

Report of the National Genetic Resources Advisory Council

USDA-ARS-NPGS National Strategic Germplasm and Cultivar Assessment and Utilization Plan

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EXECUTIVE SUMMARY

The Congressional request for a far-reaching USDA-ARS National Plant Germplasm System (NPGS) Strategic Plan in the 2018 Farm Bill is both a challenge and an unprecedented opportunity. The National Genetic Resources Advisory Council (NGRAC) is appreciative of the diligent NPGS effort to develop an appropriate response to address Congressional concerns with its National Strategic Germplasm and Cultivar Assessment and Utilization Plan. NGRAC has reviewed the draft Plan as directed in the 2018 Farm Bill and strongly supports its proposed operational improvements and request for significant additional funding. NGRAC also suggests USDA carefully consider the ten key points below, along with the Report's narrative, to make most effective and efficient use of its funding.

URGENT

- Develop both a more concise, outcome- and impact-oriented Plan that highlights strategies rather than tactics, as well as a compelling, highly condensed, non-technical two-page summary
- Invert NPGS priorities to increase emphasis on evaluation and genetic enhancement, rather than highlighting maintenance (acquisition and conservation)
- Direct initial sequencing and genotyping efforts to support quality assurance and collection rationalization, but do not delay a careful, staged implementation of these genotyping efforts in other NPGS activities, especially for genetic enhancement and pre-breeding
- Expand efforts to recruit and retain crop-specific curators, develop and provide targeted training for personnel in contemporary plant genetic diversity analyses and germplasm resource management, and locate personnel strategically
- Continue to prioritize development, functionality, and worldwide utilization of GRIN-Global

MID-TERM

- Explore efficiencies at the national scale for the propagation, processing, storage, and distribution of accessions, including expanded public-private partnerships
- Emphasize partnerships and targeted grant programs for characterization and genetic enhancement activities as a complement to expansion of ARS operations
- Focus more strongly system-wide on collection quality and utilization vs. strictly quantitative measures, including capping collection size with consideration of technical and economic aspects

LONG-TERM

- Foster collaborations among agencies and interested organizations (federal, state, tribal) and explore synergies for in situ conservation, field research, and documentation
- Ensure acquisition plans strategically consider U.S. national security and development of emergency deployment strategies

BACKGROUND

The 2018 Farm Bill directed USDA “to develop and implement a national strategic germplasm and cultivar collection assessment and utilization plan that takes into consideration the resources and research necessary to address the significant backlog of characterization and maintenance of existing accessions considered to be critical to preserve the viability of, and public access to, germplasm and cultivars”.... This request resulted from stakeholder concerns expressed to Congress about backlogs for plant germplasm maintenance and characterization in the USDA Agricultural Research Service NPGS. In response, during the last 2+ years, over 65 contributors from every NPGS genebank, ARS leadership, and University scientists contributed to the development of a National Strategic Germplasm and Cultivar Assessment and Utilization Plan.

The 2018 Farm Bill indicated “the Advisory Council (NGRAC) shall make recommendations on.... the development of the Plan.” Further, the Farm Bill stated: “On completion of the development of the plan...the Secretary shall make the plan available to the public.”

Prior to the Congressional request and subsequently, NGRAC has worked with ex-officio member, Dr. Peter Bretting, USDA Office of National Programs, to provide input to ARS on a comprehensive assessment of genetic vulnerability of all crops in the NPGS mission. In late 2020, NGRAC received a presentation on the outline of a draft Plan, but was only able to develop this report after the Council’s reactivation in Oct 2021, when the full initial Plan was received. The Strategic Plan and NGRAC report will undergo further review by USDA before submission to the National Agricultural Research, Extension, Education, and Economics Advisory Board, which will then consider submitting the report to the Secretary of the Department of Agriculture.

INTRODUCTION

The Council strongly commends the USDA-ARS for its comprehensive response to Congressional language in the 2018 Farm Bill. In developing the NPGS Strategic Plan, USDA-ARS staff, leadership, and NPGS stakeholders have obtained, compiled, analyzed, and summarized a truly massive amount of information. The Strategic Plan as reviewed by NGRAC is both a wide-ranging response to the 2018 Farm Bill as well as a highly detailed evaluation of NPGS operations among its 22 U.S. locations.

