PROJECT CAPTURE: A NATIONAL PRIORITIZATION ASSESSMENT OF TREE SPECIES FOR TREE SPECIES FOR CONSERVATION, MANAGEMENT, AND

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A variety of threats, most importantly climate change (Parmesan 2006) and insect and disease infestation (Logan et al. 2003; Dukes et al. 2009; Sturrock et al. 2011), will increase the likelihood that forest tree species could experience population-level extirpation or species-level extinction during the next century. Project CAPTURE (Conservation Assessment and Prioritization of Forest Trees Under Risk of Extirpation) is a cooperative effort across the three deputy areas of the USDA Forest Service to establish a framework for conservation priority-setting assessments of forest tree species across the entire United States.

Project CAPTURE uses extensive lists of life history trait data, as well as climate change and pest and pathogen threat information, to categorize and prioritize native tree species for conservation, monitoring, management and restoration. The geographic scope of the initial phase of the Project CAPTURE encompasses approximately 400 tree species that occur on all forested lands within the contiguous United States and Alaska. Differences in data availability require separate prioritization efforts for the native tree species of Hawai'i and other U.S. Pacific islands and for the native species of Puerto Rico and the U.S. Virgin Islands; these efforts are now under way.

The foundation of this overall effort is a flexible framework that rates species based on risk factors relating to (1) *intrinsic attributes*, such as population structure, fecundity and seed dispersal ability; (2) *external threats* to genetic integrity; and (3) *conservation factors*, including evolutionary distinctiveness and regional responsibility. The Project CAPTURE framework allows for the quantitative grouping of species into vulnerability classes that may require different management and conservation strategies for maintaining the adaptive genetic variation of the species contained within each class.

Project CAPTURE builds on previous regional National Forest System efforts to assess the vulnerability of forest tree species to climate change and other threats (Aubry et al. 2011; Potter and Crane 2010; Devine et al. 2012). It aims to address three overarching principles necessary to enhance forest resilience and resistance on forested lands of the United States in the face of climate change: (1) Genetically diverse and adapted seed and planting stock will provide the foundation for healthy forests and ecosystems in the future; (2) Gene conservation is key to preserving vulnerable species and populations for the future; and (3) Establishing and maintaining partnerships will be more important than ever (Erickson et al. 2012).

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In the face of multiple threats and uncertainty, an important forest management goal will be to safeguard existing adaptedness within tree species and create conducive conditions for future evolution, with a focus on the conservation of variability in adaptive traits (Myking 2002). Our understanding of relevant adaptive traits is incomplete or non-existent for many tree species, however. Several researchers have therefore proposed using ecological and life-history traits to evaluate species' genetic resources and predisposition to threats including climate change (Sjostrom and Gross 2006; Myking 2002; Aitken et al. 2008).

Maintaining genetic variation across multiple species will require tailoring conservation, management, monitoring and restoration efforts to species with similar vulnerabilities. Specifically, priority-setting approaches will become increasingly important when conditions are rapidly changing and needs are greater than the available capacity to respond (Millar et al. 2007). It has become increasingly clear that triage, for example, may be necessary to prioritize forest tree species and populations for conservation (St Clair and Howe 2011). Such priority-setting can include the assessment of extinction risk, but also can integrate a wide variety of other information, such as economic and ecological importance; the probability of success; and the availability of funds (Gauthier et al. 2010; St Clair and Howe 2011).

The results of priority-setting assessments can be applied for restoration and conservation planning, for the evaluation of species' genetic resources, and for the early detection of vulnerability (Devine et al. 2012; Aubry et al. 2011). Importantly, such assessments should be based on a scientifically defensible and transparent process. These assessments also must be ongoing and adaptive to account for new information (Carter et al. 2000; Millar et al. 2007; Coates and Atkins 2001).

In this context, 25 USDA Forest Service resource managers and scientists participated in a Project CAPTURE workshop in March 2014 workshop, at The Arbor Day Foundation's Lied Lodge and Conference Center, to work toward agreement on a scientifically defensible and transparent process to categorize and prioritize tree species for conservation, monitoring, management and restoration.

