The Pine Genome Initiative

—Harry L. Haney, Jr., PhD
Garland Gray Emeritus Professor of Forestry
Department of Forestry, Virginia Tech

—Robert Kellison, PhD
President, Institute of Forest Biotechnology

Forest landowners benefit from research in tree genetics, nutrition, chemical competition control, and basic sciences. For example, the straight fast-growing loblolly pine trees being planted today evolved from 60 years of tree improvement research by public agencies, forest industry, and the land grant universities. The pine genome initiative (PGI) builds on this foundation, promising healthy, highly-productive forests for the future. The purpose of the PGI is to use the revolutionary tools of genomics to develop a comprehensive understanding of the pine genome and to increase our knowledge of the molecular processes that control ecological and economic traits in pine and other coniferous forest trees.

National Plant Genome Initiative (NPGI)

The PGI is part of the broader National Plant Genome Initiative, which was established in 1998 as a coordinated national plant genome research project. Its six major objectives are: continued elucidation of genome structures and organization; functional genomics; translational plant genomics; bioinformatics; education, training, and outreach; and consideration of broader impacts

Coordination of activities, guidance, and oversight is provided by the interagency Working Group of Plant Genomics under the auspices of the Committee of Science of the National Science and Technology Council with the Office of Science and Technology (OSTP). Participating agencies include the USDA, National Science Foundation, Department of Energy, National Institute of Health, National Aeronautic and Space Administration, Agency for International Development (USAID), OSTP and the Office of Management and Budget. Each agency participates in the NPGI in a manner consistent with its specific mission.

"We make a living by what we get, but we make a life by what we give."

Winston Churchill

The NPGI supports research to accelerate advances in plant genomics. It does this by making new genomics research resources and tools widely available for use in the study of plant function, resilience, vigor, and development. This includes the expansion of federally supported plant genomics to include applications in environmental biology and biodiversity. The cornerstone of NPGI's policy is the "open free and rapid access to all information and materials generated by federally-supported plant genome research." This policy makes the U.S. a world leader in plant genomics research and its application to agriculture, health, energy, and the environment.

Current activities illustrating advances in plant genomics supported by NPGI include work on rice, poplar (Populus trichocarpa), tomato, sorgum, grape, and maize. For example, the genomic-enabled modification of poplar root development for increased carbon sequestration is being investigated by the Oak Ridge National Laboratory, Purdue University and Michigan Technological University to identify key genetic regulations that might enhance root proliferation in poplar.

Why Should Forest Landowners Be Interested?

An understanding of the pine genome offers multiple benefits leading to fundamental new discoveries and technologies. In general, the PGI will provide insights into plant evolution and permit a comparison of ancient gymnosperm with modern angiosperm plants to explain the long-term ecological success of pines. The work will uncover mechanisms that enable trees to be among the most abundant, largest and longest-lived organisms. These results will aid the restoration of environmentally sensitive forests and endangered tree species.

Knowledge from the PGI will broaden trees' ability to withstand environmental stresses and invasive pests. Economically, PGI results will improve the competitiveness of U.S. forest products and related industries, plus promoting development of renewable bio-based products, including bio-fuels. Environmentally, it will enhance the capacity to sequester carbon and lessen global climate change and accelerate the breeding of longer-lived organisms. In short, it will ensure healthier forests and more sustainable forestry practices.

Over the past six decades, using conventional breeding techniques, scientists have successfully improved conifer strains to produce straight, fast-growing trees for commercial use that are resistant to common diseases and insects. Unlocking the pine genome can accelerate the selection process for discovering new ways to capture the ecological and economic value contained in the genetic base. Dramatic improvements in rice,

maize, and other plant illustrate the prospects.

What Is Needed?

The PGI envisions a competitive grants program administered through existing federal agencies to achieve the goals of this program. To be successful, funding at $30 million per year for 5 years is required. This level is especially important at this time for two reasons. First, funding for pine genome research has lagged behind the grants for the agronomic plants included in the NPGI. Second, the large-scale transfer of forest ownership from the forest products industry to timber investment management organizations (TIMOs) is likely to curtail funding for research projects such as PGI. Furthermore, matching industry research grants from industry to partner with federal agencies becomes less likely as the land ownership shifts to TIMOs. That is, the TIMOs and large institutional investors are unlikely to contribute significant research funds because their objectives for profit maximization with medium (10- to 15-year) investment horizons are too short for them to gain substantially from long term basic research such as the PGI.

Why Research on the Pine Genome?

The PGI will serve as a model to aid in understanding all conifer genomes. For example, understanding the loblolly pine biology, the most important commercial tree crop species in the U.S., is essential to maintaining the nation's competitiveness in the global forest products market. With a planting program approaching one billion seedlings annually, pine plantations are expected to provide 70 percent of the U.S. timber supply by 2040. Currently, the species has the highest annual farm gate value of any crop other than corn.

Additionally, pines are environmentally important in fast growing plantations for carbon sequestration. They are ecologically important because of their broad geographic range and their ability to occupy soils ranging from highly fertile to degraded. Pines are representative of most conifers that have large genome sizes. Finally, pine, like other conifers, are high in cellulose and lignin content which are the two most abundant macromolecules in the biosphere.

Who is Involved?

The PGI is a coalition of scientists and experts from more than 35 universities, governmental agencies, and forest products companies across the U.S. In addition, the emphasis on unlocking the pine genome has advocates throughout the world because an accomplishment in one coniferous forest-tree species will have applications to other conifers. Scientific expertise and collaboration for the envisioned PGI effort is being offered from countries such as Argentina, Brazil, Chile, Uruguay, Australia, New Zealand, and regions from Asia, Southern Africa, Europe, and Scandinavia.

The information for this report is adapted from the Pine Genome Initiative, *a brochure prepared by the PGI implementation committee. Additionally, information is reported from the Progress Report (January 20, 2006) of the national Plant Genome Initiative, a prospectus of the Loblolly Pine Genome Project (11/10/04), minutes of various pine genome project meetings and the* Forestry Source *(May 2006).*