Major activities of the NPGS include acquisition, maintenance, characterization, documentation and distribution of plant genetic resources (PGR) – invaluable genetic diversity provided to us by Nature and our forebears. Since its inception and subsequent growth, the NPGS has uniquely and positively contributed to the food security of America and the world. It is an essential resource for continued agricultural innovation and a vital, sustainable, agricultural sector. Over time, its mission has significantly expanded, now with increasing emphasis on crop wild relatives (CWR), native North American species, and extensive genetic and breeding populations. Additionally, collaborations with initiatives like the Bureau of Land Management Seeds of Success program; the Forest Service National Reforestation, Nurseries, and Genetic Resources Program; and Plant Conservation Alliance are most effectively conducted with active NPGS participation. Finally, NPGS activities have often been challenged by increasing uncertainty in international genetic resources issues, such as access, exchange, and traceability.

Given its steady growth in collection sizes, expanded activities, global policy challenges, and constrained budgetary resources, the NPGS has done a remarkable job of fulfilling its mission and delivering significant impact on the food and agriculture sector in the U.S. and worldwide. Unfortunately, a chronic

backlog of maintenance and characterization activities currently afflicts NPGS operations. Furthermore, stakeholders have expressed their interest in more effective utilization of NPGS collections. Motivated by these concerns, Congress directly requested the USDA to develop a Strategic Plan both addressing backlogs as well as suggesting approaches to enhancing utilization of its holdings.

NGRAC members appreciate this opportunity and have reviewed the Plan, as directed in the 2018 Farm Bill. While we fully agree that a significant increase in funding is required to enable NPGS to fulfill its overall mission and interconnected activities, USDA is urged to consider the discussion below to more effectively and efficiently utilize the increased funding requested. The NGRAC report is organized in alignment with the NPGS Strategic Plan, which is based on its core activities: Maintenance and Characterization & Evaluation, with additional sections for National Security; Research, Education & Training; and NPGS Strategic Plan Format.

MAINTENANCE: SEED REGENERATION AND PROPAGULE INCREASE

The Plan hews very closely to the oft-mentioned directive from the Farm Bill to “address the significant backlog of characterization and maintenance.” It is largely written from a “backlog” perspective and focuses on seeking funding to expand activities for propagule regeneration, genotypic and/or phenotypic evaluation, collection gaps, backup safety storage, etc. Perhaps “backlog” needs to be redefined away from operational backlogs and instead defined to be the gap between what exists now and what will be needed going forward. What will be needed may well *not* include regenerating or keeping every accession, but rather prioritizing what is worth doing for each of these activities, pivoting to some new directions/processes, and probably *not* regenerating/maintaining some accessions.

Refocusing on future needs that are more streamlined is essential. Solutions to the needs identified in the Strategic Plan are essentially 50-100% budgetary increases for all NPGS units across the board. This seems highly unlikely, so if allocated funding covers less than the amount requested (funds, land, personnel, etc.), how will this document help decide what to do with that smaller amount? Responding to the Congressional request with an aspirational plan is highly commendable. However, the analysis of needs and development of operational strategies that will justify any increased funding should include how to use that funding most creatively and effectively. Critically, any plan should include priorities, so one knows what to do with less.

NGRAC suggests NPGS develop a master plan to identify optimum sites among existing USDA-ARS locations and partners (public and private) for regeneration and propagule increase. Existing NPGS sites responsible for each crop are not always the best sites for seed regeneration and propagule increase. Consider: land and labor costs, availability of irrigation, physical infrastructure, controlled environment and tissue culture facilities, relatively low pest and disease pressure, reduced likelihood of severe weather during the growing season, and staff expertise.

Economies of scale and operational efficiencies are possible when seed and clonal propagules of multiple crops are multiplied, processed, stored, quality-tested, and distributed at the same location. Rather than increase storage and distribution capability at each facility, NPGS should explore the development of one or a handful of centralized facilities to perform a range of core activities for regeneration, storage, and distribution activities:

- Regeneration via seed and clonal propagation
- Application of phytosanitary therapies to eliminate pests and diseases
- Maintenance of accessions in low temperature and cryogenic storage

- Germination and viability testing
- Processing of germplasm requests and shipment of seed and propagules

Such consolidation has already occurred in the U.S. commercial seed and nursery industry and is essential to fully benefit from automation. Such new facilities can handle millions of samples per year. Controlled environment facilities would benefit from consolidation as well, and if locations are carefully chosen, it could reduce the NPGS carbon footprint.