Consensus at the workshop was that the project focus should be to identify and categorize forest tree species on U.S. forested lands that are expected to be most vulnerable to genetic degradation in the face of multiple threats. Genetic degradation is defined as a significant reduction in the ability of a species to persist for the next century without the loss of important variation in adaptive traits. Maintaining variation in adaptive traits is an important forest management goal because it increases the likelihood (1) that individuals across the species will have adaptedness to greater range of environmental conditions, and (2) that the species (or a population within the species) will be able to continue undergoing the evolutionary process of adaptation via natural selection and thus to be able to persist in its habitat or habitats.
Conceptually (Foden et al. 2013; Booth 2013), the prioritization framework aims to assess the relationship between the severity of each of three distinct threats (Exposure to Pests and Pathogens, Expected Climate Change Pressure, and Lack of Structural Sustainability) and two

intrinsic vulnerability dimensions (Sensitivity and Low Adaptive Capacity) associated with each of those threats.

Data for two external threats (Exposure to Pests and Pathogens and Expected Climate Change Pressure), 23 intrinsic vulnerability species traits, and six conservation factors have been collected for each of the species included in the assessment. Most of the data were available from a handful of publicly available sources.
The proposed categorization and prioritization process is hierarchical and data-driven, and consists of five steps:

Step 1: Decision of which species traits (such as drought tolerance, site affinities, and frequency of large seed crops) should be included in each of several broad species attributes (such as Rarity, Regeneration Capacity, Dispersal Ability, and Environmental Limitations) in the context of each of three major threats to tree species (Exposure to Pests and Pathogens, Expected Climate Change Pressure, and Lack of Structural Sustainability). Each species is given a relative score (on a scale of 0-100) for each broad attribute.

Step 2: Determination of which species attributes (such as Rarity and Regeneration Capacity) belong in each of the two intrinsic vulnerability dimensions (Sensitivity to Threats and Low Adaptive Capacity) associated with the three distinct external threats.

Step 3: For each threat (Exposure to Pests and Pathogens, Expected Climate Change Pressure, and Lack of Structural Sustainability), grouping of species into vulnerability classes based on vulnerability dimension and individual threat severity scores using a quantitative clustering approach. For each of the three threats, species are given a vulnerability rating.

Step 4: Determination of each species' overall vulnerability score. This can be done in one of two ways: (1) Selecting the highest of the vulnerability scores from the three threats. (2) Combining the vulnerability scores for the three threats in a manner that weights each threat differently based on the perceived immediacy and severity of the threat to forest trees.

Step 5: If appropriate, assignment of higher prioritization weights to species based on additional factors, such as NatureServe conservation status and the degree to which a species' range occurs within the boundaries of the United States ("regional responsibility").

The flexibility of the Project CAPTURE framework allows for its application at multiple scales and across any area for which the relevant data exist for the species of interest. Only by considering extinction as a synergistic process of external threats and intrinsic biological traits will it be possible to make predictions of risk that approximate reality for most species, and therefore to increase the likelihood that conservation efforts will be effective (Brook et al. 2008). The Project CAPTURE assessment tool should be valuable for scientists and managers attempting to determine which species and populations to target for monitoring efforts and for pro-active gene conservation and management activities.

Literature Cited

Aitken SN, Yeaman S, Holliday JA, Wang TL, Curtis-McLane S (2008) Adaptation, migration or extirpation: climate change outcomes for tree populations. Evol Appl 1 (1):95-111. doi:10.1111/j.1752-4571.2007.00013.x

Aubry C, Devine W, Shoal R, Bower A, Miller J, Maggiulli N (2011) Climate Change and Forest Biodiversity: A Vulnerability Assessment and Action Plan for National Forests in Western Washington. vol 2012. USDA Forest Service, Pacific Northwest Region, Olympia, Washington

Booth TH (2013) Eucalypt plantations and climate change. Forest Ecol Manag 301:28-34. doi:10.1016/j.foreco.2012.04.004

Brook BW, Sodhi NS, Bradshaw CJA (2008) Synergies among extinction drivers under global change. Trends Ecol Evol 23 (8):453-460. doi:10.1016/j.tree.2008.03.011

