (Table 1) yielded mean values of ANPP well within the range of values reported previously (*1*, *5*, *6*). Forested sites were more productive than other biomes, whereas desert, alpine, and arctic sites were the least productive (Table 1 and Fig. 1). Patterns in interannual variability in ANPP across biomes, however, were in sharp contrast to patterns of average ANPP. The

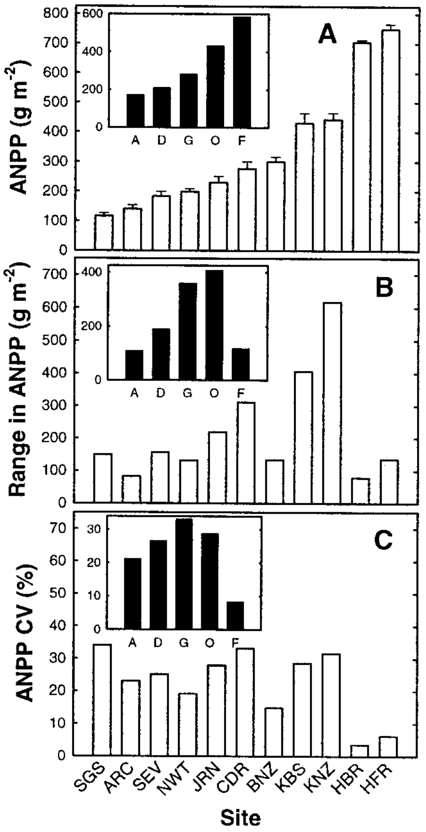

Fig. 1. (**A**) Long-term average (+SE) ANPP for 11 sites in the LTER network (Table 1; see table for site abbreviations). The inset shows the long-term average ANPP combined into biome types. A, arctic and alpine sites (ARC and NWT); D, desert sites (SEV and JRN); G, grassland sites (SGS, KNZ, and CDR); O, oldfield site (KBS); F, forest sites (HFR, HBR, and BNZ). In the grassland and forest biomes, where two similar community types were included (KNZ/CDR and HFR/HBR, respectively), these were averaged first before calculation of the biome average. (**B**) Range in ANPP for the 11 LTER sites. The inset denotes the average range by biome. (**C**) Interannual CV for the 11 LTER sites. The inset denotes the average CV by biome.

Table 1. Characteristics of the LTER sites included in the analyses of ANPP. Three-letter abbreviations correspond to those used in the figures. Means for annual precipitation and ANPP were compared with analysis of variance and least-square means (Statistical Software, version 6.12, SAS Institute); for precipitation, $F_{10,119} = 73.2$, $P < 0.001$; for ANPP, $F_{10,121} = 91.6$, $P < 0.001$. Values for precipitation and ANPP are expressed as means ± SE (in parentheses). Means with different superscripts (a through e) in the two right columns are significantly different from those of other sites.

LTER site	Vegetation type	Length of record	Precipitation (mm)	ANPP (g/m^2)
Arctic Tundra (ARC), AK	Tussock tundra	6	298.3^{d} (55.2)	140.8^{e} (13.3)
Bonanza (BNZ), AK	Balsam poplar forest	8	342.9^{d} (19.1)	299.9^{c} (15.7)
Cedar Creek (CDR), MN	Oak savanna grassland	17	826.2^{c} (47.3)	277.3^{cd} (22.3)
Harvard Forest (HFR), MA	Mixed deciduous forest	8	1195.9^{b} (44.3)	744.5^{a} (16.9)
Hubbard Brook (HBR), NH	Mixed deciduous forest	10	1412.7^{a} (72.0)	704.5^{a} (7.7)
Jornada (JRN), NM	Black gramma grassland	9	263.1^{d} (32.6)	229.1^{d} (21.3)
Kellogg (KBS), MI	Successional field (annually tilled)	10	865.6^{c} (37.8)	431.0^{b} (33.5)
Konza Prairie (KNZ), KS	Tallgrass prairie (annually burned)	23	833.6^{c} (42.1)	442.6^{b} (22.4)
Niwot Ridge (NWT), CO	Moist alpine meadow	15	1240.5^{b} (54.4)	198.7^{de} (9.2)
Sevilleta (SEV), NM	Mixed desert grassland	10	269.1^{d} (22.1)	184.5^{de} (14.7)
Shortgrass Steppe (SGS), CO	Shortgrass steppe (swale)	16	358.5^{d} (17.9)	116.5^{e} (9.9)