A further incentive for NPGS to fundamentally alter its approach to these core activities, as suggested above, is provided upon consideration of a sample of the Plan's metrics below.

Appendix D Table S7.1 (pp 48-51) indicates the backlog in regeneration/repropagation NPGS-wide is projected to decrease from 17% at present to 13% in five years and 9% in 10 years.

Appendix D Table S5.2c indicates the NPGS-wide reduction in the backlog for germination, viability and longevity testing is projected to decrease from 38% at present to 25% in five years and 19% in 10 years.

Appendix D Table S8b (pp 60-64) indicates the NPGS-wide availability of accessions is projected to increase from 87% to 90% after five years and 93% after 10 years.

Appendix D Table S4.3b (pp 14 -17) indicates the NPGS-wide back-up of NPGS PGR collections at the NLGRP will increase from 19% at present to 28% after five years and 35% after 10 years.

While there are many difficult species that could disproportionately inflate these overall backlog percentages, the improvements expected over the next ten years seem surprisingly small and incremental. We suggest a strategy that transforms NPGS routines into more efficient and targeted Best Management Practices for these fundamental activities, rather than allocating more funding to existing protocols. The Plan's intent to pursue applied research in these core activities offers an important potential improvement in efficiencies and effectiveness, but the conduct of the research and implementation of its results are only vaguely described, lack context and are not prioritized.

MAINTENANCE: PGR ACQUISITION AND IN SITU CONSERVATION

The NPGS should preferentially develop its capabilities in cutting-edge PGR management of its North American CWR, while contributing to CWR efforts worldwide. Acquisition of germplasm from other countries to augment NPGS holdings will likely be increasingly constrained by protective policies imposed by national governments worldwide. This is particularly true for systems like NPGS, which offer free access to its user community.

The initiative to develop expertise within NPGS to establish and maintain arrangements with public land management agencies for in situ conservation is exciting and promising. It would be advantageous to explore partnering opportunities with tribes and relevant non-governmental entities. The work of a few NPGS scientists skilled in PGR management and land use policy could play a key role in efficient resource conservation and contribute to many different taxa, nationally and internationally.

MAINTENANCE: DOCUMENTATION & DATA MANAGEMENT

The dynamic evolution of GRIN to GRIN-Global, which has had significant impact on internal operations and earned international recognition, is a forward-looking and noteworthy achievement of the NPGS. It should remain a very high priority. Building on this strong foundation and consideration of FAIR principles, the Strategic Plan properly seeks to continuously improve its functionalities, consolidate data management activities system-wide and ensure its germplasm holdings are thoroughly and comprehensively documented. Incorporating the open-source BrAPI (Breeding Application Programming Interface) web services is highly commended. As the Plan highlights (p 197), “Becoming BrAPI-compliant enables a secure and error-free method for GRIN-Global to share data to other BrAPI-compliant systems nationally and internationally.”

It would be helpful to explain the projected nature of ongoing collaboration with Genesys PGR. It would also be helpful to know what is planned for the compilation and curation of genomics/phenomics information and big data sets, and more generally, expand the capabilities of GRIN-Global to include more data types, including graphical data. This direction is consistent with the objective of increased emphasis on evaluation and pre-breeding over conservation and characterization. Hopefully, this will feature a tighter collaboration with existing databases, some of which are funded through USDA-ARS (e.g., MaizeGBD, GrainGenes, Genome Database for Rosaceae, Solanaceae Genomics Network, Cucurbit Genomics Database, etc.).

MAINTENANCE: LONG-TERM STORAGE

The Plan (p 58) indicates “major bottlenecks to PGR inventory control can arise from the process of assessing seed quality and quantity” and suggests the development and application of automated, nondestructive imaging and sensor systems. Multispectral imaging and machine learning could certainly be useful tools to apply in routine seed sample preparation and analysis (counting, assessing biochemical markers, etc.), but is the real intent to implement robotics, automated analytics, etc.? Overall, the research and technology development activities of the Ft. Collins unit for long-term storage of seed and clonally-propagated crops and assessment of genetic diversity are leading edge, with global impact, and another signal accomplishment of the NPGS. Additional funding for this unit is a wise investment.