Carter MF, Hunter WC, Pashley DN, Rosenberg KV (2000) Setting conservation priorities for landbirds in the United States: The partners in flight approach. Auk 117 (2):541-548. doi:10.1642/0004-8038(2000)117[0541:scpfli]2.0.co;2

Coates DJ, Atkins KA (2001) Priority setting and the conservation of Western Australia's diverse and highly endemic flora. Biol Conserv 97 (2):251-263. doi:10.1016/s0006-3207(00)00123-3

Devine W, Aubry C, Miller J, Potter KM, Bower AD (2012) Climate change and forest trees in the Pacific Northwest: Guide to vulnerability assessment methodology. USDA Forest Service, Pacific Northwest Region, Olympia, Washington

Dukes JS, Pontius J, Orwig D, Garnas JR, Rodgers VL, Brazee N, Cooke B, Theoharides KA, Stange EE, Harrington R, Ehrenfeld J, Gurevitch J, Lerdau M, Stinson K, Wick R, Ayres M (2009) Responses of insect pests, pathogens, and invasive plant species to climate change in the forests of northeastern North America: What can we predict? Canadian Journal of Forest Research-Revue Canadienne De Recherche Forestiere 39 (2):231-248. doi:10.1139/x08-171

Erickson VJ, Aubry C, Berrang P, Blush T, Bower A, Crane BS, DeSpain T, Gwaze D, Hamlin J, Horning ME, Johnson R, Mahalovich MF, Maldonado M, Sniezko R, St Clair B (2012) Genetic Resource Management and Climate Change: Genetic Options for Adapting National Forests to Climate Chage. United States Department of Agriculture Forest Service, Forest Management, Washington, DC

Foden WB, Butchart SHM, Stuart SN, Vie JC, Akcakaya HR, Angulo A, DeVantier LM, Gutsche A, Turak E, Cao L, Donner SD, Katariya V, Bernard R, Holland RA, Hughes AF, O'Hanlon SE, Garnett ST, Sekercioglu CH, Mace GM (2013) Identifying the World's Most Climate Change Vulnerable Species: A Systematic Trait-Based Assessment of all Birds, Amphibians and Corals. Plos One 8 (6). doi:10.1371/journal.pone.0065427

Gauthier P, Debussche M, Thompson JD (2010) Regional priority setting for rare species based on a method combining three criteria. Biol Conserv 143 (6):1501-1509. doi:10.1016/j.biocon.2010.03.032

Logan JA, Regniere J, Powell JA (2003) Assessing the impacts of global warming on forest pest dynamics. Front Ecol Environ 1 (3):130-137

Millar CI, Stephenson NL, Stephens SL (2007) Climate change and forests of the future: Managing in the face of uncertainty. Ecological Applications 17 (8):2145-2151. doi:10.1890/06-1715.1

Myking T (2002) Evaluating genetic resources of forest trees by means of life history traits - a Norwegian example. Biodiversity and Conservation 11 (9):1681-1696

Parmesan C (2006) Ecological and evolutionary responses to recent climate change. Annu Rev Ecol Evol Syst 37:637-669

Potter KM, Crane BS (2010) Forest Tree Genetic Risk Assessment System: A Tool for Conservation Decision-Making in Changing Times. User Guide, Version 1.2. USDA Forest Service, Eastern Forest Environmental Threat Center. http://www.forestthreats.org/current-projects/project-summaries/genetic-risk-assessment-system-description-120610.pdf. Accessed June 1 2011

Sjostrom A, Gross CL (2006) Life-history characters and phylogeny are correlated with extinction risk in the Australian angiosperms. J Biogeogr 33 (2):271-290. doi:10.1111/j.1365-2699.2005.01393.x

St Clair JB, Howe GT (2011) Strategies for conserving forest genetic resources in the face of climate change. Turk J Bot 35 (4):403-409. doi:10.3906/bot-1012-98

Sturrock RN, Frankel SJ, Brown AV, Hennon PE, Kliejunas JT, Lewis KJ, Worrall JJ, Woods AJ (2011) Climate change and forest diseases. Plant Pathol 60 (1):133-149. doi:10.1111/j.1365-3059.2010.02406.x