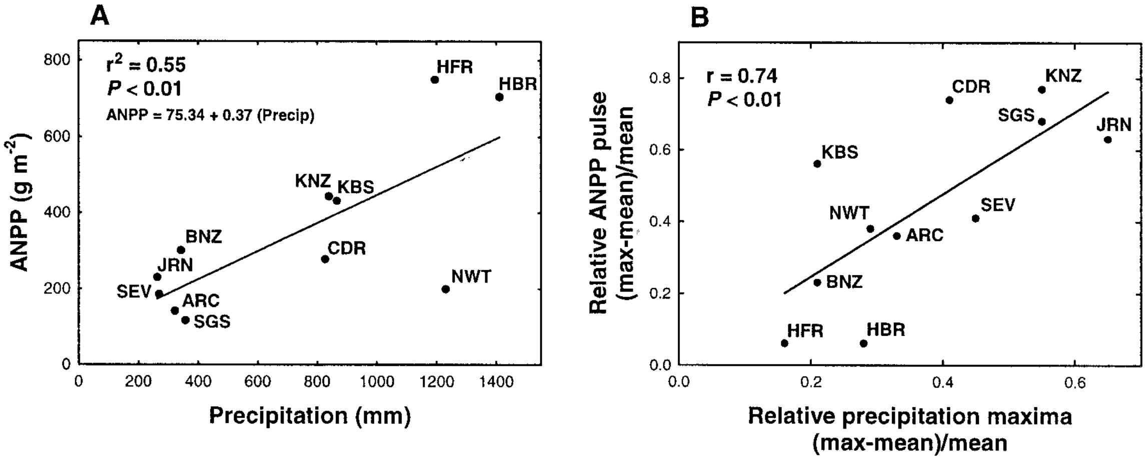

Fig. 2. (**A**) Relationship between average annual precipitation and average annual ANPP for 11 LTER sites (Table 1). [If the temperature- and nutrient-limited alpine (NWT) and arctic (ARC) sites are excluded, $r^2 = 0.83$, $P < 0.001$]. (**B**) Relationship between the relative magnitude of precipitation maxima for individual sites and corresponding ANPP pulses.

greatest range and coefficient of variation (CV) of ANPP occurred in warm, herbaceous-dominated sites [grasslands and old fields (Fig. 1)], whereas ANPP in forested sites was distinctly less variable than in the other biomes. These results support earlier predictions, based on analyses of variability in AET, that interannual variability in grassland ANPP is high (*5*).

Mean annual precipitation was a strong predictor of patterns of average ANPP across these 11 sites (Fig. 2). At continental scales, precipitation quantity is inversely related to relative precipitation variability [(CV) (*12*)], and we predicted that biomes with the most variable precipitation patterns (deserts had the greatest CV: >30%) or with the greatest range in precipitation would also have the greatest interannual variability in ANPP. However, there was no relationship between variation in precipitation (range and CV) and variation in ANPP. Thus, climatic variables useful for predicting average ecological responses across climatic gradients may not predict variability in these responses.

We explored the ANPP-precipitation relationship further by focusing on specific aspects of variability. This included quantifying the relative precipitation maxima [(maximum – mean)/mean] for the wettest year at each site or precipitation minima [(mean – minimum)/mean] for the driest year and assessing their relationship with corresponding relative ANPP pulses (maxima) or declines (minima). Predictions of climate change–related increases in the size and frequency of extreme precipitation events and droughts (*9*, *13*) prompted this analysis. We found a strong positive correlation between the magnitude of the relative maxima in precipitation and pulses in ANPP (Fig. 2). For the three grassland sites, relative pulses in ANPP were >70%, whereas in forests, production pulses were <20%. Thus, when grasslands experience unusually high precipitation levels, this biome has the capacity for large production responses.

Biome-level patterns of ANPP responses to wet years were not mirrored by a significant relationship between relative drought years and ANPP declines. Consequently, biomes across this gradient displayed asymmetric responses to precipitation extremes, perhaps due to buffering mechanisms that reduced the impact of drought on productivity. Nonetheless, the magnitude of relative ANPP pulses was positively correlated to ANPP declines across all biomes (Fig. 3). Asymmetry was again evident as several herbaceous-dominated sites (arctic and alpine, two grassland, and one desert site) exhibited larger pulses in ANPP than declines. There are several explanations for asymmetric responses to wet versus drought years. Plant physiological adjustment to water stress, soil water storage, vegetation structural constraints, and plant responses related to climatic conditions from the previous year (*6*, *7*, *14*, *15*) all may alter responses to drought. More intriguing is the absence of any sites (with at least 10% variability in ANPP) falling below the 1:1 relationship (Fig. 3). Thus, although pulses in ANPP can be dramatic in wet years, perhaps due to the release from multiple resource limitations (*16*, *17*), no sites exhibited reductions in ANPP of a similar magnitude in dry years. This constraint on potential ANPP responses to precipitation variability should be incorporated into projected global carbon budgets (*4*, *18*, *19*).