CHARACTERIZATION AND EVALUATION: COLLECTION QUANTITY AND QUALITY

Although the annual growth rate of most collections is projected to be around 1%, the NPGS must focus more strongly on collection quality and potential for utilization vs. strictly quantitative measures. Better information is required to project the cost for maintenance of new accessions, with special attention given to CWR, genetic stocks, and breeding stocks. The NPGS should focus on disproving the hypothesis that collections with increasingly large numbers of accessions analyzed with neutral genetic markers are more useful and impactful than collections based on rigorous analysis of genetic diversity.

Apart from limiting the number of accessions added to its collections, as suggested in the Strategic Plan, does NPGS have an overall acquisition strategy outside of the projected slow increase (~1% annually)? Ideally, the Crop Vulnerability Statements (CVS) developed by the voluntary Crop Germplasm Committees (CGCs) should provide prioritized, crop-specific components, but they should be updated and visionary. Some crop/taxon-specific plans for the 40+ CGCs as currently available in GRIN-Global are updated and definitive, but many are either non-existent or badly dated regarding acquisition and other core activities. Motivating decisive action in all-volunteer committees is a challenge – NPGS should

consider improving the capabilities of its crop-specific curators to more proactively lead development of CVS, complemented with appropriate stakeholder participation.

Collections should not continue increasing in size indefinitely. A cap on the size of each collection for each crop or group and its group of CWR should be established. Above that cap, incorporation of any new accession should replace an existing accession deemed redundant or disposable. Exceptions could be made if new accessions came with funding allowing them to be maintained in perpetuity.

To enable such a cap-escape mechanism, consider the establishment of an NPGS endowment, and the determination of what it costs to maintain an accession in perpetuity. With those two conditions met, the NPGS could implement an “Adopt-an-Accession” program. Both donors and germplasm depositors could fund this endowment and be acknowledged for their contribution in GRIN-Global and on the webpage corresponding to the adopted accession(s). An example of a similar funding mechanism established by Congress is the National Forest Foundation [<https://www.nationalforests.org/>].

Although mention is made of the Svalbard Global Seed Vault and adherence to international standards, the Plan suggests NPGS curators are considering rationalization and management of holdings strictly within the NPGS. Some attention should be paid to PGR management as a global undertaking. Key partners in this effort include the Crop Trust initiative [<https://www.croptrust.org/project/conservation-strategies/>]; Biodiversity International/CIAT [<https://alliancebioiversityciat.org/>]; and CGIAR Centers [<https://www.cgiar.org/research/research-centers/>].

CHARACTERIZATION & EVALUATION: GENOTYPING AND SEQUENCING

Equating “characterization” with “genotyping” and “evaluation” with “phenotyping.” (p 18) should be reconsidered. For clarity, we suggest sticking with genotyping and phenotyping, which specify exactly what assessment will be done. It is also important to provide clarifying definitions since the Congressional language includes “assessment” and “characterization”.

Genotyping and sequencing technology are evolving rapidly and will likely continue to do so. Costs are steadily going down and quality is going up very quickly. We suggest NPGS carefully stage and target sequencing activities for its holdings. As an initial step NPGS should focus on sequencing and genotyping efforts to support collection management activities: e.g., identification of accessions, verification of propagule purity, testing for adventitious presence of transgenes and phytosanitary assays. If those capabilities are successfully implemented, NPGS could more confidently pursue third-party propagation efforts, as it will have the means to verify the purity of incoming seed lots/propagules regardless of origin.

Subsequently, sequencing activities should be expanded in more complex characterization and evaluation efforts. It is not necessary to wait for the “perfect” sequencing technology, or we will wait forever. Marker technologies and now sequencing technologies have great utility when appropriately combined with other data (phenotypic evaluation, environmental, etc.). In addition, there is an opportunity cost of not finding genes or genome regions involved in important traits, since this information could have quick application in genetic enhancement. Determination of feasibility is best done on a crop-by-crop basis and will benefit from CGC input. Finally, and emphatically, in these activities NPGS should actively pursue collaborations with public and private sector stakeholders working in target crop/crop groups. At the same time, NPGS should consider the socio-political

sensitivities of domestic and international stakeholders who might object to participation by private entities.