We suggest that interactions among gradients in precipitation amounts, variability, and growth potential of the vegetation are responsible for the observed fourfold difference (Fig. 1) in biome-level variability in ANPP. As noted earlier, relative precipitation variability is thought to vary inversely with precipitation amount (*12*). We used VEMAP (Vegetation/Ecosystem Modeling and Analysis Project) climate data (*20*) from >3000 grid cells across the United States to confirm that such a relationship exists and to corroborate the relationship based on the LTER sites (Fig. 4). In both cases (VEMAP and LTER data), CVs for precipitation in deserts were much higher than in the forest sites, with grasslands being intermediate (Fig. 4). However, explaining ANPP responses to variability in precipitation among biomes requires a more complex model than those developed for individual biomes (*14*). Such a model must include both biotic components (vegetation growth potential, plant meristem density, and leaf area) and abiotic components (precipitation variability and ecosystem water deficit or surplus), all of which vary with precipitation (Fig. 4). Thus, although deserts show large relative pulses in ANPP in response to wet years, absolute ANPP responses are biotically constrained because of low plant density (meristem limitation) and

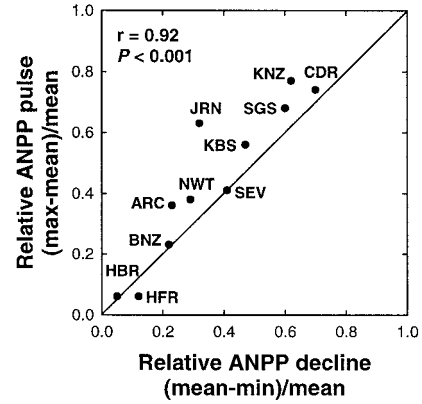

Fig. 3. Relationship between the magnitude of relative ANPP pulses (maxima) and declines (minima) for 11 LTER sites (Table 1). The 1:1 line illustrates the asymmetry that occurs because pulses in ANPP in wet years are typically greater than declines in dry years. Analyses of relative precipitation maxima versus minima yielded a symmetrical pattern around the 1:1 relationship, with a different ordering of sites (*26*), suggesting that this pattern does not reflect asymmetry in precipitation variability.

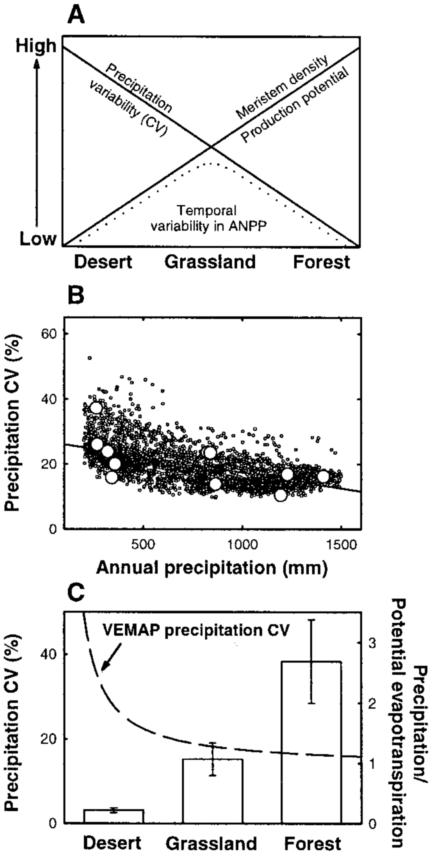

Fig. 4. (**A**) Conceptual view of how continental-scale gradients in abiotic factors such as the amount and variability of precipitation interact with biotic factors such as production potential to result in maximal temporal variability in ANPP in central U.S. biomes dominated by herbaceous plants. (**B**) Relationship between annual precipitation and precipitation variability (CV). Two data sets are shown for the range of precipitation amounts encompassed by 11 LTER sites (Table 1). For LTER sites (large open circles), $r^2 = 0.38$, $P = 0.04$. For VEMAP (*20*) data (small circles), $r^2 = 0.36$, $P < 0.001$. (**C**) Relationship (nonlinear) between annual precipitation and precipitation CV across a wider range of precipitation amounts (50 to 4000 mm), based on VEMAP data. Also shown are mean values (±SE) of the PPT/PET ratio [PET calculated from (*24*)] for desert, grassland, and forest biomes (bars). Ratios include data from 9 desert, grassland, and forested LTER sites combined with 10 sites ranging from Rock Valley, Nevada (164 mm of precipitation), to Andrews Forest, Oregon (2592 mm of precipitation); from (*6*). Although precipitation variability in forests can be similar to that in grasslands, the PPT/PET ratio for forests (2.8) suggests that water limitations and ANPP responses to precipitation variability will be reduced compared to grasslands (with a PPT/PET ratio near 1).

leaf area. Forests have potentially faster growing species and leaf areas that are several times greater, but ANPP responses are abiotically constrained because such biomes typically do not experience much precipitation variability. Or, if variability is substantial, a water surplus [estimated as the ratio of annual precipitation to potential evapotranspiration (PPT/PET)] typically exists (Fig. 4). Thus, most forests have sufficient moisture to meet evapotranspirational demands even during years with below-average precipitation; and during wet years, other resources such as light or nutrients limit production responses in forests. It is in herbaceous-dominated ecosystems, such as grasslands and old fields of the central United States, that the production potential of the vegetation is high, the PPT/PET ratio is near or below one, and substantial precipitation variability occurs (Fig. 4). These biomes display the greatest interannual variability in ANPP under current precipitation patterns (Fig. 1) and may be the most responsive to future climatic changes.

Our results have two implications. First, assessing temporal variability in primary production is important for quantifying energetic constraints on organisms, population dynamics, and community structure across a range of terrestrial biomes (*21*). Second, the inherently high climatic variability of the central United States has been described as detrimental for detecting climate change in this region (*22*). Certainly, there is evidence that long-term climate changes have caused dramatic shifts in species distributions and biome boundaries across North America (*23*). However, initial biotic responses to global changes will not be manifest as biome shifts but rather as more subtle changes in ecosystem states and processes. Our results provide a basis for predicting which biomes will respond most rapidly and strongly to global change phenomena, particularly to alterations in precipitation. If the sensitivity of ANPP in grasslands to precipitation variability portends responses to alterations in other resources, then these biomes may be especially valuable as ecological bellwethers of global change.

References and Notes

1. M. L. Rosenzweig, *Am. Nat.* **102**, 67 (1968).
2. H. Lieth, *Human Ecol.* **1**, 303 (1973).
3. O. E. Sala *et al.*, *Science* **287**, 1770 (2000).
4. D. Schimel *et al.*, *Science* **287**, 2004 (2000).
5. D. A. Frank, R. S. Inouye, *J. Biogeogr.* **21**, 401 (1994).
6. W. L. Webb, W. K. Lauenroth, S. R. Szarek, R. S. Kinerson. *Ecology* **64**, 134 (1983).
7. H. N. Le Houerou, R. L. Bingham, W. Skerbek. *J. Arid Environ.* **15**, 1 (1988).
8. S. N. Goward, S. D. Prince, *J. Biogeogr.* **22**, 549 (1995).
9. T. R. Karl, R. W. Knight, N. Plummer, *Nature* **377**, 217 (1995).
10. We also assessed growing season precipitation and evapotranspiration (*24*). Over the range of productivity encompassed by these sites, annual precipitation was the strongest predictor of variation in ANPP (Fig. 2) {$r^2 = 0.36$ for the relationship between AET and ANPP [as in (*1*)]}.
11. The LTER network began in 1980 (*25*). Each LTER site included in this analysis used unique methods for estimating ANPP (see individual site Web pages at http://lternet.edu). When multiple communities were sampled, only a representative community type was selected from each site (Table 1). We attempted to include the longest and highest quality data available from each site. Although the length of record of ANPP varied (from 6 to 23 years), there was no relationship between the length of the data set and the means or CVs for ANPP or precipitation. We also constructed data sets of average length (12 years) by random sampling of the longest data sets (Konza Prairie, Cedar Creek, and Shortgrass Steppe). Means and variances calculated for these shorter term data did not differ significantly from those from the long-term data (*26*).
12. F. I. Woodward, *Climate and Plant Distribution* (Cambridge Univ. Press, Cambridge, 1987).
13. D. R. Easterling *et al.*, *Science* **289**, 2068 (2000).
14. W. K. Lauenroth, O. E. Sala, *Ecol. Appl.* **2**, 397 (1992).
15. J. M. Paruelo, W. K. Lauenroth, I. C. Burke, O. E. Sala, *Ecosystems* **2**, 64 (1999).
16. T. R. Seastedt, A. K. Knapp, *Am. Nat.* **141**, 621 (1993).
17. D. S. Schimel, B. H. Braswell, W. J. Parton, *Proc. Natl. Acad. Sci. U.S.A.* **94**, 8280 (1997).
18. D. S. Schimel, VEMAP Participants, B. H. Braswell, *Ecol. Monogr.* **67**, 251 (1997).
19. J. M. Melillo *et al.*, *Nature* **363**, 234 (1993).
20. T. G. F. Kittel *et al.*, *Proceedings of the 10th Conference on Applied Climatology* (American Meteorological Society, Boston, MA, 1997).
21. R. B. Waide *et al.*, *Annu. Rev. Ecol. Syst.* **30**, 257 (1999).
22. T. R. Karl, R. R. Heim, R. G. Quayle, *Science* **251**, 1058 (1991).
23. H. E. Wright Jr. *et al.*, *Global Climates Since the Last Glacial Maximum* (Univ. of Minnesota Press, Minneapolis, MN, 1993).
24. C. W. Thornthwaite, J. R. Mather, *Publ. Climatol.* **8**, 1 (1955).
25. J. T. Callahan, *BioScience* **34**, 363 (1984).
26. A. K. Knapp, M. D. Smith, data not shown.
27. We thank the principal investigators, information managers, and scientists responsible for measuring ANPP at the LTER sites and J. Aber, W. Bowman, D. Schimel, G. Shaver, R. Ruess, T. Fahey, and W. Lauenroth for providing comments on earlier versions of the manuscript. Research was supported and data were provided by the NSF Long-Term Ecological Research Program, the VEMAP data group and sponsors (S. Aulenbach, NASA, the Electric Power Research Institute, and the U.S. Department of Agriculture's Forest Service), and Kansas State University. This paper is dedicated to the memory of Dr. James T. Callahan, whose foresight and support of the LTER program for over 20 years enabled these data to be collected.