CHARACTERIZATION & EVALUATION: GENETIC ENHANCEMENT/PRE-BREEDING

Historically, genebanks have put emphasis on conservation and characterization (passport data mostly). Resource and structural constraints understandably have limited rigorous evaluation of agronomic/horticultural, quality, culinary, etc. traits and pre-breeding (development of adapted germplasm). Thus, materials in genebanks have not been utilized in plant breeding or other research areas as successfully as they could be.

We suggest NPGS invert its stated priorities in its operational components (Maintenance, Characterization & Evaluation) to focus more strongly on evaluation and genetic enhancement/pre-breeding as integral activities of a genebank in a targeted, staged, and forward-looking approach. The critical outcome for a successful genebank is the substantial *utilization* of genetically diverse holdings for crop improvement. Clearly, conservation, propagation, and evaluation are important, and constitute a critical foundation for enhanced NPGS activities but are not goals in themselves (see Bretting Plan Briefing slide 9). They are necessary conditions for germplasm preservation and utilization.

Characterization and evaluation (both genotypic and phenotypic) and genetic enhancement should be conducted in conjunction with the public sector and private sector user communities, who have the necessary expertise. Rather than directing increased funding for characterization and pre-breeding activities to NPGS personnel and operations at its current 22 sites, we suggest establishing a competitive grant mechanism for PGR characterization and genetic enhancement within the USDA, but not necessarily within ARS. Large-scale projects like WheatCAP, CucCAP, RosBREED, and GEM are useful models.

Such an approach would encourage other actors to participate in the process (Universities, NGOs, private sector, international partners) and stimulate co-funded projects. NPGS (leadership, crop curators, ARS scientists) and CGC representatives should be actively involved in such a grant program. This would allow NPGS to focus on its core mission in PGR management, while providing invaluable input in conducting the targeted research. It also allows for a more effective and efficient approach to appropriately standardized phenotyping by leveraging the breadth of partners' crop-specific technical competencies and appropriate environmental and cultural conditions.

CHARACTERIZATION & EVALUATION: GENOMICS

The Plan's proposed expansion in activities and substantial commitment to Component 10: Genotypic Characterization of NPGS PGR (pp 195-197) requires a more careful and prudent analysis. The Plan's suggestion of collaborating with other genomics research programs, such as the Earth Biogenome Project (<https://www.earthbiogenome.org/>) is commended. However, when considered jointly, Components 10, 11, and 12 do not reveal a comprehensive NPGS-wide strategic plan, but seem to defer such planning until after funding is allocated. A proactive staged approach with milestones and intended outcomes would provide confidence for stakeholders and policymakers and facilitate operational adjustments. The Plan should include a rationale and specific plan for the selection of the 50-100 crops it suggests will be the focus of characterization, evaluation and pre-breeding as well as the rationale and specific plan for genotypic characterization of the 150,000 accessions identified as representing species not closely related to 200 crops prioritized for such characterization (p 196-197).

CHARACTERIZATION & EVALUATION: PHENOMICS

The Plan proposes internal expansion of digital imaging and phenomics. As in genotyping and sequencing activities, we recommend NPGS not wait for the “perfect” technology and work closely with relevant CGCs and the Plan’s suggested “Technical Steering Group” (both including public and private sector participants) to carefully stage and target phenomics activities, balancing cost: benefit. It is a good idea to inexpensively capture appropriate imagery while maintaining accessions. However, we suggest hypothesis-driven experimentation, genomic prediction, or selection, be conducted in partnership on competitively-funded projects.

Phenomic prediction of yield or “overall genetic potential”, in addition to trait replacement (aerial/automated for ground/visual phenotyping), is a challenge given the phenotypic diversity and relative lack of agronomic/horticultural adaptation for much of the NPGS holdings. However, there are multiple traits that could now be evaluated in a more efficient way, if not a high-throughput way, which is precisely what is needed in germplasm activities: e.g., leaf temperature, plant growth rate and habit, etc. Clearly not all traits are amenable, but efforts should be judiciously targeted on a crop/crop group basis. Further, the actual phenotyping activities are only a part of the overall cost. Phenomics is very similar to bioinformatics: the bulk of expense falls in post-processing, QC, and interpretation of data and requires staff with appropriate expertise.