10 July 2000; accepted 7 December 2000

Anti-inflammatory Activity of IVIG Mediated Through the Inhibitory Fc Receptor

Astrid Samuelsson, Terri L. Towers, Jeffrey V. Ravetch*

The molecular basis for the anti-inflammatory property of intravenous gamma globulin (IVIG) was investigated in a murine model of immune thrombocytopenia. Administration of clinically protective doses of intact antibody or monomeric Fc fragments to wild-type or Fcγ receptor–humanized mice prevented platelet consumption triggered by a pathogenic autoantibody. The inhibitory Fc receptor, FcγRIIB, was required for protection, because disruption either by genetic deletion or with a blocking monoclonal antibody reversed the therapeutic effect of IVIG. Protection was associated with the ability of IVIG administration to induce surface expression of FcγRIIB on splenic macrophages. Modulation of inhibitory signaling is thus a potent therapeutic strategy for attenuating autoantibody-triggered inflammatory diseases.

Although first introduced for the treatment of hypogammaglobulinemia, IVIG has since been shown to have broad therapeutic applications in the treatment of infectious and inflammatory diseases (*1*). The polyclonal specificities found in these preparations have been demonstrated to be responsible for some of the biological effects of IVIG. For example, IVIG has been used as prophylaxis against infectious agents and in the treatment of necrotizing dermatitis (*2*). Independent of these antigen-specific effects, IVIG has well-recognized anti-inflammatory activities, generally attributed to the immunoglobulin G (IgG) Fc domains. These activities, first applied for the treatment of immune thrombocytopenia (ITP) (*3*, *4*), have been extended to the treatment of a variety of immune mediated inflammatory disorders including autoimmune cytopenias, Guillain-Barré syndrome, myasthenia gravis, anti–Factor VIII autoimmune disease, dermatomyositis, vasculitis, and uveitis (*5–10*). A variety of explanations have been put forward to account for these activities, including Fc receptor blockade, attenuation of complement-mediated tissue damage, neutralization of autoantibodies by antibodies to idiotype, neutralization of superantigens, modulation of cytokine production, and down-regulation of B cell responses (*11–14*). However, the importance of any of these mechanisms to the in vivo activity of IVIG has not been established.

To investigate the mechanism by which

Laboratory of Molecular Genetics and Immunology, The Rockefeller University, 1230 York Avenue, New York, NY 10021, USA.

*To whom correspondence should be addressed. E-mail: ravetch@rockefeller.edu