Development and implementation of standardized phenotyping protocols must be critically and specifically evaluated. Due to numerous site-specific conditions, minimum spatial and phenological/temporal resolution should be defined for the project objectives, rather than applying a more generalized phenotyping protocol. For example, the expense of obtaining calibrated reflectance values and geospatial precision is very likely unnecessary for the goals of characterizing germplasm but is more relevant for germplasm users.

NATIONAL SECURITY

The NPGS should take the lead in defining national crop genetic security in the context of crop and taxon and its relation to ongoing global PGR conservation and utilization. Within the context of National Security and Emergency Management, NPGS should serve as more than a resource for PGR conservation – it should develop its capabilities as a preferred source to inform policy decisions and deliver actionable recommendations when emergency deployment of PGR is required.

RESEARCH, EDUCATION & TRAINING

Appropriately skilled personnel are essential to transform not only maintenance and characterization activities of the NPGS, but the entire set of NPGS activities. Currently, NPGS suffers from a lack of personnel with appropriate training in plant genetic resources management and utilization. The NPGS should set a high priority on recruiting diverse scientists with appropriate educational background in relevant contemporary competence in genetics, breeding, and agronomy and/or horticulture to serve as curators. If NPGS is to effectively link conservation with genetic enhancement, such scientists with expertise in relevant scientific disciplines and experience in target species are essential.

To the extent possible, NPGS should provide at least one crop (or crop group)-specific curator for each CGC and locate these scientists appropriately. Directed and significant improvements in training

programs for continuing education in plant genetic resources management are urgently needed for NPGS staff. Initial efforts led by the Ft. Collins unit are exemplary and should be significantly expanded and appropriately supported.

“Applied research” is singled out as a PGR management activity (p. 18), but its description is mostly discussed separately within three activities (maintenance, characterization/evaluation, and genetic enhancement). Either applied research should be one activity (thus, one point only) that encompasses all three of these plus the research on PGR management approaches/procedures, or it should be its own point focusing on PGR management approaches/procedures.

NPGS STRATEGIC PLAN FORMAT

While NGRAC views the enormous effort to make this a data-driven exercise as entirely impressive, such a massive report with dense narrative and numerous complex graphics mostly characterizing operational backlogs is challenging, even for scientists well-versed in PGR management. We suspect few policymakers or stakeholders will be inclined to read and evaluate the Plan as written.

The numerous infographics reflect a commendable effort to present information in a condensed format aiding interpretation, but most in their present form require a great deal of time and analysis. Some confuse rather than clarify: e.g., in Fig. 1.6 (pp 38-39) the color scheme for the top part (“a” = annual recurrent funding) is misleading. Darker shades are meant to indicate larger percentage increases, but most of this part is light gray, which suggests no change. That is not the case and is visually misleading.

The Plan is absolutely invaluable as an in-house resource, yet its mass, detail and complexity with a focus on cataloging internal operations distract from its goal of meeting Congress’s request to “develop and implement a national strategic germplasm and cultivar collection assessment and utilization plan.” It comes across very much like a tactics document, rather than a strategic plan. We suggest developing an additional, much more concise document with less text and with fewer but clearer charts that highlight the key needs and expected outcomes extracted from the larger, data-rich document. We also suggest a much stronger emphasis on identifying and cultivating partnerships, as well as the mechanisms NPGS will employ to set and monitor metrics. The NPGS Plan Briefing PowerPoint shared with the NGRAC might serve as a helpful starting template. NGRAC strongly suggests a regular, formal review of the Plan’s implementation, including ARS Administration, other federal partners, University partners, and diverse stakeholders and customers. This should complement, rather than replace, the typical five-year National Program retrospective and prospective review process. Further, NPGS should consider development of a Logic Model approach at the system and unit level as part of its planning and adjustment activities.

Finally, NGRAC vigorously recommends NPGS prepare a compelling, non-technical two-pager summarizing the needs, expected outcomes, and impacts of the NPGS Strategic Plan, so stakeholders, policymakers, and the public have an effective resource to better understand the critical importance of the NPGS mission and the benefits to U.S. agriculture and society as a whole that would accrue from increasing the current level of federal investment.

CONCLUDING REMARKS

NGRAC appreciates this opportunity to contribute to addressing the Congressional request and again commends USDA-ARS-NPGS for its conscientious response and Strategic Plan. The Council is strongly supportive of this overall effort and eager to contribute to the continued development of the Plan.

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